# वार्षिक प्रतिवेदन
# ANNUAL REPORT

## 2012-13


उत्तर पूर्वी पर्वतीय कृषि अनुसंधान परिसर
(भारतीय कृषि अनुसंधान परिषद्)
उमियम-७९३ १०३, मेघालय

ICAR Research Complex for N. E. H. Region
(Indian Council of Agricultural Research)
Umiam-793 103, Meghalaya

ICAR Research Complex for NEH Region
Umroi Road, Umiam – 793 103, Meghalaya
Telephone: 0364-2570257, Fax: 0364-2570355
Email: svngachan@rediffmail.com
Website: www.icarneh.ernet.in

**Annual Report 2012-13**



**Published by**
Director
ICAR Research Complex for NEH Region
Umiam – 793 103, Meghalaya

**Correct citation**
Annual Report 2012-13, ICAR Research Complex for NEH Region, Umiam 793 103, Meghalaya

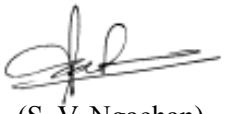
Designed and printed by ***print21***, Ambikagirinagar, R.G.Baruah Road, Guwahati - 781 024

# PREFACE

Consolidation, consortium and coverage are the way to success in technology development and delivery. The ICAR Research Complex for NEH Region, a premier institute of ICAR, has been following this path for the last 38 years in achieving its goal to address the needs of the farmers and entrepreneurs in the technology constrained North Eastern Hill region. Food production within the region needs to be doubled to meet the demand by 2050. Rice and maize are the main food crops throughout the region. At the national level annual growth rate of rice and maize is about 1% and 1.6 %, respectively. Whereas at the north eastern region these are 1.4% and 1.2%, respectively. The horticulture sector showed encouraging growth, but growth in animal husbandry and fishery sector remained low. Therefore, the region has to go a long way to achieve food sufficiency. Increasing crop yields, rather than clearing more land for agriculture is the preferred route in this voyage.

In its quest for increasing yields in agriculture and allied sectors, the Institute released nine varieties of field and horticultural crops during the reporting period and contributed several lines to the All India Coordinated programmes. Significant progress was made in standardization and application of zero tillage-based conservation agriculture, rain water harvesting and farming system development. In the animal husbandry sector, a low-cost pig housing system was developed, which not only helped to improve fattening but also reduced a number of health-related problems. The region, with its long international boundary, is at constant threat from trans-boundary diseases. The scientists of the Institute have developed competence in molecular disease diagnostics. For the first time in the country, scientists of the institute detected porcine reproductive and respiratory syndrome. Changes in the temperature and rainfall pattern are major concerns for the ecologically vulnerable NE hill region. To keep pace with such changes, the Institute has already started research towards development of climate ready technologies. State of the art facilities have been developed for carrying out research under elevated temperature and carbon dioxide environment.

I have the pleasure in presenting the Annual Report of the Institute for the year 2012-13, where among the others; the above activities are covered in detail. I compliment the editorial board for their effort in compiling the report. I also record my sincere thanks to the Director General, Dr S. Ayyappan; the Deputy Director General (NRM) Dr A. K. Sikka; the Ex-Deputy Director General (NRM) Dr A. K. Singh and the Assistant Director General (A & AF) Dr B. Mohan Kumar for their constant support and guidance that enabled the Institute to make the achievements presented here.



(S. V. Ngachan)
Director

# CONTENTS

# कार्यकारी सारांश

प्रतिवेदन (2012-13) के तहत अवधि के दौरान खाद्य एवं पोषक सुरक्षा को ध्यान में रखते हुए उत्पादकता को बढ़ाते हुए एकीकृत दृष्टिकोण तथा विकासशील उच्च उत्पादन, प्रतिबल सहनशील फसल तथा विविध पशुधनों के माध्यम से दक्ष प्राकृतिक संसाधन प्रबंधन पर विशेष बल दिया गया है। वर्ष 2012-13 के दौरान किए गए अनुसंधान कार्य की प्रमुख उपलब्धियों को निम्नवत रूप से संक्षेपित किया गया है :

## उमियम (मुख्यालय)

उच्च भूमि के पर्यावरण में केंद्र परीक्षण के तहत आरसीपीएल 1-413 (3.43 टन/हेक्टेयर), आरसीपीएल 1-103 (3.20 टन/हे.) तथा आरसीपीएल 1-82 (3.17 टन/हे.) ने उन्नत किस्म भालुम 3 (2.64 टन/हे.) की तुलना में खास तौर पर बेहतर प्रदर्शन दिखाया। समन्वित परीक्षण के तहत जिनोटाइप्स वीएल 8608 (3.15 ट./हे.), आरसीपीएल 1-412 (2.95 टन/हे.) ने स्थानीय चेक की तुलना में खास तौर पर बेहतर प्रदर्शन किए। निम्न भूमि की स्थितियों के तहत आरसीपीएल 1-466 (5.55 ट./हे.) तथा आरसीपीएल 1-300 (5.12 ट./हे.) अग्रणी प्रजातियाँ रहीं, जिन्होंने सर्वश्रेष्ठ चेकी की अपेक्षा महत्त्वपूर्ण रूप से उत्पादन लाभ दिए। 45 उच्च भूमि के प्रमुख खंडों के चावल, चार उच्च सहिष्णु तथा 4 क्षतिग्रस्त होने वाला जीनोटाईप में अल्युमीनियमटाक्सिसिटी की पहचान की गई, जो जड़ सहिष्णु अनुक्रमणिक, तना सहिष्णु अनुक्रमणिका तथा जड़/तना अनुपात के आधार पर था, जो 200 यू एम एल्युमीनियम एएलसीएल 3 तक उभर कर सामने आया। इयूरोन 514 को उच्च भूमि तथा झूम की भौमिक परिस्थितियों के लिए एक संभावनायुक्त प्रजाति के रूप में चिन्हित किया गया, जिसके माध्यम से अन्न की उपज 3-3.5 ट./हे. करना संभव है। चावल के प्रत्यारोपण के पश्चात 30 दिनों में 0.5 मे.लि/ली के हिसाब से इमीडाक्लोप्रिड का छिड़काव स्टेम बोरर (0.60% मृत हर्ट) पर प्रभावकारी पाया गया। जैवकीटनाशकों में 2 मे.लि./लि. की दर से नीम को निम्न येलो स्टेम बोरर कीटाणुग्रस्त (1.94%) तथा चावल जड़ माहू से क्षतिग्रस्त 2.21 संख्या में/पौध में) रिकार्ड किया गया। एनआईसीआरए, आरसीपीएल 1-136 तथा आरसीपीएल 1-132 के अंतर्गत ताप सहिष्णुता के संदर्भ में 600 से अधिक जीनोटाईप परीक्षण किए गए, इन्हें उच्च तापमान प्रदर्शन 45$^0$ से. (रिकवरी में 72% स्पाइकलेट फर्टिलिटी) के परिप्रेक्ष्य में अधिक सहनशील पाया गया। इसके अंदर सूख में सहिष्णुता पाया गया। मक्के में डीएमआर 306, डीएमआर 329 तथा डीएमआर 331 का उत्पादन प्रदर्शन सर्वोच्च (काब का वजन 9.0 टन/हे.) पाया गया। अतिरिक्त प्रारंभिक लाइनों में विवेक मक्का हाईब्रिड 25 (7.95 ट./हे.) सर्वाधिक उपज वाला रहा। सोयाबीन में चावल की भूसी का छिलका के साथ बर्ड स्कारिंग रीबन्स को पक्षियों (जंगली कबूतरों) से होने वाले नुकसान को रोकने में प्रभावकारी पाया गया। संयोजन प्रजातियाँ एएमएस-एमबी 5-19 (2288 कि.ग्रा./हे.), डीएसबी 16 (2623 कि.ग्रा./हे.) व पीएस 1477 (2357 कि.ग्रा./हे.) रस्ट रोग रोधी पायी गयीं। डैंसी टैंजेलोरूट स्टाक में रोपित खासी संतरे ने सर्वाधिक फल (72 संख्या में) उत्पादित किया, यदि हम इसकी तुलना न्यूसेलर सिडलिंग तथा सी. ग्रैंडिस रूटस्टाक से करें। फ्रांसीसी बीन ने सर्वाधिक उत्पादन (3.55 ट./हे., ग्रीन पाड) किया। इसके पश्चात मूंगफली (2.08 ट./हे.), तथा राइसबीन (0.53 ट./हे.) ने सर्वाधिक उत्पादन किए, जब हम खासी मैनडेरियन में अंतर्फसल से करते हैं। निम्न चिलिंग पीच वैरायटियों में पांच वर्ष में वैरायटी प्रताप फल उत्पादन के लिए अधिक उत्कृष्ट पाया गया तथा 2 मी.×2 मी. के उच्च घनत्व में पौधारोपण के तहत गुणवत्ता का आकलन किया गया। टमाटर की 38 प्रजातियाँ के बीच आर्द्रता के दबाव के सर्वश्रेष्ठ स्तर पर न्यूनतम जल क्षरण (0.33) तथा अधिकतम जड़ की लंबाई 27.85 से.मी.) वीएल टमाटर-4 से रिकार्ड किया गया। नियंत्रण के मद्देनजर जैविक रूप से उत्पादित हल्दी में करक्यूमिन अंश सर्वाधिक पाया गया।

बैगन तथा टमाटर से नया नि:सरण किया गया तथा उनमें से आठ में यूनीवर्सल प्राइमर्स 759/760 के पुष्टीकरण के पश्चात आर. सोलानासेरम का होना पाया गया। सर्वाधिक अदरक उत्पादन 14.8 ट./हे.), न्यूनतम साफ्ट रॉट संक्रमण (14.6%) तथा निम्नतम उत्पादन क्षति (3.2%) गर्म जल शोधन (47% सें.) 30 मि. + ट्राइकोडर्मा 2.5 किग्रा/50 किग्रा एफवाईएम मिट्टी में मिश्रित करने पर पौधारोपण के समय + कापर आक्सीक्लोराइड (0.3%) के मृदा प्रयोज्य कर रिकार्ड किया गया।

खुले वातावरण में उगने वाले लीलियम वैरायटियों में ब्रुनेलो में सर्वाधिक पौधा ऊंचाई (42.45 से.मी.), पत्तियों/पौध की संख्या (108.00 संख्या में) तथा स्पाइक लंबाई (41.65 से.मी.) देखा गया, जबकि फूलों/पौध की सर्वाधिक संख्या ब्रुनेलो तथा नवोना दोनों में ही अधिकतम पाया गया। सूखे या पुराने कीट म्यूजियम नमूने से डीएनए के नि:सरण के लिए साधारण तथा दक्ष चेलेक्स आधारित संशोधित डीएनए नि:सरण प्रोटोकाल को अपनाते हुए 20 वर्ष के पुराने सूखे कीट नमूनों से डीएनए को सफलतापूर्वक निकाला गया। पोषक तत्व प्रबंधन प्रचलनों के तहत 50% एनपीके + इन-रीसाइकलिंग (4.57 ट./हे.) से सर्वाधिक चावल के उत्पादन को रिकार्ड किया गया, जबकि इसके बाद 50% एनपीके + वीड बायोमास (4.53 ट./हे.) से रिकार्ड किया गया। जीरो टिलेज के तहत स्वायल माइक्रोबियल बायोमास कार्बन (एसएमबीएस) को महत्त्वपूर्ण ढंग से उच्च पाया गया। मिट्टी प्रतिरोध जेडटी के तहत न्यूनतम तथा सीटी के तहत अधिकतम जो कि सभी गहराइयों में था, पाया गया। उच्च भूमि की मिट्टी में इनफिल्टरेशन दर उच्च था, जो कंजरवेशन टिलेज + 50% एपीके + इन - सीटु रेसिड पोषण प्रबंधन 2.80) एमएम/मिन.) के तहत था। उसके पश्चात 50% एनपीके + हरित पत्ते की खाद्य (2.73 एमएम/मिन.) था। मल्चींग का रिकार्ड निम्न भूमि प्रतिरोधक (1444.4 केपीए) पाया गया, इसके पश्चात 20 सें.मी. (1611.1 केपीए) तथा 40 सें.मी. (1800 केपीए) स्टैंडिंग स्टबब्लीट 0-3 सें.मी. की गहराई रही। अवशेष को हटाने (2725 केपीए) पर 10.15 सें.मी. गहराई में उच्चतम मृदा प्रतिरोध पाया गया। निम्नभूमि चावल में जीरो टिलेज कल्टीवेशन के लिए मसूर लाइन एल-307, डीपीएल 62, डीपीएल 15 तथा एल 304 को उपयुक्त पहचाना गया। मक्का फ्रेंचबीन संरक्षण टिलेज के तहत 168% उच्च रिकार्ड किया गया। मक्का का समकक्ष उत्पादन किसानों के खेत में उगने वाले मक्का से तुलनास्वरूप किया गया।

जैविक कषि के तहत एनपीके 50% के अनुमानित डोज (आरडी) की एकीकृत प्रयोज्यता जो कि एफवाईएम के माध्यम से होगा तथा वर्मीकंपोस्ट के माध्यम से 50% आरडीएनपी जो मक्के तथा फ्रेंच बीन के ग्रीन पाड का उत्पादन में अधिकतम अन्न उत्पादन रिकार्ड किया गया। वर्मीकंपोस्ट के माध्यम से अधिकतम आलू उत्पादन 100% आरडीएन के पास पाया गया। 7 फसली चक्रों के पश्चात आरंभिक एसओसी (1.80%) की तुलना में वर्मीकंपोस्ट के माध्यम से 50% एन तथा एफवाईएम के माध्यम से 50% एन के एकीकृत प्रयोज्यता के तहत भूमि आर्गनिक कार्बन कंटेंट (एसओसी) को 28% बढ़ा दिया। एकीकृत (272.52 यूजी/जी सूखी मिट्टी) के तहत स्वायल माइक्रोबियल बायोमास कार्बन (एसएमबीसी) महत्त्वपूर्ण ढंग से उच्च पाया गया। इसके पश्चात एफवाईएम (2.67.44 यूजी/सूखी मिट्टी) के सोल एप्लीकेशन का रहा। चावल का समकक्ष उत्पादन 4 गुना बढ़ गया तथा निवल रिटर्न में भी तिगुनी वृद्धि हुई, यदि हम मोनोक्रापिंग वैली लैंड आर्गनिक फार्मिंग सिस्टम से करें। अदरक की फसल ($GEF_1$) के लिए विकसित बायोआर्गनिक जिसे केमोप्रोफाइल्ड नई दिल्ली स्थित श्रीराम इंस्टीट्यूट फार इंडस्ट्रियल रिसर्च द्वारा किया गया है। आरआई डिटेक्टर का उपयोग कर एचपीएलसी अध्ययन से प्राप्त आंकड़ा दो चीनी कंपाउंड जिनके नाम फ्रक्टोज (0.03%) तथा इनोसिटोल (0.06%) जो हर्बल एक्सट्रैक्ट्स में पाए गए।

दलदली भूमि के उठे भूभाग पर मूंगफली के संबंध में उत्पादन समकक्ष उपज (जीवाईवाई) सर्वाधिक (16.25 ट./हे.) रहा। मूंगफली के साथ टमाटर की फसली प्रणाली के पश्चात गाजर (154.90 ट./हे.) उत्पादित किया गया। अंतर्फसल प्रणाली के तहत अधिकतम उपज फूलगोभी + मटर (1:1) उत्पादित किया गया, जिसके पश्चात फूलगोभी + फूलगोभी + मेथी (1.35 ट./हे.) को उत्पादित किया गया। निम्नतम फूलगोभी + गाजर ऊपरी भूमि में उत्पादित किया गया। सरसों का बीज उत्पादन अवशेष प्रबंधन प्रचलन के अंतर्गत उच्चतम रहा, जो मक्का + सोयाबीन की दोहरी पंक्ति (अवशेष रीटेंशन) (293 कि.ग्रा./हे.) का उत्पादन रहा। मक्का + मूंगफली दोहरी पंक्ति हटाने में (5108 कि.ग्रा./हे.) के तहत अवशेष प्रबंधन पद्धति के अंतर्गत मक्के का समकक्ष उत्पादन रहा। इसके पश्चात मक्का + मूंगफली के उत्पादन क रहा जो दोहरी पंक्ति के तहत (अवशेष रीटेंशन) 4733 किग्रा/हे.) रहा।

मूंगफली का उत्पादन (1.30 ट./हे.) तुलनात्मक रूप से उच्चतम रहा जो जीमेलिनाआर - बोरिया (गमहार) के तहत किया गया, जो अलनुस नेपालेंसिस (अल्डर) की तुलना में था, जबकि यह उच्च भूमि वाले धान के मामले में बिल्कुल उलट रहा। उच्च भूमि के धान (भालुम-1) के उत्पादन में वृद्धि 32,24 तथा 42% की दर से देखा गया, जो अल्डर, गमहर तथा हेजरो के तहत किया गया। जबकि खेत का शोधन चूना तथा 80% अनुमोदित मात्रा एसएसपी का रहा। 0.23 हे. झूम खेत में छोटी-छोटी क्यारियाँ बनाई गई (28-32% ढालू), जो मेघालय के री-भोई जिले के सोनीदाम गांव में किया गया। इसमें एक निश्चित वर्टिकल अंतराल 1 एम रखा गया। खाटवेमियर गांव के एक-दूसरे झूम खेत में बन्स (एक प्रकार

का स्थानांतरण कृषि) ढालू भूमि पर अदरक की खेती की गई, जबकि एक सामान्य पद्धति के अनुसार बन्स को ढालू भूमि के साथ उठा दिया जाता है। संसाधन संरक्षण प्रौद्योगिकी के साथ सुधरे फसल उत्पादन को झूम खेत में शुरू किया गया।

प्राकृतिक वन के तहत भूमि की तुलना में भूमि उपयोग प्रणाली के तहत पीएच, मृदा जैविक कार्बन (एसओसी), माइक्रोबियल बायोमास कार्बन (एमबीसी) तथा अम्लीय फास्फेट्स, एनजाइम (एपीई) में महत्त्वपूर्ण ढंग से (पी < 0.01 से पी < 0.001) ह्रास देखने में आया, जो भूमि अंतर्मिश्रित वृक्षारोपण वन (> 28 वर्ष), वानिकी (फल/सब्जियां) – सिल्वी–पास्टोरल (> 28 वर्ष) तथा फलोद्यान (< वर्ष के साथ खासी संतरा + असम नींबू + अमरूद + आड़ूफल) के तहत देखा गया। टीएसपी के अंतर्गत किसानों को आलू की फसल उपजाने के लिए चूना (400 किग्रा/हे., फ्यूरो प्रयोज्यता), खाद आरडीएफ का 50% की दर तथा जैविक खाद 2 ट./हे.) वर्मीकंपोस्ट) डालने की सलाह दी गई। प्रशिक्षित लाभार्थियों ने सुझाए गए पैकेज को अपनाए तथा आलू का उत्पादन (प्रजाति कुफ्री ज्योति) में 128% की वृद्धि देखने को मिली।

पूर्वोत्तर के छह राज्यों के ऊपरी सतह की मृदा का एसओसी अनुसंधानालय में आकलित स्थानीय मिलान का प्रयास किया गया, इसमें भौगोलिक सूचना प्रणाली (जीआईएस) पर्यावरण में 15.61 एमएचए के भौगोलिक क्षेत्रफल को शामिल किया गया। परिणाम से यह बात देखने में आई कि एसओसी कंटेंट में मिट्टी बहुत ऊँची थी, जो 98.54% क्षेत्र में > 1% जबकि 14.4% क्षेत्र में > 2.50 एसओसी कंटेंट देखने को मिला। ठीक इसी तरह से 76.5% क्षेत्र में 20–40 एमजी/हे. एसओसी घनत्व रहा, जबकि 8% क्षेत्र में बहुत उच्च एसओसी घनत्व जो 40–60 एमजी/हे. रहा। निम्न भूमि के चावल के अनुरूपण अध्ययन में कृषि उत्पादन प्रणाली अनुरूपकर्त्ता (एपीएसआईएम) का उपयोग किया गया। खेत में किए गए लगातार तीन वर्षों के परीक्षण (2009–2011) में कैलीबरेटेड माडल का प्रदर्शन संतोषजनक रहा। चावल बायोमास का अनुरूपण मूल्य हार्वेस्ट का औसत रहा, जो तीन वर्षों का 12.9 ± 1.44 ट. हे. रहा यदि हम माफित मूल्य 12.7 ± 1.1 ट. हे. से तुलना करें, जबकि करेसपांडिंग अनुरूपण औसत (3 वर्ष) अनाज उत्पादन का 6.1 ± 0.55 ट.हे. 1 रहा, यदि इसकी तुलना पूर्व के माफित उत्पादन 5.7 ± 0.45 ट.हेक्टे.1 से करें। जल संसाधन विकास के अंतर्गत एनआईसीआरए के तहत माइक्रो रेनवाटर हार्वेस्टिंग के प्रोन्नयन हेतु एनईएच राज्यों में कुल 350 जलखंडों का प्रदर्शन किया गया। किसान सहभागिता कार्य अनुसंधान कार्यक्रम के तहत जल उत्पादकता को बढ़ाने के लिए जल के बहुउद्देश्य को प्रोन्नत करने हेतु दस रूफ वाटर हार्वेस्टिंग यूनिटों तथा 18 कृषि तालाबों का प्रदर्शन किया गया। फसल, फल, पशुधन तथा मत्स्य पालन के लिए बहुमुखी उपयुक्त जलाशय के पानी से रु. 30,350/– का निवल रिटर्न मिला, जो 2000 एम$^2$ क्षेत्रफल का था। किसानों के प्रचलन (एकीकृत नहीं) की तुलना में 312% ऊंचा था। उच्च उत्पादन वाले चावल की वैरायटी का औसत उत्पादन जो एसआरआई/आईसीएम, धलाई तथा दक्षिण गारो हिल्स के तहत था, स्थानीय वैरायटी तथा स्थानीय किसानों के प्रचलन के तहत किए गए 2.4 टन/हे. तथा 1.75 टन/हे. की तुलना में 4.7 ट./हे. तथा 3.8 ट./हे. किया गया। एकीकृत वाटरशेड विकास कार्यक्रम जिसमें जल संसाधन विकास यथा–कृषि तालाबों, जलखंडों, परकोलेशन टैंक आदि, भूमि संरक्षण उपाय यथा टेरेसिंग तथा अर्द्धगोलाकार टेरेसेज, ढालू भूमि पर कृषि, जीवविज्ञान संबंधी रुकावटों जिसमें फसल–पशुधन–मत्स्य–वृक्ष के घटक शामिल हैं, का एकीकरण शामिल है, का कम से कम 50 हे. क्षेत्र में प्रदर्शन किया गया।

500 किग्रा/हे. के हिसाब से चूने के प्रयोग से मृदा का पीएच 0.21 से 0.34 यूनिट नियंत्रण से अधिक रहा। विभिन्न जैविक स्रोतों में वर्मीकंपोस्ट के साथ 50% आरडीएफ की प्रयोज्यता एसओसी के स्तर में सुधार तथा मृदा में पोषण की उपलब्धता हेतु बेहतर साबित हुआ। मक्के की उपज तथा एन.पी. तथा के. में उपलब्ध मृदा महत्त्वपूर्ण ढंग से पीएच. बीज जो चूने के साथ मिश्रित किया गया है, सह–प्रबंध स्थापित हो गया, पेपर मिल के तलछट जो कि अम्लीय मृद सुधार के लिए बेहतर पदार्थ के रूप में चिन्हित किया गया तथा वर्ष के दौरान 60 टन चूना तलछट तैयार किए गए तथा इनका विभिन्न फसलों में उपयोग किया गया, जिससे मक्के की उत्पादकता को करीब 20% तक बढ़ाने में सफलता मिली। जिसमें गोंद का उपयोग छिपकने वाले अभिकर्त्ता के रूप में किया गया है। इससे मक्के का उत्पादन 8.5% हुआ, जबकि तुलनात्मक ढंग से इसमें 30% का सुधार 300 किग्रा/हे. के चूने के प्रयोजनीयता से हुआ तथा ज्वलंत रूप से महत्त्वपूर्ण वृद्धि परिणामस्वरूप हुआ, जो उपलब्ध एन.पी.के, सीए, एमजी तथा एस मिश्रण में हुआ, जिसमें जैविक कार्बन भी शामिल है। झूम पर आयोजित कार्यक्रम के तहत 50 हे. क्षेत्र प्रत्येक उ.पू. पर्वतीय राज्यों में विकसित किए गए, जिसमें फसलों की प्रजातियों, पशुधन, फल, वृक्ष तथा मृदा एवं पानी के संरक्षण के संबंध में कदम के साथ उन्नत कृषि प्रणाली पर बड़े पैमाने पर प्रशिक्षण तथा

जागरुकता कार्यक्रम का उपयोग किया गया। यद्यपि कृषि के पहले वर्ष उपलब्ध एन.पी.के. तथा जैविक कार्बन मिश्रण ह्रास आया, जो महत्त्वपूर्ण ढंग से एक सीमा तक हुआ।

डेयरी आधारित कृषि प्रणाली में आहार, कांसेंट्रेट तथा दवा की कुल कीमत रु. 1,10,942.50 आया। इसके साथ वार्षिक कुल आय रु. 1,14,640.00 हुआ तथा पंजीकृत निवल आय रु. 18,645.00 का हुआ। कृषि-पैस्टोरल प्रणाली 294 मानव-दिवस रोजगार उत्पन्न कर सकता है तथा रु. 1,34,174.48 का निवल आय उपलब्ध हो सकेगा तथा इनपुट-आउटपुट अनुपात 2.21 का होगा। कृषि/सब्जी आधारित फसल प्रणाली ने रु. 1,62,322.50 की कुल आय पंजीकृत की। फ्रेंचबीन-चावल-तोरिया से रु. 52,115/हे. अधिकतम आय प्राप्त की गई, जो 2300 एम$^2$ के साथ रु. 22.65/एम$^2$ में हुआ, जबकि मक्का आधारित फसल प्रणाली में रु. 30,775 की निवल आय 2500 वर्ग मी. क्षेत्रफल में अर्जित हुआ। इसने रु. 12.31/एम$^2$ पंजीकृत किया।

पशु उत्पादन विभाग में एक नवप्रवर्तित एकीकृत निम्न लागत वाला शुकर बाड़ा विकसित किया गया। यह स्थानीय रूप से उपलब्ध प्राकृतिक संसाधन जो उच्च वर्षा के मध्य उच्च एल्टीट्यूड क्षेत्र में अवस्थित है, विकसित किया गया। यह शुकर घर का नमूना वर्षा के जल के तहत हार्वेस्टिंग मैकेनिज्म तथा वर्मीकंपोस्ट यूनिट के अंतर्गत किया गया है, जो जल संरक्षण तथा गुणवत्ता युक्त खाद के उत्पादन में सहायक होगा। प्रोबायोटिक्स सैक्रोमीसेस सर्विसिए 0.375 एमसीएफयू की दर से तथा लैक्ट. स्पोरोजेन्स 12500 सीएफयू की दर से प्रतिदिन के आहार जो प्रीपबरटल गिल्ट्स सुविधाओं में बेहतर वृद्धि दर तथा पुनर्उत्पादन क्रियाकलाप को आरंभ किया। एमू (ड्रोमाइयूस्नोवाएहोलैंडडिए) चिक्स के वजन का औसत मासिक बाडी 4.55 $\pm$ 0.21, 8.05 $\pm$ 0.06, 10.90 $\pm$ 0.53 12.87 $\pm$ 0.76 14.61 $\pm$ 0.51, 17.07 $\pm$ 050, 19.73 $\pm$ 0.42, 22.40 $\pm$ 065, 25.04 $\pm$ 0.69 तथा 26.93 $\pm$ 1.88 किग्रा जो 3, 4, 5, 6, 7, 8,9,10,11 तथा 12 माह में क्रमश: था।

पशु स्वास्थ्य विभाग में पीआरआरएस (पोरसिन पुनर्उत्पादक तथा स्वशन सिंड्रम) वायरस मेघालय के शुकर में तथा पूर्वोत्तर क्षेत्र के अन्य राज्यों के शुकर में पाया गया, जो पीसीआर तथा एबी-ईएलआईएसए द्वारा किया गया। पीसीवी (पोरसिन सिराको वायरस) तथा पीपीवी (पोरसिन पारवो वायरस) 14.2% तथा 9.76% शुकरों में क्रमश: निदान किया गया। बड़ी संख्या में शुकरों (33.19%) में क्लासिकल स्वाइन फीकर वायरस (सीएसएफवी) पाया गया, जो पीसीआर द्वारा संचालित किया गया। बहु-ड्रग रोधक (एमडीआर) एसचेरीचिया कोली आइसोलेट्स ने बताया कि बहु-ड्रग रोधक ई. कोली शुकर में, बकरियों, पशुओं तथा पूर्वोत्तर भारत के मुर्गियों में प्रचलित है तथा रोधक के दरों तथा स्वरूपों में विविधता है। चिकेन से पृथक्करण में रोधक उच्चतम था, इसके बाद शुकरों, पशुओं तथा बकरियों में पाया गया। ई-कोली आइसोलेट्स के सेरोटाइपिंग परिणाम यह रहस्योद्घाटन करता है कि ये ई. कोली आइसोलेट्स 21 विभिन्न स्टेरोटाइप्स के साथ सेरोटाईप ओ 90 जो कि अध्यधिक प्रचलित सेरोटाईप है, से संबद्ध है। रोटावायरस संक्रमण जो पशुधन तथा बच्चों, ऐंटीबाडीज जो ब्रुसेलोसिस तथा आईबीआर के विरुद्ध था, का इलाज किया गया। बाबेसिया बिजेमिना का भारतीय आइसोलेट (यूमियम) अर्जेंटियाई आइसोलेट्स तथा पड़ोसी देश चीन से प्रभाव से दूर के विशेष स्थानों के संबंध में नजदीकी संबंध को प्रदर्शित किया है। इस क्षेत्र के कुत्तों से बाबेसिया कैनिसि से उत्पादित पीसीआर उत्पादों की क्नोनिंग तथा सिलसिला ने बी.कैनिस के न्यूक्लियोटाइड सीक्वेंस को दिखाया, जिसमें 93% सीक्वेंस आइडेंटिसी के साथ बी कैनिसवोजेली को दिखाया। इसलिए यह उस जीवाश्म की तरह है जैसा बी. कैनिवोजेली के उप-जातियों में है। फिलोजेनेटिकली, बी. कैनिस जो इस क्षेत्र का है, सेंट किट्स तथा नेविल (कैरेबियाई) द्वीपों के स्ट्रेन से नजदीकी रूप से संबद्ध है। एमआर 36.2 केडीए, 23.9 केडीए तथा 9.6 केडीए का तीन पोलीपेप्टाइड्स की बकरियों के सिस्टीसरकमस्टेन्यूकोलिस के दोनों सिस्टिक फ्लुड एंटीजेन्स तथा संपूर्ण किस्ट लाइसेट एंटीजेन्स को प्रतिरक्षित प्रबलतापूर्ण पोलीपेप्टाइड्स के रूप में पहचान की गई।

पर्वतीय कृषि में मशीनीकरण के तहत पावर टीलर 3 पंक्तियों में परिचालित की गई, जिसमें इनक्लाइन्ड प्लेट प्लांटर को मक्के, सोयाबीन तथा मटर की बुआई में उपयुक्त किया गया। यह ढालू क्यारियों तथा एनईएच के घाटी भूमि में उपयुक्त किया गया। एक मानवीय जीरो-टिल फ्यूरो ओपेनर के तैयार किया गया, जिसमें दो फ्यूरो ओपेनर लगा हुआ था, जो फ्यूरो को 2-3 सेमी चौड़ाई तथा 3-4 सेमी गहराई तक बिन खुद भूमि तक खोलता है। ऊर्जा के अध्ययन में बायोचर की प्रयोज्यता मृदा पीएच, मृदा जैविक कार्बन (एसओसी), उपलब्ध नाइट्रोजन, उपलब्ध पी, के तथा बायोमस उत्पादन में सुधार की दृष्टि से सुधार में सकारात्मक तथा महत्त्वपूर्ण ढंग से प्रभावकारी साबित हुआ। भले ही बायोचर के स्रोत के संदर्भ में हो, इसकी प्रयोज्यता ने मृदा पीएच में 0.26 से 0.30 यूनिट्स तक सुधार को प्रदर्शित किया। एसओसी में 4.9 से 7.4% तक नियंत्रण से बाहर तक

वृद्धि हुई। टीएसपी के तहत विभिन्न क्रियाकलापों से कुल 37000 किसान लाभान्वित हुए। मेघालय, मणिपुर, हाइलाकांदी तथा त्रिपुरा के किसानों के बीच कुल 48 ट. चावल, 26 ट. हल्दी तथा 27 ट. अदरक, 13.2 ट. मक्का, 5.05 ट. मटर, 13.2 ट. मक्का, 7.7 ट. तोरिया के अलावा सब्जियां, फलदार पौधे तथा पशुधन वितरित किए गए।

## अरुणाचल प्रदेश केंद्र

आरसीपीएल- 1-300 औसत दर्जे का प्रतिरोध प्रदर्शित किया, आरसीएम-11, सीएयू-आर-1, एसएआरएस-66 औसतन सरलता से प्रभावित होने वाला तथा तंजीत, सरस-6 औसत रूप से राइस टुंग्रो रोग से वेट राइस कल्टीवेशन के तहत प्रभावित होने वाला दिखा। मूंगफली की 10 प्रजातियों; गिरिनार-2, जीजी-7 तथा टीजी-37-ए. में उच्चतम अर्ली लीफ स्पाट व लेट लीफ स्पॉट रोगों को (टीडीआई) रस्ट, रोग तीव्रता रिकार्ड की गयी। आजाद मटर 1 (3.3 ट./हे.), तोरी का (टीएस 36 ने उच्चतम बीज उत्पादन दिया जो रुम 27 अधिक 57.9% था। विभिन्न पत्थरों का परीक्षण किया गया, इंपरैटै सीलेंड्रिका (10.6 ग्रा./वर्ग मी.$^2$) के साथ निम्नतम वीड ड्राई वजन रिकार्ड किया गया। तन्युम व वोल्कामेरिना रूट स्टाक्स ने संतरे में तना द्रवक के प्रकोप को घटा दिया। धान के विभिन्न प्रजातियों पर क्लोरपारीफोस/ट्राइजोफोस/प्रोफेनोफोस का 1 ली./हे. की दर से छिड़काव या पैराथियन (2% डी)/क्लोरपाइरीफोस (1% डी)/ मैलाथियन (5% डी) /क्विनोलफोस (1.5% डी) 25-30 किग्रा/हे. कटवार्म के प्रबंधन में प्रभावकारी पाया गया। घुघंरु ब्रीड का प्रदर्शन 9 माह की उम्र में बेहतर (49.9 $\pm$ 1.07 किग्रा) पाया गया। यदि इसकी तुलना अरुणाचल के स्थानीय शुकर (22.25 $\pm$ 1.35 किग्रा) से की जाए। जनजातीय उप योजना (टीएसपी) के तहत 9.5 टन सुधारित आलू प्रजाति (कुफ्रीज्योति) पश्चिम सियांग तथा ऊपरी सुबनसिरी जिले के किसानों के बीच वितरित किए गए तथा 189 किसानों के खेतों में करीब 4.5 हे. भूमि इसमें शामिल की गई। एनएआईपी के तहत चावल की कृषि तथा प्रजाति के शोधित विधि के शामिल करने के कारण समग्र फसल उत्पादन 25 से 56 वृद्धि हुई तथा 23.5 से 26.50% तक आय हुआ तथा 30% तक अपने खेतों में रोजगार बढ़ गया। प्रत्येक पिगरी यूनिट में औसत शुद्ध रिटर्न रु. 13,500/- हासिल किया गया तथा वार्षिक कुल आय रु. 22,500/- का हुआ।

## मणिपुर केंद्र

केंद्र द्वारा कम अवधि वाला (90-105 दिनों) वाले चावल प्रजाति आरसी मणिफाऊ 12 (4.5-5.0 ट./हे.) विकसित किया गया तथा मणिपुर सरकार द्वारा जारी किया गया। एमसी-34-9-7-77-96-62 (9.00 ट./हे.), एमसी - 34-7-7-17-94-60 (8.83 ट./हे.) तथा एमसी - 34-13-45-32-69-3 (8.33 ट./हे.) को बेहतर पाया गया। आरसीआरटी निम्न भूमि परीक्षण आरसीपीएल 1-167 (9.25 ट./हे.) तथा आरसीपीएल-145 (7.10 ट./हे.) ने उच्चतम उत्पादन को प्रदर्शित किया, जबकि आरसीपीएल-1-114 तथा आरसीपीएल-1-128 ने आरसीपीएल अपलैंड परीक्षण के तहत कम से कम उत्पादन 2416 किग्रा/हे. दर्ज किया। एआईसीआरआईपी-आईवीटी-यू-एच के अपलैंड परीक्षण के तहत प्रवेश सं. 3106 को अत्यधिक आशाज (4.03 ट./हे.) पाया गया, इसके पश्चात प्रवेश सं. 31010 (3.71 ट./हे.) तथा 3108 (3.69 ट./हे.) को बेहतर पाया गया। एआईसीआरपी के तहत मक्का यथा, सीएमएच 08-337 (9746 किग्रा/हे.), केएनएमएच 408710 (7608 किग्रा/हे.), विवेक मक्का हाईब्रिड 43 (7284 किग्रा/हे.), विवेक मक्का हाईब्रिड 25 (6898 किग्रा/हे.) तथा विवेक मक्का हाईब्रिड - 23 (6840 किग्रा/हे.) का भी प्रदर्शन अच्छा रहा। पीजन पी में दो लाइन जिनका नाम आरसीएमपी 10241-1-1 को भी बेहतर पाया गया। 100% एनपीके जेड एनबी/10 ट. एफवाईएम को मक्का प्रजाति पूसा कंपोजिट 3 (6 ट./हे.) को भी अध्यधिक अनुकूल पाया गया। एनआईसीआरए के तहत चावल प्रजाति आरसी मणिफाऊ - 7 तथा तावोथाबी ने जलमग्न स्थिति में काफी सहनशीलता दर्शायी। जबकि मक्का कल्टीवार जिसका नाम खमोथेई ह्वाईट, वैमिनफेडपोड चेचाटा है, ने ठंडे सहिष्णुता को प्रदर्शित किया । टमाटर में उच्च तापमान तथा सूखे की स्थिति में पाली हाऊस के तहत 37.21% फल उत्पादन में ह्रास नजर आया, यदि हम इसकी तुलना प्राकृतिक खेत की परिस्थितियों से करें।

टमाटर की प्रजाति मणिखामनू तथा मनीलिमा (1.96 तथा 1.95 किग्रा/प्रति पौध) को कुहासे की स्थिति में सहिष्णु पाया गया। जबकि काशी हेमंत (2.53 किग्रा/प्रति पौध) निम्न हल्की परिस्थितियों में अन्य जीनोटाइप में बेहतर प्रदर्शन करते हुए पाया गया। टमाटर की प्रजाति आरसी मणिखमेनाशिनबा 1 (चयन 9ए) को सूखे व उच्च तापमान की परिस्थिति में (1.97

किग्रा/प्रति पौध) काफी सहिष्णुता को दर्शाया। मक्का अवशेष रीसाइक्लिंग औसतन 12.-15%, 13-16% तथा 9-12% बढ़ गया, जबकि सरसों, मटर तथा दाल में क्रमश: सोल एवं अंतर्फसलीय प्रणाली के तहत सफलतापूर्वक उत्पादन हुआ। बागवानी में उच्च उत्पादन होने वाला टमाटर प्रजाति आरसी मणिखमेनाशिबा 1 ने 42.5 ट./हे. उत्पादन की संभावनाओं को बल दिया तथा यह औसतन बैक्टोरिया विल्ट को रोकने तथा लीफ कर्ल रोग को सहन करने की क्षमता को प्रदर्शित किया, जिसे मणिपुर सरकार ने जारी किया। प्रजाति है इन टारो जिसका अधिकतम उत्पादन (37.05 ट./हे.) आरसीएमसी के साथ रिकार्ड किया गया। इसके बाद आरसीएमसी-10 (35.25 ट./हे.) तथा आरसीएमसी-4 (33.93 ट./हे.) रहा। फसली प्रणाली पर आधारित कैशन फ्रूट के जैविक उत्पादन पैकेज का मानकीकरण किया गया। 60 से.मी.×20 से.मी. का अंतराल तथा 75:50:75 मात्रा में रासायनिक खाद स्वीट शकरकन्द की प्रजाति के संवर्द्धन में अनुकूल पाया गया। मणिपुर की स्थिति में पातगोभी में बोटानिकल पेस्टीसाइड पेस्टोनीम पर्यावरण अनुकूल पाया गया। वर्मीकंपोस्ट (6.25 ट./हे.) + एजोस्पिरिलम (1.9 ली./हे.) + पोटाश सोल्यूबलाइजिंग बैक्टेरिया (250 मी.ली./हे.) + अर्बुस्कुलर माइकोरिजा (2 टैबलेट्स/ प्रति पौध) को प्राकृतिक हवादार पोलीहाऊस के तहत ब्रोक्कोली (21.00 ट./हे.), बेल पेपर (7.30 ट./हे.) तथा फाल्स कोरिएंडर (24.50/हे.) ग्रेप प्लांटेशन में अंतर्फसल अत्यधिक अनुकूल पाया गया। पौध की सुरक्षा में फंगी पृथक तथा किंग चिली से चिन्हित सरकोसपोरा कैपसिसी, कोलेटोट्राईकम कैपसिसी, ग्लोमेरेला सिनगुलटा, कोरिनेसपोरा कैसिकोला, फोमा विनाशकारी है। विषाणु जो किंग चिली को संक्रमित करता है वह है पेपर वेइनाल माटल विषाणु (पीवीएमओवी) है। पशु विज्ञान में मुर्गी के मांस, बीफ, पॉर्क, दूध, शुकर के मल, पशु तथा डायरहोइयल कुत्तों के 315 नमूनों को संग्रहीत किया गया, जो विभिन्न स्थानों से था तथा क्रोमोजेनिक मीडिया, एसचेरिचिया कोली, क्लेबसीला एसपीपी, स्टेफिलोकोकस एयूरियस, एयरोमोनोस प्रजातियाँ, इंटरोकोकस प्रजातियाँ तथा सलमोनेला प्रजातियाँ को पृथक किया गया। फेनोटाइपिक वर्गीकरण जो पृथक जीवाश्म के थे, किया गया। इसके अलावा मणिपुर के विभिन्न जिलों में 6 जानवर स्वास्थ्य शिविरों का आयोजन किया गया, जिसके तहत 460 किसानों तथा 235 जानवरों को शामिल किया गया। पोल्ट्री सीड परियोजना के तहत पोल्ट्री पक्षियों के गुणवत्तायुक्त जर्माप्लाज्म की आपूर्ति को बढ़ाकर पूर्व वर्ष से 143% तक कर दिया गया। मत्स्यपालन में मणिपुर की स्वदेशी विशिष्ट मछलियों जिले नाम हैं- पैंगीअपनजियो, सिटरफैसिटस तथा डैनिओडेंगिला का मानकीकरण किया गया। इसके अलावा 51.60 लाख स्थान तथा 2 लाख फिंगरलिंग्स का उत्पादन वर्ष 2012-13 में किया गया।

## मिजोरम केंद्र

ऊपरी भूमि के चावल के अन्न का उत्पादन महत्त्वपूर्ण ढंग से ऊंचा रहा, जब बेड तथा चैनेल को बढ़ाया गया। इसके पश्चात कतार से उगाया गया तथा रिज तथा फ्यूरो का स्थान रहा। ऊपरी भूमि के स्थितियों में भालुम-3 ने सर्वाधिक अन्न (2.52 ट./हे.) उत्पादन रिकार्ड किया गया जो महत्त्वपूर्ण ढंग से उच्चतम था जब हम इसकी तुलना शेष प्रजातियों सिर्फ इयूरोन 514 (2.38 ट./हे.) को छोड़कर, करते हैं। निम्न भूमि की स्थितियों में शहसरंग प्रजाति ने महत्त्वपूर्ण ढंग से उच्चतम अन्न का उत्पादन किया। मक्के में उच्चतम अन्न उत्पादन कल्टीवर सीएमएच 08-337 (6.05 ट./हे.) व विवेक हाईब्रिड-9 (5.16 ट./हे.) के साथ देखा गया। यह तुलना खरीफ के अन्य हाईब्रिड से किया गया। रबी के मक्का में फ्यूरो सोविंग + माल्चिंग + 2 आर्थिंग अप के तहत उच्चतम अन्न उत्पादन (4.16 ट./हे.) प्राप्त किया गया। सरसों रेपसोड की फसल में उच्चतम अन्न उत्पादन देखा गया, जिसमें तरल खाद (8000 ली.) दो बिखरे प्रायोज्यता के साथ उपयुक्त किया गया। जीरो टिलेज के तहत सरसों (एम 27) का उच्चतम अन्न उत्पादन (1.41 ट./हे.) रिकार्ड किया गया, जिसके लिए वर्मीकंपोस्ट 2 ट/हे. का उपयोग किया गया। इसी तरह से मटर अंकुरण प्रतिशत तथा फली उत्पादन जीरो टिलेज कल्टीवेशन में मटर की प्रकाश आर्केल से श्रेष्ठतर साबित हुयी। आर्केल को 24 घंटे भिंगोकर तथा प्रकाश को 36 घंटे पूर्व भिंगोना श्रेष्ठ पाया गया। दाल का 36 घंटे पूर्व भिंगोना अंकुरण प्रतिशत तथा उत्पादन के लिए बेहतर परिणाम दिया। आम की प्रजाति 'आम्रपाली' को उच्च घनत्व में वृक्षारोपण संस्थापित किया गया। मिजोरम के उप-आर्द्र ग्रीष्म कटिबंधीय जलवायु में वनस्पति विकास को घटाने हेतु कैनोपी प्रबंधन के प्रभाव का मूल्यांकन किया गया। फलोद्यान को तीन विभिन्न अंतराल व्यवस्थापन के तहत 2.5×2.5 मी. 3×2.5 मी. तथा 2.5×1.5 के मी. के अंतर पर पौधों के समायोजन हेतु : 1600, 1333

तथा 2666 पौध प्रति हेक्टेयर क्रमश: स्थापित किया गया तथा नियंत्रण प्लाट के तहत 100 पौधों को व्यवस्थित किया गया। केंद्र में संवर्द्धन हेतु बनाना रिसर्च स्टेशन (बीआरएस), केरल कृषि विश्वविद्यालय, त्रिसूर, केरल से केला तथा प्लांटेन्स सकर्स एकत्र किया गया था। मिजोरम की परिस्थितियों में सभी जैविक प्रजाति के काफी अच्छे ढंग से संवर्द्धित हो रहे हैं। शीत ऋतु में निम्न तापमान तथा जल दबाव स्थितियों में टमाटर की प्रजाति पूसा रोहिणी तथा देव एनपी 5081 का प्रदर्शन बहुत अच्छा रहा तथा फल के गुच्छों तथा प्रति पौध में फलों की संख्या बढ़ने से रिकार्ड मात्रा में उत्पादन हुआ। एंथुरियम उत्पादकों के बीच चलाए गए क्षेत्र सर्वेक्षण से यह बात स्पष्ट होती है कि जैनथोमोनासक्सोनोपोडिसपव, डिफेंबैचियो द्वारा होने वाला बैक्टेरिया ब्लाइट प्रमुख बीमारी है तथा एंथुरियम उत्पादक क्षेत्र जो कोलासिब (67%) तथा आइजल (58.3%), हैं, में सभी जगहों पर व्याप्त हैं। इसके पश्चात कोलेटोट्रि कम ग्लीयासपोरिडिस (30.3 तथा 35%) तथा रिजोक्टोनिय जड़ विगलन (19% तथा 25) का स्थान है। कीट एंथुरियम की फसल को 5.5 से 55 प्रतिशत तक नुकसान पहुंचाते हैं। निम्न उत्पादन तथा पुनर्उत्पादन के तौर पर प्रदर्शन करने वाली गायों के पुनर्स्थापन के लिए सीवीएस से कुल 9 क्रास ब्रिड गाय के साथ पांच बछिया तैयार की गई। दूध के नमूनों की नियमित जांच, रिकार्ड दैनिक दूध उत्पादन आदि झुंड में मैस्टिटिस के होने को घटा दिया। सीवीएस, ए.ए.यू, खानापाड़ा से 3 माह के हैंपशायर क्रासब्रिड के कुल 30 सूअर के शावकों (24 स्त्रीलिंग तथा 6 पुलिंग) तैयार किए गए थे। 3 माह की उम्र तक सूअर के शावक का वजन 16.3 किग्रा तथा 1 माह के पश्चात सूअर के शावक का वजन 23 किग्रा तथा 5 माह की उम्र पर 28.83 किग्रा वजन हो गया। सूअर के शावकों को एकाग्र आहार के साथ पका चावल, मक्का, कोलोकेसिया, टेपियाका तथा खनिज मिश्रण एक दिन में दो बार दिया जाता है। गिल्ट एस्टरस में 7 माह तथा 10 माह की उम्र में 4 गिल्टों को प्राकृतिक सेवा के तहत बोर के साथ सर्व किया गया।

वनराजा पैरेंट स्टाक के प्रथम लेइंग का उम्र 16 सप्ताह है तथा शरीर का वजन 2.7 किग्रा तक है। पैरेंट स्टाक के शरीर का वजन जो कि एक परिपक्व शूकर का 16 सप्ताह तथा वजन 3.66 किग्रा के करीब वजन होता है। लीटर मैटेरियल के बार-बार बदलने से कोकीडिओसिस रोग नियंत्रित किया गया तथा एंप्रोलम से इलाज किया गया।

## नागालैंड केंद्र

राइसबीन लाइन आरबीएस 53 महत्त्वपूर्ण ढंग से बेहतर उत्पादन देने में कामयाब रही। चूने की प्रयोज्यता 0.6 ट./हे. से महत्त्वपूर्ण ढंग से उच्चतम उपज देने में रिकार्ड बनाया तथा राइसबीन की उपज 0.4 तथा 0.2 ट./हे. रही। चावल एकीकृत फसल प्रबंधन (आईसीएम) महत्त्वपूर्ण ढंग से उच्चतम पैदावार दिया, जिसके पश्चात एसआरआई तथा सीआरसी रहा। 100% अनुमोदित खाद की मात्रा (आरडीएफ) + फसल अवशेष की प्रयोज्यता से महत्त्वपूर्ण ढंग से उच्चतम उत्पादन (3.27 ट./हे.) चावल का रिकार्ड उत्पादन किया गया, जिसके पश्चात 100% आरडीएफ (3.05 ट./हे.) का उत्पादन रहा। 10 अप्रैल की बुआई में मूंगबीन का उच्चतम उत्पादन हुआ। मक्के की प्रजातियों की जांच जो कि आर्द्र दबाव में किया गया, से पता चला कि आरसीएम-75 नागालैंड की स्थितियों में संभावनायुक्त प्रजाति है। मेडजिफेमा तथा झरनापानी के दो झूम क्षेत्रों में दो टिकाऊ कृषि प्रणाली माडल यथा -एग्री-सिल्वी-लाइवस्टाक, एग्री-हार्टी-सिल्वी को विकसित किया गया तथा इसकी तुलना पारम्परिक झूम से किया गया। एनएआईपी-3 के तहत 0.16 हे. में बड़ी इलायची का पौधरोपण 60 किग्रा ताजा कैप्शूल का उत्पादन किया तथा धूप में सूखा देने के बाद यह 15.2 किग्रा शुष्क कैप्शूल रह गया। सूखे कैप्शूल का प्रत्येक किग्रा की बाजार में कीमत रु. 500 है तथा इस प्रकार से 7600 रु. की कुल आय हुई। झूम चावल की खेती में 18% साधारण नमक का प्रयोग किया गया, जिससे अधिकतम अन्न उत्पादन 12 तथा 20% तक किया गया। प्रौद्योगिकी अभियान के तहत बागवानी में सात एंथुरियम प्रजातियां यथा-वायलेट ह्वाइट, एल' आर्मर, क्वीन ब्लैक, 1 रेड, सिंथिया, अनासटेसिया तथा रेड शेड नेट परिस्थितियों में मूल्यांकन किया गया। अधिकतम पौधा ऊंचाई एल' आर्मर (36.4 सेमी) तथा अधिकतम पत्ते की लंबाई 25.1 सेमी तथा पत्ते की चौड़ाई (14.5 सेमी) अनासटेसिया में पाया गया। 126 कोलोकेसिया जर्मप्लाज्म का मूल्यांकन किया गया, 110 विभिन्न जर्मप्लाज्म की पहचान की गई, जो मारफोलाजिकल वर्गीकरण (आईपीजीआरआई डिस्क्रिप्टर) पर आधारित था। विभिन्न प्रजातियां जिनका मूल्यांकन किया गया, 9 पंक्ति ड्वार्फ (< 50 सेमी ऊंचाई), 68 पंक्ति मध्यम (50-100 सेमी) तथा 33 पंक्ति लंबे (> 100 से.मी.) थे। 10 पंक्तियों में कोई सकर्स नहीं था, 99 पंक्तियों में 1-5 सकर्स तथा एक पंक्ति में 6 सकर्स से अधिक रिकार्ड किए गए। आहार रूपांतरण दक्षता लंबे काले क्रास के

तथा घुंग्रू गिल्ट्स (3-4 महीने के) सांख्यिकी रूप से समान तथा 3.88 से 4.13 लंबे काले से विविध तथा 3.4 से 4.33 घुंग्रू से भिन्न थे। हल्का आकार 6.83 ± 0.42 से 8.94 ± 0.81 जो लंबे काले तथा 7.20 ± 0.55 से 10.27 ± 1.31 घुंग्रू में थे। वनराजा पक्षियों के बचे रहने का दर 80-85% लामपोंग शेनघाट गांव जो मोन जिले में है, एनएआईपी-3 के तहत है।

## सिक्किम केंद्र

निम्नभूमि आरसीआरटी ट्रायल्स पर आधारित तीन पंक्तियों यथा आरसीपीएल 123, आरसीपीएल 473 तथा आरसीपीएल 469 की पहचान मध्य पहाड़ियों के तहत बेहतर प्रदर्शन के तौर पर किया गया। तीन राजमाश प्रविष्टियां एस के आर-57, आईपीआर 96-4 तथा नावगांव राजमाश ने खरीफ तथा रबी मौसमों दोनों के तहत प्रदर्शन किया। इसने निकटतम एसकेआर 57 (1.35 ट.हे.), आईपीआर-4 (1.30 ट.हे.) तथा नगांव राजमाश परिपक्वता (115 दिनों) में पहले थे। पीली सरसों में आठ एकल पौध चयन एसएसवाई 2 (सिक्किम सरसों येलो 2) जनसंख्या आधारित किया गया, जिसके उत्पादन में विशेषता तथा परिपक्वता थी। केएमटी 2 एक तोरिया लाइन थी, जिसका चयन सेग्रीगेटिंग जनसंख्या जो एससीआर 1-2-3 का था, जनसंख्या स्थायित्व के लिए छोड़ दी गई। छत्तीस बकह्वीट जेनोटाईप्स में उच्चतम उत्पादन प्रविष्टियां आईसी-109728 (3.2 ट./हे.), पीसीबी 1 (3.13 ट./हे.), आईसी-109549 (2.4 ट./हे.), आईसी-202268 (2.12 ट./हे.) था। रेपसीड तथा सरसों सिक्किम तोरिया-2, सिक्किम सरसों येलो-1, येलो सरसों येलो-3 तथा टीएस-38 कम मस्टर्ड एफिड तथा सॉ फ्लाई कम इनफेस्ट किया गया, जो अन्य की तुलना में था। ट्राईकोस्टार (ट्राईकोडमविरिडे) बीज के तौर पर, मृदा शोधन तथ छिड़काव ज्यादा प्रभावकारी (38.00 पीडीआई) था, जो नियंत्रण से बाहर (64.77 पीडीआई) मस्टर्ड के ह्वाइट रस्ट के प्रबंधन में प्रयुक्त किया गया। कुल 80 चाउ-चाउ/स्क्वाश (सेचीयूमेड्यूल) आकलन सिक्किम से संग्रहीत किया गया था गुणवत्ता मापदंड 40 आंकलनों से अध्ययन किया गया। ट्राइकोडर्मा + गर्म पानी शोधन (एचडब्ल्यूटी)+ आवश्यकता आधारित प्रायोज्यता सीओसी 0.3% का था। वृक्ष के पत्ते (चिलावनी + यूटिस) पलवार 5 ट./हे. की दर से तथा वर्मीकंपोस्ट 1.5 ट./हे.) की दर से रिकार्ड किए गए जो तोरिया के अन्न उत्पादन (9.10 क्वि./हे.) अधिकतम था। जीआई/हेलमिंथेस का प्रचलन सब-ट्रापिकल में उच्चतम था तथा उच्च आर्द्र जोन (37.31%) के पश्चात तापमान तथा आर्द्र क्षेत्र (34.52%) रहा जो सुबलपाइन निम्न आर्द्र जोन (30.53%) तथा अल्पाइन ड्राई क्षेत्र (17.62%) की तुलना में था।

बकरियों में विभिन्न इनडोपैरासाइट्स, नेमाटोड्स (61.72%) उच्चतम पाया गया। इसके पश्चात ट्रेमाटोड्स (44.44%) तथा सेसटोड्स (33.33%) रहा। नेमाडोट्स, हेमोंचस एसपीपी में प्रीडामिनेंट (61.72%) रहा। इसके पश्चात ओएसा फांगोस्टोमम (46.91%), बुनोस्टामम एसपीपी (29.63%) रहा। 16803 दिवस पुराना वनरजा तथा ग्रामप्रिया चिक्स को पोल्ट्रीबीज परियोजना के तहत किसानों के बीच वितरित किया गया।

## त्रिपुरा केंद्र

तीन चावल की प्रजातियां (टीआरसी-2005-1, टीआरसी 2005-3 नवीन), एक क्षेत्रीय मटर (टीआरसीपी-9), एक तोरिया (टीआरसी टी 1-1-5-1) तथा दो बैगन की प्रजातियां (सिंह नाथ तथा भोलानाथ) को राज वैरिएटल जारी करने वाली समिति ने जारी किया। प्रमुख क्यूटीएल की पहचान करने के लिए डीबीटी ट्विनिंग परियोजना पूर्वोत्तर राज्यों से सूखे की सहिष्णुता वाली, 83 झूम चावल जर्मप्लाज्म की जांच की। अन्न उत्पादन तथा अन्य पहलुओं को ध्यान में रखते हुए जिस दृढ़ संकल्प वाले सूखे की सहिष्णुता वाले जैव प्रजाति की पहचान की, वह है आरसीपीएल 1-128, भालुम 3, भालुम-1, फूलबादाम तथा कटकतारा। पैरेंटल पोलीमरफिज्म सर्वेक्षण/विविधता का विश्लेषण 78 झूम चावल जर्मप्लाज्म में 30 एसएसआर मार्कर्स का उपयोग कर निष्पादित किया गया। सभी 30 एसएसआर मार्कर्स पोलीमार्फिक के जैव विविधता के संदर्भ में निष्पादित किया गया। मार्कर्स का पोलीमार्फिक सूचना मूल्य का सत्यापन 0.254 (आरएम 537) से 0.748 (आरएम 24344) से किया गया, जिसका औसत 0.595 रहा। आणविक चित्रण के लिए जैव विविधताओं (78 संख्या में) का मार्फोलाजिकल अध्ययन किया गया। एनआईसीआरए के तहत 200 एसएसआर मार्कर्स के साथ 45 जीनोटाईप्स के जैव विविधता किया गया। चावल के उत्पादन को बढ़ाने के लिए जैविक संशोधन के स्रोत के रूप में स्थानीय रूप से उपलब्ध ग्लीरीसीडिया पत्ते की सिफारिश की गई। बीज शोधन से शीथ ब्लाइट रोग को नियंत्रित किया जा सकता है। इसके पश्चात

ट्राईकोडमविरिडे का उपयोग किया जाएगा। प्रजातियों के साथ माइकोरीजा के बीजाणु घनत्व, जिनके नाम ग्लोमस, गीगास्पोरा तथा एकाउलोस्पोर है, बीन, नारियल, मक्का के क्षेत्र में उच्चतम पाए गए। इतना दायरा 400-610 प्रति 100 ग्रा. मृदा रहा। गैर-जैविक के माध्यम से 50% एन के साथ वृक्ष के पत्ते का समाविष्टीकरण मूली के उपज को बढ़ाने हेतु बेहतर विकल्प साबित हुआ। सब्जी की फसल के संदर्भ में एआईसीआरपी के तहत टमाटर के पत्ते के कर्ल जीवाणु तथा बैक्टेरियल विल्ट से 11 प्रविष्टियों का मूल्यांकन किया गया था। एआईसीआरपी (सब्जियों) के तहत बैगन के कुल फल उत्पादन का विविधीकरण 31 से 42 ट./हे. किया गया। सुरक्षित कृषि के तहत सब्जियों (ब्राकोली, शिमला, मिर्च, फूलगोभी तथा टमाटर) को उगाया गया।

चावल-तोरिया सबसे अधिक उत्पादकता की प्रणाली (7.9 ट./हे.) रही, इसके बाद चावल-मटर (3.4 ट./हे.) का है। मक्के के सबसे अधिक ग्रीन कोब का उत्पादन रिकार्ड किया गया, जो ब्राड बेड तथा फ्यूरो प्रणाली के साथ पारंपरिक टिलेज को प्रयुक्त कर दिया गया। बांस, पीवीसी इलेक्ट्रिक पाइप, पीवीसी फ्लेक्सी पाइप तथा एल्यूमीनियम शीट को शामिलकर निम्न लागत वाले ड्रिप सिंचाई प्रणाली का उपयोग केले में ढालू भूमि पर किया गया। वर्षा के टैंक ड्रिप सिंचाई प्रणाली जिसकी क्षमता 21,000 ली. है, का मानकीकरण किया गया। ऑइस्टर मशरूम में सुधार लाने के लिए हाईब्रिड कार्यक्रम के उपयोग का कार्य चल रहा है। इससे 6 एस 3×3512 के क्रासेज में 800 ग्रा./ किग्रा सबस्ट्रेट का उत्पादन देखने को मिला। स्थानीय मशरूम लेंटीनस स्क्वैरोसुलस ने सितंबर माह में 426 ग्रा/ किग्रा सबस्ट्रेट तक फल का उत्पादन किया। इसके पश्चात जून माह में 272 ग्रा./किग्रा तक उत्पादन किया गया। फेनोटाईप ट्रेट्स समूहबद्ध रूप से एकल, दोहरे तथा तिहरे में अलग से पाए गए जो काले बंगाल बकरी के बच्चे के आकार के थे। गर्भवती बकरी में भ्रूण विषयक संख्या की पहचान के लिए जीएनआरएच की चुनौती का उपयोग किया गया। ठंड के महीनों में सूअर के शावकों के मृत्यु दर को घटाने के लिए परिपूरक गर्मी देने की जरूरत पड़ती है तथा घुंग्रू सूअर के शावक के खून का जैव रासयनिक पहलुओं का मूल्यांकन किया गया। निम्न लागत के सूअर आवास की व्यवस्था की गई, जिसमें रु. 12,000/- प्रयुक्त किए गए। रंगीन ब्रायलर डामलाइन के शरीर का वजन 7 सप्ताह में 1.5 किग्रा रहा। त्रिपुरा केंद्र पर एक बायोटेक हब की स्थापना की गई। लैबको यरोहिता के हेमाटोलाजिकल तथा सेरम केमिस्ट्री का अध्ययन किया गया, जो जल के तापमान को बढ़ाता है। सिरहिनुस मृगला में मछली के भोजन के पुनर्स्थापन के तौर पर रबर सीड भोजन का उपयोग किया गया। ओमपाक बाईमैकल्टेस (पबदा) का मिश्रित संस्कृति के रूप में कार्प्स के साथ उपयोग किया गया। मछली का कुल उत्पादन 2.07 ट./हे. रहा। जनजातीय गांव (गमचाकुबरा) में कृषि वानिकी के माडल को आम, लीची, मीठा संतरा तथा तांबुल के साथ विकसित किया गया। विभिन्न चावल की प्रजातियां - रंजीत, एमटीयू 1010, टीआरसी-2005-1 (गोमती) व स्वर्ण का परीक्षण एनआईसीआरए के तहत किया गया। टीएसपी के तहत धान, मूंगफली, मक्का तथा भिंडी के बीजों को 4476 किसानों के बीच में वितरित किए गए। वर्ष 2012-13 के रबी मौसम के दौरान दलहन, मूंगफली, मक्का, ग्रीन ग्राम, ब्लैक ग्राम तथा सब्जी वाले मटर को 1125 किसानों के बीच 247 हे. क्षेत्र के लिए वितरित किए गए।

# EXECUTIVE SUMMARY

During the period under report (2012-13), major emphasis was on efficient natural resource management through integrated approach and developing high yielding, stress tolerant crop and livestock varieties for enhancing productivity with focus on food and nutritional security. The salient findings of the research work done are summarized below:

**Umiam (Headquarters)**

In the upland ecology under station trials, RCPL1 413 (3.43 t/ha), RCPL1103 (3.20 t/ha) and RCPL1 82 (3.17 t/ha) showed significantly better performance than the leading variety Bhalum 3 (2.64 t/ha). Under coordinated trails, genotypes VL8608 (3.15t/ha), RCPL1-412 (2.95 t/ha) performed significantly better than local check. Under lowland condition, RCPL1-466 (5.50 t/ha) and RCPL1-300 (5.12 t/ha) were the leading genotypes showing significant yield advantage over the best check. From a core set of 45 upland rice, 4 highly tolerant and 4 considerably susceptible genotypes to aluminium toxicity were identified on the basis of root tolerance index, shoot tolerance index and root/shoot ratio upon exposure to 200µM aluminium chloride.IURON514 was identified as potential variety for upland and *jhum* land condition with grain yield of 3-3.5 t/ha**.** Spraying of imidacloprid 17.8% SL @ 0.5 ml/l at 30 days after transplanting of rice was found to be effective against stem borer (0.60% dead heart). Amongst biopesticides, neem @ 2 ml/l recorded the lowest yellow stem borer infestation (1.94%) and rice root aphids damage (2.21 nos/ hill).Out of 600 rice genotypes tested for heat tolerance under NICRA, RCPL 1-136 and RCPL 1-132 were found most tolerant against high temperature exposure at 45 $^{0}$C (72% spikelet fertility on recovery) with tolerance for drought (RWC 48.6).In maize, yield performance of DMR 306, DMR 329 and DMR 331 was the highest (cob weight 9.0 t/ha). Among the extra early lines, Vivek Maize Hybrid 25 (7.95 t/ha) was the highest yielder. In soybean, rice straw cover along with bird scarring ribbons was found effective for preventing bird (wild pigeon) damage. Soybean genotypes AMS-MB 5-19 (2288 kg/ha), DSb 16 (2623 kg/ha) and PS 1477 (2357 kg/ha) were identified as high yielding rust resistant genotypes.

*Khasi* mandarin grafted on *Dancy Tanzelo* rootstock produced the highest fruit yield (72 nos.) as compared to nucellar seedling and *C. grandis* rootstock. French bean produced the highest yield (3.55 t/ha, green pod) followed by groundnut (2.08 t/ha), soybean (0.85 t/ ha), urdbean (0.55 t/ha) and ricebean (0.53t/ha) as intercrop in *khasi* mandarin. Among low chilling peach varieties at 5$^{th}$ year, variety Partap was found superior for fruit yield and quality traits assessed under high density planting of 2 m x 2 m.Among the38 genotypes, at highest level of moisture stress, minimum water loss (0.33) and maximum root length (27.85cm) was recorded from VL Tomato 4.The curcumin content was highest in most of the organically produced turmeric as compared to control.

New isolates from brinjal and tomato were isolated and eight of them were found to be *R. solanacearum* after confirmation with universal primers 759/760. The highest ginger yield (14.8 t/ha), minimum soft rot infection (14.6%) and lowest yield loss (3.2%) was recorded with hot water treatment (47°C) for 30 min + *Trichoderma* 2.5kg/50kg FYM mixing in soil at planting time + soil application of copper oxychloride (0.3%).Among the lilium varieties grown under open condition, the highest plant height (42.45 cm), number of leaves/plant (108.00 Nos.) and spike length (41.65 cm) were observed in Brunello while, the highest number of flowers/plant (6.00 nos. each) found maximum in both Brunello and Navona.A simple and efficient Chelex based modified DNA extraction protocol has been developed for extraction of DNA from dry or old insect museum specimen. Using this modified protocol, DNA was successfully extracted from 20 year old dry insect specimens.

Grain yield of lowland rice obtained through zero tillage (ZT, 4.61 t/ha) was found to be better than minimum (MT, 4.26 t/ha) and conventional tillage (CT, 4.37 t/ha). Among the nutrient management practices, the highest rice yield was recorded from 50% NPK + *in-situ* residue recycling (4.57 t/ha) followed by 50 % NPK + weed biomass (4.53 t/ha). The soil microbial biomass carbon (SMBC) was significantly higher under zero tillage. Soil resistance was minimum under ZT and maximum under CT at all the depths. Under uplandrianfed terrace condition, IURON514 (3.3 t/ha)

was identified as potential variety for cultivation under resource conservation technologies. In upland, infiltration rate of the soil was higher under conservation tillage + 50 % NPK + *in-situ* residue nutrient management (2.80 mm/min) followed by 50 % NPK + Green leaf manure (2.73 mm/min).Mulching recorded the lowest soil resistance (1444.4 KPa) followed by 20 cm (1611.1 KPa) and 40 cm (1800 KPa) standing stubble at 0-5 cm depth. The highest soil resistance was noticed under residue removal (2725 KPa) at 10-15 cm depth. Lentil line L307, DPL 62, DPL 15 and L 304 were identified as potential lines for zero tillage cultivation in lowland land rice fallow.Maize-French bean under conservation tillage recorded 168 % higher maize equivalent yield compared to monocropping of maize in farmers' field.

Under organic farming integrated application of 50 % recommended dose (RD) of NP through FYM and 50 % RDNP through vermicompost recorded maximum grain yield of maize and green pod yield of french bean. Maximum potato yield was recorded with 100 % RDNP through vermicompost and was found at par with 100 % RDN through FYM. The soil organic carbon content (SOC) enhanced by 28 % under integrated application of 50 % N through vermicompost and 50 % N through FYM compared to initial SOC (1.80 %) after 7 cropping cycles. The soil microbial biomass carbon (SMBC) was recorded significantly higher under integrated (272.52 µg/g dry soil) followed by sole application of FYM (267.44 µg/g dry soil). The rice equivalent yield enhanced by 4 times and net return enhanced by 3 times compared to rice monocropping in valley land organic farming system. The bioorganic ($GF_1$) developed for ginger crop was chemoprofiled at Shriram Institute for Industrial Research, New Delhi. The data obtained from HPLC study using RI detector indicated the presence of two sugar compounds i.e. fructose (0.03%) and inositol (0.06%) in the herbal extract.

In marshy land on raised beds, the total system productivity in terms of groundnut equivalent yield was highest (16.25t/ha) with groundnut –tomato cropping system followed by groundnut –carrot (15.49 t/ha).Amongst the intercropping systems, maximum yield of 14.07 t/ha was recorded with cauliflower + pea (1:1) followed by cauliflower + *methi* (13.54 t/ha), while lowest was recorded with cauliflower + carrot in both the ratio in raised beds.Seed yield of mustard under residue management practices was highest under maize + groundnut paired row (residue removal) (295 kg/ha) followed by maize + soybean paired row (residue retention) (293 kg/ha). Maize equivalent yield under residue management practices was highest under maize + groundnut paired row (residue removal) (5108 kg/ha) followed by maize + groundnut paired row (residue retention) (4733 kg/ha).

Yield of groundnut (1.30 t/ha) was comparatively higher under *Gmelina arborea*(Gamhar) than *Alnus nepalensis* (Alder) while it was reverse in case of upland paddy. Increase in productivity of upland paddy (Bhalum1) to the tune of 32, 24 and 42 % was observed under alder, *gamhar* and hedge row, respectively when the field treated with lime and 80% recommended dose of SSP.Bench terraces were made in 0.23 ha *jhum* field (28-32% slope) at Sonidan village of Ri-Bhoi district of Meghalaya with fixed vertical interval of 1m. In another *jhum* field at Khatweimer village, *buns* (kind of raised bed) were made across the slope for ginger cultivation, whereas, in normal practice *buns* are raised along the slopes. Improved crop production with resource conservation technologies introduced in the *jhum* fields. There was significant ($P<0.01$ to $P<0.001$) reduction in pH, soil organic carbon (SOC), microbial biomass carbon (MBC) and the activity of acid phosphates enzyme (APE) in soils undermixed plantation forest (>28 years), horti (fruit/vegetables)-silvi-pastoral (>28 years) and orchard (<3 years with *khasi* mandarin+ Assam lemon+guava+ peach) land use systems compared with the soil under natural forest. Integrated use of lime (@400 kg/ha, furrow application), fertilizers (@ 50% of RDF) and organic manure (@ 2 t/ha vermi-compost) was advocated to the farmers to grow potato crop under TSP. The trained beneficiaries adopted the suggested package and the yield of potato (var. *Kufri Jyoti*) was increased by 128% over the farmers' practice.

An attempt was made to estimate spatial variability in SOC inventories for surface soils across six states of NER covering geographical area of 15.61M ha in Geographical Information System (GIS) environment. Results revealed that soils were very high in SOC content with 98.54% area had >1%, while 14.4% area had > 2.5% SOC content. Similarly, 76.5% area was having SOC density of 20-40 Mg/ha while 8% area was having very high SOC density of 40-60 Mg/ha. In lowland rice simulation study, the Agricultural Production Systems Simulator (APSIM) was used. Performance of the calibrated model on field experimentation for three consecutive years (2009-2011) was satisfactory. The simulated values of rice biomass at harvest averaged over three years were 12.9 ±1.44 t $ha^{-1}$compared to measured values of 12.7±1.1

t $ha^{-1}$ while the corresponding simulated averaged (3 years) grain yield was 6.1 ± 0.55 t $ha^{-1}$against the measured yield of 5.7 ± 0.45 t $ha^{-1}$.

Under water resource development, a total of 350 *jalkunds* were demonstrated across NEH states for promoting micro rainwater harvesting under NICRA. Ten roof water harvesting units and 18 farm ponds were demonstrated to promote multiple use of water for enhancing water productivity under farmers participatory action research programme**.** Multiple use of pond water for crop, fruit, livestock and fishery gave a net return of Rs. 30,350/- from 2000 $m^2$ area which was 312 % higher than the farmers' practice (no integration). The average productivity of high yielding rice varieties under SRI/ICM in Dhalai and South Garo Hills was 4.7 t/ha and 3.8 t/ha, as against 2.4 t/ha and 1.75 t/ha with local variety and local practice. Integrated watershed development programme involving water resource development viz., farm ponds, *jalkunds*, percolation tanks etc., soil conservation measures viz., terracing and half-moon terraces, across the slope cultivation, biological barriers including integration of crop-livestock-fish-tree components were demonstrated in at least 50 ha area.

Application of lime @500 kg/ha increased the soil pH to the tune of 0.21 to 0.34 units over control. Among the different organic sources, application of vermicompost along with 50% RDF proved better in improving the pH, status of SOC and available nutrients in the soil. Maize yield and soil available N, P and K was significantly correlated with pH. Paper mill sludge was identified as excellent material for acid soil amelioration and 60 tonne lime sludge was procured during the year and applied to various crops which enhanced productivity of maize by about 20%**.**Seed pelleting with lime, using gum arabic as sticking agent, improved maize yield by 8.5% compared to 30% improvement by furrow-applied lime @300 kg/ha. Under Flagship programme on *jhum*, 50 ha area is being developed in each NEH states incorporating improved varieties of crops, livestock breeds, fruits, trees and soil and water conservation measures along with large scale training and awareness program on improved farming systems**.** Slashing and burning resulted in significant increase in available N, P, K, Ca, Mg and S contents including organic carbon. However, first year of cultivation caused reduction in the available N, P, K and organic carbon content to a significant extent.

In dairy based farming system total cost of feed, concentrate and medicine was ₹ 1, 10,942.50 with an annual gross income of ₹1, 14,640.00 and registered net income of ₹18, 645.00.Agro-pastoral system could generate 294 man-days employment and net income of ₹ 1,34,174.48 giving an input – output ratio 2.21. Agri/vegetable based cropping system registered total income of ₹ 1, 62,322.50. The maximum income of ₹ 52,115/ha was realized from French bean-rice-*toria* in 2300 $m^2$ with ₹22.65/$m^2$, while maize based cropping system registered net income of ₹ 30,775 from 2500 $m^2$ area registering ₹12.31/$m^2$.

In Animal Production, low cost pig pen was developed with locally available natural resources for high rainfall mid to high altitude region. This pig house model was also integrated with rain water harvesting mechanism and vermicompost unit. Supplementation of probiotics *Saccromyces cervisiae* @ 03.75mcfu and *Lact.sporogens* @12500 cfu in daily diet in pre-pubertal gilts facilitates better growth rate and onset of reproductive activity.The average monthly body of weights of Emu *(Dromaius novaehollandiae*) chicks were 4.55±0.21, 8.05±0.06, 10.90±0.53, 12.87±0.76, 14.61±0.51, 17.07±0.50, 19.73±0.42, 22.40±0.65, 25.04±0.69 and 26.93±1.88 kg at the age of 3, 4, 5, 6, 7, 8, 9, 10, 11 and 12 month, respectively.

In Animal Health Division, PRRS (porcine reproductive and respiratory syndrome) viruses were detected in pigs of Meghalaya and in pigs of other states of NE Region by PCR and Ab-ELISA. PCV (porcine circo virus) and PPV (porcine parvo virus) were diagnosed in 14.2% and 9.76% pigs, respectively. A large numbers of pigs (33.19%) were found to be infected with classical swine fever virus (CSFV) as detected by PCR. The study on multi-drug resistant (MDR) *Escherichia coli* isolates indicated that multi-drug resistant *E. coli* is prevalent in pigs, goats, cattle and chickens in North East India and there is variation in the rates and patterns of resistance. Resistance was highest in the isolates from chickens, followed by pigs, cattle and goats. The serotyping results of the*E.coli* isolates revealed that these *E. coli* isolates belonged to 21 different serotpyes with serotype O90 being the most prevalent serotype. Rotavirus infection in livestock and children, antibodies against Brucellosis and IBR have been diagnosed.The Indian isolate (Umiam) of *Babesia bigemina* showed its close relation with Argentinian isolate and distinctly placed away from the isolates of neighbouring country China. Cloning and sequencing of PCR products generated from *B.canis* isolated from dogs of this regions showed nucleotide sequence of *B.canis* is having 93% sequence identity with *B.canisvogeli* . Therefore it is

likely that the organism is sub-species of *B. canisvogeli*. Phylogenetically, *B.canis* of this region are closely related to strain from Saint Kitts and Nevis (Caribbean) islands. Three polypeptides of *Mr* 36.2 kDa, 23.9 kDa and 9.6 kDa were recognized as immune dominant polypeptides of both cystic fluid antigens and whole cyst lysate antigens of *Cysticercustenuicollis* of goats.

For mechanization of hill agriculture, power tiller operated 3 row inclined plate planter for sowing maize, soybean and pea in terraces and valley lands of NEH region was designed and developed.A manual zero-till furrow opener was designed having having two furrow opener which opens furrow of 2-3 cm width and 3-4 cm depth on untilled soil.In energy studies, application of biochar had positive and significant effect on improvement of soil pH, SOC, available N, P, K and biomass yield. Irrespective of sources of biochar, its application improved the soil pH by 0.26 to 0.30 units, increased SOC ( 4.9 to 7.4%) over the control.A total number of 37000 farmers benefited from various activities under TSP. A total of 48 t rice, 13.2 t of maize,7.7 t toria,26 t turmeric and 27 t ginger, 13.2 t maize, 5.05 t pea, besides vegetables, fruit saplings and livestock were distributed to the farmers of Meghalaya, Manipur, Hailakandi (Assam) and Tripura.

**Arunachal Pradesh Centre**

RCPL 1-300 showed moderately resistant, RCM 11, CAU-R-1, SARS 66 were moderately susceptible and Ranjit, SARS 6 were susceptible to rice tungro disease in wet rice cultivation. Among 10 groundnut genotypes; GIRNR 2, GG 7 and TG 37 A recorded highest terminal disease intensity against rust, early leaf spot and late leaf spot respectively. In field pea, the highest green pod yield was recorded in var. Azad Pea 1 (3.3 t/ha). *Toria* var. TS36 registered 57.9% higher seed yield over M27. Among the various mulches tested, lowest weed dry weight was recorded with *Imperata cylendrica*(10.6 g/$m^2$). *Tanyum* and Volkamariana root stocks reduced the incidence of stem borer in mandarin. Foliar spray of Chlorpyriphos / Triazophos / Prophenophos @ 1 litre/ha or dusting of Parathion (2%D) /Chlorpyriphos (1%D)/ Malathion (5%D) / Quinolphos (1.5%D) @ 25-30 kg/ ha on various varieties of paddy was found effective for the management of cutworms. Performance of a Ghungroo breed at 9 months of age was better (49.9± 1.07 kg) as compared to Arunachal local pigs (22.25± 1.35 kg). Under Tribal Sub Plan (TSP) 9.5 t seed potato (var. Kufri Jyoti) seeds were distributed in West Siang and Upper Subansiri district and covered about 4.5 ha of land in 189 farmers' fields. Under NAIP due to the introduction of improved method of rice cultivation and variety, overall crop yield increased by 25 to 56%, income by 23.5 to 26.50% and employment by 30%. On an average net return of Rs. 13,500/- was obtained in each piggery unit with an annual gross income of ₹ 22, 500/-.

**Manipur Centre**

A short duration (90-105 days) rice variety RC Maniphou 12 (4.5-5.0 t/ha)was developed by the centre and released by the Govt. of Manipur. MC 34-9-7-77-96-62 (9.00 t/ha), MC 34-7-7-17-94-60 (8.83 t/ha) and MC 34-13-45-32-69-3 (8.33 t/ha) have been found promising. Under RCRT low land trial RCPL 1-167 (9.25 t/ha) and RCPL 1-145 (7.10 t/ha) shown higher productivity; whereas, RCPL 1-114 and RCPL 1-128 recorded better performance with mean yield 2416 kg/ha under RCRT upland trial. Under upland trials of AICRIP-IVT-U-H, entry no. 3106 was most promising (4.03 t/ha), followed by entry no. 31010 (3.71 t/ha) and 3108 (3.69 t/ha). Under AICRP, maize, entries viz., CMH 08-337 (9746 kg/ha), KNMH 408710 (7608 kg/ha), Vivek Maize Hybrid 43 (7284 kg/ha), Vivek Maize Hybrid 25 (6898 kg/ha) and Vivek Maize Hybrid 23 (6840 kg/ha) performed well. In pigeon pea, two lines namely RCMP1018-1-2 and RCMP 10241-1-1 were found promising. Application of 100% NPKZnB + 10 t FYM was found to be most suitable in enhancing the yield in maize var. Pusa Composite 3 (6 t/ha). Under NICRA, rice var. RC Maniphou7 and Taothabi shown tolerance to submerged condition; whereas, maize cultivar namely Khamathei White, Vaiminpheiand Chechata shown cold tolerance. In tomato, high temperature and drought condition under poly house has resulted 37.21% decline in fruit yield as compared to natural field condition. Tomato varieties Manikhamnu and Manileima (1.96 & 1.95 kg/plant) were found to be tolerant against frost condition; whereas, Kashi Hemant (2.53 kg/plant) performed better over other genotypes under low light condition. Tomato var. RC Manikhamenashinba 1 (Selection 9A) showed tolerance to drought and high temperature(1.97 kg/plant). Maize residue recycling on an average increased 12-15%, 13-16% and 9-12% grain yields of succeeding mustard, pea and lentil, respectively under sole and intercropping system. In horticulture, a high yielding tomato variety RC Manikhamenashinba 1 developed at centre having yield potential of 42.5 t/

ha, moderate resistance to bacterial wilt and tolerance to leaf curl disease was released by Govt. of Manipur. In taro, maximum yield (37.05 t/ha) was recorded with RCMC 9; followed by RCMC 10 (35.25 t/ha) and RCMC 4 (33.93 t/ha). Organic production package for passion fruit based cropping system was standardized. A spacing of 60cmx 20 cm and fertilizer dose 75:50:75 was found suitable for enhancing the yield of sweet potato var. Gouri (33.0 t/ha). Botanical pesticide Pestoneem was found suitable for eco-friendly pest management in cabbage. Application of Vermicompost (6.25 t/ha) + *Azospirillum* (1.0 l/ha) + Potash Solubilizing Bacteria (250 ml/ha) +Arbuscular Mycorrhiza (2 tablets/plants) was found most suitable for broccoli (21.00 t/ha), bell pepper (7.30 t/ha) and false coriander (24.50/ha) intercropped in grape plantation under naturally ventilated poly-house. In plant protection, the fungi isolated and identified from king chilli were *Cercospora capsici*, *Colletotrichum capsici*, *Glomerella cingulata*, *Corynespora cassicola*, *Phoma destructiva*. The virus infecting king chilli was *Pepper veinal mottle virus* (PVMoV). In animal science, 315 samples of chicken meat, beef, pork, milk, faecal samples from pig, cattle and diarrhoeal dogs were collected from various locations and using chromogenic media, *Escherichia coli*, *Klebsiella* spp., *Staphylococcus aureus*, *Aeromonas* spp. *Enterococcus* spp. and *Salmonella* spp. were isolated. Phenotypic characterization of the isolated organisms was done. In addition. 6 animal health camps were organized at different districts of Manipur covering 460 farmers and 235 animals. Under poultry seed project, supply of quality germplasm of poultry bird was increased by 143% over previous year. In fisheries, breeding and culture techniques for potential indigenous ornamental fishes of Manipur *viz.,Pangia pangio, Schitura fasciatus and Danio dangila* were standardized. In addition, 51.60 lakhs spawn and 2 lakhs fingerlings were produced during 2012-13.

**Mizoram Centre**

The grain yield of upland rice was significantly higher under raised bed and channel followed by line-sowing and ridge and furrow. In upland conditions, Bhalum 3 recorded highest grain yield (2.52t/ha) which was significantly higher than rest of the varieties, except IURON 514(2,38t/ha). In lowland conditions, var. Shahsarang produced significantly higher grain yield. In maize, higher grain yield was observed with cultivar CMH08-337(6.05t/ha) followed by Vivek hybrid 9 (5.16t/ha) by than other hybrids in *kharif*. In *rabi* maize, higher grain yield was obtained under furrow sowing +mulching + earthing up (4.16t/ha). Highest grain yield was observed in mustard/rape seed with application of liquid manure (8000L) in two split applications. Under zero tillage, highest grain yield of mustard cv. M 27(1.41t/ha) was recorded with application of vermicompost 2t/ha. Similarly, under zero tillage cultivation of pea, germination per cent and pod yield of cv. Arkel was superior to cv. Prakash. Pre-soaking of Arkel for 24 hours and Prakash for 36 hours was found to be best. Pre-soaking of lentil for 36 hours resulted in better germination percentage and yield. High density planting of mango var. Amrapali was established to evaluate the effects of canopy management in reducing the vegetative growth in sub-humid warm tropical climate of Mizoram. The orchard was laid out in three different spacial arrangements with spacing of 2.5x2.5 m, 3x2.5 m and 2.5x1.5m for accommodating plants: 1600, 1333 and 2666 plants per hectare, respectively and in control plot only 100 plants were maintained. Nineteen genotypes of banana and plantains suckers were collected from Banana Research Station, Kerala Agriculture University, Thissur, Kerala for multiplication at centre. All the genotypes responding very well under Mizoram conditions and are at vegetative stage. In the winter season coincided with low temperature and water stress conditions, tomato var. Pusa Rohini and Dev NP-5081 performed well and recorded more yield due to increase in fruit set and more no. of fruits/plant. Field survey among Anthurium growers revealed that the bacterial blight caused by *Xanthomonas axonopodis* pv. *Dieffenbachiae* was major disease and prevalent in almost all anthurium growing regions of Kolasib (67%) and Aizawl (58.3%), followed by *Colletotrichum gloeosporioides* (30.3 and 35%) and *Rhizoctonia* root rot (19% and 25. The insect-pests damage on the anthurium crop ranged from 5.5 to 55 per cent

A total of 9 crossbred cows along with five female calves were procured from CVSc, A.A.U, Khanapara for replacement of low productive and reproductive performances cow. Regular screening of milk samples, recording daily milk yield etc. resulted in reduction in occurrence of mastitis in the herd. A total number of 30 piglets (24 F & 6 M) Hampshire cross breed of 3 months old were procured from C.V.Sc., A.A.U, Khanapara, and the total body weight were assessed monthly. The weight of the piglet at 3 months of age was 16.3 kg and after one month the piglet gained the weight of 23 kg and at 5 months of age the piglet gained the weight of 28.83 kg. The piglets were fed with

concentrate feed along with cooked rice, maize, *Colocasia*, tapioca and mineral mixture twice a day. The gilts came into estrus at 7 months and at the age of 10 months 4 gilts were served with the boar by natural service.

The age at first laying Vanaraja of parent stock was 16 weeks and body weight gained up to 2.7 kg. The body weight of parent stock of matured males at 16 weeks was around 3.66 kg. Coccidiosis disease was controlled by frequent changing of litter material and treat with amprolium.

**Nagaland Centre**

Rice bean line RBS 53 recorded significantly higher yield attributes and yield. Lime application 0.6 t/ha recorded significantly higher yield attributes and yield of the rice bean followed by 0.4 and 0.2 t/ha. In rice integrated crop management (ICM) recorded significantly higher yield followed by SRI, and CRC. Application of 100 % recommended dose of fertilizer (RDF) + crop residues recorded significantly higher yield (3.27 t/ha) of rice followed by 100 % RDF (3.05 t/ha). 10th April sowing recorded significantly highest yield attributes and yield of the mung bean. The screening of maize varieties under moisture stress revealed that RCM 75 is the potential variety for Nagaland conditions. In two *jhum* fields of Medziphema and Jharnapani, two sustainable farming systems models *viz.*agri-silvi-livestock, agri-horti-silvi have been developed and being compared with traditional*jhum*. Under NAIP-3, large cardamom plantation of 0.16 ha yielded 60 kg of fresh capsules and after sun-drying yield was 15.2 kg of dry capsules. Each kg of dry capsules fetched ₹ 500 in the market and thus gross income of ₹ 7600 realized. In *jhum* rice application of 18 % common salt recorded maximum grain yield. Under technology mission in horticulture seven anthurium varieties *viz.,* Violet White, L'Armour, Queen Black, 1st Red, Cynthia, Anastacia and Red were evaluated under shade net conditions. The maximum plant height was recorded by L'Armour (36.4 cm) and maximum leaf length (25.1 cm) and leaf breadth (14.5 cm) was found in Anastacia.Out of 126colocasiagermplasm evaluated, 110 different germplasm have been identified based on the morphological characterization (IPGRI descriptor). Among the genotyoes evaluated, 9 lines were dwarf (< 50 cm height), 68 lines were medium (50 – 100 cm) and 33 lines were tall (>100 cm). The 10 lines recorded no suckers, 99 lines had 1 – 5 suckers and one line recorded more than 6 suckers. The feed conversion efficiency of Large Black cross and Ghungroo gilts (3-4 months age) was statistically similar and varied from 3.88 to 4.13 in Large Black and 3.4 to 4.33 in Ghungroo. The litter size varied from 6.83±0.42 to 8.94±0.81 in Large Black and 7.20 ±0.55 to 10.27±1.31 in Ghungroo. The survival rate of the Vanaraja birds was recorded as 80-85 % at Lampong Shenghah village of Mon districts under NAIP-3.

**Sikkim Centre**

Based on lowland RCRT trials, three lines *viz*. RCPL 123, RCPL 473 and RCPL 469were identified as better performing lines under midhills. Three rajmash entries *viz.,*SKR 57, IPR 96-4 and Naogaon Rajmash performed well under both the *kharif* and *rabi* seasons and yielded SKR57 (1.35 t/ha), IPR96-4 (1.30 t/ha) and Naogaon Rajmash (1.30 t/ha). SKR 57 and Naogaon Rajmash were earliest in maturity (115 days). In yellow sarson, eight single plant selections were made in SSY 2 (Sikkim Sarson Yellow 2) population based on yield contributing traits and maturity. KMT 2 a *toria* line selected from the segregating population of SCR 1-2-5 have been put for population stability. Out of 36 buckwheat genotypes, the highest yielding entries were IC 109728 (3.2 t/ha), PRB 1 (3.13 t/ha), IC 109549 (2.4 t/ha), IC 202268 (2.12 t/ha). Among 14 different germplasm of rapeseed and mustard Sikkim *Toria* 2, Sikkim Sarson Yellow 1, Yellow Sarson Yellow 3 and TS 38 were less infested by mustard aphid and saw fly in comparison to others. Trichostar (*Trichoderma viride*) as seed, soil treatment and spray was most effective (38.00 PDI) over the control (64.77 PDI) in managing white rust in mustard. In total 80 numbers of chow-chow (*Sechium edule*) accessions were collected from Sikkim and quality parameters were studied for about 40 accessions. Application of *Trichoderma* +hot water treatment (HWT) of rhizome+ need based application of COC 0.3% showed less incidence of soft rot (15%) followed by Neem cake+ HWT+need based application of COC 0.3%.Tree leaf (*Chilawney+Utis*) mulch @ 5 t/ha and vermicompost @ 1.5 t/ha recorded the maximum grain yield (9.10 q/ ha) of *toria*. The prevalence of GI-helminthes was higher in subtropical and high humid zone (37.31 %) followed by temperate and humid area (34.52 %) as compared to subalpine low humid zone (30.53 %) and alpine dry area ( 17.62 %). In goat, among the various endo-parasites, nematodes (61.72 %) were found higher followed by trematodes (44.44%) and cestodes (33.33 %) and among nematodes,

*Haemonchu*s spp. was predominant (61.72%) followed by *Oesophagostomum* (46.91%), *Bunostomum* spp. (29.63%). A total of 16803 day old Vanarajaa and Grampriya chicks were supplied to the farmers of Sikkim under Poultry Seed Project.

**Tripura Centre**

Three rice varieties (TRC 2005-1, TRC 2005-3, Naveen), one field pea (TRCP 9), one *toria* (TRC T1-1-5-1) and two brinjal varieties (Singhnath and Bholanath) were released by State Varietal Release Committee. Under DBT twinning project for identification of major QTLs for drought tolerance, 83 *jhum* rice germplasm from NE states were screened. Based on grain yield and other traits, the promising drought tolerant genotypes identified were RCPL 1-128, Bhalum 3, Bhalum 1, Phulbadam and Kataktara. Parental polymorphism survey/ diversity analysis was carried out in 78 *jhum* rice germplasm using 30 SSR markers. All the 30 SSR markers were polymorphic across the genotypes. Polymorphic information values of the markers underwent a variation from 0.254 (RM537) to 0.748(RM 24344) with an average of 0.595. Genotypes (78 nos) used for molecular characterization were also used for morphological studies. Genotyping of 45 genotypes with 200 SSR markers was also done under NICRA.

Locally available *Gliricidia* leaf was recommended as a source of organic amendment for increasing the rice yield. Sheath blight disease could be controlled with the seed treatment followed by application of *Trichoderma viride*. Spore density of mycorrhiza with species, namely *Glomus*, *Gigaspora* and *Acaulospora* was highest in bean, coconut, maize field in the range of 400-610 per 100 g soil. Tree leaf incorporation along with 50% N through inorganic fertilizer was found best option in increasing radish yield. Under AICRP on vegetable crops, total 11 entries were evaluated for tomato leaf curl virus and bacterial wilt. Total fruit yield of brinjal under AICRP (vegetables) varied from 31 to 42 t/ha. Under protected cultivation, vegetables viz., broccoli, capsicum, cauliflower and tomato were grown.

Rice-*toria* showed highest system productivity (7.9 t/ha) followed by rice-pea (3.4t/ha). Highest green cob yield of maize was recorded with broad bed and furrow system with conventional tillage. Low cost drip irrigation systems involving bamboo, PVC electric pipes, PVC flexy pipes and aluminium sheet are introduced in banana under sloppy land. Rain tank drip irrigation system with 21,000 lit water capacity was standardized.In order to improve oyster mushroom, hybridization programme is in progress showing the production of 800 g/kg substrate in the crosses of 6S3 x 3512. A local mushroom, *Lentinus squarrosulus* produced fruit bodies (426g/kg substrate) in September followed by 272 g/kg in June. Phenotypic traits were found to be clustered separately for single, twin and triplet kidding size in Black Bengal Goat. GnRH challenge is used to identify the fetal number in pregnant goat. There was a need of providing supplemental heat to reduce mortality rate in piglets during cold months. Blood biochemical profiles were evaluated in Ghungroo piglets. A low cost pig shelter with cost involvement of ₹ 12,000/- has been made. The body weight of coloured broiler dam line at 7 week age was 1.5 kg. A biotech hub has been established at Tripura Centre. Hematological and serum chemistry of *Labeo rohita* were studied with increase in water temperature. Rubber seed meal was used as a replacement of fish meal in *Cirrhinus mrigala*. *Ompak bimacultus* (pabda) was attempted in composite culture with carps. The total fish production was 2.07t/ha. In a tribal village (Gamchakubra), Agroforestry model was developed with mango, litchi, sweet orange and arecanut. Rice varieties *viz.,* Ranjit, MTU 1010, Gomati and Swarna were tested under NICRA. Under TSP, seeds of paddy, groundnut, maize and okra were distributed in 716 ha among 4476 farmers. During *rabi* season of 2012-13, seeds of lentil, groundnut, maize, green gram, black gram and vegetable pea were distributed to 1125 farmers covering an area of 247 ha.

# 1. INTRODUCTION

The ICAR Research Complex for NEH Region established since 1975 has gone a long way in generating technologies as an outcome of basic, strategic and applied research. The Institute having multidisciplinary approach in serving seven hill states of the region encompasses 16 major disciplines in eight divisions of agriculture and allied sciences. The annual report is the outcome of the activities in six regional centres besides headquarters at Umiam and 14 Krishi Vigyan Kendras (KVKs). It is also mandated to teach and guide students from universities including Central Agricultural University. Realizing the need of the region, the institute visualized three flagship programme *viz*., improvement of shifting cultivation, temperate horticulture and trans-boundary diseases during the XII Five Yearly Plan. The Institute has a very strong extension network programme for all the north eastern states through 14 KVKs. Some competitive projects such as NAIP, NICRA, NHB, DBT and DST funded programme, TSP, NFBSFARA (National fund for basic, strategic and frontier application research in agriculture) etc. are operational in the region disseminating modern technologies for livelihood security in backward districts of the region. This includes truthfully labeled seeds, quality planting materials, quality animal, poultry and fish seeds including proto-type implements and tools suitable for hill agriculture, soil health testing kits, diagnostic kits for animal parasites and diseases. With the support from the Council headquarters, the strength of scientists in the complex has reached to 120 during the period under report. Several in-house projects, mostly of interdisciplinary nature, are being pursued. The strategic research on climate change adaptation and mitigation under NICRA is a major research thrust area of the institute. There are 14 AICRPs, 5 network and 15 collaborative projects in operation. The institute has strong linkage with other ICAR Institutes & Universities in the region and ICAR Institutes outside the region as well with International organizations like IRRI, ICRISAT, ILRI, IWMI. The Institute also collaborates with government sponsored agencies like NERCOMP, MRDS, and IFAD Loan Project; several NGOs and farmers bodies for technology extension.

## Thrust areas

- To evolve sustainable integrated farming systems for *jhum* improvement and restoration of degraded lands.
- To increase the overall productivity of different crops through research in cereals, pulses, oilseeds, horticultural crops including temperate horticulture, agroforestry species, fisheries and other economical crops.
- Development of feed and fodder resources including locally available fodder for livestock.
- Improvement of citrus plantation to reinvigorate the citrus industry.
- Animal health coverage and improvement of livestock production system including trans-boundary diseases.

## Mandate

- To undertake basic and applied research for delivering technologies based on sustainable farming system for different agro climatic and socio-economic condition.
- To improve the productivity of crops, livestock and fishery.
- To act as a repository of information on natural resources, different farming and land use systems.
- To impart training on research methodology and application of improved technologies for enhancing agricultural productivity.
- To collaborate with the state departments for agricultural development in the region and testing and promotion of improved farming and land use systems.
- To collaborate with national and international agencies.
- To provide consultancy.

## HUMAN RESOURCES

| Category | Sanctioned post | Filled post | Vacant posts |
|---|---|---|---|
| **Institute** | | | |
| RMP | 1 | 1 | |
| Scientific | 181 | 120 | 61 |
| Technical | 253 | 239 | 14 |
| Administrative | 129 | 112 | 17 |
| Skilled Support | 114 | 112 | 2 |
| **Total** | 678 | 584 | 94 |
| **KrishiVigyan Kendra** | | | |
| Scientific | 14 | 6 | 8 |
| Technical | 162 | 143 | 19 |
| Administrative | 28 | 18 | 10 |
| Supporting | 30 | 28 | 2 |
| **Total** | 234 | 195 | 39 |

## BUDGET

**Actual expenditure for 2012-2013 (₹ in lakh)**

| Particulars | Non - plan | | Plan | |
|---|---|---|---|---|
| | Allocation | Expenditure | Allocation | Expenditure |
| **A. Recurring** | | | | |
| Establishment charges | 4276.36 | 4267.35 | - | - |
| Travelling allowances | 36.00 | 35.50 | 22.0 | 21.97 |
| Other items (HRD) | - | - | 15.00 | 14.90 |
| Contingencies, research & operational expenses | 718.64 | 717.98 | 538.0 | 538.00 |
| **Total (A)** | **5031.00** | **5020.83** | **575.00** | **574.87** |
| **B. Non-Recurring** | | | | |
| Works/administrative/ minor works | 310.00 | 309.75 | 300.00 | 298.17 |
| Equipment's/furniture etc. | 50.00 | 49.77 | 190.00 | 189.74 |
| Livestock | - | - | 10.00 | 10.00 |
| Books | - | - | 30.00 | 29.55 |
| Repair & maintenance | - | - | 195.00 | 194.00 |
| **Total (B)** | **360.00** | **359.52** | **725.00** | **721.46** |
| **C. TSP** | **-** | **-** | **165.00** | **164.98** |
| **Total (A+B)** | **5391.00** | **5380.34** | **1300.00** | **1296.33** |
| **Total (A+B+C)** | **5391.00** | **5380.34** | **1465.00** | **1461.31** |

## LIBRARY

| Nature of publication | No. of copies available |
|---|---|
| Books and reports | 28232 |
| Back volumes of journals | 11063 |
| Foreign journals | 15 |
| Indian journals | 160 |
| Popular journals | 45 |
| Hindi books | 3242 |
| Magazine | 8 |

## LABORATORIES

The institute's headquarters at Umiam, is well equipped with laboratory facilities in all the divisions of natural resource management, crop sciences, horticulture, animal sciences (for disease diagnosis), fisheries and agricultural engineering. A Biotechnology Centre equipped with the state of art instruments has been established for catering to the research needs in rice, horticulture and other disciplines. A post-harvest processing unit is in operation in agricultural engineering division. A well-equipped workshop is also

in place for research and development, fabrication and repair of agricultural implements and tools in the division of agricultural engineering. State of art facilities such as FATE, CTGC, Biochar unit, TOC analyser, DNA sequencers, bio-safety cabinet for isolation works under containment condition, six numbers of Environmental Control Chambers, rainout shelters, transgenic facilities has been developed/ initiated. Central laboratory with sophisticated instruments has been established at headquarters. The laboratories in all the six centres of the Institute are also being strengthened with basic as well advanced instrumentation facilities.

## IT FACILITIES

IT facility has been developed at the Division of Social Sciences. It included an AC Lab of SAS installed 10 computers with projector and internet facility along with UPS power backup of 2.30 h. The lab has seating capacity for 20 people. The lab is also having 3 licenses of SPSS and 2 licenses of STATISTICA. All the three software *viz.*, SAS, SPSS and STATISTICA have perpetual license. The SAS software available in the division can be installed on any number of official machines. Besides software and hardware, complete manuals of SAS, both in soft and hard copies, are also available and any NARS personnel can get it along with the SAS software free of cost. Online ARS-NET examination facilities developed at the Umiam are functional since 2012. The KIRAN a dedicated website managed by the Institute has started providing much needed service including integrated agro-advisory services through SMS.

## IMPORTANT MEETINGS

### National Seminar under NAIP-III, organized at ICAR Research Complex for NEH Region, Umiam

A two day National Seminar on *"Livelihood options for small and marginal farmers in fragile ecosystems"* was organized during 9-10th August, 2012 at ICAR Research Complex for NEH Region, Umiam, Meghalaya. Dr Bangali Baboo, National Director, NAIP, ICAR New Delhi inaugurated the programme in the presence of Dr D.N. Borthakur, Chairman, Consortium Advisory Committee, NAIP-III, Dr S.V. Ngachan, Director, ICAR Research Complex for NEH Region, Umiam, Dr A.P. Srivastaava, National Coordinator, NAIP-III along with other dignitaries.

**Release of publication by Dr Banagali Baboo, ND, NAIP & Dr D.N. Borthakur, Chairman, CAC, NAIP-3**

About 150 delegates including members from other consortia under NAIP-III, programme leaders and Scientists of ICAR, Universities etc. and research scholars from all over the country attended the seminar.

### Second Review Workshop of National Initiative on Climate Resilient Agriculture (NICRA)

The 2nd Review Workshop of the NICRA-ICARNEH project was held on 30-31st January, 2013 at ICAR Research complex for NEH region, Umiam. Dr Anil Kumar Singh, Hon'ble Vice Chancellor, Rajmata Vijaye Raje Scindhia Krishi Vishwa Vidyalaya, Gwalior graced the occasion as chief guest and the function was presided over by the Dr S.V. Ngachan, Director, ICAR Research Complex for NEH Region, Umiam, Dr A.K. Pathak, former Director of Research, AAU, Jorhat, Dr R.J. Rabindra, Dean, CPGS, Umiam and Dr M. Maheswari, PI of the NICRA project, CRIDA, other experts from different parts of the country also attended the review workshop.


**Release of booklet by Dr A.K. Singh, VC, RVRSKVV, Gwalior and other dignitaries**

**Workshop cum Farmers' Fair organized and released new crop varieties by Manipur centre**

The Workshop cum Farmers' Fair on "*Agriculture and food security in the context of climate change*" was organized at ICAR Research Complex for NEH Region, Manipur Centre, Imphal during 12-14 October, 2012. The event was inaugurated by Sh. Mohammed Abdul Nasir, Hon'ble Minister of Agriculture, Govt. of Manipur as Chief Guest on 12th October, 2012; while Shri Rajesh Agarwal, IAS and Commissioner of Agriculture, Govt. of Manipur and Dr S.V. Ngachan, Director, ICAR Research Complex for NEH Region, Meghalaya acted as Guest of Honour and President, respectively. Directors of state department of agriculture, veterinary and fisheries were also participated during the function. Hon'ble Minister of Agriculture, Govt. of Manipur also released new rice variety RC Maniphou 12 and tomato variety RC Manikhamenashinba1, developed by ICAR, Manipur Centre. Seeds of newly released varieties of rice and tomato were also distributed to the farmers at the occasion. More than 2000 farmers from different districts of the states have participated in the 3 days farmers' fair. One Farmers-Scientists interaction programme was also organized during the programme on 13th and 14th October, 2012. Prizes were awarded for best exhibition in the farmers' fair by ICAR.

**Workshop cum Farmers' Fair and distribution of prizes for best exhibits**

**Regional seminar under NAIP-III, organized at ICAR Complex, Manipur Centre**

A two day Regional Seminar on*"Site specific farming system options for disadvantaged areas*" was organized during 5-6th July, 2012 at ICAR Research Complex for NEH Region, Manipur Centre, Lamphelpat, Manipur. Dr S.V. Ngachan, Director, ICAR Research Complex for NEH Region, Umiam inaugurated the programme in the presence of Dr G.C. Munda, CPI, NAIP-III, Joint Directors/Cluster Leaders of ICAR Research Complex for NEH Region, Regional Centres, Co-PIs of NAIP, Comp-III and other scientist and research staff. In the two days Regional Seminar, presentations on the progress of the NAIP, Comp-III subproject were made by the cluster leaders and the CO-PIs from the partner institutions of the subproject. The achievements of different interventions were discussed for cross learning and also for horizontal spread of the successful interventions in the other disadvantaged areas.

**Dr S.V. Ngachan, Director, ICAR Complex, Umiam addressing the gathering in regional seminar**

**Stakeholders' meet at ICAR, Sikkim Centre organized**

Two days State level Stakeholders' Workshop on "*Bridging research to extension: strategies and policies*" hosted by ICAR Research Complex for NEH Region, Sikkim centre was held on October 11-12, 2012 in Hotel Mayfair. Prof. M.P. Pandey, Vice chancellor, BAU, Ranchi, Jharkhand inaugurated the programme. Dr Jay G. Varshney, ICAR Sikkim centre, Dr R. P. Medhi, Director, NRC for Orchids, Sh S. Pradan, Secretary, FS & ADD, Govt. of Sikkim were also present on the occasion. Nearly 90 participants


**Prof. M.P. Pandey, Vice chancellor, BAU, Ranchi in inaugural function of stakeholders meet**

from different organizations and farmers gathered in the inaugural session. A souvenir on the Workshop was also released at the meet.

### Two days training cum input distribution programme organized at Arunachal Pradesh Centre

A two days training cum input distribution programme under NICRA at Jairampur was inaugurated by Sh. Setong Sena, Hon'ble Minister of Agri-Horti, Govt. of A.P. He encouraged the young entrepreneurs engaged in farming activities. He also suggested for adoption of scientific technologies for commercial crops and backyard poultry. Dr R. Bhagawati, Joint Director, highlighted the vagaries of climate change in farming sector and possible mitigation strategies. Altogether, 276 farmers from different villages and Self Help Groups, officers from line departments, public leaders of Changlang district attended the programe. The farmers were distributed seeds of 6 t Ranjit var. of rice; 1.5 t DMH 849 var. of Maize; 0.6 t JS 335 var. of Soybean; 0.20 t Arka Anamika var. of okra, 500 saplings of tissue cultured banana cultivar Grand Naine; 4000 nuclear seedlings of Khasi Mandarin; 50 kg oyster mushroom spawn; 1000 nos. of day old chicks of Vanaraja poultry bird, feeds and medicines. Moreover, they were also distributed 3 rolls of 200 micron UV stabilized poly film; 3 rolls of shade net and 5 rolls of Silpaulin for construction of protected structures and *jalkund*.

### Vetting Workshop on District Contingency Plan for North East Organized at Umiam

A two days vetting workshop was organised during 18-19th April 2012 at Conference Hall, ICAR Complex, Umiam. The programme was chaired by the Director, ICAR Complex, Umiam. The experts from Nodal Institute CRIDA, the Programme Coordinators & SMS of KVKs from the North East, Scientists of Umiam attended the programme. The contingency plan for each district was discussed and necessary inputs for improving the plan were incorporated during the workshop.

**The participants of Vetting Workshop on District Contingency Planning**

### Awareness cum interaction programme on "Jhum Improvement"

Two days awareness cum interaction programme on "Jhum Improvement" under NICRA was held during 27-28th December, 2012 at ICAR Research Complex, Umiam. Thirty eight farmers (21: Male; 17: Female) from Sonidan, Nongkya and Khatweimer participated. The farmers were exposed to various experimental models and practices *viz*., Integrated farming systems, Agroforestry interventions, Deep litter pig husbandry, Zero tillage pea and lentil cultivation, land use models for hill slope vegetable cultivation, organic farming etc. The seeds/seedlings of high yielding varieties of crops were also distributed to the farmers. Scientist-Jhum farmer's interaction meet was also arranged in the concluding session to clarify the doubts/problems faced by the farmers and to get the feedback from them.

**Awareness cum Interaction Programme on "Jhum Improvement"**

## DISTINGUISHED VISITORS

### Visit of Dr Charan Das Mahant, Hon'ble Union Minister to ICAR Complex, Umiam, Meghalaya

Dr Charan Das Mahant, Hon'ble Union Minister of State for Agriculture and Food Processing Industries made his visit to the Complex headquarters on 15 December, 2012. The Hon' minister addressed the scientists and staffs of the Institute and asked for renewed interest in agricultural research and extension for bringing benefits to the farmers of the region. The hon'ble union minister inaugurated the phenomix facilities of NFBSFARA project. Dr Mohan Kumar, ADG, (Agronomy & Agroforestry) also accompanied the minister and briefed him about the activities of

**Dr Charan Das Mahant, Hon'ble Union Minister addressing the staff at ICAR Complex, Umiam**

ICAR in the region. Dr S.V. Ngachan, Director of the Institute exposed the minister with various activities of the Institute including fields, laboratories and extension activities in the farmers field.

### Visit of Dr S. Ayyappan, Secretary (DARE) & DG (ICAR) to AP Centre

Dr S. Ayyappan, Secretary, DARE and Director General, ICAR, New Delhi paid his maiden visit to ICAR Research Complex for NEH Region, Arunachal Pradesh Centre, Basar on 30th & 31st March, 2013 along with Dr S.N. Puri, Vice Chancellor, CAU, Imphal, Manipur as Guest of Honour and inaugurated the newly constructed building of Tissue Culture Laboratory and Polyhouse. He visited all the units of experimental field research and laboratory facilities developed at the centre. During the august gathering, Dr S.V. Ngachan, Director, ICAR Research Complex for NEH Region, Umroi Road, Umiam, Barapani welcomed all the dignitaries and guests assembled from different departments, progressive farmers, press and media where Sh. Kanki Darang, ADC, Basar, Shri A.K. Purkayastha, Advisor to the Department of Agriculture, Govt. of Arunachal Pradesh attended the function. Dr S.N. Puri, V.C., CAU expressed his satisfaction witnessing the tremendous development and spectacular change and contribution of ICAR, A. P. Centre, Basar during the last four years from his previous visit with Ex-DG, Dr Mangala Rai. The Joint Director, Dr R. Bhagawati offered his vote of thanks to all the dignitaries and support rendered by the Hon'ble Minister of Agriculture, Govt. of A.P., participating officials, public leaders, press and media and most importantly the farming community.

**Dr S. Ayyappan, DG & Secretary visiting the exhibits in Arunachal Pradesh centre**

### Visit of Chairman, QRT, PDP to Sikkim Centre

Dr S.K. Dwivedi, Chairman QRT, PDP, Hyderabad visited the poultry seed project centre at ICAR Research complex for NEH Region, Sikkim Centre, Gangtok on 08th October, 2012 to review the progress of work done under the Poultry Seed Project. Chairman interacted with the beneficiary farmers of the project regarding the field performance of Vanaraja and Grampriya birds. Farmers said that the birds were performing well in the field condition and they were getting nutritional as well as economic benefits by rearing the Vanaraja and Grampriya birds. Chairman, Dr S.K. Dwivedi also distributed the chicks of Vanaraja and Grampriya birds to the beneficiary farmers.

**Dr S.K. Dwivedi, Chairman QRT, PDP, Hyderabad interacting with scientists in Sikkim Centre**

## IMPORTANT EVENTS

### ICAR-RC, NEH, Tripura Centre, released six improved crop varieties

Improved crop varieties as recommended by Tripura State Seed Sub Committee, Govt. of Tripura were ceremonially released by His Excellency the

Governor of Tripura, Dr D.Y. Patil on the 22nd June, 2012 in a programme organized by ICAR Research Complex for NEH Region, Lembucherra, Tripura (West). The crop varieties released are three rice (Naveen, TRC 2005-1, TRC 2005-3), one *toria*: TRC T-1-1-5-1 and two Brinjal (Bholanath and Singnath) varieties.

**Inauguration by His Excellency the Governor of Tripura, Dr D.Y. Patil**

**Crop varieties releasing by His Excellency the Governor of Tripura**

### Tribal farmers in climate resilient agriculture

An awareness programme cum input distribution prograamme was organized in Sohra (Cherapunjee) on 18th May, 2013. The program was presided by Dr P.W. Khongjee, Hon'ble MLA, Sohra and the chief guest of the function was the Hon'ble chief Minister of Meghalaya, Dr Mukul Sangma. The programme was also graced by the former chief Minister Dr Donkupar Roy Dkhar. More than 1500 farmers from Cherapunjee attended the programme. The Chief Minister in his address to the gathering ask for the steps for conserving natural resources and need to adopt improved technologies to adapt climate change. The tribal farmers are most vulnerable to climate change due to lack of resources and fragility of the ecosystems they live-in. Dr Donkupar Roy asked the scientific community and other stakeholders to come together to revive the degraded ecosystem of Cherapunjee.

**Dr Mukul Sangma, Hon'ble chief Minister, Meghalaya distributing inputs to farmers**

Large quantities of inputs including more than a ton of rice seeds, 500 kg maize, 10000 fish fingerlings, 150 livestock's, 2000 fruit/plantation crops sapling including briquettes, botanicals, small tools etc. were distributed to the farmers. DrS.V. Ngachan, Director, ICAR Complex, Umiam assured the all possible supports for improving livelihood of tribal farmers and offered the vote of thanks .

### Participation in SAU–ICAR–CII Industry Meet

ICAR Research Complex for NEH Region, Tripura Centre had participated in SAU–ICAR –CII industry meet organized at the college of Fisheries, CAU, Lembucherra, Tripura on the 3rd July, 2012 An exhibition displaying our research as well as extension activities was arranged and Shri. Manik Sarkar, Hon'ble Chief Minister, Govt. of Tripura and Dr S.N. Puri, Hon'ble Vice Chancellor, CAU had visited ICAR pavilion and interacted with the scientists.

**Hon'ble Chief Minister of Tripura interacting with scientists**

### Commercialization of farm tools and machinery

M/s. North East Enterprises, Forest Colony, Chimpu, Itanagar, Papum Pare Distt., Arunachal Pradesh has been licensed for commercial production and marketing of farm tools and implements (Adjustable row marker and Cono-weeder) for three


**Licensing of farm implements for commercialization**

years from the date of signing MoU in accordance with the technical guidelines and instructions of ICAR Research Complex for NEH Region.

**Seed distribution to tribal farmers under TSP a mega program of Complex for rural livelihood**

A total number of 37000 farmers were covered under TSP during 2012-13. The seeds distributed for major crops were 5050 kg of Arkel (pea), 3000 kg of PSM 3 (pea), 11000 kg of HQPM 5 (Maize), 500 kg of All Rounder (maize), 850 kg of QPM 9 (maize), 35040 kg of DMH 849 (maize), 28000 kg of HQPM1 (maize), 10920 kg of M27 (toria), 12740 kg of Naveen (paddy), 11000 kg of Gomati (paddy), 40 kg of Bhalum (paddy), 54000 kg of Ranjit (paddy) and 6120 kg of MTU 1010 (paddy) etc. The other crop seeds distributed were 26000 kg of Megha turmeric, 27120 kg of Nadia (ginger), 225 kg of DTL-15 variety of lentil, 2100 kg of WBL 77 variety of lentil, 25 kg of rice bean, 700 kg of Kufri Jyoti (potato), 100 g of F1 papaya, 500 g of Ashmita (cauliflower), 500 g of Cp (raddish), 2 kg of Nantus (carrot), 3 kg of P. Nasdar (ridgegourd), 2.6 kg of bitter gourd, 200 numbers of banana sucker, 450 numbers of dahlia plant, 180 bottles of bio-organics, 25 numbers of maize shellers, 1100 numbers of *Khasi* mandarin saplings, 200 numbers of guava saplings, 100 numbers of peach plant, 200 kg of okra, 1750kg of Arka Anamika variety of bhindi, 301 g of F1 brinjal, 10 kg of French bean seeds, 5 kg of cucumber, 5 kg of P. Navin variety of bottle guard, 5 kg of pumkin, 400 kg of ICGS-76 variety of groundnut, 6210 kg of TAG-24 variety of groundnut, 3750 kg of JS 335 variety of soybean, 240 kg of JS 905 variety of soybean, 240 kg of Js-9560 variety of soybean, 2250 kg of PDM-139 variety of green gram, 1008 kg of pigeon pea, 3000 kg of black gram , 1000 kg of T9 variety of black gram, 20250 numbers of Amur and Common carp breed of fish and 35 numbers of TxD breed of piglets were distributed.

**Seed distribution cum training programme conducted under TSP in Nagaland**

Seed Distribution Ceremony at Jalukie Town Hall of Peren district was organized by ICAR Research Complex for NEH Region, Nagaland Centre, Medziphema in collaboration with the Confederation of Naga Farmers' Union (CONFU), Peren on 28th of April, 2012 under Tribal Sub Plan (TSP). 0.5 t RCM 76 var. of maize and 0.7 t Ranjit var. of paddy from ICAR were distributed to the farmers. About 650 farmers gathered in the programme from 25 different villages of the district. Mr. T.R. Zeliang, Minister, Veterinary & Animal Husbandry, Govt. of Nagaland was the Chief Guest of the programme and the Deputy Commissioner, Peren district chaired the meeting in presence of Dr B.C. Deka, Joint Director, ICAR Research Complex, Nagaland Centre.

Two days training programme on *'New technologies in maize production'* was organized by KVK Dimapur, ICAR Research Complex for NEH Region, Nagaland Centre at KVK, Dimapur in collaboration with the Directorate of Maize Research, New Delhi on 10-11th of July, 2012 under Tribal Sub Plan (TSP). The Chief Guest of the function Dr. C. Rajkhowa, Director, NRC on Mithun, Jharnapani released a folder on "Cultivation of Maize (*Zea mays* L)" both in English and Nagamese dialect sponsored by DMR New Delhi under TSP**.** A total of 50 maize farmers from Mon, Zunheboto, Phek, Wokha and Dimapur districts of Nagaland attended the training. Two SMS from KVK Zunheboto and NEPED also participated along with other farmers. Maize seeds (Hybrid and composite) and farm implements (weeder and maize sheller) were also distributed to the beneficiaries.

**Training cum field day on climate resilient agriculture organized at Kolasib**

Two days Farmer Field Day cum Training workshop on "Climate Resilient Technologies of Mizoram" under NICRA was held on 19-20th Feb., 2013 at ICAR-RC-NEH Region, Mizoram Centre. Sixty four progressive farmers including women and youths from 12 villages from Kolasib and Aizawl districts attended the training in presence of chief guest Mr. Lalduhawma, President, All Mizoram Farmer Union (AMFU). Soil water conservation measures, scientific cultivation of fruits

**Inaugural programme of the training on climate resilient agriculture**

and vegetables, scientific pig and poultry farming etc. were discussed. The farmers were exposed to various climate resilient technologies through practical/field demonstration of *rabi* crops developed by ICAR, Mizoram Centre.

## AWARDS AND RECOGNITIONS

During the period under report, the scientists of the Institute bagged a number of prestigious awards of ICAR and other Departments. To mentions a few are, outstanding Inter-disciplinary team research award, Swami Sahajanand Saraswati outstanding extension scientist award and Jawaharlal Nehru Young Scientist award of ICAR, young scientist award of societies etc. More than 10 scientists were trained abroad in various frontier areas of research under NAIP, DBT, SAARC programme, etc.


**Scientists with the Interdisciplinary team research award (NRM)**

# 2. RESEARCH ACHIEVEMENTS

## MEGHALAYA

### Weather (2012-13)

Various weather parameters, e.g. air temperature, soil temperature, relative humidity, wind speed, pan evaporation, rainfall, bright sunshine hrs, etc. were recorded daily at 06:22, 08:30 and 13:22 hr, respectively during the period April, 2012 to March, 2013 at Agro meteorological Observatory located at Umiam and the details have been given below:

**Air temperature**

The mean monthly maximum temperature varied from 29.2 °C (May) to 20.9 (January). May was the hottest month and temperature remained in between 26.8 to 33.0 °C. Maximum temperature recorded for a single day was highest (33.6 °C) on 3rd April and lowest (17.7 °C) on 11th January. The temperature gradually decreased from August to January, and then started increasing.

Mean monthly minimum temperature varied from 20.3 °C in the month of July to 4.6 °C in the month of January. Mean monthly minimum temperature started rising from April to July and then started declining till January. On daily basis, record of minimum temperature was highest (22.2 °C) on 16th July and lowest (0.2 °C) on 9th January. Fig 1 depicts the


**Fig 1 Monthly variation of mean maximum and minimum temperatures**

variation of monthly maximum and minimum temperature during 2012 (April)-2013 (March).

**Sunshine hour and cloud cover**

The mean sunshine hour on monthly basis at Umiam ranged from 3.4 hr/day in the month of June to 8.8 hr/day in the month of January during 2012-13. From June to September, daily bright sunshine remained below 5 hr/day. Mean monthly variation of sunshine and cloud cover has been shown in the fig 2.

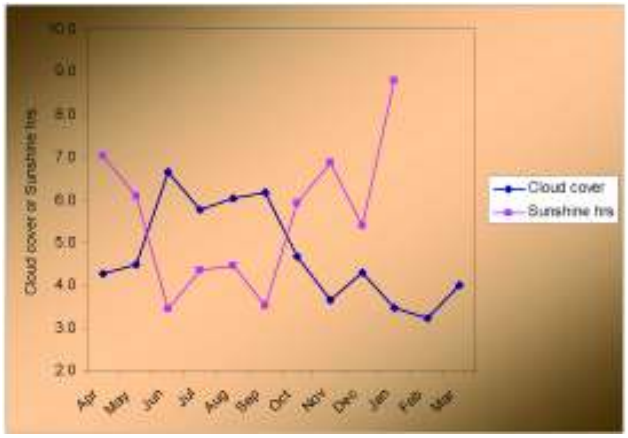



**Fig 2 Monthly variation of mean cloud cover and sunshine hours**

**Soil temperature**

During morning, soil temperature at 5 cm depth varied from 24.9 (July) to 11.5 °C (January), whereas at 10 cm depth it varied from 25.1 (July) to 13.2 °C (January). Soil temperature at 20 cm depth varied from 26.2 to 15.2 °C in the same months, respectively. During morning hours, mean monthly temperature of soil up to 20 cm depth was highest in the month of July and lowest was in the month of January.

During evening, soil temperature at 5 cm depth varied from 30.3 (July) to 23.5 °C (December), whereas at 10 cm depth it varied from 29.1 (July) to 21.6 °C (January). Soil temperature at 20 cm depth varied from 28.1 to 20.4 °C in the same months, respectively. Like the morning soil temperature, during evening hours also mean monthly temperature of soil up to 20 cm depth was highest in the month of July and lowest was in the month of January. The range of soil temperature is highest during morning and top 5 cm soils. Figures 3 and 4 depicts soil temperature variation during morning and evening, respectively.

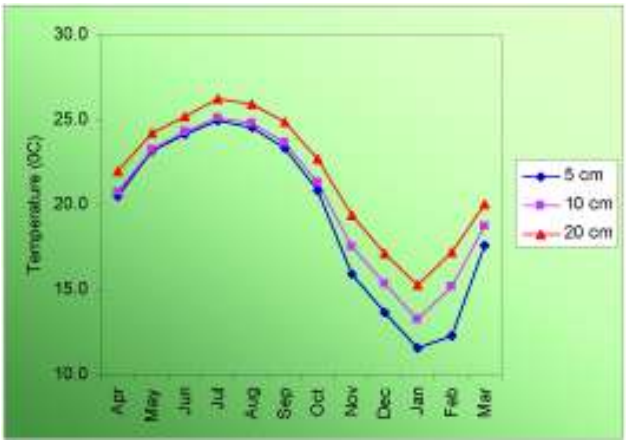



**Fig 3 Monthly variation of mean soil temperature during morning**

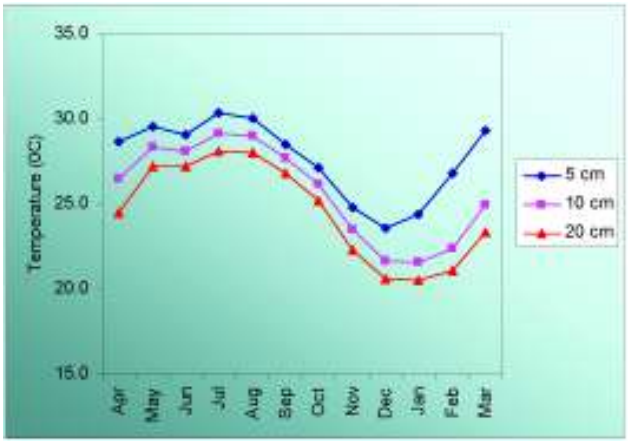



**Fig 4 Monthly variation of mean soil temperature during evening**

## Rainfall and rainy days

Total rainfall received during January to December 2012 at Umiam was 2087.2 mm distributed over 164 days (considering precipitation of more than 2.5mm). Yearly rainfall was 549.4 mm lees than during 2011, which was about 20% less than the normal annual rainfall. Rainfall occurred in 10 months baring February, March and December. The range of rainfall was 30 mm during November to 440 mm in the month of August. About 65% of the rainfall was received during monsoon season i.e. during June to September. Highest amount of rainfall in a single day was recorded on 11th May (87.2 mm). Month of August was the wettest during 2012 (Fig. 5).

## Evaporation

Total monthly evaporation was highest in the month of April (107.9 mm) and lowest (56.5 mm) in September (Fig. 5). Evaporation recorded in a single day was highest (7.4 mm) on 20th April and lowest (0.07 mm) on 15th July. From November to March evaporation exceeds rainfall indicating a period of water deficit. The deficit was highest during March with a deficit difference of -72.6 mm.

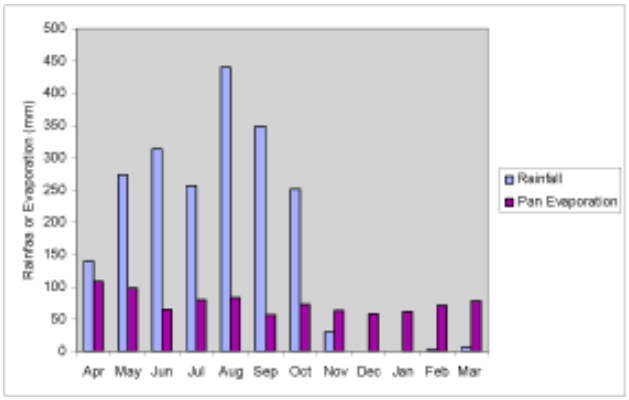



**Fig 5 Distribution of monthly total rainfall and evaporation**

## Relative humidity

Mean monthly relative humidity at Umiam was highest in the month of September (82.9 %) and the lowest in March (66 %). In general mean relative humidity remains high during monsoon months (above 80%) and then falls till February. Figure 6 depicts the variation of mean monthly relative humidity at Umiam.


**Fig 6 Variation of monthly mean relative humidity**

## Speed

Mean monthly wind speed ranged from 1.4 km/hr in the month of October to 4.7 km/h in the month of April. During the rainy season wind blew at a speed of average 2 km/h. 16th May 2012 was the day with highest mean wind speed of 10.6 km/h during 2012-13.

## CROP SCIENCES

### RICE

#### Upland

In the upland ecology, four station yield evaluation trials and three coordinated yield evaluation trials were conducted. In the station trials, RCPL 1-413, RCPL 1-103 and RCPL 1-82 showed significantly better performance than the leading variety Bhalum 3 (Table 1). In the various coordinated trials; VL 8608, RCPL 1-412, VL 8657, and HPR 2795 performed significantly better than local check Bhalum 1 and Bhalum 3.

**Table 1 Promising upland rice genotypes identified through yield evaluation trials**

| Coordinated trials | | Station trials | |
|---|---|---|---|
| **Genotype** | **Yield (t/ha)** | **Genotype** | **Yield (t/ha)** |
| VL 8608 | 3.15 | RCPL 1-413 | 3.43 |
| VL8657 | 2.81 | RCPL 1-103 | 3.20 |
| RCPL 1-412 | 2.95 | RCPL 1-82 | 3.17 |
| HPR 2795 | 2.31 | RCPL 1-128 | 2.97 |
| Bhalum 1 | 1.55 | Bhalum 3 | 2.64 |

#### Lowland

In the lowland ecology, eight yield evaluation trials were conducted with Megha SA2 and Shahsarang as check varieties. Table 2 lists the genotypes that performed better than checks. RCPL 1-300 and RCPL 1-466 were the leading genotypes showing significant yield advantage over the best check. Other genotypes were better than Megha SA2.

**Table 2 Promising lowland genotypes identified through yield evaluation trials**

| Genotype | Yield (t/ha) |
|---|---|
| RCPL 1-300 | 5.12 |
| RCPL 1-408 | 4.27 |
| RCPL 1-307 | 3.85 |
| RCPL 1-466 | 5.50 |
| STN 1-2 | 4.54 |
| STN 1-3 | 4.25 |
| STN 1-12 | 4.05 |
| STN 1-9 | 4.02 |
| IIRON 210 | 4.06 |
| Megha SA2 | 2.98 |
| Shasarang | 3.57 |
| CD (*P*=0.05) | 1.25 |

#### Screening and molecular analysis for aluminium toxicity tolerance

#### Root growth analysis

From a core set of 45 upland rice genotypes, tolerant and susceptible genotypes were identified on the basis of root tolerance index (RTI), shoot tolerance index (STI) and root/shoot ratio (R/S) upon exposure to 200µM aluminium chloride. Four highly tolerant and 4 considerably susceptible genotypes were identified. Tolerant genotypes were N861 (RTI=99.27%, STI=107.73%, R/S=0.31, control; 0.28, treatment) followed by Yimyu (RTI=99.21%, STI=118.44%, R/S=0.36, control; 0.34, treatment), Motodhan (RTI=97.16%, STI=86.97%, R/S=0.32, control; 0.38, treatment) and Vietnam-1 (RTI=91.89%, STI=86.44%, R/S=0.33, control; 0.49, treatment). Susceptible genotypes were Lespah (RTI=23.94%, STI=99.20%, R/S=0.39, control, 0.09 treatment), VL31329 (RTI=27.65%, STI=78.39%, R/S=0.39, control; 0.14, treatment), RCPL 1-13 (RTI=36.37%, STI=84.34%, R/S=0.36, control; 0.16, treatment), UPR 2919-14-1-1 (RTI=50%, STI=83.07%, R/S=0.40, control; 0.25, treatment). To further confirm the tolerant and susceptible nature of the genotypes, a panel of upland genotypes (Aaha, N861, Sanrifirri, Motodhan, Vietnam 1) and susceptible (RCPL 13, Lespah, VL 31329) were used for studying their root parameters upon exposure to aluminium stress. Seeds were germinated on a paper for four days and grown in hydroponic media in control (pH 7.0 without Al) and treated (pH 4.5 with Al) for seven days. Roots of seedlings were detached from seeds, and measurements were taken in a root scanner (Table 3).

To ascertain the mechanism of aluminium accumulation in the tolerant and susceptible genotypes, $AlCl_3$ exposed roots were stained with hematoxylin (Fig 1). It was observed that between the two highly


**Fig 1 Control and $AlCl_3$ treated root tips of three genotypes of rice. N861 shows absorption and retention of Al in root tips while Lespah shows severe damage of root tip upon exposure to Al. Yimyu shows absorption and transportation of Al away from root**

**Table 3 Root length, area and diameter of tolerant and susceptible genotypes (data presented an average of two independent experiment ± SD)**

| Genotypes | Root length (mm) | | Root area ($mm^2$) | | Root diameter (mm) | |
|---|---|---|---|---|---|---|
| | Control | Treatment | Control | Treatment | Control | Treatment |
| Aaha | 3527.85± 250.81 | 2255.45±284.33 | 1397.8±8.63 | 838.445±50.99 | 0.397455 | 0.387345 |
| N 861 | 1673.35±81.95 | 1382.45±66.11 | 758.08±46.84 | 603.125±25.70 | 0.43775 | 0.362835 |
| RCPL 1-13 | 3889.7±44.55 | 2335.8±190.21 | 1689.65±62.86 | 875.465±17.37 | 0.427385 | 0.36717 |
| Yimyu | 2834.05±125.65 | 2331.6±16.40 | 1140.115±132.11 | 879.07±3.30 | 0.367185 | 0.38219 |
| Lespah | 4479.7±166.31 | 3045.55±239.21 | 1668.4±42.85 | 1221±62.51 | 0.36593 | 0.417635 |
| Sanrifirri | 2753±29.84 | 1871.9±68.17 | 897.71±6.94 | 826.08±38.21 | 0.31956 | 0.318855 |
| Motodhan | 5125.05±201.60 | 3561.65±138.24 | 1686.49±52.17 | 1209.14±73.62 | 0.323255 | 0.37425 |
| Vietnam 1 | 3511.8±14.28 | 2539.15±11.81 | 1207.15±5.59 | 883.4±20.08 | 0.3555 | 0.36206 |
| VL 31329 | 3139.25±166.10 | 1872.8±112.10 | 1237.545±91.42 | 788.4±18.38 | 0.36254 | 0.394805 |

tolerant genotypes, N861 tolerated Al very likely by accumulating and restricting it to roots while Yimyu apparently has a mechanism of Al exclusion or transportation away from roots.

### AAS analysis

To track the movement of the absorbed Al in different parts of rice seedlings, two highly tolerant (N 861 and Yimyu) and susceptible (Lespah) genotypes were grown in control condition in hydroponics culture for 7-days and thereafter treated with 160 µM $AlCl_3$ for 3-days. Roots, leaves and stem were collected and analysed in an AAS700 (Lab India) atomic absorption spectrophotometer.

As evident from the aluminium concentration in different plant parts after exposure for a different time period (Fig 2), in N 861 (showing highest tolerance to Al) major part of the absorbed Al was retained in the root and after 24 hours, a part of it moved to stem. However, movement of absorbed Al to leaf was effectively stopped even after 24 hours.

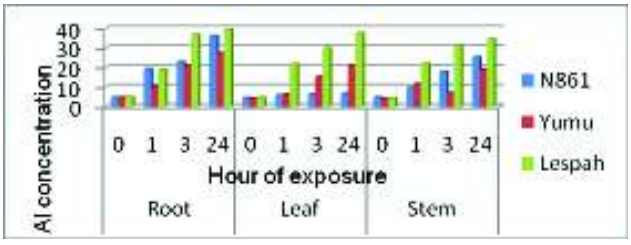



**Fig 2 Aluminium concentration (ppm on dry wt. basis) in different plant parts of three genotypes**

### Gene expression analysis

Expression analysis of ADH (alcohol dehydrogenase), GS (Glucan Synthase), GLP (Germin like proteins), tRNA (tRNA synthetase), OR (oxidoreductase), TCR (Two component response regulator like proteins), ATPase and MS (Malate synthase) genes were done. Three genotypes, i.e. N 861 and Yimyu (Al tolerant) and Lespah (Al sensitive) were taken for time course experiment of aluminium exposure (0 hr. to 24 hrs.). In the tolerant genotypes, there was a strong down regulation of GLP and strong up regulation of ADH genes (Fig 3). On the other hand, in the susceptible genotype, there was strong up regulation of GLP and moderate down regulation of GS and tRNA genes.

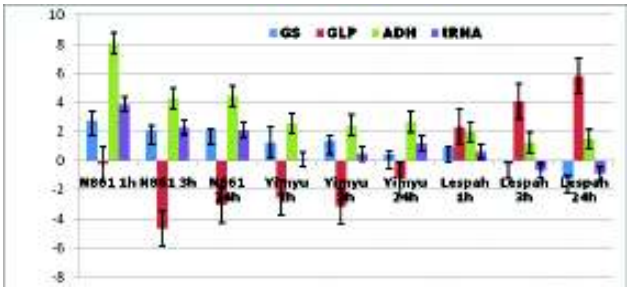



**Fig 3 Expression analysis of GS, GLP, ADH and tRNA**

### Screening for heat tolerance at reproductive stage

Exposure of the genotypes to 45˚C at early booting stage showed burning of leaf tips, yellowing of leaves, abnormal growth of panicle, stunted growth of panicle, chaffy grains, etc. symptoms (Fig 4) during recovery

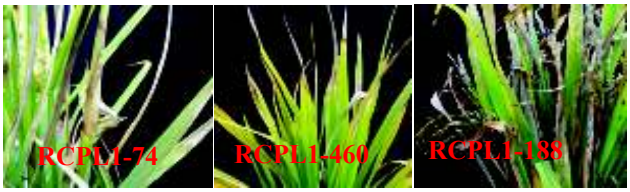



**Fig 4 Rice genotypes showing various abnormalities after exposure to elevated temperature (45°C) at booting stage**

and panicle emergence. Spikelet fertility was found as 29.19% (RCPL1-188), 21.33% (RCPL1-185), 18.41% (RCPL1-74), 10.42 (RCM 17), 9.19% (RCPL1-132), 8.92% (RCPL1-186).

**Phenomic evaluation for cold tolerance**

One hundred and fifty three genotypes selected from previous years' experiment were phenotyped at two locations. Chlorophyll content, RWC, cell membrane stability, pollen fertility, panicle weight, grain filling, seed weight, plant height and biomass were measured. Weather data were also collected from the actual site of the experiment from July, 2012 (start of active tillering). Spectrophotometric estimation showed significant reduction (except some cases) in chlorophyll content under stress condition. Three groups of genotypes were identified. First group showed very high reduction in stress – DR 92 (6.43 mg/g), second group showed non-significant reduction – Balakaun (0.28 mg/g) and the third group showed significant increase in stress – IRCTN-91-95 (1.87 mg/g). Genotypes were significantly different for relative water content (RWC) but there was no definite trend (stressed and unstressed). For cell membrane stability, genotypes were not significantly different. In general, genotypes flowered early (6-11 days) under non-stressed condition. However, genotype Nonglowai (cold tolerant), HR 3941-34 (cold susceptible) flowered 18 and 19 days early respectively under non-stressed condition. While genotypes Dullo-10A, Borkot, Miyang 93 (all tolerant) flowered 8 – 12 days early under stressed condition. There was no significant difference in the number of viable pollen grains between stressed and non-stressed locations probably because at flowering stage temperature difference was not significant (Fig 5). Among the traditional cold tolerant lines, some lines showed increased pollen fertility under non-stressed condition e.g. Newli while some other genotypes showed increased pollen fertility in the stressed condition e.g. Nonglowai. Panicle weight was significantly reduced under stress condition. Panicle weight reduction was highest in IRCTN-91-57 (10.12 g) followed by Kuki (9.82g), Niver (8.24g) and HR-3941-34 (7.98g). Panicle weight reduction was lowest in IRCTN-91-96 (0.25g) followed by Gurrah (0.38g) and RCPL1-5C (0.89g). It is interesting to note that the genotypes that showed a reduction in panicle weight also showed sensitivity to low temperature (1-9 scale) at seedling stage. All genotypes showed spikelet fertility reduction under stress. Fertility reduction ranged from 4 per cent to complete sterility. In the genotype Kuban 3, spikelet fertility increased under low-temperature condition. Most of the genotypes also showed significant reduction in 100 seed weight. Highest reduction was recorded in the genotype Kuki (0.94 g) followed by IRCTN-91-57 (0.87 g), Niver (0.76 g). Lowest reduction was seen in IRCTN-91-96 (0.015 g) and RCPL 1-5C (0.02 g). One of the genotypes, Kuban 3, showed an increase in seed weight (2.0 g) under low-temperature condition. Correlation studies among various post flowering characters (Table 4) indicated that cell membrane stability (CMS), panicle weight and seed weight are most important characters to be considered for phenotyping.

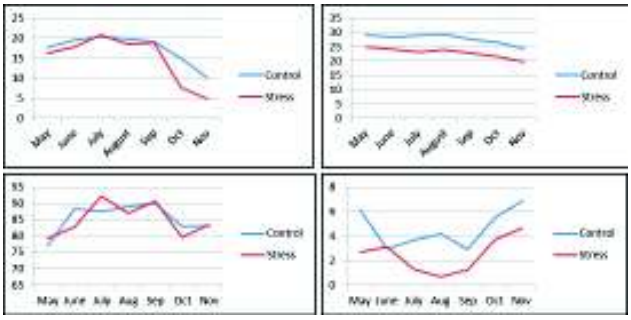



**Fig 5 (Top left to bottom right) minimum temperature, maximum temperature, relative humidity and bright sun shine hour at the experimental plot (Upper Shillong)**

**Table 4 Correlation among various post flowering characters recorded from 153 genotypes**

| Variables | Pollen fertility | Panicle weight | Seed weight | Chlorophyll content | CMS | Biomass | Relative water content |
|---|---|---|---|---|---|---|---|
| 50% flowering | -0.039 | 0.074 | 0.278 | -0.101 | 0.185 | 0.024 | -0.086 |
| Pollen fertility | 1 | 0.056 | 0.022 | -0.072 | 0.032 | 0.027 | 0.108 |
| Panicle weight | 0.056 | 1 | 0.506* | -0.444* | 0.356* | -0.706* | -0.094 |
| Seed weight | 0.022 | 0.506* | 1 | -0.075 | 0.552* | -0.557* | 0.229 |
| Chlorophyll content | -0.072 | -0.444* | -0.075 | 1 | -0.192 | 0.456* | 0.029 |
| CMS | 0.032 | 0.356* | 0.552* | -0.192 | 1 | -0.493* | 0.138 |
| Biomass | 0.027 | -0.706* | -0.557* | 0.456* | -0.493 | 1 | -0.089 |

## INSECT PESTS

### Varietal screening

Out of five paddy varieties screened against major insect-pests of rice, Manipuri Red recorded the lowest yellow stem borer (*Scirpophaga incertulas*) infestation (0.83%) and rice root aphids (*Tetraneura nigriabdominalis*) damage (6.03 nos./hill).

### Evaluation of pesticides

Out of three paddy seed treatments, imidacloprid 17.8% SL @ 3 ml/kg recorded the lowest number of root aphids (*Tetraneura nigriabdominalis*) (0.98/hill) and rice leaf folder (*Cnaphalocrosis medinalis*) damage (0.26%). Spraying of imidacloprid 17.8% SL @ 0.5 ml/l at 30 days after transplanting of rice was found to be effective against stem borer (0.60% dead heart). Amongst biopesticides, neem @ 2 ml/l recorded the lowest yellow stem borer infestation (1.94%) and rice root aphids damage (2.21 nos/hill). However, spraying of karanjin @ 2 ml/l was found effective against rice leaf folder infestation (0.52%).

## DISEASES

Under AICRIP, 984 entries were screened against rice blast in uniform blast nursery pattern and 72 two entries were found to be resistant (Table 5).

**Table 5 Screening for rice blast**

| Screening trial | No. of entries | Resistant entries |
|---|---|---|
| NSN 1 | 154 | 8 |
| NSN 2 | 599 | 21 |
| NSNH | 64 | 10 |
| NHSN | 100 | 19 |
| DSN | 67 | 14 |
| **Total** | **984** | **72** |

## MAIZE

### Varietal evaluation

Eight coordinated trails and one trial each in germplasm evaluation, composite evaluation were conducted. Among all the lines, yield performance of DMR 306, DMR 329 and DMR 331 was the highest (cob weight 9.0 t/ha). Among the extra early lines, Vivek Maize Hybrid 25 was the highest yielder (Table 1).

**Table 1 Performance of promising maize genotypes identified in yield evaluation trials**

| Group | Genotype | Cob yield (t/ha) | Days to 50% silking |
|---|---|---|---|
| Hybrid extra early | Vivek maize Hybrid 43 | 7.82 | 53 |
| | Vivek Maize Hybrid 25 | 7.95 | 58 |
| Hybrid medium duration | CMH 08-337 | 8.47 | 65 |
| | CMH 08-156 | 8.56 | 65 |
| QPM Hybrids | QPM 106,117 | 8.1 | 85 |
| | QPM 103 | 7.7 | 83 |
| | QPM 109 | 6.62 | 85 |
| | RCM 76 | 4.8 | 63 |
| Trial No. 102 | ZR 217 | 8.5 | 66 |
| | ZR 202 | 8.2 | 69 |
| | ZR 208 | 7.7 | 65 |
| | RCM 76 | 4.8 | 63 |
| Trial No. 63 | DMR 306 | 9.0 | 59 |
| | DMR 329 | 9.0 | 66 |
| | DMR 331 | 9.0 | 59 |
| | DMR 315 | 8.9 | 65 |
| | DMR 319 | 8.5 | 66 |
| | DMR 328 | 8.0 | 66 |
| Trial No. 64 | DMR 418 | 7.7 | 61 |
| | DMR 401 | 6.8 | 65 |
| | DMR 416 | 6.28 | 61 |
| Trial No.61 | DMR 117 | 7.0 | 68 |
| | DMR 116 | 6.1 | 67 |
| | DMR 136 | 6.0 | 67 |

### Identification of heat tolerant maize genotypes

### Determination of critical temperature for screening at seedling stage

Seedlings of RCM 1-1 were subjected to different temperatures (33, 36, 39, 42 and 45 °C) for 2, 4, 6 and 8 hours without prior induction and were allowed to recover at the normal temperatures (25 °C). Survival percentage of seedlings decreased with the increase in temperature above 39 °C. Highest mortality of seedlings was recorded at 45 °C, and this temperature was selected for further screening. Ten-day old seedlings of 132 genotypes (composites) were subjected to heat treatments at 42 to 45 °C continuously for eight hours and then allowed to recover at 25 °C for 72 hours. Sixteen genotypes, listed below, showed more than 50% seedling recovery. However, no genotype survived beyond 45 °C. Genotypes that showed tolerance are; RCMGP 20, RCMGP 29, RCMGP 39, RCMGP 40, RCMGP 47, RCMGP 55, RCMGP 63, RCMGP 75, RCMGP 77, RCMGP 104,

RCMGP 105, RCMGP 119, RCMGP 122, RCMGP 125, RCMGP 121, RCMGP 124, RCMGP 127, RCMGP 128, RCMGP 129 and RCMGP 131.

Pollen grains of 16 selected genotypes were exposed to 35 °C, 38 °C, 40 °C, 42 °C and control (25 °C) temperatures under high-humidity (100%) as low-humidity condition (40-45% humidity).Higher temperature induced various deformities in the grain, including desiccation, bursting and abnormal pollen tube growth (Fig 1). Three genotypes i.e. RCMGP 63, RCMGP 105 and RCMGP 47 were found to be heat tolerant at 42 °C under both low and high humidity. Pollen tube growth for a longer duration (20 hrs) was observed under high-humidity than low-humidity (5 hrs). Interestingly, when pollen grains of maize genotype RCMGP 122 were exposed to 35 °C; their germination was higher in comparison to the normal temperature of 25 °C (Fig 2).


**Fig 1 Pollen desiccation (A), pollen bursting (B) and abnormal pollen tube growth (C) in maize pollen upon exposure to elevated temperature**

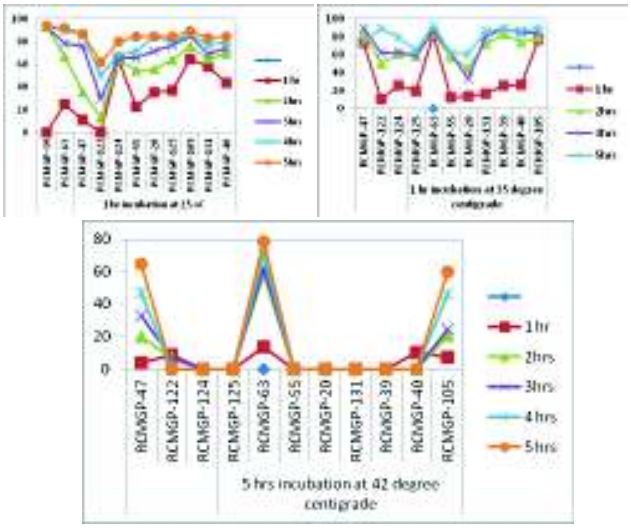



**Fig 2 Effect of temperature on pollen germination of different genotypes**

A comparative nutritional quality analysis of 10 maize genotypes, found to be heat tolerant at seedling stage, was also carried out. Seed samples were taken from the field grown plants at Umiam. Genotype RCMGP 125 showed higher fat content (5.85% of dry weight) as compared to other genotypes. Similarly, crude protein content of RCMGP 105 was highest (11.08% of dry weight).

**Development of quality protein maize (QPM) through marker aided selection (MAS)**

One hundred eighty five $BC_2F_3$ and 150 $BC_2F_4$ plants were grown for evaluation using foreground and background selection. Some agronomic selection was also exercised. Foreground selection using *umc*1066 identified 185 plants, which were homozygous for *opaque 2*. Several lines showed abnormality, disease susceptibility, etc. and were rejected. All $BC_2F_4$ plants were homozygous for *opaque 2*. Through agronomic evaluation at the green cob stage, 52 $BC_2F_4$ individuals were selected. All these individuals were selfed and used for background analysis using 115 SSR markers spread over all the chromosomes (selected from the panel of Sigma M4193). Harvested cobs were characterized for ear characters (Fig 3) and grains were screened for opaqueness (Fig 4) using light box test. Recurrent parent genome recovery ranged from 90-94% (Table 2).

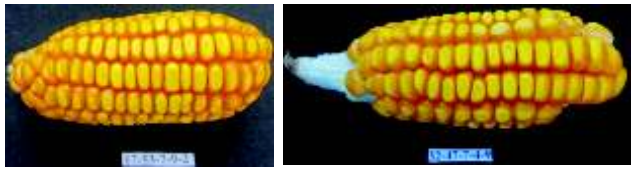


**Fig 3 Ear characters of some selected individuals**

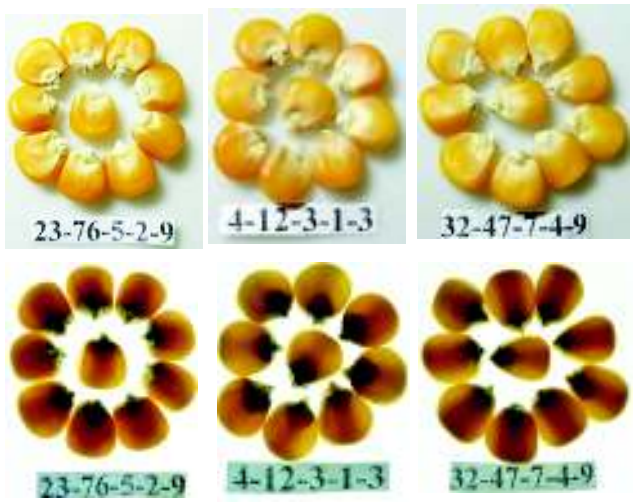



**Fig 4 Screening of grains for opaqueness**

**Table 2 Recovery of recurrent parent genome in some selected lines**

| Line No. | Recovery of RP genome (%) | Line No. | Recovery of RP genome (%) |
|---|---|---|---|
| 2-13 | 90.10 | 1-3 | 94.00 |
| 9-2 | 94.30 | 4-9 | 92.80 |
| 10-1 | 92.45 | 2-7 | 94.30 |
| 4-7 | 91.33 | 2-9 | 93.25 |
| 5-1 | 91.90 | 9-2 | 94.30 |

## DISEASES

### AICMIP: Trap nursery

Twelve genotypes were evaluated for naturally occurring diseases in 1-5 (TLB, MLB) and 1-9 (Common rust) rating scale under trap nursery trial from AICMIP, DMR, New Delhi. In the trial, only one genotype i.e. CM 123 did not receive turcicum leaf blight and maydis leaf blight. The remaining eleven genotypes (CM 117-4, LM 16, CM 119, CM 118, BML 5, CM 121, CM 139, CM 130, CM 123, CM 142, CM 116, CM 202) received all the three diseases.

### Screening for *Turcicum* leaf blight resistance

Five (Early Maturity, Extra Early Maturity, Medium Maturity, Late Maturity, Specialty Corn) screening trials were conducted in row system with two replications. Altogether, 231 genotypes were screened for resistance/susceptibility against Turcicum leaf blight. Of these genotypes, 5 were resistant, 98 moderately resistant, 102 moderately susceptible, 25 susceptible and 1 highly susceptible to turcicum leaf blight of maize under Umiam conditions.

## INSECT PESTS

### Indigenous botanicals against maize weevil

Eight indigenous botanicals leaf powders viz., neem, lantana, nishinda, datura, papaya, eupatorium, tulsi and ageratum @ 5g/100g maize seed were tested against maize weevil (*Sitophilus zeamais*) as grain protectants. Treatment with lantana leaf powder recorded the lowest seed damage (4.4%) and grain weight loss (0.87%).

## PULSES

## LENTIL

### Introduction of varieties

Four new lentil varieties were tested during *rabi* 2012-13. Moitree and PL 6 were early maturing while NDL 1 and PL 8 were full season varieties. Yield obtained at Umiam is presented in Table 1.

**Table 1 performance of lentil varieties**

| Full season | | Early | |
|---|---|---|---|
| Variety | Yield (t/ha) | Variety | Yield (t/ha) |
| NDL 1 | 1.11 | Moitree | 0.92 |
| PL 8 | 1.25 | PL-6 | 0.89 |

## PEA

## INSECT PESTS

### Eco-friendly management of major insect pests

Stem fly, *Melanagromyza phaseoli,* leaf miner, *Phytomyza horticola* and aphid, *Acyrthosiphon pisum* were found major pests of pea. Seed treatment with Imidachloprid (Gaucho) @ 3ml/kg of seed, single spray of Acetamprid (Trend) @ 0.1 % and fixing yellow sticky traps @ 1 trap/100m$^2$ provided excellent control of these major pests and significantly increased the yield over control

## OILSEEDS

## INSECT PESTS

### Natural enemy complex of major pest of oilseeds and their interactions in Meghalaya

Parasitoids, *Cotesia* spp. (Fig 1), *Diaeretiella rapae*, *Brachymerialasus*, *Ascogaste* spp. and predators, *Cocinella septumpunctata, C. transversalis* (Fig 2), *Coelophora saucia* (Fig 3), *Oenopyia* Kirby, *Oenopyia sexarata, Hormonia* species are commonly seen in soybean and groundnut. Besides, four types of spiders *viz.*, Jumping spiders (*Marpissa calcuttaensis* and *Phidippus* spp), Lynx spiders (*Argiope pulchella* and *Oxyopes rubisternum*), Wolf spiders (*Lycosa pseudoannulata*) and Orb spinners (*Leuchge decorate*, *Lariniatabia* and *Cyrtophora carrisae*) were also found

**Fig 1 *Cotesia* spp. emerging from leaf folder larva**

**Fig 2 *Coccinella transversalis***

**Fig 3 *Coelophora saucia***

throughout the season. In mustard, maximum population of aphid parasitoid, *Diaretiella rapae* and predator, *C. septumpunctata*, was found during December to March and January, respectively. Fascinatingly, population of all these natural enemies was positively correlated to their respective host population.

**Rapid technique of sex differentiation in immature stage of parasitoid wasp, *Hyposoter ebeninus* Gravenhorst**

Male biased sex ratio is the major problem in mass rearing of many bio-agents including dominant larval parasitoid of cabbage butterflies, *Hyposoter ebeninus* Gravenhorst (Ichneumonidae: Hymenoptera). Cultures of the parasitoids in pupal (cocoon) stage (Fig 4) are generally delivered to different locations for field releases where it is difficult to maintain the appropriate sex ratio (Fig 5). Insufficient female parasitoids within released population are one of the limitations in the success of effective biological control programme. Therefore, by using different combinations of physical cocoon parameters, the technique was developed to recognize sexes in immature stage of parasitoid wasp, *H. ebeninus*. If coccon weight (W)>0.02; then it certainly yield female. This technique is simple, robust and will require minimum technical knowledge with more than 90 per cent accuracy.

**Fig 4 *H. ebeninus* cocoons**

**Fig 5 *H. ebeninus* female (left) and male (right)**

## SOYBEAN

## DISEASES

**Survey and surveillance of soybean diseases**

*Sclerotium rolfsii* collar rot was recorded in low intensity (0.85-2.92 %). Frog eye leaf spot (*Cercospora sojina*) was also present in very low intensity in Plant breeding and Pathology trials. Purple seed stain (*C. kikuchii*) was also noted in harvested grains. Yellow mosaic virus (YMY) was recorded in varying degree (5-100% plant infected). Rust (*Phakopsora pachyrhizi*) severity i.e. per cent disease index (PDI) ranged 17.44-80.77. YMY infected genotypes showed less rust disease severity. Rhizoctonia aerial blight was observed ranging from 5-30%. Pod blight (*Colletotrichum truncatum*) was present in varying degree (PDI 0.7 - 46.66). In all seven diseases were recorded in and around Umiam farm area.

**Reaction of newly developed AICRP soybean genotypes to rust disease**

Total 37 test entries were tested in field for rust resistance under initial varietal trial (IVT). Bragg and JS 335 were check varieties, which showed highly susceptible (PDI 80.77)) and susceptible (PDI 64.44) respectively. None of the entries were absolutely resistant and highly resistant. Four entries i.e. KDS 705 (PDI 17.44), RSC 01-05 (PDI 32.22), KDS 693 (PDI 18.15) and KDS 708 (PDI 18.55) were moderately resistant. Among the remaining test entries 13 were moderately susceptible, 16 susceptible and 6 highly susceptible.

**Assessment of yield losses and identification of tolerant genotypes to consortium of diseases**

Eight test genotypes (Sl. nos. 1-8) and check var. JS 335 in AVT 1 and 16 genotypes (Sl. nos. 1-26) and check vars. Bragg and JS 95-5 in AVT 2 (Table 1) were grown under fungicide protected and unprotected conditions and yield losses were estimated. Yield losses ranged from 2.4 to 72.9% in AVT 1 and 6 to 54.9% in AVT 2. Based on yield potential and loss, genotypes JS 20-41 (1073 kg/ha) and MAUS 504 (1119 kg/ha) were identified as high yielding resistant (RHY) genotypes in AVT 1. In AVT 2 genotypes, AMS-MB-5-19 (2288 kg/ha), DSb16 (2623kg/ha) and PS1477 (2357 kg/ha) were categorized as RHY. None of the genotypes were found tolerant in AVT 1. DS 2708 was resistant low yielding (RHY). Nine genotypes were susceptible high yielding tolerant (SHYT) and 13 susceptible low yielding (SLY).

**Management of soybean rust through nutrients and fungicide application**

Five sub plot treatments *viz*., 1) foliar spray application of 2% $KNO_3$, 2) 1% $MgSO_4$, 3) 1% micronutrient, 4) 1% raw *neem* oil and 5) soil application of recommended doses of fertilizer (40:60:40 NPK) were tested under fungicide protected and unprotected conditions (main plot) in a split plot

**Table 1 Reactions of soybean genotypes in AVT 1 and AVT 2 to consortium of diseases, yields and losses**

| Sl.no | Genotypes | Rust (PDI) | Pod blight (PDI) | RAB (% plant infected) | YMV (% plant infected) | Yield (kg/ha) | Yield loss (%) | Category |
|---|---|---|---|---|---|---|---|---|
| 1 | AMS 59 | 61.88 | 0 | 30 | 25 | 333 | 31.7 | SLY |
| 2 | DS 2706 | 82.99 | 0 | 0 | 2 | 681 | 32.4 | SLY |
| 3 | DS 2708 | 90.32 | 0.37 | 0 | 2 | 689 | 14.2 | RLY |
| 4 | DSb 19 | 37.00 | 0.37 | 0 | 20 | 684 | 32.5 | SLY |
| 5 | JS 20-41 | 44.11 | 0 | 5 | 5 | 1079 | 2.4 | RHY |
| 6 | KDS 701 | 14.14 | 0 | 0 | 3.5 | 608 | 50.0 | SLY |
| 7 | MAUS 504 | 50.00 | 0.37 | 0 | 50 | 1119 | 15.0 | RHY |
| 8 | PS 1499 | 5.00 | 0 | 20 | 5 | 316 | 72.9 | SLY |
| 9 | JS 335 | 7.50 | 1.1 | 5 | 7.50 | 315 | 28.4 | SLY |
| 10 | AMS 243 | 68.33 | 0 | 0 | 0 | 1960 | 19.29 | SLY |
| 11 | AMS-MB-5- | 77.05 | 0 | 0 | 0 | 1923 | 30.40 | SLY |
| 12 | AMS-MB-5-19 | 72.05 | 0 | 0 | 0 | 2288 | 5.96 | RHY |
| 13 | BAUS 40 | 81.10 | 0 | 0 | 0 | 1575 | 52.99 | SLY |
| 14 | DS 12-5 | 77.94 | 0.37 | 0 | 0 | 1290 | 24.92 | SLY |
| 15 | DSb 16 | 55.55 | 0 | 0 | 0 | 2623 | 8.17 | RHY |
| 16 | Dsb 18 | 45.94 | 1.11 | 0 | 20 | 2262 | 17.86 | SHY(T) |
| 17 | JS 20-29 | 86.11 | 1.11 | 0 | 0 | 2022 | 27.67 | SHY(T) |
| 18 | KBS 8 | 83.88 | 0 | 0 | 0 | 2040 | 29.74 | SHY(T) |
| 19 | MACS 1311 | 82.61 | 1.11 | 0 | 0 | 1977 | 24.41 | SHY(T) |
| 20 | MACS 1336 | 58.16 | 0 | 0 | 0 | 2008 | 27.84 | SHY(T) |
| 21 | PS 1476 | 60.33 | 0 | 0 | 0 | 2562 | 20.53 | SHY(T) |
| 22 | PS 1477 | 67.16 | 1.48 | 0 | 0 | 2357 | 6.17 | RHY |
| 23 | RK S63 | 74.10 | 0 | 0 | 0 | 1818 | 27.41 | SLY |
| 24 | SL 778 | 80.88 | 12.59 | 0 | 0 | 1672 | 30.01 | SLY |
| 25 | SL 871 | 78.99 | 2.22 | 10 | 0 | 1842 | 37.07 | SLY |
| 26 | VLS 76 | 82.24 | 0 | 2 | 0 | 2008 | 19.69 | SHY(T) |
| 27 | Bragg (check) | 71.11 | | 0 | 10 | 1997 | 37.38 | SHY(T) |
| 28 | JS 93-5 (check) | 84.77 | 0 | 0 | 0 | 2033 | 16.89 | SHY(T) |

design under field condition. Yields were higher in fungicide protected treatments compared to unprotected treatments. Neem oil spray recorded the highest B:C under both protected (4.77) and unprotected (5.44) conditions. Rust disease was low i.e. 21-23 in protected and 34-39 PDIs in unprotected treatments without any significant difference. Economics of various treatments is presented in table 2

**Table 2 Economics of various treatments used for management of soybean rust**

| Treatments protected | Grain yield (kg/ha) | Selling price @ '12/=kg (A) | Cost of two fungicide sprays ' | Cost of treatments | Total cost* ' (B) | Profit './ha (A-B) | B:C |
|---|---|---|---|---|---|---|---|
| 1 | 1597 | 19164 | 1398 | 16218 | 17616 | 1548 | 0.09 |
| 2 | 1153 | 13836 | 1398 | 8018 | 9416 | 4420 | 0.48 |
| 3 | 1540 | 18480 | 1398 | 7618 | 9096 | 9464 | 1.05 |
| 4 | 1546 | 18552 | 1398 | 1818 | 3216 | 15336 | 4.77 |
| 5 | 1613 | 19356 | 1398 | 4640 | 6038 | 13318 | 2.21 |
| Treatments unprotected | | | | | | | |
| 1 | 744 | 8928 | 0 | 16218 | 16218 | -7290 | - |
| 2 | 789 | 9468 | 0 | 8018 | 8018 | 1450 | 0.18 |
| 3 | 1122 | 13464 | 0 | 7618 | 7618 | 5846 | 0.77 |
| 4 | 977 | 11724 | 0 | 1818 | 1818 | 9906 | 5.45 |
| 5 | 1461 | 17532 | 0 | 4640 | 4640 | 12892 | 2.78 |

*Excluding cost of cultivation; Cost of hexaconazole Rs. 640/= /L; *Neem* oil Rs. 402/= /L; Micronutrient Rs. 328/=/L Sticker Rs. 450/= /L; Magnesium sulphate Rs. 350/= /kg; Potassium .nitrate Rs. 380/=/kg

## INSECT PESTS

### Eco-friendly management of birds' menace in soybean

Wild pigeon (*Columbia livia*) (Fig 6) is a major grainivorus bird, often cause damage to the germinating soybean seeds. They cut the young seedlings from the base (Fig 7) and therefore directly affect the plant population in field. Different locally available farm byproducts were exploited for temporary covering of germinating seeds**.** Among all, rice straw cover along with bird scarring ribbons was found to be most superior for preventing bird (wild pigeon) damage followed by maize cover with scarring ribbons and scaring ribbons alone. It reduced 83%, 76% and 17.22% seeding damage, respectively as compared to open field. It is cheaper, safest and farmer-friendly technique for small and marginal farmers.

**Fig 6 *Columbia livia***

**Fig 7 Damaged seedlings**

### Bio-rational management of leaf folder, stem fly and blister beetles of soybean

Leaf folder, stem fly, leaf beetle and blister beetles were found major pests of soybean. Besides, moderate incidence of leaf eating caterpillar, *Spodoptera litura* was also observed. Seed treatment of Confidor 17.8 SL @ 2ml/kg of seeds was found to be very effective against stem flies, where only 2.67% damage was recorded. BIPM package having seed treatment of Imidacloprid (Gaucho) @ 2ml/kg of seeds and two alternate sprays of N.S.K.E 5% crude extract and *Beaveria bassiana* 1x10$^9$cfu/ml @ 6ml/litre of water at 15 days interval was found to be most effective against all major pests and significantly increase the yield of soybean over control.

## GROUNDNUT

## INSECT PEST

### Eco-friendly management of major insect pests of groundnut

Blister beetle, *Mylabris pustulata,* white grub, *Holotrichia serrata* and leaf beetle*, Monoleptasignata* were recorded as a major pests during this season. Seed treatment of imidacloprid (Gaucho) @ 3ml/kg of seeds and two sprays of N.S.K.E. 5% along with myco-insecticide, *B. bassiana* 1x10$^9$cfu/ml @ 6ml/l provided excellent control of white grubs, blister beetles and leaf beetles and significantly enhanced the yield over control.

## MUSTARD

## INSECT PEST

### Farmer- friendly management of mustard aphid and cabbage butterfly

Different eco-friendly management modules were evaluated against mustard aphid, *Liphaphis erysimi*. Brassica ecosystems of Meghalaya are reasonably prosperous in terms of natural enemies, where more than 60% natural parasitism/predation occurs. Considering this facts in mind, eco-friendly module consisting of inundative release of predator, *Coccinella septumpunctata* @ 200/acre + parasitoid, *Diaeretiella rapae* @ 500 mummified aphids/acre + single spray of 2% sugar solution before flowering stage + improvised yellow sticky traps @1trap/100m$^2$ was found most effective against aphids; it increased 87% yield over control. Another module consisting of alternate spray of Neem oil @ 2ml/l and Confidor 17.8SL @ 2ml/litre of water two times just before flowering was also effective against aphids; however it was harmful to the bio-agents and pollinators visit during flowering stage.

## FRUITS

## CITRUS

### Performance of tissue cultured and grafted plants of *khasi* mandarin

Tissue cultured and grafted plants of *khasi* mandarin (Rootstocks viz., *Citrus volkamariana, C. latipes, C. taiwanica, C. reshni and C. jambhiri*) of nine years old were evaluated for plant growth, yield and fruit quality attributes. Tissue cultured plants recorded the highest plant height (342.5 cm), stem diameter (91.68 mm), plant canopy spread (140.0x140.0 cm) and least fruit yield/plant (97 Nos.). Among the rootstock, *C. reshni* was found to be vigorous in plant height (316.0 cm), rootstock diameter (88.62 mm), scion diameter (75.0 mm), plant canopy spread (130.0x133.0 cm) and fruit yield (199 Nos.). Physico-chemical attributes of *khasi* mandarin fruits revealed that the highest fruit weight (106.09 g), fruit length (55.35 mm), fruit

diameter (59.55 mm) ,TSS (10.85%) and least number of seed/fruit (16.13 Nos.) were recorded in tissue cultured plant. Among the rootstocks, the highest TSS (9.60%), â carotene (4.32 mg/100 g) and lowest acidity (0.60%) were observed in *C. reshni* rootstock whereas, the highest juice content (46.88 ml) and lowest peel thickness (2.45 mm) were noticed in *C. latipes and C. taiwanica* rootstock, respectively.

**Performance of nucellar and grafted plants of *khasi* mandarin**

Nucellar and grafted plants of *khasi* mandarin (Rootstocks viz*., Dancy Tanzelo* and *C. grandis)* of five and half years old were evaluated for their growth and yield performance. The highest plant height (360.0 cm), rootstock diameter (125.0 mm), scion diameter (109.44 mm) and plant canopy spread (135.0x140.0 cm) were recorded in *C. grandis* rootstock. *Khasi* mandarin grafted on *Dancy Tanzelo* rootstock produced the highest fruit yield (72 Nos.) and dwarfing plant growth habit as compared to nucellar seedling and *C. grandis* rootstock. Physico-chemical attributes of *khasi* mandarin fruits revealed that fruit weight (109.04 g), fruit diameter (61.36 mm) and â carotene content (6.02 mg/100 g) were found to be highest in nucellar plants while, least number of seed (17.43 Nos.), peel thickness (2.92 mm) and highest juice (42.14 ml) and TSS content (8.70%) was observed in *C. grandis* rootstock.

Similarly performance of nucellar and grafted plants of *khasi* mandarin (Rootstocks viz*., Citrus volkamariana, C. jambhiri, C. latipes,* Rangpur lime*, DancyTanzelo* and *C. grandis*) of four and half years old were also studied. The highest plant height (303.0 cm), scion diameter (74.71 mm) and fruit yield (53.0 Nos.) were recorded in *C. jambhiri* rootstock while, *C. volkamariana* rootstock recorded the highest stock diameter (89.02 mm). However, highest canopy spread was observed in Rangpur lime and *C. grandis* rootstocks in East-West (151.0 cm) and North-South (250.0 cm) direction, respectively. Physico-chemical study of *khasi* mandarin fruits revealed that the highest fruit weight (108.52 g), fruit length (57.09 mm) and fruit diameter (61.45 mm) were observed in *C. jambhiri* rootstock. The highest juice content (42.67 ml) and TSS (8.10%) was noticed in *Dancy Tanzelo* rootstock. The least number of seed/fruit (12.72) and acidity content (0.53%) was recorded in Rangpur lime rootstock and highest β carotene content (6.02 mg/ 100 g) in *C. grandis* rootstock.

**Performance of *khasi* mandarin grafted on four rootstocks for growth, yield and fruit quality**

*Khasi* mandarin grafted on four rootstocks viz*., C. jambhiri,* Rangpur lime, *C. latipes* and *C. grandis* of three and half years old was evaluated for their growth, yield and quality attributes. Rangpur lime rootstock exhibited the vigorous growth for plant height (277.0 cm), stock diameter (74.46 mm), scion diameter (64.34 mm) and canopy spread (134x119 cm) as compared to other rootstocks. Fruiting was noticed among all the rootstocks except *C. grandis*. However, highest fruit yield (92 Nos.) was noticed in Rangpur lime rootstock. Physico-chemical study of *C. jambhiri* and Rangpur lime rootstocks revealed that the highest fruit weight (124.09 g), fruit length (56.0 mm), fruit diameter (63.25 mm), juice content (45.67 ml), TSS (8.30%) and lowest acidity (0.68%) were observed in Rangpur lime rootstocks while; least peel thickness (3.21 mm) was noticed in *C. jambhiri* rootstock.

**Intercropping with *khasi* mandarin**

Five crops *viz.,* French bean, ground nut (ICGS-76), soybean (JS-335), rice bean (RCRB-1-6) and urd bean (T-9) were grown as intercrops during *kharif* season in seven years old *khasi* mandarin orchard. French bean produced the highest yield (3.55 ha, green pod) followed by ground nut (2.08 ha), soybean (0.85 ha), urd bean (0.55 ha) and rice bean (0.52 ha).

**Effect of mulching on plant growth, fruit yield and quality of *khasi* mandarin**

An experiment on mulching viz., black polythene, pine tree leaves, farm grass, leaves of rice bean, *Flemingia macrophylla*, *Crotolaria tetragona* and *Tephrosia candida* along with control (without mulch) was executed on eight years old *khasi* mandarin. The leaves and grass were applied @ 2 kg/m$^2$ twice in a year *i.e.* July and November. The highest plant height (301.0 cm), stem diameter (82.52 mm), plant canopy spread (155.0x142.5 cm) and fruit yield (89.6 nos.) were recorded in *C. tetragona* mulch. Whereas, yield and weed density was found to be lowest in black polythene mulch (39 Nos. & 1.10 kg/m$^2$, respectively) followed by pine leaves (1.48 kg/m$^2$) and highest in control (3.50 kg/m$^2$). Similarly, physico-chemical study of fruits revealed that the highest fruit weight (115.27 g) fruit length (55.22 mm), fruit diameter (62.60 mm), juice content (42.0 ml), TSS (8.60%) and least acidity content (0.77%) were recorded in *C. tetragona* mulch.

The lowest peel thickness (2.20 mm) and seed/fruit were noticed in control (without mulch).

## INSECT PESTS

### Mechanical control of citrus trunk borer

Hammering on the oviposition and larval infestation site (Fig 1) was most effective amongst all mechanical control methods against citrus trunk borer (*Pseudonemorphus versteegi*) which recorded the lowest number of grubs (0.33 nos/plant) and adults (0.33 nos/plant) emerged. Insertion of iron wires into the larval tunnels resulted in lower number of adult emergence holes. Blocking oviposition sites and holes with mud also significantly reduced adult emergence holes/plants as compared with control.

**Fig 1 Egg (left) and larval infestation (right) of citrus trunk borer on *khasi* mandarin**

## DISEASES

### Evidence of citrus huanglongbin disease in North-east India: One of the major causes of citrus decline

The citrus huanglongbin (HLB), earlier known as citrus greening disease (CGD) is considered as the major cause of citrus decline. It is caused by a phloem-limited fastidious á-proteobacterium, *Candidatus* Liberibacter spp. Three species of '*Ca.*Liberibacter' are currently recognized as the pathogenic bacteria responsible for citrus HLB disease: '*Ca.* L. asiaticus', the most widespread species, is found in tropical and subtropical areas in Asia, Brazil and North America; '*Ca.* L. africanus' is mostly restricted to Africa and is sensitive to high temperatures; and '*Ca.* L. americanus' is currently found only in Brazil.

Differential symptoms viz., vein yellowing, severe chlorosis with green vains, sectorial chlorosis and mottling, leaf yellowing, Zn-deficiency-like symptom (Fig 2a) are often confused with nutritional deficiencies and viral infections. The symptomatic plant samples were collected from experimental farm as well as farmers' field of Meghalaya, Nagaland and Mizoram.

Presence of HLB disease has been identified in the samples from all areas and different citrus cultivars (sweet orange, pumelo and *khasi* mandarin including some wild type germplasm) through PCR technique using *Ca. Liberibacter asiaticus* – 16S rDNA and ribosomal protein gene specific primers (Fig 2b). The colony of Asian citrus psyllid, (*Diaphorina citri)* the vector of HLB has been observed in new flushes of *khasi* mandarin during April-May, 2012 (Fig 2c). For further confirmation, the amplified fragments

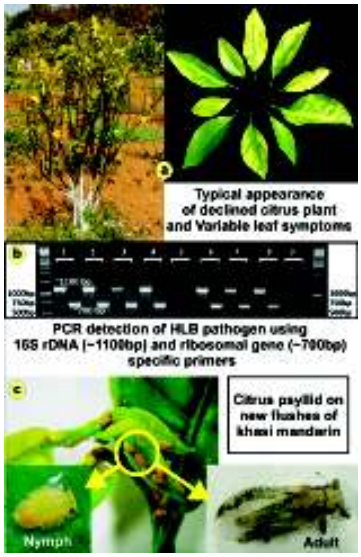



**Fig 2 Variable symptom, PCR detection and vector of HLB disease**

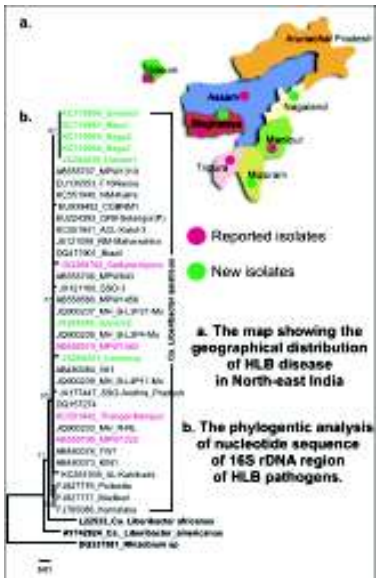



**Fig 3 Distribution and phylogeny of *Ca.* L. asiaticus from North-east Indian**

were sequenced and compared with the reported isolates. The phylogenetic analysis confirmed the presence of *Ca. Liberibacter asiaticus* in the collected samples. The existence of HLB was reported earlier from Assam, Meghalaya, Sikkim, Tripura and Manipur. The present study confirmed the existence of HLB disease throughout North-east India (Fig 3).

### Citrus foot/root rot and gummosis (*Phytophthora* spp.)

**a) Isolation and identification of *Phytophthora*:** Thirteen isolates of *Phytophthora* spp. from citrus infected tissues as well as soil bait were isolated and identified using primers ITS4/ITS6. Among the 13 *Phytophthora* spp., 6 of them were identified as *P. citrophthora* .

b) **Identification of bio-control agents:** Morphologically identified seven collected species of *Trichoderma* were cloned and sequenced and confirmed as *T. asperellum* (KC874892), *T. harzianum* (KC874893), *T. koningiopsis* (KC874894), *T. brevicompactum* (KC874895), *T. longibrachiatum* (KC874896), *T. virens* (KC874897) and *T. saturnisporium* (KC874898).

c) **Development of molecular tool for rapid diagnosis of *Trichoderma* spp:** A PCR based simple, robust and a reliable identification tool based on sequence length polymorphism in ITS1 region of *Trichoderma* was developed. This method is cost and time effective and obtains reliable identification in a single day.

d) ***In-vitro*bio-efficacy test of native *Trichoderma* spp. against *P. nicotianae*:** Six *Trichoderma* spp. as well as volatile and non-volatile compounds were tested for bio-efficacy against *P. nicotianae.* In dual culture, among the six *Trichoderma* spp., maximum inhibition (57.85%) was produced by *T. saturnisporium* followed by *T. harzianum* (56.98%). In volatile compound effect experiments, four ways experiments (inoculation of bio-agent and pathogen on same '0' day, bio-agents 1, 2 and 3 days ahead to pathogen) were conducted. In all experiments, *T. brevicompactum* followed by *T. saturnisporium* was found superior over other species. In non-volatile experiment with 10, 20 and 30% culture filtrate, *T. brevicompactum* followed by *T. harzianum* were found superior.

e) **Development of method for mass multiplication of *T. brevicompactum***: The method for mass multiplication of *T. brevicompactum* was developed in liquid based culture as the non-volatile compound of *T. brevicompactum* were found most effective. A product was prepared using *T. brevicompactum* in jaggery based medium containing 30g jaggery and 5g yeast extract. The medium was dispensed in 1000 ml conical flasks containing 500ml jaggery solution and sterilized. The flasks were inoculated with mycelium plugs from 14 days old culture and allowed to grow for 12 days at 25°C. A layer of *Trichoderma* collagen was observed on the surface of medium. The jaggery medium with *T. brevicompactum* was agitated. The agitated mix was diluted to 20% with water and used for treating rhizomes of ginger and followed by drenching after every 30 days. The product was found most effective.

f) **Isolation of fungicide resistant strains of *Trichoderma***: *Trichoderma* species were subjected to four fungicides (carbendazim, copper oxy-chloride, metalaxyl+mancozeb and mancozeb) at 1, 10, 100, 1000 and 2000 ppm concentration in order to see their tolerance to fungicides and isolation of resistant strains. All the tested *Trichoderma* spp. were tolerant to copper oxy-chloride (COC), metalaxyl+mancozeb and mancozeb up to 2000 ppm. But *T. viride,T saturnisporium*, *T. virens* and *T. asperellum* behaved differently producing more growth than 1000 ppm in metalaxyl + mancozeb combination. However, they were unable to grow in carbendazim amended media at the concentration above 10 ppm.

## GUAVA

### Performance of guava varieties/hybrids under meadow orchard

At 3rd year, genotype RCGH 7 (Fig 1) outperformed the RCG 11 with respect to yield attributes when evaluated under meadow orchard 2 m x 1.5 m (3333 plants/ha). The number of fruits and fruit yield per tree was highest in RCGH 7 (70 No. and 9.66 kg/plant) compared with RCG 11 (31 No. and 4.37 kg/plant). However, RCG 11, recorded highest fruit weight, fruit length and diameter (142.85 g, 6.32 cm and 6.50 cm, respectively) while minimum in RCGH 7 (137.41 g, 6.24 cm and 6.35 cm, respectively). With respect to fruit quality, RCG 11 recorded the higher TSS and ascorbic acid and lowest acidity (10.60%, 185.12 mg/100 g and 0.51%, respectively.) than RCGH 7 (10.10%, 178.83 mg/100 g and 0.65%, respectively). While total sugar was recorded highest in RCGH 7 (7.81%) followed by RCG 11 (7.24 %).

**Fig 1 Guava hybrid RCGH 7**

**Effect of ethephon on guava cv. Allahabad Safeda to extend harvesting time**

To extend the harvesting time in guava cv. Allahabad Safeda, ethephon (300, 600, 900 ppm and control) was sprayed on 30th March and 10th April on whole tree canopy. The result revealed that the harvesting was extended by 15 to 21 days compared to control in all treatments. The maximum delay in 1st harvest was recorded in 900 ppm (14th Oct) followed by 600 ppm (09th Oct) while earliest in control (23st Sep). Among the treatments least reduction in the yield was recorded with 300 ppm (19.78 kg/tree) followed by 600 ppm (18.00 kg/tree) and 900 ppm (17.10 kg/tree) but was significantly less than control (22.42 kg/tree). However, fruit weight (145.11 g) fruit length (6.72 cm) and breadth (6.89 cm) were recorded maximum in treatment with 900 ppm. The lowest values in control viz., 110.23 g, 5.71 cm and 6.02 cm were recorded for fruit weight, length and breadth respectively. In quality, TSS values did not differ significantly among 300 ppm (10.71 %), 600 ppm (10.52%) and 900 ppm (10.11%). The lowest acidity was recorded in 900 ppm (0.59%). The ascorbic acid content was recorded highest in 900 ppm (212.45 mg/100g) and minimum in control (178.90 mg/100g).

**Evaluation of guava lines under high density planting**

The primary branches of four guava lines viz., L 49, RCG 11, RCGH 1 and RCGS 1 were pruned in March 2011 to evaluate the performance under high density planting of 1.7 x 1.7 m (3460 plants/ha), 2.5 x 2.5 m (1600 plants/ha) and 5.0 x 5.0 m (400 plants/ha). After one year of primary branch pruning, the plant height was recorded highest in plant density of 1.7 m x.1.7 m (2.28 m) followed by 2.5 m x 2.5 m (2.05 m) while lowest in 5.0 m x 5.0 m (1.54 m). While, plant girth was recorded highest in 5.0 m x 5.0 m (6.82 cm) followed by 2.5 m x 2.5 m (5.82 cm) and 1.7 m x.1.7 m (4.65 cm). Similarly, canopy spread (NS x EW) was recorded maximum in 5.0 m x 5.0 m (2.09 m x 2.17 m). However, minimum was recorded in 1.7 m x.1.7 m followed by 2.5 m x 2.5 m. The number of fruits and fruit yield were recorded highest in 1.7 m x.1.7 m (44.42 No. and 6.83 kg/pant) followed by 2.5 m x 2.5 m (38.50 No. and 5.79 kg/plant) and lowest in 5.0 m x 5.0 m (36.67 No. and 5.19 kg/plant). The 2.5 m x 2.5 m plant density recorded highest fruit weight, fruit length and breadth (150 g, 6.31 cm and 6.67 cm, respectively) followed by 1.7 m x.1.7 m (147.9 g, 6.23 cm and 6.46 cm, respectively) and lowest in 5.0 m x 5.0 m (141 g, 6.05 cm and 6.31 cm, respectively). The spacing 1.7 m x.1.7 m recorded highest TSS (8.00%) and lowest acidity (0.44%). While, ascorbic acid content was recorded highest in 5.0 m x 5.0 m (129.42 mg/100 g).

With respect to varieties/hybrids, the plant height was recorded highest in RCGS-1 (2.21 m) followed by RCGH 1 (2.08 m) while lowest in RCG 1 (1.72 m). Similarly, plant girth and canopy spread (NS x EW) were recorded highest in RCGS 1 (6.82 cm, 2.02 m and 2.19 m, respectively). The no. of fruits and fruit yield were recorded highest in L-49 (53.89 No. and 8.95 kg/pant) followed by RCGH 1 (42.89 No. and 5.90 kg/plant) and lowest in RCGS 1 (27 No. and 4 kg/plant). Similarly, L 49 recorded highest fruit weight, fruit length and breadth (162.6 g, 6.25 cm and 6.62 cm, respectively) followed by RCGS 1 in fruit weight (148.8 g) and RCGH 1 in fruit length and breadth ( 6.51 cm and 6.55 cm, respectively). The variety RCGH 1 recorded highest TSS, ascorbic acid and lowest acidity (8.00%, 144.51 mg/100g and 0.44%, respectively) followed by L 49 (7.83%, 134.84 mg/100g and 0.44%, respectively).

## INSECT PEST

**First report on elephant beetles of the genus *Xylotrupes* attacking guava**

Elephant beetles of the widespread genus *Xylotrupes* (Coleoptera: Scarabaeidae) was reported for the first time attacking the fruit of guava. Adults of the elephant beetle *Xylotrupes siamensis* Minck have been found feeding on the flesh of developing guava fruits in Meghalaya (Fig 2) causing considerable losses in relative yield (35-45%). Preliminary investigations determined that the degree of damage from *Xylotrupes* in experimental orchards varied most significantly according to the maturation dates of the guava varieties

**Fig 2 Adults of elephant beetle**

**Survey of major insect pests of fruits crops**

Survey conducted for monitoring of different fruit flies species on different fruit crops revealed that *Bactrocera dorsalis* infestation on plum, guava, peach,

*Prunus nepalensis* and s*ohphie* (*Myrica esculenta*) and *B. zonata* on peach only. Occurrence of adult citrus trunk borer (*Anoplophora versteegi*) from second fortnight of March to first fortnight of August, citrus leaf miner (*Phyllocnistis citrella*) from second fortnight of February to first fortnight of December and fruit sucking bug from December to January were observed on *khasi* mandarin.

## PEACH

### Evaluation of peach varieties for yield and quality characters under HDP

Among three low chilling peach varieties at 5th year (Fig 1), var. Partap was found superior for the various fruit yield and quality traits assessed under high density planting of 2m x 2m. The result revealed that the earliest fruit maturity was recorded in Partap (17th April) while delayed in Shan-e-Punjab (28th April). In fruit traits viz., fruit yield per plant, fruit weight, fruit length and diameter were recorded maximum in Partap (8.10 kg/plant, 56.31 g, 4.51 cm and 4.32 cm, respectively) followed by Flordasun (6.23 kg/plant, 50.11g, 4.21 cm and 4.04 cm, respectively). In quality attributes, highest TSS and lowest acidity were recorded Partap (11.23$^0$B and 0.51%) while ascorbic acid content was recorded maximum in Shan-e-Punjab (6.43 mg/100g).

**Fig 1 View of peach orchard**

### Effect of thinning time and fruit spacing in peach var. Flordasun

Five year old peach var. Flordasun were hand thinned on full bloom, 10, 20, 30 and 40 days after full bloom (DAFB) by spacing flowers or fruits at 10, 15, 20 and 25 cm along the shoot on whole tree canopy. The result showed that thinning done on 20 DAFB with fruits spaced at 15 cm apart recorded advanced in fruit maturity (11 April) by 12 days compared to control. Among the treatments least reduction in fruit yield was recorded in 20 DAFB (15.89 kg/tree) but significantly less than control (18.10 kg/tree). The fruit yield showed decreasing trend but fruit weight, fruit length and diameter showed increasing trend when fruit spacing varied from 10 cm to 25 cm. However, fruits thinned at 30 DAFB recorded highest fruit weight, fruit length and diameter (49.91 g, 4.41 cm and 4.33 cm, respectively). In fruit quality, TSS was recorded maximum in thinning at full bloom (12.49 $^0$B) whereas lowest acidity (0.30%) and highest reducing sugar (3.97%) was recorded in 20 DAFB. While, ascorbic acid content was recorded maximum in 10 DAFB (7.22 mg/100 g).

### Evaluation of rejuvenated peach varieties

Medium to old/senile peach trees were primary branch pruned by retaining 50 cm length during Nov-Dec 2011. After one year, among the three low chilling varieties fruit yield per tree was recorded highest in Partap (16.64 kg/tree) while lowest in Shan-e-Punjab (11.75 kg) followed by Flordasun (12.10 kg/tree). Similarly fruit weight, fruit length and diameter were recorded maximum in Partap (66.03 g, 4.99 cm and 4.91 cm, respectively) followed by Flordasun (52.21g, 4.61 cm and 4.47 cm, respectively). In fruit quality, highest TSS and lowest acidity were recorded Flordasun (10.13$^0$B and 0.56%) while ascorbic acid content was recorded maximum in Partap (8.89 mg/100g)

## UNDER UTILIZED FRUITS

### Performance of grafted and seedling plants of *sohiong*

Grafted plants of *sohiong* (*Prunus nepalensis*) showed the better performance with respect to rootstock diameter (45.04 mm), number of branch/plant (10.4 Nos.) and number of leaves/plant (439.2) than seedlings except plant height (253 cm) and plant spread (109.0x110.8 cm) at three years after planting.

### Variability in *sohshang* genotypes

Six genotypes of *sohshang* (*Elaeagnus latifolia*) were evaluated for their plant growth and fruit yield at three years after planting. Genotype *Sohshang* 4 exhibited the highest plant height (380 cm), canopy spread (300 cm x 270 cm) and number of fruits/plant (231) whereas genotypes *Sohshang* 2 and *Sohshang* 5 produced the highest shoots/plant (6 each). Physico-

chemical parameters of fruit revealed that the genotype *Sohshang* 3 showed the highest fruit weight (8.99 g) and fruit length (30.79 mm) while, *Sohshang* 4 showed the highest pulp recovery (71.10%) and TSS content (12.30%). However, least acidity content was observed in *Sohshang* 6 genotype. Similarly, yield and physico-chemical study of four years old ten genotypes of *Sohshang* were also undertaken. The number of fruits/plant, fruit weight, fruit length, fruit diameter, seed weight, pulp content, TSS, acidity and sugar content ranged from 54.0-578.0, 6.8 g -10.49 g, 29.13-35.70 mm, 18.49-21.83 mm, 1.35-2.90 g, 66.85-80.38%, 5.30-8.80% 2.30-3.84% and 3.57-8.69%, respectively.

## BANANA

## DISEASES

### Full genome characterization of *Banana bunchy top virus* (BBTV) from Meghalaya

Preliminary characterization of BBTV from Meghalaya (Umsning and Umiam isolates) on the basis of DNA R segment showed similarity to "Pacific-Indian Oceans" group. The six genomic DNA components of Meghalaya (Umiam) isolate of BBTV were amplified by polymerase chain reaction (PCR) with specific primers using total DNA extracted from infected banana leaves. The resulting ~1.0 Kb amplicons were cloned and sequenced. Analysis of sequence data revealed the presence of six full-length components of BBTV: DNA-R (NCBI Acc. No. KC119098), DNA-U3 (KC466373), DNA-S (KC466374), DNA-M (KC466375), DNA-C (KC466376), and DNA-N (KC466377). The detailed features of these components of the BBTV Umiam isolate are presented diagrammatically in fig 1.

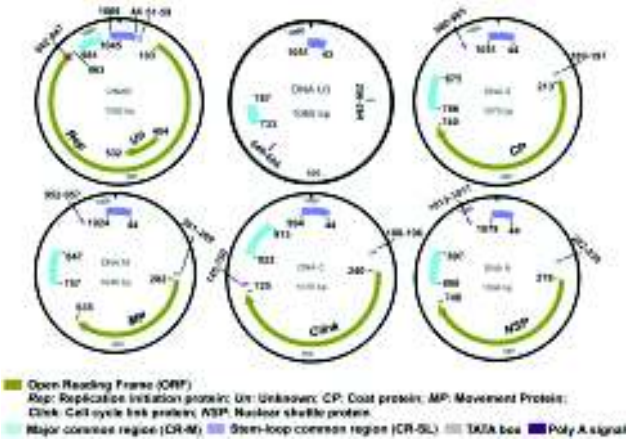


**Fig 1 Genome organization of the BBTV Umiam (Meghalaya) isolate**

The analysis of sequence data showed that six DNA components of BBTV shared two conserved regions: stem-loop common region (CR-SL) and a major common region (CR-M) (Fig 2). The CR-SL contains a predicted stem-loop structure with the conserved nucleotide sequence 'TATTATTAC' (Fig 3). Alignment of this region revealed variations at 17 positions. Three iterated sequences with the sequence 'GGGAC' (Fig 2) were found to be present in the CR-SL region of each component as these iterated sequences are known to perform important role in the replication of BBTV. This is the first report on full genome of BBTV from NE India.

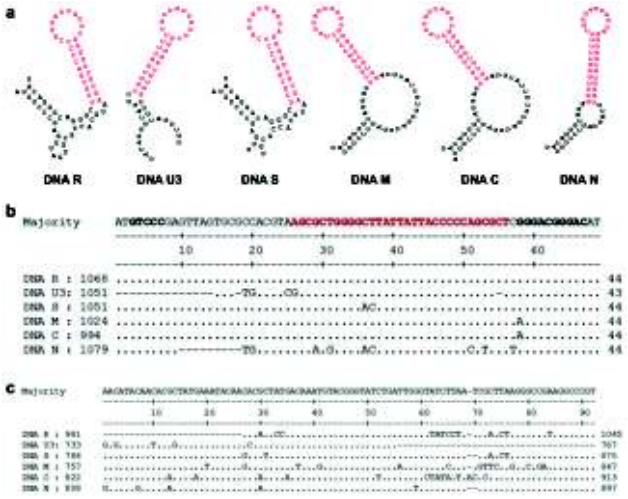



**Fig 2 The predicted stem-loop structure (a), sequence alignment of CR-SL (b) and CR-M (c) region of each genomic component Umiam isolate of BBTV. The nucleotide coordinates of the sequences are shown in each case as 'Majority'. Symbols like '.' indicate identity with majority and '–' indicate deletion. The stem-loop region and iterated sequences in CR-SL is indicated by red colour and bold form, respectively**

## VEGETABLE CROPS

## TOMATO

### Varietal evaluation

Under determinate segment, genotype 09/TODVAR 4 (39.19 t/ha) of AVT-II and 11/TODVAR 06 (28.98 t/ha) of IET trials were best for the yield and related traits. However, genotype 11/TOINDVAR 5 with yield of 35.41 t/ha and TSS (4.6°B) of AVT-I was best over check ArkaVikash (22.58 t/ha) under the indeterminate category.

### Screening of gemplasm against moisture stress

Thirty eight genotypes of tomato were collected and screened under polyhouse at three level of soil moisture (90±2.3%, 80±2.3% and 70±2.3%). Among the genotypes, at highest level of moisture stress minimum water loss (0.33) and maximum root length (27.85cm) was recorded from VL Tomato 4 (Fig 1). However, the maximum TSS (4.8°B) and lycopene content (9.70 mg/100g) was recorded from the genotype MCTR 3. The pollen viability was highest (95 %) in MT 11. The highest Vit-C (25.2 mg/100g) and lowest (59.59%) relative water content (RWC) was recorded from the genotype LE 1-2 and MCTR 4B, respectively. Under moisture stress condition the best genotype for yield/plant was Megha Tomato 3 (2.15 kg) and MT 11 (1.88 kg) under indeterminate group and TOVAR 6 (1.80 kg) and TOVAR 7 (1.60 kg) under determinate group. The identified lines can be used for the hybridization and selection.


**Fig 1 Best performing tomato genotype under moisture stress**

### Irrigation scheduling in tomato

The experiment was conducted under low cost polyhouse and irrigation was given at 5, 7 and 10 days intervals to 10 indeterminate genotype of tomato. The highest plant height (120cm), number of branches (18), roots length (25cm) average fruit weight (65g) was recorded from the VL Tomato 4 irrigated at 40-50% moisture stress (5 days intervals). However, among the genotypes, highest fruits yield per plant (2.33 kg) was recorded from MT 3. Similarly, at same level of moisture (40-50%) the lycopene content (9.66 mg/100g) and TSS (5.6°B) was highest in MCTR 4B.

## INSECT PESTS

### Bio-rational management of major insect pest of tomato

Different bio-pesticides were evaluated against tomato fruit borer (*Helicoverpaarmigera*) under field conditions. Among all, *Bacillus thuringiensis* @ 1.5 ml/lit and Anonin @2ml/lit treatments recorded lowest damage by *H. armigera* (3.02 and 3.05 % infested tomato fruits, respectively) and yield increase was found to be about 56.33% higher than control.

## DISEASES

### Bacterial wilt

Among the tomato genotypes, highest yield (36.75 t/ha) and lowest wilting (6.0%) was recorded from the genotype 11/TOBW 3 of IET trials. Likewise, in brinjal the lowest wilting (0.0%) and highest yield (32.83 t/ha) was recorded from the genotype 09/BRBWRES 4 of AVT-II trial.

## FRENCH BEAN

### Collection and evaluation of French bean germplasm

Out of 50 genotype of French bean, the highest yield/plant was recorded from the Mizoram collection MZFB 5 (318.20 g) followed by RCMFB 88 (235.73 g) and RCMFB 75(235g). The pod length was maximum in RCMFB 1(17.0 cm) followed by MZFB 27(14.2 cm) and the lowest was in pulse type genotype Nagaland Collection 1 (8.45 cm) with highest dry matter content (43%). The earliest in flowering was MZFB 28 (27days) while MZFB 43 (44 days) was late in flowering.

### INM in French bean

Among nine treatments, the plant height (316.53 cm), leaf area (49.23 $cm^2$), number of pods per plant (40.06), yield per plant (266.65g) and per hectare (12.60 t/ha) were recorded highest from the treatment $T_5$ (1/2 FYM +50% NPK) followed by $T_6$ (1/2 pig manure +50% NPK). For number of nodules per plant, yield per plant and yield per hectare, the treatment $T_5$ and $T_6$ were at par. In organic treatments, $T_2$ (pig manure 5t/ha) found best for plant height (287.9 cm), leaf area (44.76$cm^2$), number of pods per plant (38.39), number of nodules per plant (39), yield per plant

(219g), yield per hectare (10.07t) and root length (27.33 cm). Among the organic and INM treatments, the lowest growth, yield and nodulation was recorded from the $T_4$ (vermicompost 2.5 t/ha) and $T_8$ (½ vermicompost + 50% NPK). However, all the INM treatments were best for pod weight, number of nodules per plant, yield per plant, yield per hectare over purely inorganic treatment $T_9$ (Full NPK).

## INSECT PESTS

### Effect of biocontrol agents on nodulation and other growth parameters of French bean

A trial was conceptualized and conducted with 15 treatments including control and absolute control. Highest number of nodulation was observed in plants treated with *Bacillus* sp. The highest germination percentage and chlorophyll content was observed in plants treated with *T. harzianum S1* and *Burkholderia cepacia*, respectively.

## BRINJAL

## INSECT PEST

### Eco-friendly management of brinjal fruit and shoot borer

Different IPM modules evaluated against shoot and fruit borer, *Leucinodes orbanalis* revealed that, the module consisting of mechanical destruction of infested shoots and fruits (fortnightly), pheromoene traps (Leucilure) @ 100 traps/ha, single spray of Spinosad 0.002% and Novaluron 0.01% reduced about 93% infestation of *L. orbanalis* over control.

## DISEASE

### Evaluation of brinjal varieties for bacterial wilt (AICRP)

In Brinjal, Long (AVT-1) segment varieties 10/BRLVAR-1, Punjab Sadabahar and KasiTaru were 100% susceptible to bacterial wilt. However, genotype 10/BRLVAR-5 was best for yield (31.17t/ha) and resistant to bacterial wilt.

## CHILLI

### Collection and evaluation of chilli germplasm

Total 25 genotype of chilli (including 16 new collection) were evaluated for the yield and related traits. The highest yield per plant were recorded from BEC (455 g/plant) followed by Kasi Anmol (397.17g). Kasi Anmol also showed tolerant to fruit rot in chilli.

## DISEASES

### Preliminary detection of *Chilliveinal mottle virus* (ChiVMV) infecting chilli in Meghalaya

An evaluation of 40 chilli germplasm (*Capsicum chinense* Jacq. and *C. frutescens* L.) grown at experimental farms during *kharif* season (2012) showed natural occurrence of veinal mottle disease (Fig 1a) in all germplasm. The *Potyvirus* infection in symptomatic chilli plants was detected through reverse transcription (RT)-PCR test using *Potyvirus* specific degenerate primers (Fig 1b) and further confirmed through mechanical transmission assay (Fig 1c). Upon sequencing of amplified fragments, the partial cylindrical inclusion protein (CI) and helper component protease (HcPro) domains of four potyvirus isolates from Meghalaya shared 98-100% identity at nucleotide and amino acid level to each other. Further comparison of Meghalaya isolates with previously reported chilli infecting potyviruses showed nucleotide sequence identity of 82.2-89.4%, 73.8-74.3% and 57.3-63.1% with *Chilliveinal mottle virus* (ChiVMV), *Pepper veinal mottle virus* (PVMV) and other potyviruses, respectively and amino acid identity of 94.3-97.9%, 87.0-87.6% and 59.8-67.4%, respectively with the sameat partial CI domain. Similarly, for partial HcPro domain, Meghalaya isolates shared nucleotide sequence identity of 80.7-83.9%, 73.3-73.7% and 55.1-63.2%, amino acid identity of 92.8-94.9%, 85.1-86.2% and 50.3-64.6% with ChiVMV, PVMP and other potyviruses, respectively. In nucleotide and amino acid based bootstrap test of Neighbor-Joining phylogeny of partial CI and HcPro sequences, four Meghalaya isolates grouped with earlier reported ChiVMV isolates (Fig 1d). Whole genome characterization for further confirmation is in progress.

### Bacterial wilt (*Ralstonia solanacearum*) of solanaceous crops

a) **Isolation of pathogen:** New isolates from brinjal and tomato were isolated and eight of them were found to be *R. solanacearum* after confirmation with universal primers 759/760.

b) **Development of PCR based rapid method for detection of *R. solanacearum*:** A PCR based rapid, simple, robust and inexpensive detection method for *R. solanacearum* was developed using bacterial ooze from infected tissues directly as a source of DNA. The *R. solanacearum fli* C successfully even at 1:50 dilution of original bacterial ooze.

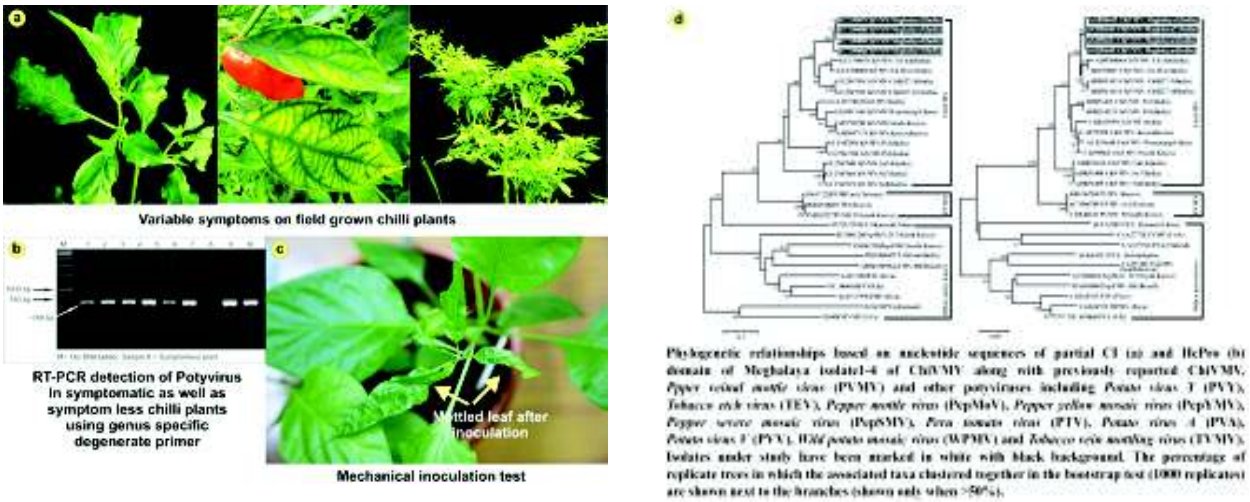



**Fig 1 Symptomatology, bio-assay and detection of chilli infecting *Potyvirus: Chilliveinal mottle virus* (ChiVMV)**

**c) Characterization of *R. solanacearum* isolates using PCR based molecular tools:** Characterization of *R. solanacearum* isolates following universal scheme of "multi-locus sequence typing" (MLST) of five house-keeping and three virulence-related genes. All the eight genes (*ppsA, gyrB, adk, gdhA, gapA, hrpB, fliC*, *egl*) were amplified for isolates from brinjal and tomato. The amplified products of *fliC* gene of one *R. solanacearum* isolates were cloned and sequenced commercially and submitted to NCBI gene bank (**Accession No.** KC834785).

**d) Management of bacterial wilt of brinjal**: The plot treated with *B. subtilis* (BS 2) had minimum infection (47.2%) and highest fresh yield (24.22 t/ha).

**e) Management of bacterial wilt of tomato**: Among the treatment, the plots treated with *P. fluorescens* (403) was found effective with minimum infection (11.1%) and maximum fresh yield (34.9 t/ha) compared with other treatments.

**f) Isolation of new bio-control-agents and testing their bio-efficacy:** Three isolates of bio-control agents *Burkholderia cepacia* (PB2, PBY, PB21) were isolated from soil samples. Identification of the isolates was done using BD Phoenix 100. *In-vitro* bio-efficacy test (confrontation technique) of all the three *Burkholderia* isolates against three fungal plant pathogens (*Colletotrichum lindemuthianum, Pyricularia oryzae* and *Phytophthora* sp.) showed PBY isolate as the most effective against *C. lindemuthianum* and *P. oryzae* with inhibition percentage of 56.02 % and 45.11 % respectively. However, isolate PB2 was most effective against *Phytophthora* sp. compared with others with inhibition percentage of 45.94%.

## OKRA

### Evaluation of germplasm

Out of total 205 accessions of okra including 5 checks viz., Phule Utkarsh, VRO 6, VRO 5, Hissar Unnat and Pusa A 4 were evaluated during June to October, 2012. Accession IC 128091 (35 days) and Check A4 (45.67days) was found to earliest for days to flowering. The dwarfing genotype with shortest intermodal length was IC 433641 (3.05 cm) and IC 57733 (3.80 cm). The pod length was recorded maximum from the genotype IC-332458 (16.24 cm) and EC 32398 (15.71cm). The highest yield per plant was recorded from the IC 12883 (254.43 g) followed by IC 13995A (251.13 g), IC 117252 (230g) and A 4 (223g).

## INSECT PESTS

### Bio-rational management of major insect pests of okra

Blister beetle, *Myllabris pustulata* was found most destructive pest of Okra. Among all the treatments, two sprays (20 days interval) of entomopathogenic fungus, *Beaveria bassiana* 1x$10^9$cfu/ml @ 5ml/l at flowering stage was found most effective against blister beetles, followed by Neem oil 0.3% @ 2ml/l of water.

## CHOW-CHOW

### Vegetative propogation in chow-chow : A novel technique

An experiment was conducted during October, 2012 to March, 2013 to study the response of hormones on the stem cuttings (bottom, lower middle, upper middle, top portion of stem), suckers and fruit sprouts of 2 and

3 nodes treated with IBA (commercial grade-Rootex) for the conservation and multiplication of diseases free true to type genotype of chow-chow. Of the treatments the root initiation was started 15-18 days after planting in sterilized growing medium. The 45-60 days (Fig 1) old cuttings/seedlings become ready for transplanting. The highest survival was recorded in the seedlings form fruit sprout (80-90%) followed by suckers (75-80%) and top shoot (66-75%) and upper middle shot (50-70%). There was no segnificant difference between the cutting of 2 and 3 nodes. From the experiment it was found that chow-chow germplasm can be conserved and multiplied best through suckers and top shoots.

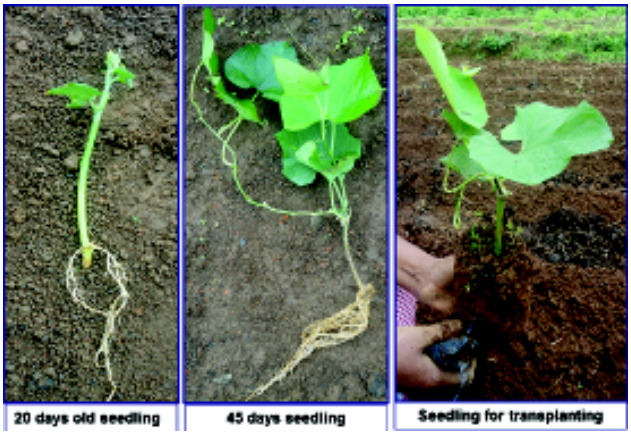



**Fig 1 Different stages of chow-chow (*Sechium edule*) seedling**

## RADISH

### Effect of planting time and cultivars on seed production in radish

Among the three radish genotypes studied viz., Light Pink, Meghalaya Selection 1 and White Long, maximum seed setting (86%), highest number of branches per plant (18.0), seed yield (48.0 g/plant) and total seed yield (1.30 t/ha) was recorded from Meghalaya Selection 1 with planting time of first week of November followed by first week of December.

## INSECT PESTS

### Bio-rational management of major insect pests

Aphid, *Brevicoryne brassicae* and cabbage butterfly, *Pieris brassicae* were observed major pests of radish. Natural parasitism of both these pests was very high. Fixing of yellow sticky traps @ 2 traps/ 100m$^2$ and conservation of natural enemies along with spraying of *Bacillus thuriengiensis* var. *kurstaki* (Lipel 8SP) @ 2g/l of water were found superior over all the other treatments.

## DOLOCHOS BEAN

Among the Dolichos bean (AVT-I) genotypes, for days to 50% flowering 10/DOLPVAR 5 (69.33 days) was identified as earliest while, 10/DOLPVAR 10 was late (110days) for flowering. The highest yield (12.16 t/ha) was recorded from the genotype 10/DOLPVAR 8. All the genotypes were susceptible to aschochyta leaf blight.

## ASH GOURD

Among the ash gourd hybrids, 10/ASGHYB 1 was identified as the best for the average fruit weight (4.6kg), yield/plant (13.80 kg) and total yield (35.88 t/ha) over the check IVAG 90 (28.43 t/ha).

## COLE CROPS

## CABBAGE

### Evaluation of cabbage hybrids

Among the cabbage hybrids, the highest yield was recorded from the CABHYB 4 (79.50 t/ha) followed by CABHYB 3 (74.50 t/ha) of AVT 1 trials. However, none of the hybrids of 10/AVTII and 12/IET trials were best over the local check H 139 for marketable head weight and yield per hectare.

### Off- season production of vegetables

During rainy season under low cost polyhouse early maturity cultivar Pusa Meghna and Pusa Early Synthetic were grown and average curd weights were recorded as 350 g and 300 g, respectively. The succeeding crop tomato was grown and highest yield was recorded from Megha Tomato 2 (3.0 to 3.5 kg/plant) however, the maximum no. of fruit was recorded in Megha Tomato 3.

### Standardization of vegetable based farming system model

Under vegetable based farming system during March to October the highest yield per unit area were recorded from brinjal cultivar Megha Brinja l2 (39.18 t/ha) followed by tomato variety Megha tomato 3 (31.25 t/ha). Among the French bean genotype, the highest yield was recorded from variety Arka Subidha (7.69 t/ha). Green Bell variety of capsicum also showed highest yield over California Wonder. Cucumber cultivar Kalyanpur Hara yielded 27.0 t/ha. From

economic point of view the highest income was recorded from brinjal, ₹ 3,91,800/ha.

## INSECT PESTS

### Bio-intensive management of major pests of cole crops

Cutworm, was found major pest during seedling stage. Placing of grass heaps or rice straw @ 3 heaps/ 10m$^2$ during evening time and collection and destruction of hidden cutworm larvae from the bottom of heaps during morning, was found excellent management practice against cutworms. Furthermore, non-chemical practices also prevent toxicity to Mermithid nematodes (Fig 1) and Tachinid flies (Fig 2), which are most potential natural enemies of cutworm and naturally kills about 70-75% cutworm larvae under field conditions. During later stages, cabbage butterfly, *P. brassicae* was found major pest. Among all the treatments, *Bacillus thuriengiensis* var. *kurstaki* (Lipel 8SP) @ 2g/l of water and Spinosad (Tracer 20EC) @ 0.5ml/l of water were found to be the superior treatments against *P. brassicae* which reduced almost 93% butterfly damage over control.

**Fig 1Mermithid nematode emerging from cutworm**

**Fig 2 *Exoristalarvarum***

### Influence of host plants on reproductive behavior of *Pieris brassicae* and its parasitoid

Host plants of *P. brassicae* viz., cabbage, broccoli, cauliflower and knol-khol were found to have significant influence on egg distribution and leaf surface preference for oviposition and pupation. The number of egg masses was highest on knol-khol; however, the number of eggs per mass was highest on cabbage (Fig 3). Similarly, larval incidence was also highest on cabbage throughout the season, indicating that cabbage is the most preferred host. Natural parasitism on *P. brassicae* larvae by *Hyposote rebeninus* (Fig 4) was higher on knol-khol and cabbage. The weight of the third instar parasitized caterpillars was the highest on cabbage, suggesting that cabbage is the most favourable host of *P. brassicae* for producing excellent quality *H. ebeninus* parasitoids.

**Fig 3 Egg laying poster of *P. brassicae***

**Fig 4 Egg laying poster of *H. ebeninus***

### Effects of different host plants on biology of large white butterfly, *P. brassicae*

Life cycle of cabbage butterfly, *P. brassicae* (Fig 5) was studied on four common host plants viz., cabbage, cauliflower, knoll-khol and broccoli. Developmental period (from eggs to adult) was found to be significantly lower ($F=9.57$, $P<0.01$) on cabbage followed by knol-khol and highest on broccoli. Furthermore, inverse relationship was found in body weight of butterfly and developmental period. Overall, development of *P. brassicae* was much faster on cabbage than other hosts; but its body weight was considerably higher on cauliflower.

**Fig 5 Life cycle of *P. brasicae***

## RADISH

### Bio-rational management of major insect pests of radish

Aphid, *Brevicoryne brassicae* and cabbage butterfly, *Pieris brassicae* were observed major pests of radish. Natural parasitism of both these pests was very high. Fixing of yellow sticky traps @ 2 traps/ 100m$^2$ and conservation of natural enemies along with spraying of *Bacillus thuriengiensis* var. *kurstaki* (Lipel 8SP) @ 2g/l of water were found superior over all the other treatments.

## SPICES

### TURMERIC

**Varietal evaluation**

Ten different genotypes of turmeric were evaluated. The highest plant height of 119.2 cm was observed in BSR 2 followed by Rajendra Sonia (113.8cm), whereas the lowest was recorded in Suranjana (91.63cm). Pratibha recorded the highest leaf length and leaf breadth (58.93cm and 16.90cm, respectively). However, the lowest leaf length was recorded in Suranjana (42.27cm) and the lowest leaf breadth was recorded in Narendra Haldi (12.03cm). Maximum yield was recorded in Rajendra Sonia (46.93 t/ha) and the lowest was observed in Roma (21.93 t/ha). The dry recovery was recorded highest in Kedaram (24.50%) and lowest in Narendra Haldi (16.00%). Kedaram shows the highest curcumin content of 9.17 % whereas BSR 2 recorded the lowest with 1.82% only. The highest oleoresin content of 22.8% was observed in Narendra Haldi and BSR 2 recorded the lowest with 6.24%.

### GINGER

**Varietal evaluation**

Among 10 genotypes, plant height was observed highest in Varada (80.17cm) whereas the lowest plant height was observed in Suravi (62.70cm). Highest leaf length (28.10 cm) and leaf breadth (3.37cm) was recorded in Varada and Suprabha, respectively. On the other hand, the lowest leaf length (22.83cm) and leaf breadth (2.87cm) was observed in Suprabha and khasi Local, respectively. Maximum yield was observed in $V_3S_1$-8 with 4.5 t/ha. Dry recovery percentage ranged from 17.10-29.91% and crude fiber content ranged from 4.21-7.85 % among the genotypes. Oleoresin content was recorded highest in Surachi (10.50%) and lowest in Mahima (3.90%). The highest volatile oil content of 2.65% was recorded in Mahima and lowest (1.73%) in Himgiri.

**Quality analysis of organically grown turmeric and ginger**

The eight samples of turmeric and nine samples of ginger were received from various KVKs viz., Ri-Bhoi, East Sikkim, Kokrajhar, Kolasib, Basar, KarbiAnglong, Dimapur, Tura and Imphal West under Biotechnology led organic farming project. The quality analysis such as curcumin content and oleoresin were done for turmeric while crude fibre and oleoresin of ginger were estimated. The curcumin content was highest in most of the organically produced turmeric as compared to control. The curcumin content in organic turmeric ranged from 3.65% in KVK, Basar to 7.33% in KVK, Tura and in control turmeric it ranges from 3.82% in KVK, Karbi Anglong to 5.41% in KVK, Kokrajhar, the oleoresin content of organic turmeric ranges from 9.35 % in KVK, East Sikkim to 30.2% in KVK, Tura and in control turmeric it ranges from 8.4% in KVK, Ri-Bhoi and KVK, Karbi Anglong to 19% in KVK, Dimapur. Similarly, the oleoresin content of ginger was also found to be highest in organically produced ginger as compared to the control sample, whereas in the case of crude fibre, it was found to be highest in control sample as compared to the organically produced sample. The crude fibre in organic ginger ranged from 4.01% in KVK, Ri-Bhoi to 8.06% in KVK, Kolasib, whereas, in the case of control it ranged from 5.75% in KVK, Ri-Bhoi to 8.90% in KVK, Karbi Anglong. The oleoresin content in organic ginger ranged from 4.10% in KVK, Basar to 8.2% in KVK, Tura, whereas, in control ranged from 5.1% in KVK, Dimapur to 7.85% in KVK, East Sikkim.

## DISEASES

**Management of bacterial wilt of ginger**: Out of six treatments, *Trichoderma brevicompactum* + *P. fluorescens* (403) was found effective with minimum infection (22%), and maximum fresh yield (12.3 t/ha). However, the yield loss percentage (16.7%) was found to be lowest in *Bacillus* sp. (507) treated plots.

**Pot trial:** Eight *Trichoderma* spp. were tested for their efficacy on growth of ginger and management of bacterial wilt under pot conditions. In general, the yield increased as compared to control invariably with *Trichoderma* spp. The pots treated with *T. brevicompactum* showed lowest yield loss percentage (0.56%) and maximum yield/pot (1.15 kg).

**Management of soft rot (*Pythium* spp) of ginger**

a) **Field trial:** A trial was conducted to evaluate the field efficacy of treatments against soft rot of ginger. The highest yield (14.8 t/ha), minimum infection (14.6%) and lowest yield loss (3.2%) was recorded with HWT (47°C) for 30 min + *Trichoderma* 2.5 kg/50kg FYM mixing in soil at planting time + copper oxychloride (0.3%) need based soil application. Whereas, in another treatment with application of poultry manure @ 2.5 t/ha in the plots followed by rhizome treatment with *T. harzianum*

@ 5 g/kg and finally covering the bed with mulch (*Ambrosia* spp.) recorded highest yield (15.0 t/ha), infection % (15.5) and yield loss % (3.4%) among all the treatments.

**b) Pot trial:** In a pot experiment, the effect of eight *Trichoderma* spp. on ginger growth parameters viz., plant height, number of shoots, height of shoots, shoot diameter, leaf total chlorophyll content, number of leaf in main shoot, leaves length, leaf chlorophyll index were studied. All the growth parameters including rhizome development (number of fingers, finger length, finger diameter and thickness) and yield (1.15kg) were found to be highest in plants treated with *T. brevicompactum.* Minimum yield loss (5.9 %) was also recorded in *T. brevicompactum.*

## TUBERCROPS

## COLOCASIA

### Initial evaluation trial

The experiment was conducted with eight colocasia entries of which three genotypes were from Barapani. Other entries could not be received. Maximum plant height was recorded in Nayabunglow (IC No. 592251) 122.83 cm with maximum number of side shoots (5.33). AR Col-7 (IC No. 592256) recorded the highest number of cormels (16.33) per plant whereas cormel yield (13.33 t/ha) and total yield (20.33 t/ha) recorded maximum in the variety AR Col 6 (IC No. 592255). Chemical analysis has shown that dry matter content and starch was found highest in Nayabunglow with 30.88 % and 24.63 %, respectively whereas AR Col 6 had highest total sugar (3.64 %) and oxalic acid (0.25 %).

### Multi-location trial in colocasia

The maximum plant height (Table 1) was recorded in the variety BCC 1 (84.17 cm). The variety ML 9 (IC No. 592247) recorded the highest number of cormels (9.33) per plant whereas cormel yield (12.33 t/ha) and total yield (14.67 t/ha) was depicted highest in the variety SJ 1 (Fig 1) Leaf blight incidence was found to be the lowest (15.0%) in ML 2 (IC No. 592246).

**Fig 1 Colocasia variety ML 2 and SJ 1**

### Phenology of colocasia in relation to climate change

Thirty eight genotypes of colocasia were planted in May end and evaluated for high yield, quality and other attributing characters. Monthly biometrics performance like plant height, leaf production, leaf area index (LAI) and girth were recorded. The line Nayabunglow (IC No. 592251) recorded a maximum plant height for the month of October (96.50 cm), November (100.17 cm) and December (92.75 cm). Leaf production was found to be maximum in C 3 during the month of October and December with 6.33 t/ha and 5.66 t/ha, respectively whereas Panchmukhi had maximum leaf production during the month of November (6.0 t/ha). LAI was found to be highest in Kandha 5 during October (1.40) whereas during the month of November and December BCC 1(1.24) and BCC 2 (1.24) had their highest LAI. Petiole girth was found to be highest in the genotype Meghalaya Collection 1 (17.65 mm) for the month of October whereas ML 9 (IC No. 592247) had the maximum for the month of November (18.56 mm) and December (17.67 mm)

AR Col 1 (IC No. 592252) recorded maximum number of cormels per plant (24.0) whereas cormel

**Table 1 Performance of six colocasia varieties**

| Genotype | Plant height (cm) | No. of side shoots/ plant | No. of cormels/ plant | Cormel yield (t/ha) | Total yield (t/ha) | Leaf blight incidence (%) |
|---|---|---|---|---|---|---|
| IC No. 592245 | 77.25 | 5.67 | 6.00 | 10.00 | 13.33 | 21.00 |
| IC No. 592246 | 69.50 | 2.33 | 6.33 | 7.67 | 14.33 | 15.00 |
| IC No. 592247 | 77.00 | 3.67 | 9.33 | 4.00 | 11.00 | 20.00 |
| SJ 1 | 78.67 | 6.00 | 7.00 | 12.33 | 14.67 | 19.00 |
| Meghalaya Collection 1 | 82.36 | 4.67 | 7.00 | 10.67 | 14.00 | 17.00 |
| BCC 1 | 84.17 | 4.00 | 8.66 | 9.67 | 13.67 | 20.00 |

yield and total yield was found to be highest in AR Col 6 (IC No. 592255) with 16.67 t/ha and 33.33 t/ha, respectively. Dry matter content was highest in AR Col 2, IC No. 592253 (42.62 %) whereas starch was highest in Telia (61.0 %). Total sugar and oxalic acid was found to be highest in Surya (9.70 %) and Nainital (0.42 %).

## SWEET POTATO

### Varietal evaluation

Seventeen different sweet potato varieties were evaluated for yield and other characters. The variety S 107 recorded the highest tuber yield of (38.3 t/ha). The maximum tuber length (21.53 cm) was recorded in Kokrajhar Red, whereas tuber diameter was highest (7.82 cm) for the variety Gauri.

In another trial among six sweet potato varieties studied, S 107 recorded the highest total tuber yield (38.3 t/ha). Dry matter content was found to be highest (48.46%) for the variety Kokrajhar Red, whereas the X 24 recorded the highest ascorbic acid of 25.71%. Starch and â-carotene was found to be highest in the variety X 24 (8.78 %) and S 107 (22.637 mg/100g), respectively.

## FLORICULTURE

## LILIUM

### Varietal evaluation

Five cultivars of Lilium were planted in December, 2012 under open and net house conditions were evaluated for vegetative and floral characters. The varieties grown inside the net house exhibited the more plant height, spike length and field life as compared to open condition. However, varieties grown under open condition recorded the highest flower size, flowering duration, vase life and took least days to flowering.

**Fig 1 Lilium in open condition**

Among the varieties grown under open condition, the highest plant height (42.45 cm), number of leaves/plant (108.0 Nos.) and spike length (41.65 cm) were observed in Brunello while, the highest number of flowers/plant (6.0 nos. each) found maximum in both Brunello and Navona. However, Navona also recorded the prolonged flowering duration (12.0 & 8 days) and least days to flowering (88 & 93 days) both in open and net house condition. The cultivar Original Love recorded to have the maximum flower size (17.70 & 16.27 cm, respectively) and vase life (7 & 6 days, respectively) under open and net house condition.

## GERBERA

### Evaluation of gerbera hybrids under low cost polyhouse

Twenty-three genotypes including 15 exotic gerbera hybrids were evaluated under low cost polyhouse. The highest leaf length (33.12cm), maximum leaf breadth (8.88 cm) ,maximum plant spread (56.3 $cm^2$), maximum flower stalk length (58.14cm), maximum flower stalk diameter (6.98 mm) and maximum no. of flowers/plant (5.6 nos.) were recorded in Alesmera. Rising sun recorded the maximum field life (21.5 days) whereas, Dubai showed maximum flower disc diameter (2.8$cm^2$). RCGH 117 produced the largest flower diameter (10.14 $cm^2$) and the maximum No. of leaves/plant (39.4 nos.) along with RCGH 7. Maximum number of suckers/plant (3.80 nos) was recorded in RCGH 7and maximum vase-life (13.0 days each) was recorded in Torbin, C.F. Gold and Stanza.

## ANTHURIUM

### Performance of anthurium varieties under net house condition

Two varieties of anthurium viz., Acropolis and Tropical red were planted during March 2012 in flower pots inside the net house. The vegetative and floral characters were studied. The maximum spadix length (4.25cm), spathe length (6.45cm), number of leaves/ plant (5.00 nos.), leaf length (15.77cm), girth of flower stalk (3.50mm), vase life (18 days) and days to flowering (187 days) were observed in Acropolis. However, the maximum plant height (23.35cm), spadix width (7.09mm), spathe width (5.65cm), flower stalk (24.32cm), leaf length (29.12cm), leaf width (11.92cm), angle of spathe over spadix ($38.90^0$) and field life (70 days) were recorded in Tropical red.

## ORCHIDS

### Standardization of protocol for multiplication of indigenous orchids

A simple reproducible protocol for *in vitro* seed germination, multiple protocorm like body formation using pseudostem segments and plantlet regeneration of *Cymbidium giganteum* was standardized. Pseudo-stem segments were cultured in two culture medium phase supplemented with a range of TDZ (0.2-4.4 mg/l). The two culture medium phases were;

**a. Semi solid culture medium phase:** Pseudostem segments (0.5 cm) were cultured on half-strength MS medium with sucrose, 1.5 $gL^{-1}$ activated charcoal, 8 $gL^{-1}$ Difcobacto agar and supplemented with a range of TDZ concentrations (0.2-4.4 $mgL^{-1}$) in glass culture bottles (200 ml) containing 40 ml of the medium.

**b. Dual-phase culture medium (solid phase + liquid phase):** An attempt has been made to culture Pseudo-stem segments on dual phase culture medium containing 30 ml of semi solid medium as mentioned above and overlaid with 10 ml liquid fraction of the same medium fortified with TDZ. Dual phase culture medium supplemented with 0.2 mg/L TDZ was found to be the effective condition on the induction of multiple shoot buds /protocorm like bodies in the pseudo-stem segments and suitable for development for multiple plantlets of this rare orchid species.

## MOLECULAR ENTOMOLOGY

### Modified protocol for DNA extraction from museum preserved insect specimen

A simple and efficient Chelex based modified DNA extraction protocol has been developed for extraction of DNA from dry or old insect museum specimen. Using this modified protocol, DNA was successfully extracted from 20 year old dry insect specimens. The quality of DNA was good enough to successfully amplify the PCR fragment up to 400bp of cytochrome oxidase I (COI) gene of mitochondrial genome.

### Biodiversity and colour polymorphism in ladybird beetles of multi-crop system of Meghalaya

More than 20 species of ladybird beetles were collected from multi-crop ecosystem of Meghalaya (Fig 1). Ten species were successfully identified based on established taxonomical keys. A study on molecular characterization of colour polymorphism is underway. Ten species specific DNA barcodes based on partial COI gene of mitochondrial genome were developed for coccinellid beetle.

**Fig 1 Biodiversity and colour polymorphism in ladybird beetles of Meghalaya**

### Molecular tool for reliable species identification in the genus *Henosepilachna*

Species within the genus *Henosepilachna* are phytophagous and some species are major pests of cucurbits and solanaceous crops. The identification of these species mainly relies on patterns of black spots on elytra and genital structures. *H. pusillanima* and *H. septima* have overlapping external morphological features which makes their identification very difficult. During the course of molecular characterization, sequence length polymorphism was detected in Internal Transcribed Spacer I (ITSI) region. Hence, molecular tool has been developed based on ITSI region of the genome. This PCR based tool is very simple and reliably differentiate *H. pusillanima* and *H. septima.*

### Species specific DNA barcode of sawfly, *Arge xanthogastor*: A new pest of roses in Meghalaya

The sawfly, *Arge xanthogaster* (Cameron) (Hymenoptera: Argidae), has recently emerged as a major pest of roses in Meghalaya and causes around 80% damage to wild and cultivated rose plants. As per primary scientific literature, this is a first report of *A. xanthogaster* as a pest of roses from the country. Interestingly, *A. xanthogaster* of Meghalaya was found morphologically variable up to some extent to that of previously reported specimens of Manipur and Sikkim

(Fig 2), indicating that *A. xanthogaster* in Meghalaya could be a new subspecies or race (Fig 3). Since this species belongs to a difficult species complex of genus, *Arge* in which species are difficult to distinguish and till date no DNA barcode has been developed for this group. Therefore, species specific DNA barcode based on standard barcoding cytochrome oxidase I (COI) gene of mitochondrial DNA was developed (NCBI Accession no. JX532103) (Fig 4).

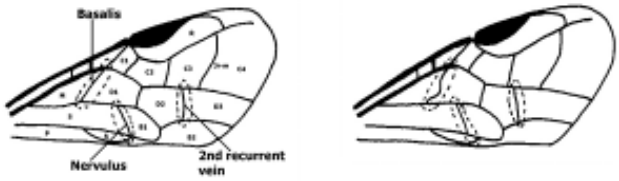



**Fig 2 *A. xanthogaster* forewing 1, variant of Meghalaya (24A); Forewing 2, Variant of Sikkim and Manipur (24B), 3r-m=3rdCubital cross vein; A= Anal cell; B1-B2 +Brachial cells 1& 2; C1-C4= Cubital cells 1-4; D1-D3= Discoidal cells 1-3; M= Medial cell; P=Postellan cell; R= Radial cells; S= Sub median cells**

**Fig 3 *A. xanthogaster* laying egg inside the rose stem**

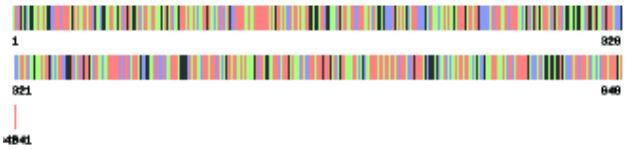



**Fig 4 DNA barcode of *A. xanthogaster* based on standard barcoding cytochrome oxidase I (COI) gene of mitochondrial DNA**

## CONSERVATION AGRICULTURE

### Standardization of nutrient requirement of rice

Grain yield of lowland rice was not significantly influenced by different tillage practices but was significant with the different nutrient management practices. Grain yield obtained through zero tillage (4.61 t/ha) was found to be higher (Fig 1) as compared to minimum and conventional tillage. However, among the nutrient management practices, the highest yield was recorded from 50% NPK + *in-situ* residue recycling (4.57 t/ha) followed by 50 % NPK + weed biomass (4.53 t/ha). The soil microbial biomass carbon (SMBC) was significantly higher under zero tillage.

The chlorophyll index at 30 DAT were relatively higher under zero tillage (ZT). Chlorophyll index was recorded slightly higher under 50 % NPK + green manuring. SMBC was found to be significantly influenced by tillage and nutrient management practices. Among the different tillage practices, zero tillage recorded higher soil organic carbon (SOC) and SMBC content. The SOC was higher under 50% NPK + *in-situ* residue management practice and SMBC was higher under 50 % NPK + green manuring. The soil resistance recorded after the harvest of rice at different depths (0-5 cm, 5-10 cm and 10-15 cm) increased with the soil depth. Soil resistance was minimum under ZT and maximum under CT at all the depths. Highest soil resistance of 355KPa, 473.33 KPa and 632.50 KPa were recorded under conventional tillage at 0-5 cm, 5-10 cm and 10-15 cm soil depth, respectively, after harvest of rice. Among the different nutrient management practices, highest soil resistance was recorded under 100 % NPK application (365kPa, 481 kPa and 667 Kpa) at three depths, respectively.

**Fig 1 Rice under zero tillage (Shahsarang 1)**

In *rabi* season, the green pod yield of pea varieties Arkel and Prakash were significantly influenced by different tillage and nutrient management practices. Green pod yield was be highest under ZT for both varieties i.e., 5.92 t/ha for arkel and 9.14 t/ha for Prakash, followed by MT (5.82 t/ha) for Arkel and (8.86 t/ha) for Prakash (Fig 2). Among the nutrient management practices effect on Arkel green pod yield was higher under 50 % NPK + weed biomass. In case of Prakash, the green pod yield was higher under 50 % NPK + weed biomass, whereas, length of pods, weight of seeds/pod was higher in 50 % NPK + *in-situ* residue management. Number of nodules/plant and weight of nodules/plant were higher under MT for both varieties.


**Fig 2 Pea varieties Prakash and Arkel during flowering stage under zero tillage**

In upland, initially *Crotolaria* spp. was grown as green manure crop in between two rows of rice and it was harvested during tillering stage at 35 DAS. About 10 t green manure/ha was produced which was recycled. Grain yield of upland rice (IURON 514) was significantly influenced by nutrient management practices but the effect of different tillage was not significant (Fig 3). Yield obtained under conventional tillage (3.25 t/ha) was relatively higher as compared to conservation tillage though the difference was non-significant. Among the nutrient management practices, 50% NPK + green leaf manure recorded higher grain yield (3.20 t/ha).

**Fig 3 Rice variety IURON 514 in upland conditions under conservation tillage**

From the entire yield attributes recorded, test weight and effective tillers/m row length were significantly influenced by tillage and different nutrient management practices. The test weight was higher under conservation tillage and 50% NPK + *in-situ* residue management. Chlorophyll index at flowering stage was observed to be higher under conventional tillage. Among the different nutrient management practices, chlorophyll index was recorded higher in 100% NPK application. Infiltration rate of the soil was higher under conservation tillage + 50% NPK + *in-situ* residue nutrient management (2.80 mm/min) followed by 50% NPK + green leaf manure (2.73 mm/min). The cumulative infiltration was higher under conservation tillage + 50% NPK + *in-situ* residue nutrient management followed by 50% NPK + weed biomass.

**Mitigating abiotic stresses and enhancing resource-use efficiency in pulses in rice fallows through innovative resource conservation practices**

Rice-lentil cropping system was evaluated in both upland and lowland conditions under different tillage and residue management options. In upland, rice (var. IURON 514) was grown under different tillage practices with the objective to get optimum yield and to conserve soil and water. Rice grown under MT-ZT (minimum tillage for rice and zero tillage for lentil) system recorded significantly higher yield (3.41 t/ha) in comparison to CT-CT (conventional tillage for both rice and lentil) system (2.46 t/ha). Two lentil varieties (DPL 62 & DPL 15) were grown in rice fallow under zero tillage under different rice residue management practices.

In lowland, two rice varieties *viz*., Mendri (long duration local) and Shahsarang 1 (medium duration and HYV) were evaluated in *kharif* season. Two lentil variety *viz*., early duration with high biomass (DPL 81) and medium duration with high biomass (IPL 406) were grown in rice fallow under zero tillage under different rice residue management practices. The performance of early duration HYV variety Shahsarang 1 was better giving higher grain yield of about 5.02 t/ha compared to the local variety Mendri (3.63 t/ha). It was also noted that local rice variety Mendri taken longer duration to mature in comparison to the

improved medium duration variety Shahsarang 1. Taking the advantages of comparatively shorter duration of Shahsarang 1, sowing of lentil could be made earlier. The lentil crop grown after high yielding rice variety Shahsarang-1 recorded better growth parameters as compared to lentil grown after long duration rice, Mendri in lowland.

The rice stubble management practices significantly influenced the yield attributes and yield of lentil both in upland and lowland. There was 65% and 30.2% enhancement in seed yield of lentil in upland due to mulching and 40 cm stubble heights compared to residue removal, respectively. In lowland condition, mulching and 20 cm stubble heights also recorded relatively higher lentil yield compared to residue removal (Fig 4) but the extent of yield enhancement was lower than the upland. The effect of varieties was significant on pods per plant and seed yield whereas, it was nonsignificant on seeds per plant and test weight in upland. While in lowland, the effect of rice varieties had non-significant effect on lentil plant stand, height, yield attributes and yield. Among different rice stubble management practices, the highest soil moisture content was observed under mulching followed by 40 cm and 20 cm standing stubbles (Fig 5). Infiltration rate were significantly higher under mulching and 40 cm stubble height in upland and lowland trial, while lower infiltration rate was observed from residue removal in both the land conditions. Among the residue management practices, mulching recorded significantly higher DHA and SMBC followed by 40 cm stubble height compared to residue removal in upland.

**Fig 4 Performance of lentil (IPL 406) under different stubble management in lowland condition**

Mulching recorded the lowest soil resistance (1444.4 KPa) at 0-5 cm depth followed by 20 cm (1611.1 KPa) and 40 cm (1800 KPa) standing stubble (Fig 6). The highest soil resistance was noticed under residue removal (2725 KPa) at 10-15 cm depth. The resistance was much higher at flowering. The leaf relative water content (LRWC) was measured at 60 and 90 DAS of lentil in upland. At both the stages, average LRWC values were less than 60% indicating

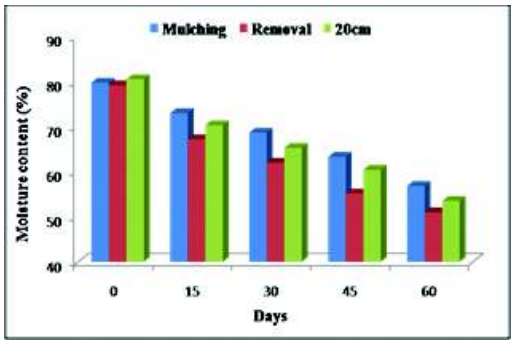



**Fig 5 Soil moisture content at 0-5 cm depth of soil in lowland**

moisture stress in plant. Mulching and 40 cm standing stubble resulted in 26% and 17% enhancement in LRWC in 60 DAS and 14% and 10% enhancement in LRWC in 90 DAS in comparison to residue removal, respectively.

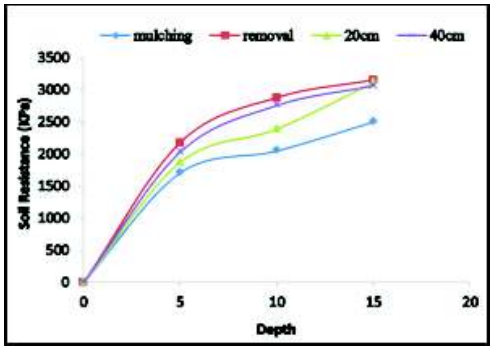



**Fig 6 Soil resistance in lentil plots at flowering stage in upland condition**

## Screening of lentil varieties for zero tillage cultivation in lowland rice fallow

Field experiment was conducted with 16 lentil germplasm for finding their suitability for cultivation under lowland rice fallow under zero tillage (Fig 7). A furrow was opened in between two rice lines using a

**Fig 7 Screening lentil varieties for zero tillage cultivation in lowland**

manual furrow opener during first week of December after harvest of lowland rice. A fertilizer dose of 20: 60: 40 kg NPK/ha was applied. The potential varieties identified for lowland land rice fallow were L 307 (1.87 t/ha), DPL 62 (1.69 t/ha), DPL 15 (1.67 t/ha) and L 304 (1.51 t/ha).

**Farmers participatory action research programme on enhancing water productivity**

Five integrated rain water management technologies *viz.*, conservation agriculture (CA) in rice and maize based cropping systems, roof water harvesting (RWH) for diversified use, multiple use of pond water (MUW) for enhancing water productivity, raised and sunken bed (RSB) technology for crop diversification and system of rice intensification (SRI) for higher productivity were demonstrated in a participatory mode in 70 farmers field covering 30 villages across Ri-Bhoi District, Meghalaya during 2010-12. The productivity enhancement with rice-pea sequence under conservation tillage was 229% compared to farmers' practice of rice monocropping. The rice equivalent yield (REY) recorded with rice-pea sequence was 2143 kg from 2000 $m^2$ (10.7 t/ha). Similarly, maize-French bean under conservation tillage recorded 168% higher maize equivalent yield compared to monocropping of maize. Due to roof water harvesting and subsequent recycling of harvested water for crop/livestock production, the system productivity enhanced by 304% and multiple use of pond water for diversified farming activities enhanced system productivity by 375% compared to farmers' practice. Adoption of raised and sunken bed (RSB) system resulted maximum enhancement in system productivity (348%) compared to monocropping of rice (farmers' practice) under conventional practice in lowland. System of rice intensification enhanced rice productivity by 40%. Multiple use of pond water for crop, fruit, livestock and fishery gave a net return of Rs. 30,350/- from 2000 $m^2$ area which was 312% higher than the farmers' practice (no integration). The maximum enhancement in net return was observed with RSB (487%) followed by maize-French bean under conservation agriculture (465%) over respective farmers' practices.

Raised and sunken bed technology generated maximum employment of 60 man-days from 1000 $m^2$ area whereas, multiple use of pond water for harnessing complementary interaction of crop-fish-livestock generated 73 man days from 1500 $m^2$ area in a year compared to 11 and 24 man-days under respective farmers' practices. Adoption of various conservation measures and crop diversification enhanced water use efficiency (WUE) by 12 % with maize-*toria* system under CA to as high as 373% under MUW. Maximum WUE was achieved with rice-pea system under CA (19.69 kg/ha/mm) followed by diversified use of water under RWH (15.88 kg/ha/mm) compared to 5.99 to 7.79 kg/ha/mm under monocropping of rice and 6.23 kg/ha/mm under monocropping of maize under farmers' practice. The WUE recorded with multiple use of water was 1.56 kg fish/ha/mm (10.4 kg rice/ha/mm) compared to 0.33 kg fish/ha/mm under farmers' practice. The water productivity of rice- pea system was Rs. 9.57/$m^3$ water compared to Rs. 2.66/$m^3$ water under farmers' practice. The cost of water harvesting through roof water harvesting system was estimated at Rs.119/$m^3$ and the water productivity was Rs. 583/$m^3$ hence benefit or cost ratio of roof water harvesting was 5:1.

## ORGANIC FARMING

**Management of soil fertility using organic inputs in important vegetable crop based multiple cropping systems**

A field experiment was laid out under Network Project on Organic Farming to evaluate the efficacy of various on farm and off farm produced organic sources of nutrients/formulations on productivity and soil health. The recommended dose of fertilizer was 80: 60: 40 kg/ha of NPK, respectively. Organic manures such as FYM and vermicompost was selected as base manure and applied on N-equivalent basis. P requirement was adjusted by applying rock phosphate (Mussorie). All the crop residues of previous crops were recycled within the plot for improvement of soil fertility.

Result revealed that significant increase in crop growth and grain yield of maize were recorded in all the cropping sequences and nutrient management sources over control (Fig 1). Integrated application of 50% RDNP through FYM and 50% RDNP through

**Fig 1 Organic crop production under vegetables based cropping system**

vermicompost recorded maximum grain yield of maize and green pod yield of French bean, however, 100% RDNP through FYM produced comparable yield with that of integrated nutrient source in case of tomato. Maximum yield of potato was recorded with 100% RDNP through vermicompost and was found at par with 100% RDN through FYM. Maximum available N, P and K were recorded under integrated followed by sole application of FYM. The SOC enhanced by 28% under integrated compared to initial SOC (1.80%) after 7 cropping cycles. The soil microbial biomass carbon (SMBC) was recorded significantly higher under integrated (272.52 µg/g dry soil) followed by sole application of FYM (267.44 µg/g dry soil) than other treatments. Maize + soybean – French bean (256.12 µg/g dry soil) cropping system registered significantly SMBC compared to other systems.

**Management of soil fertility using organic inputs in important field crop based multiple cropping systems**

Integrated application of 50 % RDNP through FYM and 50% RDNP through vermicompost (VC) along with spraying of *panchagavya* (PG) recorded maximum grain yield of maize, *toria* and French bean followed by 50% RDNP through FYM + 50% RDNP through VC. Integrated application of 50% RDNP through FYM + 50% RDNP through VC along with PG and 50% RDNP through FYM + 50% RDNP through VC were recorded comparable green cob yield of maize, seed yield of *toria* and pod yield of French bean (Table 1). Improvement in physico-chemical properties of soil was observed due to application of different organic manures. Among the nutrient sources, maximum SMBC was recorded with FYM+VC+ PG (204.74 µg/g dry soil) compared to other nutrient supply after 4 cropping cycles.

**Production and economics of organic farming systems**

Two organic farming system experiments one each for valley and terraced land (Fig 2) condition was evaluated under organic production practices. The integrated farming system model (0.68 ha) for valley land included vegetables (potato, tomato, carrot, French bean, cabbage, okra, brinjal), composite fish culture, a dairy unit, lowland rice, fodder component and fruits in pond embankments. The model under terrace condition included fruits + legume, spice crops (ginger/turmeric), oilseeds (groundnut, *toria*), pulses (black gram, French bean), cereals (rice & maize), etc.

In the models, vermicomposting, leguminous hedge row species (*Tephrosia* sp) on fences, green leaf manuring, application of farmyard manure, rock phosphate, neem cake etc. was followed for managing soil fertility and providing nutrition to crops. The results revealed that rice equivalent yield enhanced by 4 times and net return enhanced by three times in valley land farming system. Similarly, the productivity enhancement under terrace condition was four times


**Fig 2 Organic farming system in upland terrace conditions**

**Table 1 Yield (t/ha) of crops as influenced by various sources of nutrient supply**

| Nutrient sources | Maize-*toria* (Seed) | | Maize (green cob) -French bean | |
|---|---|---|---|---|
| | Maize | *Toria* | Maize | French bean |
| 50% RDNP through FYM + 50% RDNP through VC | 3.36 | 0.53 | 70.75 | 8.64 |
| 50% RDN through FYM + 50% RDN through VC +PG | 3.52 | 0.56 | 23.77 | 2.37 |
| PG (3%) spray | 1.43 | 0.09 | 73.73 | 9.10 |
| Biodynamic manure | 1.50 | 0.11 | 21.49 | 2.15 |
| PG+ Biodynamic manure | 2.99 | 0.17 | 25.54 | 2.55 |
| Control | 0.66 | 0.04 | 9.10 | 0.91 |
| CD (*P* =0.05) | 0.52 | 0.06 | | 8.40 |

compared to maize monocropping. Hence, farming system approach is a viable alternative for enhancing productivity and income under organic production practices.

## BIOORGANICS

### Chemo Profiling of Bioorganic $GF_1$

The bioorganic developed for ginger crop ($GF_1$) was sent for chemo profiling at Shriram Institute for Industrial Research, New Delhi. The material was subjected to Liquid Chromatographic Profile using RI Detector and Liquid Chromatographic Profiling of the herbal extract using PDA-detector and LC-MS/MS. The observations were as follows:

*i)Liquid Chromatographic Profile using RI Detector*

The data obtained from HPLC study using RI detector indicated the presence of two sugar compounds namely fructose (0.03%) & inositol (0.06%) in the herbal extract.

The finding has been presented in table 1 below:

**Table 1 Liquid Chromatographic profiling of the herbal extract using Refractive Index Detector (Sugar Profiling)**

| Component | Content (%) |
|---|---|
| Fructose | 0.03 |
| Inositol | 0.06 |
| Glucose, Sucrose, Maltose & Raffinose | Not detected |

*ii) Liquid Chromatographic Profiling of the herbal extract using PDA-detector and LC-MS/MS:*

The HPLC chromatogram showed the presence of eight components in the extract.

The findings of this study have been given in the following table 2.

The findings of the above studies carried using different chromatographic techniques indicated that the given herbal extracts contains ethanol, sugars and various phyto-compouds.

## CROPPING SYSTEM RESEARCH

### Effect of soil acidity amelioration practices on different maize varieties

Second year field experiment was carried out to study the effect of three ameliorating practices (furrow application of lime @ 500 kg/ha, FYM @ 10 t/ha, furrow application of lime @ 250 kg/ha + FYM @ 5 t/ha) compared with control (recommended dose of NPK) over five varieties of maize (Vijay Composite, RCM 1-1, RCM 1-3, RCM 75 and RCM 76). Among ameliorating practices, furrow application of lime @ 250 kg/ha + FYM @ 5 t/ha gave highest grain yield (4.86 t/ha) which was followed by furrow application of lime @ 500 kg/ha (Table 1). There was no significant effect on grain yield of maize among different varieties although RCM 1-3 recorded highest grain yield (4.58 t/ha). The variety RCM 1-3 recorded higher grain yield (5.28 t/ha) with the furrow application of lime@ 250 kg/ha + FYM @ 5 t/ha.

### Evaluation of sea weed sap on performance of maize and rice

Field experiments were conducted during the rainy (*kharif*) season to study the effects of foliar application of different concentrations of seaweed extracts prepared from *Kappaphycus* sp. (K sap) and *Gracilaria* sp. (G sap) on growth, yield and quality of maize and rice. Among K saps, 15% K sap concentration recorded relatively higher dry matter accumulation, LAI, yield attributes of maize and rice. It was closely followed by 10% K sap application. Similar trend was also observed in case of G sap. Application of 15% K

**Table 2 Liquid chromatographic profiling of the herbal extract using PDA-detector and LC-MS/MS**

| Peak no. | Retention time (min) | Normalized Per centage (by HPLC) | Molecular mass (by LCMS/MS) | Name of probable compounds |
|---|---|---|---|---|
| 1 | 4.7 | 18.2 | 134.13 | m-cymol |
| 2 | 5 | 2.7 | 180.16 | Feluric acid |
| 3 | 5.2 | 2.9 | 238.24 | 3-Hydroxyflavanone |
| 4 | 5.5 | 12.1 | 454.68 | Betulinic acid |
| 5 | 5.8 | 32.5 | 168.23 | Diphenylmethane |
| 6 | 6.7 | 3.0 | 463.41 | O-beta-D-glucopyranoside |
| 7 | 7.1 | 1.7 | 472.70 | Terminic acid/Maslinic acid |
| 8 | 7.3 | 26.9 | 136.23 | 2,6-dimethyl-2,4,6-Octatriene/Terpinene/Phyllandrene/ Ocimene/Camplene/Pinene/Limonene/Myrcene |

**Table 1 Effect of ameliorating practices on grain yield (t/ha) of different varieties of maize**

| Treatment ☞ / Variety ☟ | Recommended NPK ($T_1$) | $T_1$ + Lime (500 kg /ha) | $T_1$ + FYM (10 t/ha) | $T_1$ + Lime (250 kg/ha) + FYM (5 t/ha) | Mean (Variety) |
|---|---|---|---|---|---|
| Vijay | 3.92 | 4.29 | 3.97 | 4.45 | 4.16 |
| RCM1-1 | 3.51 | 4.51 | 3.67 | 4.62 | 4.08 |
| RCM1-3 | 3.93 | 4.77 | 4.33 | 5.28 | 4.58 |
| RCM 75 | 3.53 | 4.78 | 4.38 | 5.21 | 4.48 |
| RCM 76 | 3.61 | 4.53 | 4.13 | 4.73 | 4.25 |
| Mean (Treatment) | 3.70 | 4.58 | 4.10 | 4.86 | |
| CD (*P*=0.05) for Treatment (T) = | 0.48 | | | | |
| CD (*P*=0.05) for Variety (V) = | NS | | | | |
| CD (*P*=0.05) for T x V = | NS | | | | |

sap, 10% K sap and 15% G sap sprays significantly increased the maize yield by 13.1%, 11.4% and 10.4%, respectively over control (water spray). There was no significant difference between K saps and G saps in terms of growth and productivity of maize and rice. As regards to both of K saps and G saps, lower level (2.5% and 5%) application did not make considerable impact on maize and rice performance. 7.5% K saps along with 50% RDF recorded lowest parameters for growth as well as yield of maize. The nitrogen (N) content in maize (1.8%) and rice (1.5%) as well as protein content in maize grain (10.47%) was significantly highest in 15% K sap followed by 15% G sap than control. However, P and K content in maize and rice grain did not vary significantly with the treatments although there is an upward trend of their concentration with incremental dose of sea weed saps. Increasing amount of sea weed sap concentration (for both K and G sap), increased the amount of nutrient uptake (N, P & K) and was lowest in 7.5% K saps with 50% RDF.

## FORAGE CROPS

Six advanced lines of forage cowpea were evaluated in RBD with three replications. The yield of 8.01 t/ha was recorded with AVTC 1 followed by AVTC 2 (7.66 t/ha) while lowest green fodder was recorded with AVTC 4. The five advanced 2 lines of forage cowpea were also evaluated. Highest green forage yield of 9.74 t/ha was recorded with AVTC-2-5 which was significantly superior to rest of the advanced line tested under the trial. Another forage cowpea trial was conducted with five advance line of forage cowpea namely AVTCS 2-1 to AVTCS 2-5 revealed maximum plant height of 84.75 cm with AVTCS 2-2 which was statistically at par with AVTCS 2-1 and AVTCS 2-5. The leaf to stem ratio was maximum with AVTCS 2-3 which was on power with AVTCS 2-2 and AVTCS 2-5. However, the production efficiency was maximum with AVTCS 2-2 and AVTCS 2-5 resulting into highest green forage yield of 8.75 t/ha with AVTCS 2-5 followed by AVTCS 2-2 (8.17 t/ha). The forage yield recorded with AVTCS 2-3 was also comparable. Initial varietal trial in ricebean namely IVTR 1- IVTR 7 were tested for their forage yield during *kharif* season. At 85 days age stage, highest plant height of 71.94 cm was recorded with IVTR 1 which was almost similar to the plant height of 70.02 cm registered by IVTR 6. However, production efficiency was maximum with IVTR 2 (0.12 t/ha/day) followed by IVTR 1 (0.11 t/ha/d) resulting into improvement in green forage yield IVTR 2 which was almost equal to the yield recorded by IVTR 1. The second advanced varietal trial on forage in Ricebean, AVTR 2-2 attained maximum plant height of 83.2cm with highest leaf stem ratio. However, maximum production efficiency of 0.11 t/ha/day was registered by AVTR 2-3. The green fodder yield followed the similar pattern by registering highest green fodder yield of 9.63 t/ha in AVTR 2-3 followed AVTR 2-2. Forage rice bean trial was conducted with three advance line of forage cowpea namely AVTRS 2-1 to AVTRS 2-3 revealed that the leaf to stem ratio was maximum with AVTRS 2-1 (0.29) followed by AVTRS 2-3 (0.15) and AVTRS 2-2 (0.14). However, the production efficiency was maximum with AVTRS 2-1 resulting highest green forage yield of 10.9 t/ha followed by AVTRS 2-2 (9.85 t/ha).

### Effect of phosphorus level on growth and yield of rice bean

Phosphorus dose of promising line of AVTR 2-1 and AVTR 2-3 ricebean were standardized with four

levels (0, 30, 60 and 90 kg $P_2O_5$ /ha). Plant height and leaf/stem ratio was recorded significantly higher with AVTR 2-1 than AVTR 2-2 which resulted in significantly higher green forage yield. Application of phosphorus at increased level did not influence the plant population but plant height and leaf/stem ratio significantly improved at increased level up to 60 kg $P_2O_5$/ha, thereafter, at 90 kg $P_2O_5$/ha no significant effect was noticed. The green fodder yield followed the similar trend by registering highest yield at 60 kg $P_2O_5$/ha which was significantly higher than 0 and 30 kg $P_2O_5$/ha (Table 1).

**Table 1 Response of rice bean lines to phosphorus level**

| Treatment | Plant population ($m^2$) | Plant height (cm) | Leaf/ stem ratio | Green fodder yield (t/ha) |
|---|---|---|---|---|
| **Cultivars** | | | | |
| AVTR 2-1 | 22.00 | 47.65 | 0.72 | 6.69 |
| AVTR 2-2 | 23.58 | 42.34 | 0.66 | 6.98 |
| CD (*P*=0.05) | NS | 3.75 | NS | 0.45 |
| **Phosphorus level (kg/ha)** | | | | |
| 0 | 21.33 | 32.58 | 0.62 | 5.58 |
| 30 | 22.83 | 43.72 | 0.67 | 6.00 |
| 60 | 23.83 | 52.05 | 0.73 | 7.07 |
| 90 | 23.17 | 51.64 | 0.74 | 6.93 |
| CD (*P*=0.05) | NS | 1.75 | 0.18 | 0.31 |

## DEVELOPMENT OF MARSHY LAND FOR CROP PRODUCTION

### Evaluation of groundnut based cropping system

The marshy land was developed by making raised and sunken bed system in which the ratio of raised and sunken bed was standardized. (2:3 raised to sunken bed) having 3-5 feet depth. Rice and maize based cropping system for raised bed had also been identified. Since groundnut is emerging as a potential crop, groundnut based cropping system is also being identified and confirmed through continuing the experiment which comprised of seven winter/summer vegetables grown after groundnut and were compared with groundnut fallow system. The yield of groundnut was marginally less when grown in sequences than groundnut-fallow. Maximum yield reduction was noticed when groundnut was grown after radish (1.63 t/ha) while minimum reduction was recorded with French bean (3.73 t/ha) which was 4.40% less than the yield recorded with groundnut fallow system. The total system productivity in terms of groundnut equivalent yield (GYY) was significantly improved due to various cropping sequence as compared to groundnut fallow. Highest GYE of 16.3 t/ha was obtained with groundnut –tomato cropping system followed by groundnut –carrot (1.55 t/ha). The lowest GYE of 8.27 t/ha was recorded with groundnut-cauliflower.

The groundnut crop was also sequenced with field crops in which *toria*, rajma, rice bean, lentil linseed and wheat were compared with groundnut-fallow. It was observed that non-leguminous crops significantly reduced groundnut yield as compared to legume crops. Maximum yield reduction was recorded with *toria* and wheat. The total system productivity in terms of groundnut equivalent yield (GEY) was maximum with groundnut-linseed (6.67 t/ha). The lowest GYE of 3.01 t/ha was recorded with groundnut - *toria* which was, however, 18.05% higher than groundnut-fallow system under mid hill altitude of North East India.

### Response of sunken bed rice to width of raised bed and types of crops grown on raised bed

The effect of raised bed width and types of crops grown on raised bed on the yield of rice grown in sunken beds was assessed. Raised bed width of 1m, 2m, 3m and 4m on which different stature crop like maize, rice, soybean and groundnut were sown on raised bed and the effect of these crops was assessed on the yield of rice grown in sunken bed. It was observed that the yield of sunken bed rice was significantly reduced with the height of the crops grown in the raised bed. Maximum yield reduction in rice was noticed due to maize and minimum with groundnut. The yield reduction in rice with different crop in follows the order of maize > rice> soybean > groundnut. The raised bed width of 1m had less effect on the yield of rice grown in sunken beds while other raised bed widths were at par with each other. The interaction of types of crops and raised bed width was significant recording highest yield of 3.74 t/ha due to groundnut grown on raised bed width of 2.0 m followed by the same crop grown on 1.0 m raised bed width.

### Effect of raised bed height on vegetable crops during winter season

The effect of different raised bed heights on winter vegetables was also evaluated by growing cabbage, cauliflower, pea, carrot and radish at 20, 30, 40 and 50 cm raised bed height. Results showed that highest yield in terms of cabbage equivalent yield (CEY) at 40 cm raised bed height was similar to 30 cm raised bed

height. Amongst the crops, maximum CEY of 26.5 t/ ha was recorded with pea followed by cabbage. Radish was the lowest yielder. It was also observed that the yield of crops significantly improved with the increase of raised bed height (up to 40 cm) except cabbage which registered maximum yield up to 30 cm while pea crop yield increased up to 50 cm height of raised bed indicated that legumes crops could be successfully grown up to 50 cm while other vegetables realized high yield with 30 x 40 cm size of raised bed.

**Effect of cauliflower based intercropping system on system productivity**

The interspaces of wide space cole crops were utilized by growing of intercrops. Amongst the intercrops, pea, methi, coriander and carrot were identified promising for improving total system productivity. Thereafter, to increase the productivity of intercropping system row, ratio of intercrops in 1:1 and 1:2 ratio with cauliflower were tested. Highest cauliflower yield was observed with sole crops as compared to intercropping system which was higher with 1:1 ratio as compared to 1:2 ratio. Amongst the intercropping systems, maximum yield of 14.1 t/ha was recorded with cauliflower + pea (1:1) followed by cauliflower + *methi* (13.5 t/ha), while lowest was recorded with cauliflower + carrot in both the ratios. Amongst the intercrops, highest cauliflower equivalent yield (CEY) of 6.91 t/ha was recorded with carrot grown with cauliflower in 1:2 row ratio. However, the total system productivity of 18.1 t CEY/ha was recorded with cauliflower + pea (1:2) followed by cauliflower + pea (1:1) ratio indicated that pea was the less competitive crop in improving total system productivity of cauliflower based intercropping system. Hence, pea crop can be recommended with cauliflower based intercropping system for sustainable production under mid hill altitude of Meghalaya.

**Development of rice-fish system for sunken bed area**

Five rice + fish systems were compared with rice as well as fish alone. Rice yield significantly improved when grown in association with fish. The yield further improved when rice + fish system were either supplemented with supplementary feed for fish or adoption of azolla dual cropping with rice. Highest rice yield of 5.0 t/ha was recorded with rice + fish + azolla + feed which was however 1% higher than rice + fish + azolla system indicated that azolla was sufficient enough to provide feed required for fish in rice + fish system. Amongst the fish species the growth of both species were at par depending on the fingerlings density. The common carp yield of 416.75 kg/ha was recorded with rice + fish + azolla + food followed by rice + fish + food system. But highest fish yield was recorded when fish was reared in pond with artificial feeding which registered 718.22 kg/ha.

**Performance of *rabi* crops in different ecologies**

Pea based cropping sequences were evaluated on raised beds in marshy land area as well as on upland dry terraces in hill slopes ecosystem. Amongst the two ecosystems, raised bed recorded the highest pea yield of 2.1 t/ha which was 21.62 % higher than that of dry terraces. Among *kharif* crops maximum pea equivalent yield (PEY) of 5.12 t/ha was recorded with Frenchbean followed by maize crop. The yield of pea was comparatively higher when grown after legumes recording the highest yield of 2.24 and 2.10 t/ha when grown after French bean and groundnut, respectively. The lowest pea yield was recorded when grown after rice and maize crops. The total system productivity (TSP) was maximum with raised bed (5.13 t/ha) and lowest with dry terraces (4.37 t/ha) indicated suitability of raised bed for obtaining higher yield than that of dry terraces. Amongst the cropping system highest, TSP was recorded with French bean- pea cropping system (7.37 t/ha), while lowest was with rice – pea (3.154 t/ha).

**Effect of ecologies on lentil production**

Lentil crop was assessed after *kharif* crops under two ecosystems. There were four cropping system tested in two environment in split plot design with three replications. The lentil equivalent yield (LEY) was more with dry terraces during *kharif* season while during *rabi* season highest lentil yield was observed due to raised bed as compared to dry terraces. However, the total system productivity of both the ecosystem was almost at par due to less water requirement of lentil crop during winter season.

Amongst the *kharif* crops, highest lentil equivalent yield (LEY) of 5.14 t/ha was recorded with okra followed by French bean (2.75 t LEY) indicating profitability of vegetables in the cropping systems. Lentil yield was higher when grown after legume crops as evident from the highest lentil yield of 1.79 t/ha when grown after French bean followed by groundnut. Lentil yield was lowest when grown after maize.

Higher LEY of okra and French bean enhanced total system productivity (TSP). Maximum TSP of 6.71 t/ha was recorded with okra–lentil cropping system followed by French bean - lentil. The lowest TSP of 2.64 t/ha was recorded with groundnut -lentil which was 154.22 per cent lower than that of okra - lentil cropping system under study.

## WATER MANAGEMENT

### Residue management and conservation tillage in rice-based system

The grain yield of *rabi* crops (pea, mustard, wheat and lentil) was increased significantly due to mulch compared to no-mulching. Further, zero tillage for *rabi* crops along with residue retention resulted significantly higher yield of crops compared to other tillage and residue management practices.

**Table 1 Effect of mulching, and conservation tillage on yield of *rabi* crops (2011-12)**

| Treatment | Yield kg/ha | | | |
|---|---|---|---|---|
| | Pea | Mustard | Wheat | Lentil |
| Mulch | 1250 a | 296.3 a | 2045 a | 397.5 a |
| No mulch | 1046 b | 296.3 b | 1732 b | 346.3 b |
| **Tillage** | | | | |
| CT- residue removal | 1100 bc | 213.3 c | 1488 c | 310.8 b |
| ZT for all crops, residue retention | 1160 b | 335.0 a | 1128 c | 410.8 a |
| ZT For *rabi* crops, residue retention | 1250 a | 253.3 b | 2025 b | 440.8 a |
| Reduced tillage, residue Incorporation | 1080 c | 279.2 b | 2913 a | 325.0 b |

The soil moisture content at 0-45 cm depth was marginally higher under the mulching plot compared to no mulch plot. The moisture content among the tillage practices was higher under zero tillage for all crops. However, the moisture content at 60 and 90 DAS was almost at par under both the tillage systems (Fig 1).

The grain yield of rice was 5.8 t/ha under zero tillage with residue retention followed by the treatment where reduced tillage was practiced along with residue incorporation. The lowest grain yield of rice was recorded in the treatment where zero tillage was practiced for *rabi* crops.

### Conservation agriculture in rice for enhancing resource use efficiency and crop diversification

Different conservation measures were evaluated for improving productivity of *rabi* crops. The yield of pea and mustard was significantly increased due to mulching compared to no mulching. The yield pea and mustard was significantly higher under conventional tillage - conventional tillage both in rice and *rabi* crops (Table 2).

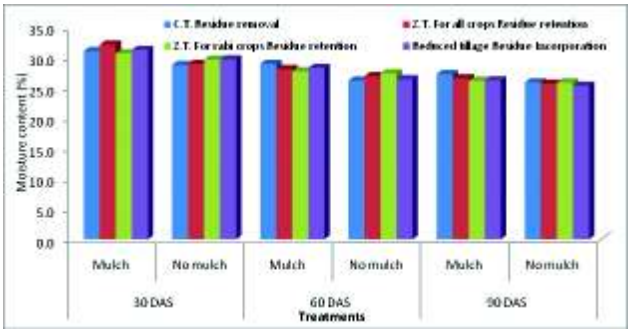



**Fig 1 Moisture content (%) in 0-45 cm under various treatments**

**Table 2 Effect of residue management and conservation tillage for *rabi* crops (2011-12)**

| Treatment | Yield (kg/ha) | |
|---|---|---|
| | Pea | Mustard |
| Mulch | 1494a | 493.8a |
| No mulch | 1300b | 368.8b |
| **Tillage** | | |
| Conventional - Conventional | 1650a | 512.5a |
| Furrow Raised Bed – FRB | 1338b | 487.5ab |
| Conventional - FRB | 1350b | 350.0c |
| Conventional – Zero Tillage | 1250b | 375.0bc |

The soil moisture content at 0-45 cm depth was marginally higher under the mulching plot compared to no mulch plot. The moisture content among the tillage practice was higher under furrow raised bed – furrow raised bed compared to other tillage practices.

The highest grain yield of rice obtained under Conventional – Furrow Raised Bed (FRB) tillage system was at par with the treatment where conventional tillage – conventional tillage system was followed (Table 3). Straw yield and harvest index of rice followed the similar trend as that of grain yield. The lowest grain yield of rice was recorded under Furrow Raised Bed - Furrow Raised Bed (FRB) tillage practices. Different tillage practices could not exert any significance influence on weed density and dry weight.

**Table 3 Yield attributes and yield of rice as influenced by various tillage practices**

| Treatment | Total population no./ 0.5 $m^2$ | Dry wt. (g)/ 0.5 $m^2$ | No. of panicle/ hill | Grain/ panicle | Plant dry wt. (g) | 1000 seed wt. (g) | Grain yield (kg/ha) | Straw yield (kg/ha) | Harvest Index |
|---|---|---|---|---|---|---|---|---|---|
| Conventional- CT | 31.50 | 30.07 | 11.6 | 90.3 | 39.3 | 24.3 | 5600 | 9333 | 37.4 |
| Furrow Raised Bed- FRB | 27.67 | 38.60 | 8.6 | 65.3 | 38.8 | 20.8 | 2300 | 8500 | 32.4 |
| Conventional- FRB | 34.83 | 32.40 | 9.2 | 100.0 | 44.3 | 28.0 | 6833 | 9466 | 41.9 |
| Conventional- Zero Tillage | 39.50 | 35.63 | 10.0 | 86.3 | 38.4 | 24.4 | 4666 | 9033 | 34.0 |
| CD (*P*=0.05) | NS | NS | 1.9 | 25.4 | NS | 5.2 | 988.2 | 890.9 | 3.8 |

**Evaluation of resources conserving option on productivity and water use efficiency (WUE) of maize - *toria* cropping system**

The seed yield of *toria* was highest under conventional tillage (374 kg/ha) followed by zero (353 kg/ha) but the stover yield was highest under zero tillage (3327 kg/ha) followed by conventional tillage (2697 kg/ha). Seed yield of mustard under residue management practices was highest under maize + groundnut paired row (residue removal) (295 kg/ha) followed by maize + soybean paired row (residue retention) (293 kg/ha). The stover yield was highest under maize + groundnut paired row (residue retention) followed by maize + in-situ green manure (residue removal). The lowest seed yield was obtained under maize + in-situ green manure (residue removal) (253 kg/ha) followed by maize + soybean paired row (residue removal) (255 kg/ha).

The soil moisture content at 0-45 cm depth was marginally higher under zero tillage over conventional tillage. The moisture content of the soil increased gradually from 30 and 60 DAS and slightly decreased in 90 DAS. No significant differences in grain yield and maize equivalent yield (MEY) due to tillage practices was observed. The under straw yield of maize followed the similar trend as that of grain yield. Maize equivalent yield under residue management practices was highest under maize + groundnut paired row (residue removal) (5108 kg/ha) followed by maize + groundnut paired row (residue retention) (4733 kg/ha). The straw yield was highest under maize + In-situ green manure (residue retention) followed by maize + In-situ green manure (residue removal). The lowest maize equivalent yield was obtained under maize + In-situ green manure (residue removal) (3218 kg/ha) followed by maize sole (residue retention) (3428 kg/ha).

Both tillage practices and intercropping systems significantly influenced the weed density and dry weight (Fig 2). Significantly lower weed density and dry weight accumulation was recorded under conventional tillage. Significantly higher weed density and dry weight accumulation was also recorded under sole maize with or without residue retention. Maize + groundnut intercropping recorded the lowest weed population.

Maize + soybean

Maize + groundnut

**Fig 2 Crop performance under different tillage and residue practices**

**Conservative measures through broad leaved vegetables and maize intercropping in terrace situation.**

Maize intercropped with ash gourd was found to be the best system for the terrace condition of mid altitude of Meghalaya as this system recorded maximum soil moisture and grain yield of Maize. The lowest grain yield was recorded under Maize + Cucumber followed by Maize sole (Table 4).

Sole maize recorded significantly higher weed density and dry weight, while maize + ash gourd system recorded the lowest weed density and dry weight.

**Efficient water management in strawberry through micro irrigation**

The soil moisture content at 0-45 cm depth was generally higher under plastic mulch over straw mulch (Fig 3). Among the irrigation levels, highest soil moisture content was recorded under irrigation at 1.2 EPan at 30 DAS. At 60 & 90 DAS highest soil moisture content was recorded under 1.0 EPan followed by 0.8 and 1.2 EPan.

The yield attributes and berry yield of strawberry was highest under black polythene mulch than straw mulch. Among the irrigation levels, irrigation at 1.0 EPan resulted in maximum berry yield followed by irrigation at 1.2 EPan indicating the need for providing adequate water to the crop. Excess water over 1.0 PET is a waste especially under mulching, the berry yield was also found best under 1.0 PET (Table 5).

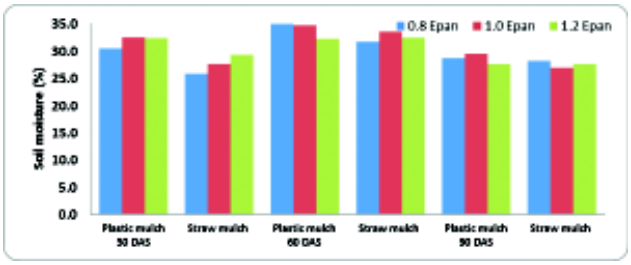



**Fig 3 Moisture content (%) in 0-45 cm under various treatments**

**Effect of mulching and drip irrigation on growth and yield of tomato under terrace condition**

The soil moisture content at 0-45 cm depth was generally higher under 60 DAP after planting (DAP) compared to 30 DAP in different treatments. At 30 DAP, the highest soil moisture was recorded under drip irrigation + black polythene mulch. At 60 DAP, the soil moisture content was marginally higher under rice straw mulching and drip irrigation compared to rest of the treatments. The fruit yield of tomato was highest under drip irrigation + rice straw mulching followed by rice straw mulching. The lowest fruit yield of tomato was recorded under drip irrigation followed by farmers' practice (Table 6).

Weed density was significantly higher in the treatment that received drip irrigation; the lowest weed density was recorded under rice straw mulching. Similarly, the lowest weed dry weight was recorded under rice straw mulching and was at par with the

**Table 4 Performance of maize as influenced by intercropping with broad leaved vegetables**

| Treatment | Total population no./ 0.5m² | Dry wt. (g)/ 0.5m² | Plant dry wt. (g) | Wt. of cob (g) | No. of seed / cob | Root dry wt. (g) | 1000 seed wt. (g) | Grain yield (kg/ha) | Straw yield (kg/ha) | Harvest Index |
|---|---|---|---|---|---|---|---|---|---|---|
| Maize sole | 107.3 | 14.2 | 169.5 | 21.3 | 154.8 | 43.6 | 169.5 | 3783 | 7433 | 33.8 |
| Maize + Pumpkin | 100.0 | 13.55 | 164.1 | 23.0 | 130.1 | 42.2 | 164.1 | 4033 | 7767 | 34.2 |
| Maize + Cucumber | 80.3 | 12.15 | 167.8 | 23.8 | 156.2 | 42.4 | 167.8 | 3767 | 7767 | 32.7 |
| Maize + Ash gourd | 77.8 | 11.5 | 182.7 | 19.0 | 152.1 | 45.9 | 182.7 | 4333 | 7800 | 35.7 |
| CD(*P*=0.05) | 22.39 | 1.74 | 10.4 | NS | NS | NS | 10.4 | 471.1 | NS | NS |

**Table 5 Growth, yield attributes and yields of strawberry as influenced by different mulching**

| Treatment | No. of berry/ plot | | | Berry wt. (kg/ plot) | | | Berry yield (kg/ ha) | | |
|---|---|---|---|---|---|---|---|---|---|
| Irrigation levels (EPan) | Plastic mulch | Straw mulch | Mean | Plastic mulch | Straw mulch | Mean | Plastic mulch | Straw mulch | Mean |
| 0.8 | 217 | 149 | 183.0 | 1.8 | 2.1 | 1.9 | 2446 | 2893 | 2669 |
| 1.0 | 429 | 292 | 360.5 | 3.8 | 2.7 | 3.2 | 5226 | 3689 | 4458 |
| 1.2 | 311 | 227 | 269.0 | 3.1 | 2.5 | 2.8 | 4240 | 3429 | 3835 |
| Mean | 319.0 | 222.7 | - | 2.9 | 2.4 | - | 3971 | 3337 | - |

**Table 6 Growth, yield attributes and yields of tomato as influenced by different mulching**

| Treatment | Plant height (cm) | Fruit/plant | Fruit yield (kg/ha) | Straw yield (kg/ha) |
|---|---|---|---|---|
| Drip irrigation | 39.6abc | 12.4c | 25000c | 1400ab |
| Drip irrigation +Rice straw mulching | 41.2bc | 34.0a | 35000a | 1500a |
| Drip irrigation + black Polythene mulching | 37.6bc | 24.2b | 29444b | 1400ab |
| Rice straw mulching | 45.7a | 25.9b | 30000b | 1350bc |
| Farmer's practice | 45.4a | 19.8bc | 26333c | 1200d |

treatment that received drip irrigation+ rice straw mulching. Significantly higher weed dry weight was recorded under drip irrigation.

## AGROFORESTRY

### Development of self-sustainable integrated farming system

### Productivity of annual crops

Yield of groundnut (1.30 t/ha) was comparatively higher under *Gmelina arborea* (Gamhar) than *Alnus nepalensis* (Alder) while it was reverse in case of upland paddy. Under hedge row, the productivity of other crops are 2.44 t/ha (soybean), 11.6 t/ha (turmeric), 5.90 t/ha (ginger), 2.61 t/ha (low land paddy), 0.79 t/ha (mustard), 0.56 t/ha (rape seed var.TS 36), 0.67 t/ha (rape seed var. Varuna) and 582 kg/ 0.14 ha (vegetables) (Table 1).

**Table 1 Productivity (t/ha) of annual crops in IIFS field**

| Crop | Variety | Under Alder | Under Gamhar | Under Hedge row |
|---|---|---|---|---|
| Groundnut | ICGS 76 | 1.19 | 1.30 | |
| Paddy (Upland) | Bhalum 1 | 1.27 | 1.11 | |
| Soyabean | JS 335 | | | 2.44 |
| Turmeric | Lakadong | | | 11.6 |
| Ginger | Nadia | | | 5.90 |
| Paddy (Lowland) | Shasarang | | | 2.61 |
| Mustard | M 27 | | | 0.79 |
| Rape seed | TS 36 | | | 0.56 |
| Varuna | | | 0.67 | |

### Impact of lime and phosphorus on upland paddy yield

Increase in productivity of upland paddy (Bhalum 1) to the tune of 32, 24 and 42 per cent was observed under alder, gamhar and hedge row, respectively when the field treated with lime and 80% recommended dose of SSP (Table 2).

**Table 2 Impact of lime and phosphorus application on grain yield (t/ha) of upland paddy under different land uses**

| Treatments* | Land uses | | |
|---|---|---|---|
| | Under Alder | Under Gamhar | Under Hedge raw |
| $L_0P_0$ | 1.13 | 0.93 | 0.99 |
| $L_0P_1$ | 1.14 | 1.07 | 1.25 |
| $L_0P_2$ | 1.24 | 1.13 | 1.44 |
| $L_1P_0$ | 1.15 | 1.12 | 1.28 |
| $L_1P_1$ | 1.33 | 1.19 | 1.65 |
| $L_1P_2$ | 1.66 | 1.23 | 1.71 |

*$L_0$ - No Lime, $L_1$ - Lime @ 2.5 t/ha, $P_o$ - No SSP, $P_1$- 40% recommended dose of SSP,
$P_2$ - 80% recommended dose of SSP

### Influence of bio-organics on ginger and turmeric

Turmeric rhizomes treated with bio-organics (22 L) recorded 28 per cent higher yield than the untreated one. Similarly, 11 per cent increase in ginger yield was observed when treated with bio-organics (GF 1).

### Evaluation of lentil varieties under different conditions

The grain yield of lentil was more with addition of vermicompost and mulching irrespective of varieties. On an average 25 per cent increase in yield was observed with incorporation of vermicompost. About

**Fig: 1 Heavy fruiting in genotype MGHMP-06 of *Mucuna pruriens***

17 per cent (with vermicomposting) and 37 per cent (without vermicomposting) more yield was recorded due to mulching. Among the seven lentil varieties tested PL 126 outperformed followed by PL 211 and PL 639 (Table 3).

**Table 3 Grain yield (kg/ha) of lentil varieties under different practices**

| Varieties | No vermicompost | | | Vermicompost | | |
|---|---|---|---|---|---|---|
| | No mulched | Mulched | Mean | No mulched | Mulched | Mean |
| PL 126 | 210 | 466 | 338 | 524 | 710 | 617 |
| PL 211 | 326 | 424 | 375 | 454 | 542 | 498 |
| PL 639 | 352 | 440 | 396 | 444 | 484 | 464 |
| PL 4 | 284 | 410 | 347 | 396 | 464 | 430 |
| VL 4 | 304 | 418 | 361 | 436 | 480 | 458 |
| VL 120 | 186 | 310 | 248 | 284 | 324 | 304 |
| L 4147 | 126 | 346 | 236 | 248 | 364 | 306 |
| Mean | 255 | 402 | 329 | 398 | 481 | 440 |

### Livestock production

In the livestock component, 145 nos. duck eggs, 157 nos. kroiler eggs, 1100 kg chicken meat, 250 kg goat meat, 1700 kg pig meat and 3561 litre milk were obtained (Table 4).

**Table 4 Livestock productivity in the IIFS field**

| Livestock | Production |
|---|---|
| Duck (65 birds) | 145 nos. eggs |
| Poultry (broiler @ 200 per batch-3 batchs/ Kroiler @ 100 per batch-1 batch) | 157 nos. eggs, 1100 kg meat |
| Goat (17 nos) | 250 kg meat |
| Pig (2 nos) | 1700 kg meat |
| Cattle (2 milching cows & 2 calves) | 3561 ltr milk |

### Genetic improvement of *Mucuna pruriens*

In two successive elimination/evaluation trials, 224 genotypes of *Mucuna pruriens* collected from different parts of the country including North East were reduced to 20 genotypes. One genotype IC83195 was used as check which was found to be the best check genotype among the five checks evaluated in the preceding years. Highest seed yield was obtained from collection UPMP-06 (2.19 t/ha) which was statistically at par with MGHMP-06 (1.74 t/ha), UPMP-11 (1.74 t/ha) and significantly higher than WBNMP-03(1.27 t/ha), WBNMP-07 (1.24 t/ha) and MNPMP-02 (1.16 t/ha) and check IC83195 (1.05 t/ha). Significant variation was observed in all the morphological traits such as days to flower initiation, days to maturity, inflorescence length, flowers/inflorescence, number of clusters/plant, pod length, pod width, pods per cluster, 100 seed weight and yield. Inflorescence length was longest in NGLMP-41 (51.90 cm) followed by MGHMP-11 (46.44 cm) and NGLMP-25 (46.00 cm). Broad sense heritability was highest for 100 seed weight (0.98) followed by inflorescence length (0.95), and flowers per inflorescence (0.89); for yield heritability broad sense was 0.64. Genotypic coefficient of variations for these traits was 60%, 56%, 49.7% and 53%, respectively. For yield trait, significant and positive correlation was observed between yield and number of clusters per plant (r=0.80).

All the collections were also screened against rust (*Uromyces mucunae*) during 2010-11 and 2011-12. On the basis of rust severity (%), defoliation and infection on new growth, ten collections were rated as resistant (viz. WBNMP 3, ASMMP 30, WBNMP 7, NGLMP 28, WBNMP 6, WBNMP 1, UPMP 2, TRPMP 2, UPMP 11 and NGLMP 25) in the 1st year of evaluation. In the 2nd year, few resistant collections were further screened in replicated trail for confirmation. Finally only three accessions viz. WBNMP 3, WBNMP 6, and NGLMP 25, with average rust severity <10 % were rated as resistant, infection on new growth was almost negligible and defoliation was also very less in these accessions. Disease pressure during both the years was very high since average rust severity on few highly susceptible accessions was above 70% (MGHMP 11, RJSMP 3). Telia were also observed on few highly susceptible accessions.

## SOIL SCIENCE

### Soil quality under different land use systems in hilly ecosystem of Meghalaya

Four different land use systems viz. mixed plantation forest (>28 years, MPF), horti (fruit/

vegetables)-silvi-pastoral (>28 years, HSP), orchard (<3 years with *khasi*mandarin+ Assam lemon+guava+ peach, ORD) and natural forest (NF), lying adjacent to each other in hill slopes ranging from 38-48% were used for the study. The soils are acidic, deep, well drained, clay to silty clay loam in texture. The site is at an elevation of 1080 m above MSL, lies in the sub-tropical hill zone of Meghalaya with mean annual rainfall of 2439 mm.

There was significant ($P$<0.01 to $P$<0.001) reduction in pH, soil organic carbon (SOC), microbial biomass carbon (MBC) and the activity of acid phosphates enzyme (APE) in soils under MPF, HSP and ORD land use systems compared with the soil under NF. However, the reduction in activities of dehydrogenase and â-glucosidase enzyme enzymes in ORD was not significant compared to the NF. Study clearly indicated that clearing the forest and converting them to other land use systems significantly affected the soil quality. Higher pH, SOC, MBC and enzyme activities in soils under NF were due to positive effect of surface cover, vegetation, and lack of tillage and fertilization. Management practices that reduces the pH and minimizes the addition of organic matter to soil may reduce enzyme and microbial activities in soil. The reduction in activities of the enzymes and MBC in soils under MPF, HSP and ORD land use systems as compared to the NF can be attributed to the decrease in SOC and pH of the soils because the activities of these enzymes and MBC showed significant positive correlations with SOC and soil pH. Moreover, low enzyme activities are presumably due to the fact that the microbial biomass, which is the principal source of soil enzymes, is lower in these soils.

Among the enzymes studied, APE activity was more predominant in soils. The predominance of soil enzyme activities is more related to the ecological role and kinetic characteristics of the enzymes despite the effects of soil chemical and physical properties, geology and land use. The enzyme studied were significantly intercorrelated (r values up to 0.57, $P$<0.001) and may suggest that these enzymes have similar origin and persistence in soil.

The mean values of the studied soil quality parameters were the lowest in HSP land use system followed by MPF and ORD. The management practices *viz*., tillage, fertilization, liming, irrigation etc. have profound influence on soil quality. The soil management practices adopted particularly for growing vegetable under HSP land use system had significant bearing on the quality of the soil. Growing vegetables round the year for >28 years adopting intensive tillage and fertilization contributed more towards deterioration of the overall quality of soil under HSP land use system. Moreover, sloppy nature of land, relatively more exposure of soil to high rainfall and soil erosion hasten the process of deterioration of the soil quality. Soil quality deterioration in MPF land use system was relatively less and the quality may improve further with time due to positive impacts of surface cover, vegetation and lack of fertilization and tillage. The ORD is very recent (<3 years old) and with time there may be further deterioration of soil quality.

**Technological interventions for improving livelihood security of tribal farmers**

Under the TSP project, HYV seeds/tubers of crops (rice, vegetables and potato), fingerlings of improved breeds of fish, seedlings of fruits crops *viz*., orange and peach, PVC tank of 1000 l capacity for roof water harvesting as well as other inputs like lime, fertilizer, vermicompost were distributed among the tribal farmers of Mawpyrshong village, East Khasi Hills district, Meghalaya. Four hundred thirty one farmers were benefitted. Potato being an important crop of the locality, an on farm demonstration cum training on improved method of cultivation of potato was conducted (Figs 1 and 2). Integrated use of lime (@ 400 kg/ha, furrow application), fertilizers (@ 50% of RDF) and organic manure (@ 2 t/ha vermi-compost) was demonstrated to the farmers to grow potato crop. The trained beneficiaries adopted the INM practice and the yield of potato (*cv.Kufri Jyoti*) was increased to the tune 128% over the farmers' practice. Three numbers of vermi-compost production units (size of each unit 10'x2'x2.5') were established in the village. A training programme on vermi-compost production technology was organized at ICAR complex, Umiam on 13th June, 2012 and 25 farmers from Mawpyrshong

**Fig 1 Method demonstration on INM for cultivation of potato**

**Fig 2 Potato crop in farmers' field**

village took part in the programme. Fifteen *jalkund* were established in the village to harvest rain water for cultivation of crops during the winter season. Method demonstration programme on cultivation of fruits was organized at the village on 19th July, 2012 and the role of fruit cultivation for livelihood improvement was explained to the farmers. Field demonstration cum training programme on fish farming for livelihood improvement was organized on 7th July, 2012 and fingerlings of improved varieties of fish were distributed among the farmers.

**Spatial variability in distribution of organic carbon stocks in the soils of North East India**

Northeastern region of India (NER) has wide variation in physiography and climatic condition. Because of its strategic settings in the phyto-biomass rich landscape of Eastern Himalaya, the soils are rich in organic carbon. However, sporadic information on field scale observations is available on soil organic carbon (SOC) content at regional level. Information on status and spatial variability of SOC and its complex interaction with land use systems are scanty. Therefore, an attempt was made to estimate spatial variability in SOC inventories for surface soils across six states of NER (*viz.,* Assam, Manipur, Meghalaya, Nagaland, Sikkim and Tripura covering geographical area of 15.61 Mha in Geographical Information System (GIS) environment. Results revealed that soils were very high in SOC content with 98.54% area had >1%, while 14.4% area had > 2.5% SOC content. Similarly, 76.5% area was having SOC density of 20-40 Mg/ha while 8% area was having very high SOC density of 40-60 Mg/ha. A total of 339.8 Tg (1Tg= $10^{12}$g) SOC stocks were estimated on an area of 10.10 M ha surface soils representing all major land use systems, with major share of it (>50%) coming from forest soils. Complex interaction of geographic location, rainfall, soil texture and land use practices significantly influenced spatial variation in SOC content, density and stock. The SOC content as per cent of total geographical area was highest in Sikkim followed by Nagaland, Manipur, Meghalaya, Assam and Tripura (Fig 3).

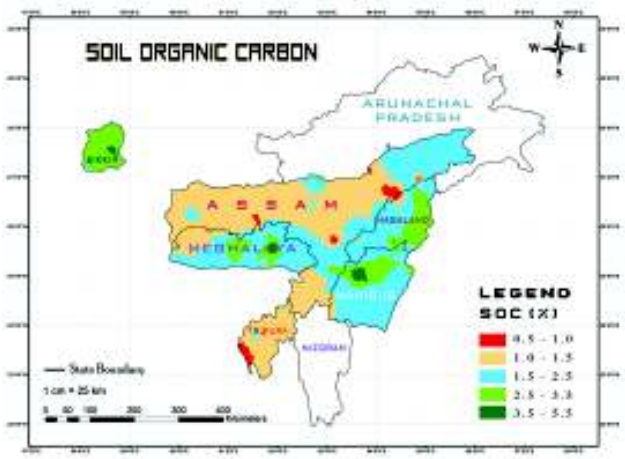



**Fig 3 Spatial distribution map of SOC content across NE Region of India**

**Date of transplanting and fertilizer-N levels on rice productivity - simulation studies**

Rice–fallow system dominates the rainfed lowland agricultural production systems of Northeastern Hill Region (NEH) of India. In this region, rice transplanting period spreads over 40 days (early July to mid August) while in hills, transplanting starts as early as middle of May to mid week of July (spreads over 50 days). This is due to sole dependence for water supply on monsoon rainfall, lack of information about optimum date of transplanting and partly, due to lack of farm mechanization and use of local genotypes. This results in inconsistent behaviour of yield response of rainfed rice to different transplanting dates with seasonal variation in monsoon rain, even for the same set of management practices including genotypes, fertilizer levels etc. An attempt was made to study the effects of different transplanting dates and fertilizer-N levels on plant growth and grain yield of rice in a rainfed rice-fallow system in NHR of India involving field experimentation for 3 consecutive years (2009-2011) and simulation for 25 years (1987-2011). For simulation study, the Agricultural Production Systems

Simulator (APSIM), a farming system model that combines accurate yield estimation in response to management with prediction of long-term consequences of farming practice on productivity, was used. Performance of the calibrated model on field experimentation for three consecutive years (2009-2011) was satisfactory. The simulated values of biomass at harvest averaged over three years (2009-2011) were 12.9 ±1.44 t ha$^{-1}$ compared to measured values of 12.7±1.1 t ha$^{-1}$ while the corresponding simulated averaged (3 years) grain yield was 6.1 ± 0.55 t ha$^{-1}$against the measured yield of 5.7 ± 0.45 t ha$^{-1}$ (Fig 4). The root mean square error (RMSE) was 0.48 t ha$^{-1}$ and normalized RMSE was 5.6% of the observed yield. Late transplanting (21$^{st}$ July) always indicated higher inconsistency (CV >33%) and some yield penalty (12-14% less) over early transplanting (7-14$^{th}$ July). Shifting from without nitrogen (N)-fertilization to 60 kg N ha$^{-1}$ increased average grain yield (over 25

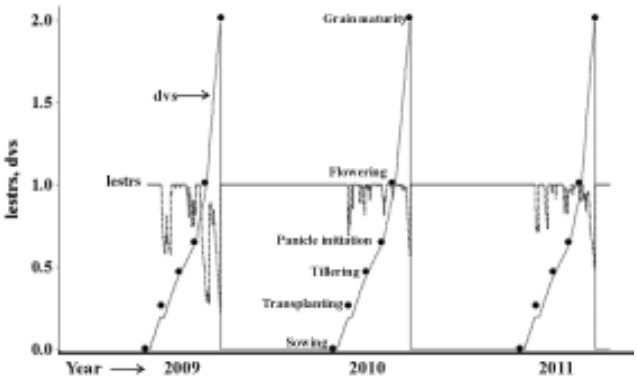



**Fig 5 APSIM simulated (solid lines) drought stress factor reducing leaf expansion (lestrs) at different measured phonological stages of rice growth transplanted on 7$^{th}$ July for three consecutive years (2009-2010)**

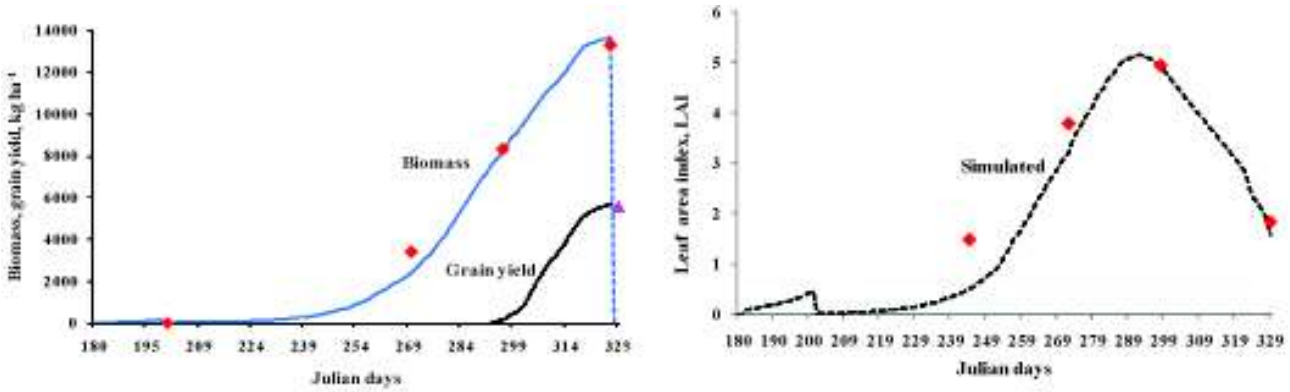



**Fig 4 Simulated (solid and dash lines) and measured biomass of the whole crop ( ◆ ), grain yield ( ▲ ) and leaf area index ( ◆ ) of rice transplanted on 21$^{st}$ July, 2010 (calibration of APSIM**

years) by 19% and increasing N-fertilization further to 90 kg N ha$^{-1}$, rice grain yield increased by 23% over without-N fertilization. Distribution and amount of rainfall received from post-flowering to grain maturity affected rice yield significantly (r = +0.66) and delay in transplanting after 14$^{th}$ July resulted in yield penalty due to reduction of rainfall by more than 50% received during that period. Other weather variables (temperature, radiation etc.) had minimal effect on rice yield due to leaf water stress (Fig 5). Among the different adoption options, transplanting on or before 14$^{th}$ July with 60 kg ha$^{-1}$ fertilizer-N in three splits - 50% basal, 25% at tillering and 25% at panicle initiation can increase the rice productivity by more than 2 times than the existing level (<2 t ha$^{-1}$ including upland rice) at NEH of India.

**Impact of elevated carbon dioxide and temperature on rice productivity in the mid altitudes- results from a simulation study**

Manifestation of climate change evident from a decreasing trend in monsoon rainfall and mean minimum temperature while increase in average and mean maximum temperatures during rice growing season at mid altitude Meghalaya pose a serious threat to the rice production *vis-à-vis* food security of the region. A bio-physical calibrated and validated model APSIM (Agricultural Production Systems Simulator) was used to evaluate the impact of projected climate change on rice productivity under different levels of nitrogen (N) fertilization. The simulation (1987-2011) results indicated increase in rice grain yields with increase in $CO_2$ concentration while changes (-/+) in

average temperature showed yield penalty (Fig 6). Elevation of $CO_2$ concentration from current 390 ppm to 550 ppm under farmers practice (without N), projected rice yield (average of -2, no change, +2 and +4°C temperatures) of HYV cultivar (Shahsarang) increased from 3.67 t ha$^{-1}$ to 4.57 t ha$^{-1}$. On further increase in $CO_2$ concentration to 700 ppm, however, rice yield increased marginally (< 4%). With the decrease in average temperature by 2°C from the ambient temperature (June-November) of 22.2°C, the projected rice yield (average of 390, 550 and 700 ppm $CO_2$) decreased from 4.93 t ha$^{-1}$ to 3.29 t ha$^{-1}$ while crop maturity period increased by 30%. On increasing the temperature by 2°C from 22.2°C, the projected rice yield remained unaffected but at 4°C increase over 22.2°C, simulated rice yield declined by 14% (Fig 7). Shifting from without N to increase in rate of N fertilization (@ 60, 90 and 120 kg ha$^{-1}$), simulated rice yield increased by 10 to 19% with $CO_2$ level of 550 ppm over 390 ppm. However, with the change in temperature (±2°C), the projected rice yield under different levels of N fertilization decreased by 12 to 41% and the reduction was more with the decrease compared to increase in temperature. The rate of decline in rice yield with the change (-/+) in temperatures was more at higher doses (90 to 120 N kg ha$^{-1}$) compared to lower doses of N fertilization (0 to 60 N kg ha$^{-1}$).

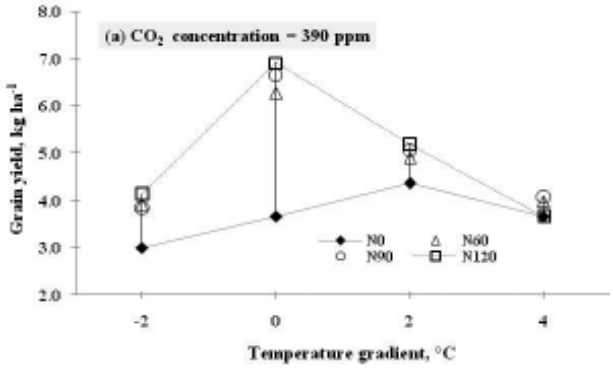



**Fig 6 Effect of change in average temperatures (-/+) on long term (1987-2011) simulated rice yield**

Results from the simulation study revealed that despite changes in average temperature (-/+), elevated $CO_2$ level up to 550 ppm can substantially improve the rice productivity under farmers practice (without N fertilizer) while at higher level of $CO_2$ concentration (700 ppm), intensive application of fertilizer-N (@ of 60-90 kg N ha$^{-1}$) can have synergistic effect on rainfed rice productivity. Decrease in temperature is the most detrimental in reducing the rice productivity since

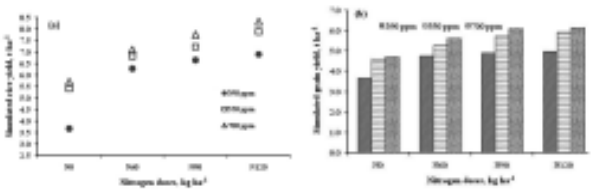


**Fig 7 Effect of elevated $CO_2$ concentration on simulated rice yield at (a) ambient temperature of 22.2 °C and (b) averaged over temperature gradient (-2 to +4°C)**

cardinal temperature for optimum rice growth at mid-altitude Meghalaya is already at lower threshold level (<23°C). However, application of N-fertilizer @ 90 kg ha$^{-1}$ could be a possible immediate adaptation strategy under changing climate in the subtropical climate of mid-altitude Meghalaya.

**Effect of nutrient management practices on soil organic carbon and available nutrients**

Field experiments were conducted to study the impact of nutrient management practices on carbon dynamics of acid soil using maize (var. RCM 76) and groundnut (var. ICGS 75) as test crops with 15 different treatments combinations of nutrient management (inorganic, organic and integrated). It was observed that integrated nutrient management (Lime + 50% RDF + manures) practices significantly increased the maize yield over inorganic source (Lime +50% RDF). Soil organic carbon was significantly increased due to application of compost @ 5 t/ha over control. Application of lime @ 0.5 t/ha increased the soil pH to the tune of 0.21 to 0.34 units over control. Among the different organic sources, application of vermicompost along with 50% RDF proved better in improving the status of SOC and available nutrients in the soil. Maize yield and soil available N, P and K significantly correlated with pH (*$P$<0.05, **$P$<0.01). Synergistic relationship among the soil available nutrients was significantly correlated. Recovery of organic carbon varied from 26 to 39% of total organic carbon across different nutrient management practices under both maize and groundnut crops. By and large recovery is more in the treatments receiving organic manures.

**Seed pelleting with lime and seed priming with zinc and phosphorus for improving crop growth and productivity**

Seed pelleting with lime, using gum arabic as sticking agent, improved maize yield by 8.5%

compared to 30% improvement by furrow-applied lime @300 kg/ha. However, effect of lime-pelleting in French bean was comparable with that of furrow-applied lime. NPK (RD) + lime (@300 kg/ha) resulted in doubled yield of maize while inclusion of FYM @5 t/ha along with NPK and lime further boosted the yield-improvement up to 110%. In screening of the seed priming agents, 16 h seed treatment with 1% solution of both Zn and P was found highly effective in improving the germination and seedling vigour of maize (Fig 8). Seed priming improved the seedling height by 17% in hydro-priming and 32% in osmo-priming with Zn and P (compared to unprimed seed) along with associated increase in root and shoot weight at 15 DAS. Seed treatment with human and cow's urine (diluted) was also found effective in improving the germination, height and biomass of seedlings in maize (Fig 9).

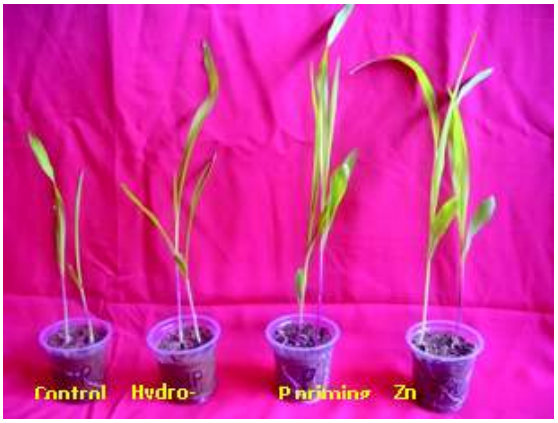



**Fig 8 Effect of seed priming with P and Zn on maize growth**

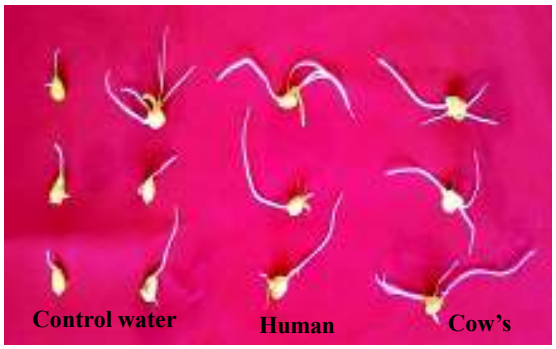



**Fig 9 Effect of seed treatment with urine on maize germination**

### Soil acidity, phosphorus fixation and phosphate requirement in soils of Meghalaya

Four hundred ninety seven soil samples from across the seven districts of Meghalaya were analyzed for their soil acidity and mineral contents. Soil acidity in Meghalaya seems to be rising as 80.2% of the soils were found strongly acidic (pH<5.50) against the previous report of 53% strongly acidic soils (Figs 10 &11). The soils of East Khasi Hills were most acidic (median pH 4.68), while Garo Hills soils were least acidic (median pH 5.47). P, Ca and Mg were found deficient in >80% of the samples; Zn and B were found deficient in >60% samples, respectively, with some other minerals also showing significant deficiencies in the soils of Meghalaya, and these were highly correlated with their contents in fodder and animal blood. Due to strongly acidic nature of soils and abundance of exchangeable Al, P fixation capacity of soils were found very high, with 2.25% reduction in P adsorption with every 0.1 unit increase in soil pH. Citric acid application was found effective in reducing P adsorption by such soils. According to P sorption isotherms' results, P requirement of the strongly acidic soils (pH 4.5 – 5.0) in Meghalaya was found in the range of 90-130 kg $P_2O_5$/ha against the currently recommended dose of 60 kg $P_2O_5$/ha.

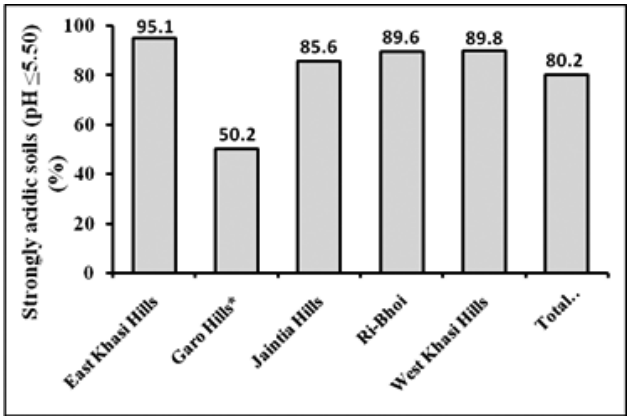



**Fig 10 Extent (%) and distribution of strongly acidic soils (pH = 5.50) in Meghalaya (*represents all the three districts of Garo Hills**

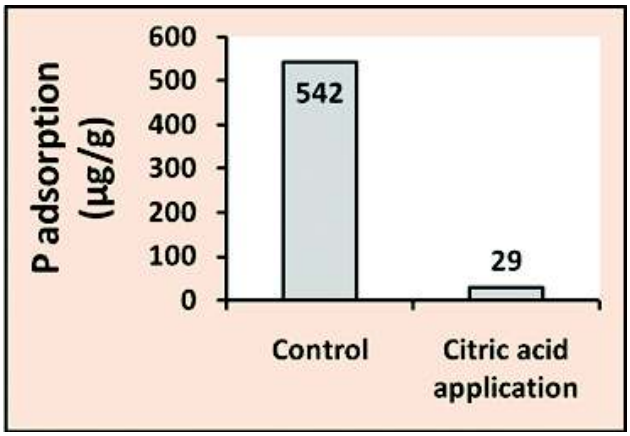



**Fig 11 Effect of citric acid application on P adsorption by an acid Inceptisol of Meghalaya (pH 4.5)**

**Altitudinal variation of soil acidity parameters and fertility under*jhum* cultivation in Meghalaya**

Soil samples were collected from different *jhum* cultivated areas for from altitudes groups (upper, middle, lower and lowermost). Upper elevation recorded statistically highest values of exchangeable acidity, $Al^{3+}$, $H^+$ and total acidity compared to lower elevations. On average, it recorded 49.2, 25.7 and 16.3% higher values of these acidity parameters, respectively. Surface soils had comparatively low values of these parameters than subsurface soils. Lime requirement was 4.79 and 4.75 t $ha^{-1}$ in upper and subsurface soils, correspondingly compared to lower and subsurface soils, respectively (Table 1). In contrast to acidity parameters, available nutrient contents were significantly highest at the surface soil layer and lowermost elevation of the *jhum* lands. However, available N and P contents were in the lower range irrespective of the elevations and depths. The soil organic carbon was maximum in the lowermost devations and decreased with the increase in elevation.

**Impact of *jhuming* cycles on soil fertility and acidity parameters in soils of Meghalaya**

Effect of *jhuming* practices i.e. before *jhuming,* after slashing and burning, and first year of cultivation on acidity and fertility parameters of soils in Meghalaya was studied. Slashing and burning practices showed significant increase in available nutrients including organic carbon content while noticeably reducing the exchangeable acidity, $Al^{3+}$, $H^+$ and total acidity. However, first year of cultivation resulted in a significant increase in exchangeable acidity and $Al^{3+}$ irrespective of the soil depths (Table 2). Similarly, slashing and burning resulted in significant increase in available N, P, K, Ca, Mg and S contents including organic carbon (Table 3). However, first year of cultivation caused reduction the available N, P, K and organic carbon content to a significant extent.

**Effect of land uses on carbon stocks, fertility and acidity parameters of soils in Meghalaya**

Soil samples were collected from different land uses and depths to study the impact of land uses, soil depths and their interaction on soil fertility, carbon stocks and acidity parameters. For this, soils from mixed forest, pine forest, guava-pineapple, ginger, paddy, chilli and fallow lands were collected and analyzed for the above parameters. Land uses and soil depths significantly altered the carbon stocks, acidity parameters and fertility of soils. Mixed forest (36 Mg $ha^{-1}$) and pine forest (34.8 Mg $ha^{-1}$) recorded the maximum carbon stocks compared to other land uses. However, the detrimental parameters like total acidity, exchangeable acidity, $Al^{3+}$, $H^+$ were lower in agriculture and horticulture land uses in comparison to mixed forest and pine forest land uses. Exchangeable acidity, $Al^{3+}$ and $H^+$ were in the range of 3.33-5.67, 0.93-1.42, 2.08-4.25 meq $100g^{-1}$, respectively. Available nutrients were in the order of mixed forest >pine forest >paddy >ginger >guava-pineapple >chilli>fallow land uses. The SOC was maximum in mixed forest followed by paddy field and pine forest.

**Table 1 Altitudinal variations in soil acidity parameters under *jhum* cultivation in Meghalaya**

| | Depth (cm) | pH | | Exchangeable, meq $100g^{-1}$ | | | Total acidity (meq $100g^{-1}$) | pH depen. Acidity | LR (t $ha^{-1}$) |
|---|---|---|---|---|---|---|---|---|---|
| | | $H_2O$ | KCl | Acidity | Al | H | | | |
| Upper | 0-15 | 5.33 | 4.69 | 3.63 | 1.20 | 2.26 | 7.21 | 3.58 | 4.63 |
| | 15-30 | 5.28 | 4.64 | 3.73 | 1.13 | 2.43 | 7.33 | 3.60 | 4.93 |
| | 30-45 | 5.16 | 4.62 | 4.00 | 1.47 | 2.87 | 7.67 | 3.67 | 4.80 |
| | Mean | 5.26b | 4.65ab | 3.79ab | 1.27a | 2.52ab | 7.40a | 3.62b | 4.79b |
| Middle | 0-15 | 5.70 | 4.98 | 2.87 | 1.00 | 1.87 | 6.92 | 4.05 | 5.37 |
| | 15-30 | 5.57 | 4.73 | 4.13 | 1.30 | 2.83 | 7.67 | 3.54 | 5.77 |
| | 30-45 | 5.31 | 4.68 | 4.97 | 1.30 | 3.67 | 8.00 | 3.03 | 5.33 |
| | Mean | 5.53a | 4.80a | 3.99a | 1.20a | 2.79a | 7.53a | 3.54b | 5.49a |
| Lower | 0-15 | 5.55 | 4.71 | 2.13 | 0.93 | 1.20 | 7.04 | 4.91 | 4.23 |
| | 15-30 | 5.46 | 4.64 | 3.10 | 1.30 | 1.77 | 7.08 | 3.98 | 4.37 |
| | 30-45 | 5.46 | 4.62 | 3.60 | 1.33 | 2.30 | 7.83 | 4.23 | 4.23 |
| | Mean | 5.49a | 4.66ab | 2.94bc | 1.19a | 1.76bc | 7.32a | 4.37a | 4.28bc |
| Lower most | 0-15 | 5.80 | 4.63 | 2.07 | 0.80 | 1.27 | 5.96 | 3.89 | 4.37 |
| | 15-30 | 5.58 | 4.66 | 2.70 | 1.07 | 1.63 | 6.38 | 3.68 | 4.07 |
| | 30-45 | 5.39 | 4.60 | 2.87 | 1.17 | 1.70 | 6.75 | 3.88 | 4.50 |
| | Mean | 5.59a | 4.63b | 2.54c | 1.01b | 1.53c | 6.36b | 3.82b | 4.31bc |

**Table 2 Effect of *jhuming* practices on soil acidity parameters in Meghalaya**

| Particular | Depth (cm) | pH | | Exchangeable, meq 100g$^{-1}$ | | | Total acidity (meq 100g$^{-1}$) | pH depen. Acidity | LR (t ha$^{-1}$) |
|---|---|---|---|---|---|---|---|---|---|
| | | $H_2O$ | KCl | Acidity | Al | H | | | |
| Before Jhum | 0-15 | 5.48 | 4.69 | 4.80 | 1.80 | 3.00 | 9.63 | 4.83 | 5.20 |
| | 15-30 | 5.39 | 4.68 | 5.20 | 2.20 | 3.00 | 10.38 | 5.18 | 6.00 |
| | 30-45 | 5.35 | 4.61 | 5.80 | 2.00 | 3.80 | 10.63 | 4.83 | 6.00 |
| | Mean | 5.41c | 4.66a | 5.27a | 2.00a | 3.27c | 10.21a | 4.95a | 5.73a |
| After Slash & Burn | 0-15 | 5.69 | 4.79 | 4.40 | 1.00 | 3.40 | 7.25 | 2.85 | 5.00 |
| | 15-30 | 5.67 | 4.55 | 5.20 | 1.40 | 3.80 | 9.63 | 4.43 | 5.20 |
| | 30-45 | 5.23 | 4.60 | 5.40 | 1.60 | 3.80 | 10.00 | 4.60 | 5.50 |
| | Mean | 5.53b | 4.65a | 5.00b | 1.33c | 3.67a | 8.96b | 3.96b | 5.23b |
| 1$^{st}$ year Jhum | 0-15 | 5.84 | 4.65 | 4.90 | 1.30 | 3.60 | 7.00 | 2.10 | 4.80 |
| | 15-30 | 5.78 | 4.63 | 5.10 | 1.30 | 3.80 | 7.50 | 3.15 | 5.20 |
| | 30-45 | 5.53 | 4.57 | 5.30 | 1.80 | 3.50 | 8.25 | 2.20 | 5.60 |
| | Mean | 5.72a | 4.62a | 5.10b | 1.47b | 3.63b | 7.58c | 2.48c | 5.20b |

**Table 3 Effect of Jhuming practices on soil fertility in Meghalaya**

| *Jhum* practices | Depth (cm) | BD (g cm$^{-3}$) | Moisture (g 100g$^{-1}$) | OC | N (kg ha$^{-1}$) | P | K | Ca (meq 100g$^{-1}$) | Mg | S (kg ha$^{-1}$) |
|---|---|---|---|---|---|---|---|---|---|---|
| Before Jhuming | 0-15 | 1.21 | 31.3 | 1.74 | 313.4 | 16.65 | 151.8 | 0.65 | 0.40 | 12.46 |
| | 15-30 | 1.28 | 33.1 | 1.53 | 263.2 | 15.18 | 122.1 | 0.40 | 0.55 | 14.08 |
| | 30-45 | 1.33 | 33.6 | 1.11 | 238.2 | 13.71 | 92.4 | 0.50 | 0.20 | 12.46 |
| | Mean | 1.27b | 32.6a | 1.46b | 271.6b | 15.18b | 122.1b | 0.52b | 0.38a | 13.00b |
| After Slash& Burn | 0-15 | 1.22 | 24.8 | 1.38 | 401.2 | 22.28 | 195.4 | 1.02 | 0.48 | 17.87 |
| | 15-30 | 1.27 | 31.0 | 1.95 | 326.0 | 22.03 | 146.2 | 0.92 | 0.38 | 17.33 |
| | 30-45 | 1.38 | 34.7 | 2.00 | 275.8 | 19.10 | 110.9 | 0.65 | 0.40 | 17.87 |
| | Mean | 1.29b | 30.2c | 1.78a | 334.3a | 21.14a | 150.8a | 0.77a | 0.48a | 17.69a |
| 1$^{st}$ year *Jhum* | 0-15 | 1.23 | 27.7 | 1.44 | 213.1 | 19.58 | 144.5 | 0.85 | 0.45 | 13.54 |
| | 15-30 | 1.29 | 31.4 | 0.59 | 238.2 | 18.12 | 121.5 | 0.65 | 0.45 | 14.62 |
| | 30-45 | 1.54 | 34.0 | 1.61 | 238.2 | 14.93 | 103.6 | 0.52 | 0.38 | 13.00 |
| | Mean | 1.35a | 31.0b | 1.21c | 229.8c | 17.54ab | 123.2b | 0.60b | 0.50a | 13.72b |

## CLIMATE CHANGE IMPACT AND ADAPTATION STRATEGIES IN HILL AGRICULTURE (NPCC)

### Trend analysis of long term weather variables in mid altitude Meghalaya, North-East India

Northeastern Hill Region (NHR) of India, by virtue of its strategic setting in the frail landscape of Eastern Himalaya falls in the most vulnerable zones of abrupt climate change. Despite this, little attention has been given to understand climate change impact implications. In the present study, longtime (1983-2010) weather variables have been analyzed to detect trend changes using non-parametric Mann Kendall test in mid altitude of Meghalaya (Umiam: 250 41/ N latitude, 910 55/ E longitude, 1010mmsl). Results revealed that total annual rainfall trend increased non-significantly at the rate of 3.72 mm year$^{-1}$. Contribution of monsoon months (JJAS) declined marginally at the rate of 1.70 mm while pre - (MAM) and post- monsoon (ONDJF) months increased non-significantly at an annual rate of 3.18 mm and 1.16 mm, respectively (Fig 1). Probability analysis showed a high frequency of anomalies ($p$>0.6) of either deficit or excess in occurrence of normal monsoon rainfall. Number of rainy days and extreme rainfall events (RX1 day maximum>100mm) exhibited a non-significant increasing trend @ 1.7 days and 1.9 days per decade, respectively. Maximum temperature reflected a linear, significant rising trend (+0.086$^0$C year$^{-1}$) while minimum temperature enumerated a non-significant decreasing trend (-0.011$^0$Cyear$^{-1}$). Mean temperature also manifested a significant rising trend (Fig 2) at an annual rate of 0.031$^0$C while annual evaporation loss significantly decreased (@ 5.75 mm year$^{-1}$). Correlation studies affirmed that atmospheric

evaporative demand was relatively more sensitive to changes in sunshine duration(r= +0.63) followed by wind speed (r= +0.41) and vapour pressure deficit (r = 0.11). Climatic water balance studies (rainfall and PET) reflected an increasing trend of water surplus during May to July (Z: +0.08 to 1.56) whereas, a reverse trend (declining, Z: -0.56 to -0.87) was observed during post monsoon months (December to February).

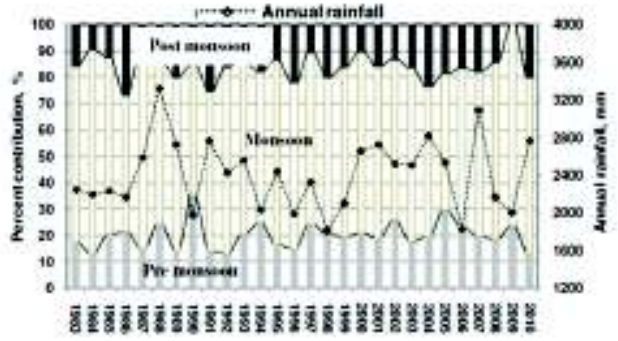



**Fig 1 Temporal variation in annual and seasonal rainfall distribution pattern at Umiam**

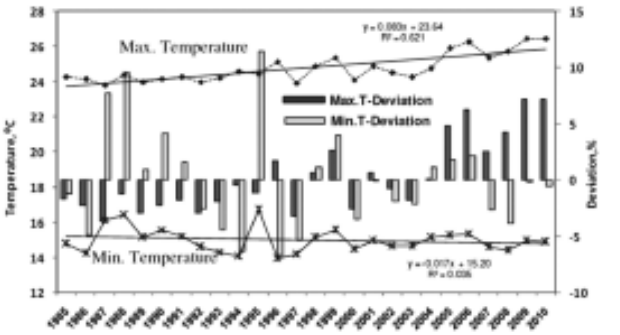



**Fig 2 Long term changes in minimum and maximum surface temperature at Umiam, Meghalaya**

**Cherrapunjee:** The annual rainfall at Cherrapunjee between 1969-2000 did not show any characteristics variation and indicated a pattern of increasing-decreasing trend in between a range of 8000-20000 mm (Fig 3). A total rainfall of as high as 23442.4 mm was recorded in the year 1974 followed by 17948.2 mm in the year 1988 and the lowest amount of 6910.9 mm in 1978 followed by 7425.3 mm in 1980. The average annual rainfall over decades showed a slightly increasing pattern i.e. 10967.07 mm, 11778.53 mm, 11789.0 mm in 1971-80, 1981-90, 1991-2000, respectively.

As observed, the number of rainy days at Cherrapunjee was fluctuating within a range of 130-160 days (Fig. 4). The lowest number of rainy days was recorded in the year 1990 (116 days) followed by

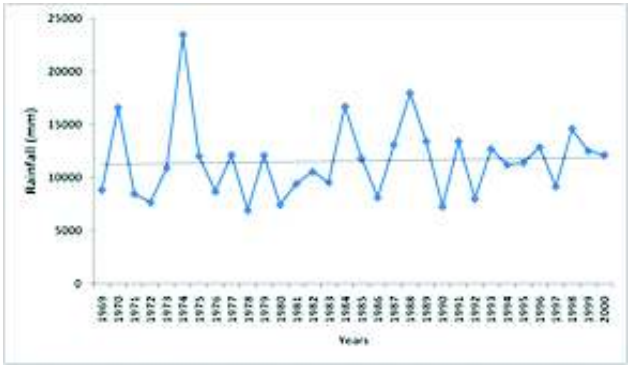



**Fig 3 Annual rainfall of Cherrapunjee from 1969-2000**

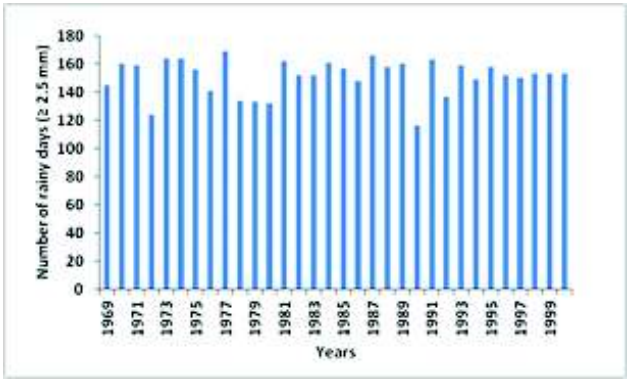



**Fig 4 Total number of rainy days at Cherrapunjee from 1969-2000**

the year 1972 (124 days) and the highest was recorded in the year 1977 (169 days) followed by the year 1987 (166 days).

As per the analysis of Pre-monsoon, Monsoon and Post-monsoon period from 1969-2000, the number of rainy days in pre monsoon was recorded in between 35-55 days. The highest rainy days was recorded in the year 1977 and 1981 (54 days) followed by 1985 (53 days). During monsoon, the number of rainy days was recorded within 80-110 days. The highest rainy days was recorded in the year 1996 (108 days) followed by 1991 (104 days). In post monsoon period, the number of rainy was recorded in between 10-30 days. The highest was found in 1973 (26 days) followed by 1988 (22 days).

Over three decades (1971-80, 1981-90, 1991-2000), the number of rainy days showed a increasing-decreasing pattern in pre monsoon and post monsoon. The number of rainy days in monsoon showed a sharp increasing trend with the decades (Table 1).

Over the decades (1971-80, 1981-90, 1991-2000), the pre monsoonal rainfall showed an increasing trend whereas, monsoonal and post monsoonal rainfall

showed an increasing-decreasing trend with decades (Table 1). The number of extreme rainfall events at Cherrapunjee ranged between minimum of 15 days to maximum of 55 days between 1969-2000. The highest number of extreme rainfall event was found to be in the year 1974 (56 days) followed by the year 1988 (51days) (Fig 5).

**Table 1 Total number of rainy days over decades at Cherrapunjee**

| Seasons | 1971-1980 | 1981-1990 | 1991-2000 | Long term seasonal average rainy days |
|---|---|---|---|---|
| Pre- monsoon | 405 | 436 | 410 | 42 |
| Monsoon | 931 | 945 | 972 | 95 |
| Post- monsoon | 140 | 151 | 145 | 15 |
| Annual average number of rainy days | 148 | 153 | 153 | 152 |

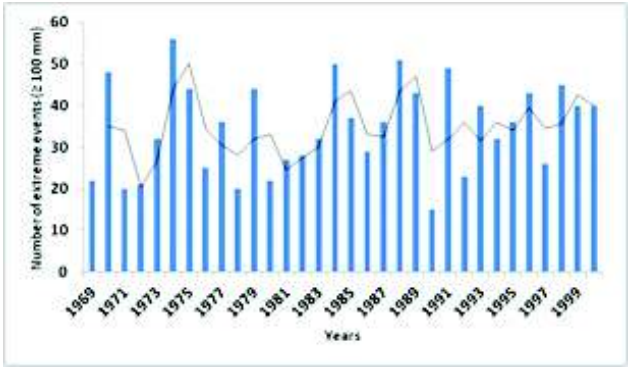



**Fig 5 Extreme rainfall event over 30 years at Cherrapunjee**

The number of extreme rainfall event during the pre-monsoon months showed an increasing trend from 52 days to 76 days between the decades 1981-1990 to 1991-2000. Whereas , during the monsoon months, the number of extreme event showed an increasing trend from 245 days to 283 days between the decade 1971-1980 to 1981-1990. The number of extreme events in the post monsoon months showed an increasing-decreasing pattern.

At Cherrapunjee, the ranges of single day extreme rainfall events were grouped with a minimum of 100-200 mm/day to a maximum of = 700 mm/day (Table 2).

The number of days experiencing rainfall between 100-200 mm/day and 200-300 mm/day showed an increasing trend with decades whereas, a decreasing trend in the number of days was experienced for more than 700 mm/day.

**Table 2: Total number of extreme rainfall events over decades at different range at Cherrapunjee**

| Rainfall range (mm/day) | 1971-1980 (in days) | 1981-1990 (in days) | 1991-2000 (in days) |
|---|---|---|---|
| 100-200 | 191 | 192 | 223 |
| 200-300 | 58 | 82 | 96 |
| 300-400 | 30 | 34 | 24 |
| 400-500 | 16 | 19 | 17 |
| 500-600 | 11 | 10 | 7 |
| 600-700 | 6 | 7 | 4 |
| =700 | 8 | 4 | 3 |

The annual average maximum temperature over 32 years showed an increasing trend whereas the annual minimum temperature showed a decreasing trend with years.

The soil samples were collected from various land uses of Cherrapunjee during dry season and coal mine soil found to have maximum organic carbon content followed by natural forest at 0-20 and 20-40 cm depth, respectively. Barren land and quarrying sites contained minimum SOC (Fig 6)

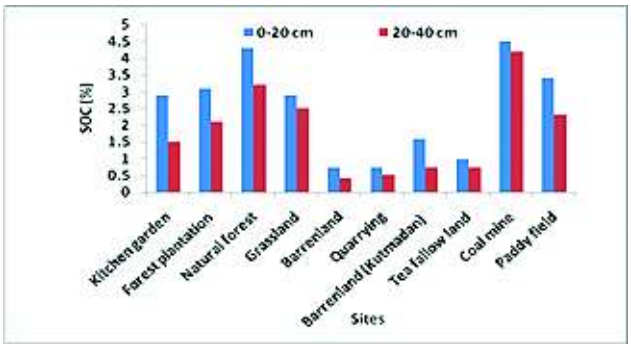



**Fig 6 Soil organic carbon content in different land uses of Cherrapunjee**

## FARMING SYSTEM RESEARCH

Micro watersheds compromising of Dairy based land use (FSW-1), Mixed forestry (FSW-2), Silvi-pastoral land use (FSW-3), Agro-pastoral system (FSW-4), Agri-horti-silvi-pastoral (FSW-5), Silvi-horticultural system (FSW-6), Natural forest block (FSW-7) and Timber- based farming system (FSW-8) is being evaluated on long term basis at ICAR Research Complex for NEH Region, Umiam, Meghalaya.

**Dairy based farming system (FSW-1)**

Dairy based farming system was evaluated on a micro watershed of 1.39 ha area including 0.45 ha of forest land. The area under planned land use was 0.94 ha of which 0.22 ha terrace area falls under annual fodder crops and the remaining under broom and guinea grass production. The average slope of the watershed was 32.02%, the lower terraces consisting of 1-5 were utilized for production of annual fodders with maize + cowpea – cowpea and maize – cowpea cropping sequence. The terrace riser area was utilized for the production of guinea grass while 2500 $m^2$ sloppy area was under broom grass which yielded 13.5 t of green leaves and eatable tender shoots during the lean period. Three milch cows along with their calves were maintained in the system. Fodder crops/grasses which were grown along the micro-watershed produced fodder which was made available for the dairy animals. A total production of 26.42 t of green fodder yield was obtained from the watershed of which maximum green fodder of 13.5 t was recorded from broom leaves. Cultivated fodder crops like maize, cowpea, rice bean and perennial guinea grass were utilized as green fodder from June to November. During lean period, broom grass was available for 4 months i.e. December to March. The remaining one month i.e. in April, only paddy straw was used to feed the animals. During the month of May, 50% green fodder was made available from guinea grass and 5% from paddy straw. An analysis of fodder production and requirement revealed that total green fodder from forage crops was 26.42 t, while the requirement for dairy animals was 31.0 t, showing a deficit of 4.59 t/annum.

Total concentrate, paddy straw and medicine were arranged from open market amounting to ₹ 95,995/-. Keeping in view of farmer's family in the watershed, all labours were considered as farmer's works, while feed concentrate, paddy straw mineral mixture and medicine were procured from the market and milk yield was considered to be the farmer's income. The milk yield obtained from the system was 5145 litre (assuming farmer's requirement was 456 liter) giving a gross return of ₹ 1,72,283/-. Less milk yield was due to non-availability of feed to the animal for three months. Besides 31 tonnes of FYM produced from cow dung, urine, crop residues and weed biomass in the system. Considering family labour as a system of employment for dairy based farming, total cost of feed, concentrate and medicine was ₹ 1, 10,943/- with an annual income from the system (₹ 1, 14,640/-) registered net income of ₹18, 645/-.

To increase the nutritional quality of fodder, cowpea varieties were evaluated in the watershed. Three varieties of oats for green fodder during February and March, grown in the watershed showed potential for green fodder yield where a total production of 3840 t/ha was obtained with kent and AOSC 3 (2800 t/ha). Lowest green fodder was obtained with AOSC 4.

**Silvi-pastoral system (FSW-3)**

Silvi-pastoral system was established on 2.94 ha area of forest land of which 2.05 ha was under planned land use. The average slope of the area was 32.18%. The upper portion of the micro-watershed comprising an area of 0.74 ha was utilized for broom grass production to fulfill the fodder requirement for the animal during lean period. Green fodder of 2642 t was produced out of which 4.63 t green leaves were used for cow and goat from November to February. Furthermore, the broom sticks produced was used as a source of fuel woods.

Thirteen goats (4 males, 9 females) were maintained in this system. The goats were allowed to graze for 3 hours per day and green fodder @ 3 kg per adult along with 250 g of concentrates per adult was supplemented. The goats consumed a total of 3.6 t guinea grass, 2.16 t *Symingtonia* leaves and 0.46 t of concentrate. Poultry (500 broilers) chicks were also reared in three cycles as a subsidiary source of income of which 10 broilers chicks were dead. The total body weight attained was 1078 kg with average body weight of 2.2 kg/bird. The gross income from this system was ₹ 1,42,600/- with an expenditure of ₹ 60,220/- on feed, concentrate and procurement of one day old chicks resulting into a net profit of ₹ 82,380/- from the watershed.

The lower half portion of the watershed was planted with fodder trees species comprising of *Symingtonia populnea*, *Bauhinia purpurea, Ficus* spp, *Schima wallichii, Indigofera indica* and wild cherry to provide green leaf fodder to the goats during lean period. The growth and development attributes of tree species revealed that the tallest plant was of *B. purpurea* (13.35 m) while lowest plant height was recorded in *S. populnea* (4.70 m), which may be due to the frequent lopping of plants for green leaf fodder for the goats. The circumference at basal height was maximum with *S. wallichii* and *S. populnea*, while at breast height the circumference was more with *S. populnea* followed by *B. purpurea*. Mixed perennial grasses had been planted between the fodder trees to conserve soil and water and to provide a supplementary source of fodder for grazing.

**Agro –pastoral system (FSW-4)**

Agro-pastoral system was 0.64 ha area having an average slope of 32.42% with a forest land of 0.06 ha and a planned land used area of 0.58 ha. Terracing was practiced along the area which enhanced the surface area by 28.2 %, resulting in 0.49 ha area of terraced land and 0.33 ha terrace risers, respectively. The terrace area was utilized for growing cereals, oilseeds, spices and vegetables. About 75% of the total area was utilized for 200% cropping intensity which resulted with a production of 5019.19 kg of rice equivalent yield (REY) excluding the green fodder from guinea grass. It was observed that French bean-rice-*toria* cropping system registered maximum total system productivity followed by ginger. The lowest yield of turmeric+ cucumber showed minimum values of total system productivity.

The output in terms of income (₹/$m^2$) revealed maximum output of ₹ 56.6/$m^2$ obtained from ginger followed by turmeric (₹ 45.1/$m^2$). In general maximum output was obtained from vegetables/spices crop. Rice crop registered ₹ 6.50/$m^2$ output. The lowest output of ₹ 5.25/$m^2$ was observed with black gram and Groundnut (₹ 5.30/$m^2$) in the watershed. An integrated approach with crops and livestock showed that maximum income was obtained from cow milk (₹ 1,55,850/-) following crop component (₹ 1,41,121/-) registering a gross income of ₹ 2,96,971 from Agro-pastoral system. This system could generate 294 man days employment amounting to ₹ 44, 100/- adding the cost of other input amounting to ₹ 1, 62,797/-. The net income of ₹ 1, 34,174/- was obtained giving an input – output ratio 2.21. The cow dung produced in the Agro-pastoral system (31 t) was utilized for the crop production in the system. Production of Guinea grass on terrace risers in the lower and middle part of the watershed and broom grass on the top portion of the watershed provided green fodder which was sufficient for 8 months for the two dairy unit without any extra input/ management cost. Production of grasses on terraces risers reduced the yield of main crops, however this was compensated with the continuous availability of green fodder for the animals maintained in the micro-watershed.

**Agri-horti-silvi-pastoral system (FSW-5)**

Total area of Agri-horti-silvi-pastoral system was 1.58 ha. Out of which, 0.55 ha was under forest while 1.03 ha under planned land use area. The average slope of the micro-watershed was 41.77 %. In this system 0.10 ha of foothills was used for agricultural use but due to failure of agriculture crops vegetables were grown in the terrace, 0.25 ha for horticulture use and 0.44 ha for silvi-pastoral crops. In the lower terraces, crops like capsicum, French bean and Okra were grown during *kharif* season and French bean, pea, cauliflower and cabbage were grown during *rabi* season. One dairy cow unit was attached to this system. The middle portion of the system was utilized for fruit crops like Assam lemon, pineapple and guava. On terrace risers, Guinea and Congo-signal grasses were planted for green fodder production also with an aim to prevent soil erosion. Pineapples were planted in double row system as an intercrop with Assam lemon. Forest block consisted of *Alnus nepalensis* and *S. wallichi* for timber and fuel wood, staking of black pepper plants on these trees was also practiced, while *Ficus* and *S. populnea* were used for green leaf fodder production during lean period. In between the tree species, broom grass was grown as a companion crop for soil and water conservation and fodder production. The Agri-horti-silvi-pastoral system produced 5,658.99 kg rice equivalent yield (REY) registering a gross return of ₹ 1,41,475/- followed reveled maximum REY of 1087.12 kg with capsicum -French bean -pea was obtained followed by tomato- okra- Cabbage. Lowest REY was recorded with Tomato- Okra- pea sequence; height may be due to less area allotted to the sequence. Among the fruit crops, maximum REY of 54.08 kg was obtained in Guava followed by pineapple (34 kg). Input: output relationship indicated maximum net return with Dairy registering a net income of ₹ 81,688/-, followed by vegetable production (₹ 36,074/-), Intercropping (₹ 20,754/-). Minimum return was achieved from orchard component amounting to ₹ 2,234/-. A gross income of ₹ 25, 461/- was recorded from this system. The three numbers of pigs attained 290kg weight in 290 days registered gross return of ₹ 34,800/- with cost of production of ₹ 23,400/-. One dairy cow produced total milk of 2323.5lit added ₹ 88, 688/- in gross return from the system. The FYM of 10.2 t/ha from cow voids, weeds and farm waste was used in the system. The system as a whole registered a gross and net income of ₹ 1,41,475/- and ₹1,43,813/- respectively.

**Silvi-horticultural system (FSW-6)**

The total area of Silvi-horticultural system was 3.13 ha with a forest land of 2.17 ha and planned land use of 0.96 ha. The average slope of the area was 53.18 %. Lower terraces covering an area of 510.00 $m^2$ was

utilized for growing spices and vegetables like turmeric + bottle gourd, turmeric + pumpkin, turmeric + sponge gourd and turmeric + cucumber under vegetable cropping concept. The middle portion of the system was utilized for fruit crops such as pineapple and guava. Upper portion of the system was covered with the forest tree spp. *A. nepalensis*. The productivity of the system is depicted in Table 1.

**Table 1 Silvi-horticultural system (W-6)**

| Cropping system | Area ($m^2$) | Production (kg) | | Value (₹) |
|---|---|---|---|---|
| Turmeric | 172.86 | 384 | | 7,680 |
| Turmeric + sponge gourd | 64.00 | 163 | 9.50 | 3,308 |
| Turmeric + bottle gourd | 65.42 | 148 | 63.60 | 4,868 |
| Turmeric + pumpkin | 98.40 | 221 | 116 | 5,000 |
| Turmeric + cucumber | 88.14 | 198 | 39 | 4,155 |
| Guava | 4313 | 45 | | 450 |
| Pineapple | 2,400 | - | - | |
| Total | 7201 | | | 25,461 |

**Timber –based farming system (FSW-8)**

The area of timber-based farming system was 0.52 ha of which 0.02 ha was under forest and 0.50 ha under planned land use. The average slope was 41.35 %. The planned land use system was covered by tree species of *Michelia champaka* and *M. oblonga*. The growth performance of planted trees and their developmental attributes showed better growth and development in *M. blonga* by registering plant height of 20.50 m and plant spread of 6.60 x6.72 (m) in N x S and E x W direction respectively, while *M. champaka* could attain a plant height of 19.98 m with plant spread of 6.60x6.72 m.

**Integrated farming system for food and nutritional security**

One hectare area was earmarked for accommodating different components of Integrated Farming System in which 7000 $m^2$ area was allotted to Agri/Vegetable based cropping system, 2000 $m^2$ was to horticulture and 500 $m^2$ was under water harvesting pond on which fish culture was started. The 500 $m^2$ area was kept for livestock sector vermicompost unit, threshing floor and miscellaneous uses. Among the 7000 sq m area, 2300 sq m was allotted to French bean-rice-*toria*, 2500 $m^2$ for maize based cropping system, 900 sq m spice based cropping system, 600 $m^2$ for groundnut based cropping system and 700 $m^2$ vegetable based cropping system.

The production potential of various agri/vegetable based cropping system registered total income of ₹ 1,62,323/-. The maximum income of ₹ 52,115/- from French bean-rice-*toria* in 2300 $m^2$ with $m^2$ income of ₹ 22.65/-, while maize based cropping system registered net income of ₹ 30,775/- from 2500 $m^2$ area registering ₹ 12.31/$m^2$, spice based cropping system registered net income of ₹ 43930.50/- from 900 $m^2$ with per $m^2$ income of Rs. 48.81 $m^2$ and the vegetable based cropping system recorded net income of ₹ 30,762/ from 700 $m^2$ area only and registered of ₹ 43.94/- $m^2$. The minimum income of ₹ 4,740/- with ₹ 7.9/ $m^2$ was realized from groundnut based cropping system. The data on rice equivalent yield (REY) of various cropping systems revealed that and turmeric+ sponge gourd recorded highest REY (4.68 kg/ $m^2$) followed by turmeric + cucumber 4.52 kg/$m^2$) and turmeric + squash (4.34 kg/$m^2$), groundnut- *toria* produces lowest REY (0.40 kg/$m^2$). Rest of the cropping sequences remained in- between in terms of rice equivalent yield from the system.

**Horticulture block**

The orchard component is having 2000 $m^2$ area in which four fruits species were planted during 2010-11. The Assam lemons, guava, peach and orange were planted in an area of 351 $m^2$, 633 $m^2$, 396 $m^2$, and 620 $m^2$, respectively. The saplings of fruit plants were planted during 2010. On the terrace riser in fruit orchard, shrubs, legume seed (*Tephrosia* sp.*)* were sown for site stabilization and in-situ fertility management. Observation on the height and diameter of fruit plants reveals that peach and guava had attained more height and diameter while orange was the shortest one having plant height of 102 cm with a diameter of 10.50 cm.

The inter space of this orchard block was made productive by growing sweet potato, cowpea, brinjal as ground cover crop while pineapple and papaya were the second storey crop. Total area under fruit crop 1540 $m^2$ was utilized for growing of intercrops. The production potential of this intercropping system could fetch ₹ 7,550/-. While the expenditure various orchard management and crop production was ₹ 12,000/- resulting into a loss of ₹ 4,450/-.

**Livestock Husbandry**

In livestock components (Fig.1) of Integrated Farming system, 600 broiler chicks were reared in six rotations of 100 birds each for a cycle of 35-40 days. One week was the gap period between two cycles for cleaning of the shed. There was 7.5 % mortality recorded due to disease and unforeseen circumstances. The broiler chicks attained a weight of 2.45 kg/bird in 42 days. Besides, 50 layer birds were maintained on the farm for egg production. The poultry variety Vanaraja which is mostly liked by the local people was kept in this herd, in which 45 birds were the female and 5 birds were male. The layer birds were kept in partial scavenging system to reduce the cost of rearing of birds. The total cost of production of broiler and layer was ₹ 69,075/- and ₹ 19,075/- while the gross return was ₹ 1, 49,270/- and ₹ 24,500/- registering a net return of ₹ 80,193/- and ₹ 5425/- respectively. The less income from layer was due to high cost of chicks and feed besides, rearing cost of pullet period.

**Fig 1 Livestock component of IFS**

The third livestock component was pig. Generally the farmer's rear 2-3 pigs per family, hence keeping in view the farmers' requirement and desire, 03 pigs were reared in the system. The pigs were reared for 304 days and improved species of Hampshire x *Khasi* Local was chosen. During this period, the final average weight was 89.67 kg/pig. The total cost of production was worked out to be ₹ 30.209/-, while the gross return were ₹ 34,800/-, with a net return of ₹ 4591/- per 3 pigs. Hence the average net return of ₹ 1530/- per pig was realized in the system.

**Fishery**

The fish pond in 500 $m^2$ area was lined with polythene and tested for water storage continuously for two years. After testing 500 fingerlings were released during second year of experimentation. The harvested water was utilized for giving one pre-sowing irrigation to French bean and one supplementary irrigation to standing crop of *toria*. Hence, with the help of harvested water the cropping intensity of farm area of 2300 $m^2$ was brought fewer than 300%. Besides, 85 kg fish were harvested which on sale gave gross return of ₹ 8,500/- with the cost of cultivation of ₹ 3400/- only and hence the net income was Rs. 5100/- per annum from fish sector.

**Economics**

The component wise cost of cultivation and net return revealed the maximum net income of ₹ 90,211/- only was obtain from livestock component, followed by vegetable and spices. The orchard component registered negative net return of ₹ 4450/- due to the maintenance cost of horticulture area including fruits plant. With regard to the B:C ratio the maximum was obtain from spices production (4.4), followed by vegetable production (2.48) and fishery (2.50). The negative B:C ratio obtained in orchard component (0.63) was due to the high cost of maintenance and less return form intercropping might be due to the effect of newly developed waste land. In all from one hectare area a total expenditure of ₹ 2,13,958/- with gross return of ₹ 3,87,916/- registered a net return of ₹ 1,73,957/- annum.

**Livelihood improvement of tribal farmers through integrated farming system approaches**

Livelihood improvement of tribal farmers through participatory research on integrated farming system was undertaken on 450 farmers in 9 villages. The livelihood improvement of rural people through farming system approach was under taken in 09 villages using 450 farmers were in the categories of Agri-horti (vegetable), 43 farmers, (Agri-horti-piggery), 13 farmers, (Agri-horti-fishery), 03 farmers, (Agri-horti-poultry) systems with *jalkund* and 08 farmers, (Agri-horti-piggery). The improvement in yield of vegetable was in the range of 15-20%. In livestock, 50% increase mark in body weight in pig and 70% in broiler chicks were observed. The farmer has taken up the programme with great interest. The overall improvement in the livelihood of the farmers to the tune of 12 % as compared to their basic information was observed.

## BIO DIVERSITY OF PLANT PATHOGENS IN NEH REGION

**Biodiversity Project**: Few new reports based on molecular evidence (ITS1-5.8S-ITS2 sequence) viz. *Rhizoctonia solani* AG 1-IB on *Basella alba* and *Mucuna pruriens* have been published. Molecular characterization of powdery mildew pathogens has also been done and sequences have been deposited in Gene

bank. Regular surveys are also being conducted for collection.

## MUSHROOM

**Project**: All India Coordinated Project on Mushroom

Evaluation of Oyster mushroom strains: Six strains were evaluated on paddy straw based substrate. PL-12-02, 03 and 06 performed well under Umiam conditions (Table1).

**Table 1 Performance of oyster mushroom strains**

| Strains | Average yield (kg/100 kg dry substrate) |
|---|---|
| PL-12-01 | 61.4 |
| PL-12-02 | 69.0 |
| PL-12-03 | 68.6 |
| PL-12-04 | 60.3 |
| PL-12-05 | 52.0 |
| PL-12-06 | 69.7 |
| CD (*P*= 0.05) | 7.3 |

Mean of 6 replications; Harvesting was done up to second harvest only

3. Mushroom spawn was supplied to various farmers, also distributed under TSP (Tribal Sub Plan), cultures were also supplied to NGO's, State Deptt. etc.

| Commodity | Quantity | Amount (₹) |
|---|---|---|
| Spawn sale | 712.2 kg | 35,610 |
| Fresh Mushroom | 159.6 kg | 7,980 |
| Culture tubes | 38 | 1900 |
| **Total** | | **45,490** |

4. Various mushroom species like *Laccaria* sp., *Ramaria* sp. etc. were collected and deposited at DMR, Solan, H.P.

**a. Trainings**

| Activity | Duration | No. of participants |
|---|---|---|
| Training programme on mushroom cultivation (Under TSP) | 4.12.12 to 10.12.12 (7 days) | 20 |
| Training spawn production and mushroom cultivation to students from Doon PG College | 16.03.13 to 25.03.13 (10 days) | 2 |
| Training program on mushroom cultivation | 31.10.12 to 01.11.12 (2 days) | 29 |
| Training program on mushroom cultivation | 09.08.12 (1 day) | 3 |

**b. Demonstrations, Exhibitions etc.**

| Activity | Date | No. of participants |
|---|---|---|
| Demonstration to students from Rolling stone school | 21.11.12 | 16 |
| Demonstration to farmers from Mizoram | 21.11.12 | 22 |
| Display of mushrooms in Exhibition on Foundation day of the Institute | 09.01.13 | Many farmers |

## AGRICULTURAL MECHANIZATION

### Characterization of weed biomass derived biochar and their effect on corn biomass yield

Pot experiment was conducted to see the effect of weed biomass derived biochar on soil properties and maize crop growth. Sixteen treatment combinations were used for the study consisting of produced biochar alone and in combination with fertilizers (N, P and K). The mean biochar productivity ranged between 23 to 48%, however, highest biochar recovery was from pine needles and lowest was that of *Setaria* sp. By and average, produced biochar contained 8 to 11% moisture whereas, organic matter content varied from 76 to 84% and ash content ranged from 16 to 24%. Application of biochar had positive and significant effect on improvement of soil pH, soil organic carbon (SOC), available N, P, K and biomass yield.

Irrespective of sources of biochar, its application increased the soil pH by 0.26 to 0.30 units and SOC by 4.9 to 7.4% over the control. Biochars derived from different sources alone increased the available N from 4.5 to 21.3 ppm. The P availability varied from 3.32 ppm (*Lantana* biochar) to 3.68 ppm (Corn stalk biochar) as compared to 3.14 ppm in control. Biochar increased the corn biomass yield from 10 to 26%.

### Design and evaluation of power tiller operated inclined plate planter

Power tiller operated three row inclined plate planter for sowing maize, soybean and pea in terraces and valley lands of NEH region has been designed and developed (Figs 1 & 2). Chain and sprocket mechanism is used for getting drive from ground wheel to seed metering shaft. Bevel gears are used for operating the seed plates. The planter was tested in the laboratory by calibrating it for pea, maize and soybean. Field test was conducted in the institute research farm for sowing of pea (Table 1).

**Fig 1 Inclined plate planter in operation**

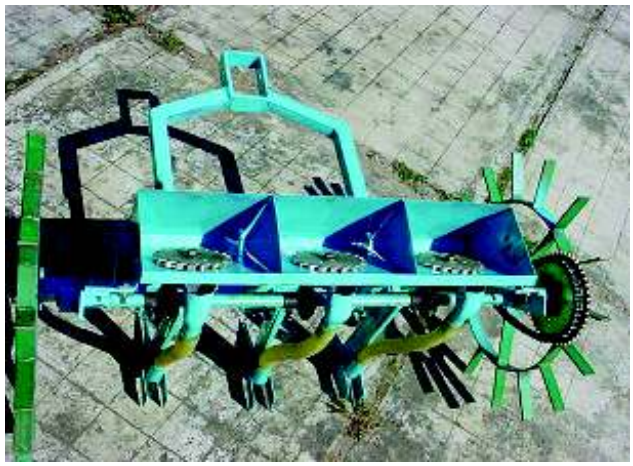


**Fig 2 Developed inclined plate planter**

| | |
|---|---|
| Dimensions (l x w x h), mm | : 900 x 990 x 610 |
| Weight (kg) | : 45 |
| No. of rows | : 3 |
| Row spacing range (mm) | : 130-280 |
| Furrow opener | : Shoe type |
| Change of row spacing | : By sliding the furrow openers on tool bar |
| Seed hopper | : Combined single seed hopper with 3sections |
| Seed metering mechanism | : Inclined plate with edge cells |
| Power transmission | : From ground drive wheel to seed feed shaft through chain, sprockets and set of bevel gears |
| Ground drive wheel (mm) | : 560 (Tip dia.) |
| Provision for sowing | : By selecting seed plates for different crops by changing the transmission ratios |

**Table 1 Field performance result of inclined plate planter for sowing of pea**

| | | | |
|---|---|---|---|
| Area covered (ha) | 0.08 | Average depth of sowing (mm) | 46 |
| Row spacing (mm) | 250 | Average plant population (plant/m$^2$) | 58 |
| Average seed rate (kg/ha) | 55 | Average field capacity (ha/h) | 0.135 |

### Light weight cutting type fruit harvester

A light weight (0.6 kg) cutting type fruit harvester has been designed and developed with two meter long aluminium handle (Fig 3). Its cutting knife has been made from mild steel sheet and tempered by water quenching. Below the cutting blade, a ring of 150 mm diameter with a net has been provided to hold the fruits. By this equipment 300 to 400 fruits can be harvested per hour with zero damage in fruit.

**Fig 3 Light weight cutting type fruit harvester**

### CO emission characteristics of beehive briquettes

Emission characteristic of carbon monoxide (CO) from burning beehive briquette made of three combinations of charcoal and soil is shown in (Fig 4). There was no significant difference in emission of CO from all three combinations of beehive briquettes. Highest CO emission (0.11%) was observed with $S_1$, followed by $S_2$ (0.1%) and $S_3$ (0.09%).

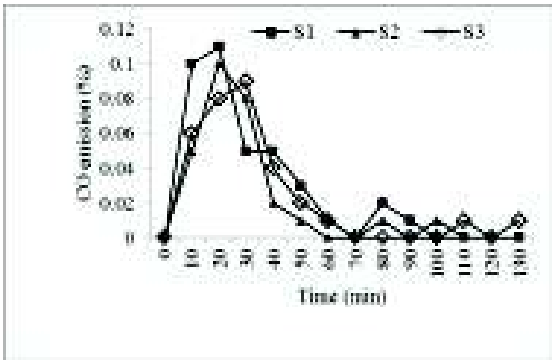



**Fig 4 Emission characteristics of carbon monoxide (CO) from burning beehive briquette, {Charcoal: soil ratio; 60:40 ($S_1$), 50:50($S_2$) and 40:60($S_3$)}**

### Design and installation of Earth-Air Heat Exchanger (EAHE) for cooling/heating of polyhouse

A polyhouse of 32 $m^2$ floor area has been constructed with all sides covered by 250µm thick poly-ethylene sheet (Fig 5). The EAHE has been placed 1.5 m below ground level. The heat exchanger is a grid of 75 mm inner diameter mild steel pipes connected by elbows and 'T's. Each pipe is 6 m long and placed at 400 mm spacing. The steel scraps collected from lathe machine have been spread at the sides of each pipes to increase heat exchange between soil and pipes thereby with circulating air inside the pipes.

After each two pipes of the grid one butterfly valve has been placed to divert the air so as to control the length of pipe (Fig 5). By this way the travel length of air can be changed from 12 to 48 m to find out optimum length and airflow rate to get maximum heat exchange. A blower of 3000 rpm and 400 mm impeller diameter will be used to control the flow of air inside the pipe grid. A data logger has been placed inside the polyhouse to record temperature and humidity at 15 min interval.

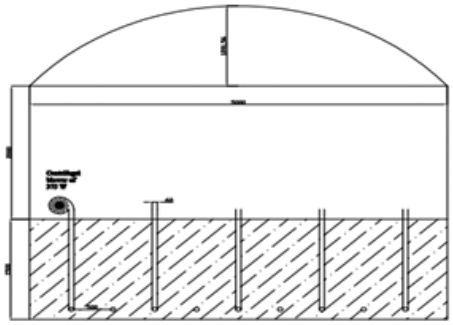


**Fig 5 Butterfly valve arrangement and basic layout of the polyhouse with EAHE**

### Physico-mechanical properties of *Prunus nepalensis* fruit and seed

A study was conducted to determine the physical and mechanical properties of *Prunus nepalensis* fruit and seed (Fig 6) which are necessary for designing machines for handling, processing and storage. The average thickness, geometric mean diameter, arithmetic mean diameter and surface area of fruit and seed determined experimentally were 18.20, 19.16, 19.18 mm, 1156.61 $mm^2$ and 13.96, 14.93, 15.02 mm, 701.17 $mm^2$, respectively. The seed was less spherical than the fruit. The average unit mass, 1,000 grain mass, volume, true density, bulk density and porosity were

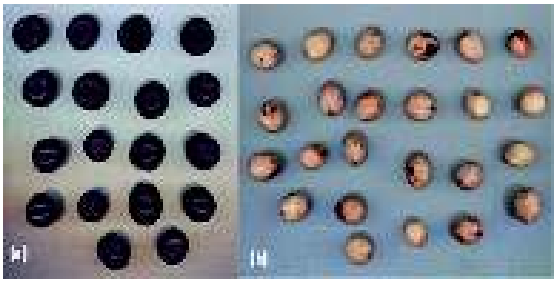


**Fig 6 Scanned images of *Prunus nepalensis* fruits (a) and seeds (b)**

measured as 5.09, 5141.14 g, 4.89 $cm^3$, 1057.68, 598.08 kg $m^{-3}$ and 43.42 %, respectively whereas, for seed these values were 1.83g, 2050.40 g, 1.62 $cm^3$, 1178.84, 508.80 kg $m^{-3}$ and 57.94 % respectively.

The angle of repose of fruit and seed was 26.43 and 22.13°, respectively. GI sheet surface had the highest coefficient of friction and the static coefficient of friction was lowest against aluminium with both fruit and seed. Fruit had higher friction than seed due to higher moisture content. Hardness of fruit was 0.966 kg.

### Adjustable zero till furrow opener

A manual zero-till furrow opener (Fig 7) was designed with a two furrow opener which opens furrow of 2-3 cm width and 3-4 cm depth on untilled soil. Furrow openers are narrow tine with rake angle of 30° with two small boards to overturn soil. This is adjustable between 200-600 mm row to row distance. A long pulling handle and a guiding handle have been provided for operation. Two labourers are needed to operate this. It is suitable for making furrow for paddy, mustard, pea, lentil for sowing in zero till condition. Its capacity ranges from 0.06 to 0.2 ha/h depending on row width.

**Fig 7 Adjustable zero till furrow opener**

### Prototype feasibility testing of light weight power tiller with attachments

Light weight power tiller (BCS make) of 69 kg weight and 4.1 kW engine (Fig 8) was tested with rotavator, cultivator and ridger attachments. Rotavator having 12 nos. of L-shape blades fitted in 4 rows was tested for field performance. The width of coverage was 45 cm with 8 cm average depth of operation. Degree of soil pulverization was very good. The cultivator with 3 tines could cover total width of 40 cm with 12 cm average depth of operation. The ridger attachment was able to open furrow with 26 cm top width and 12 cm depth.

**Fig 8 Lightweight power tiller with different attachments**

## POST HARVEST MANAGEMENT AND PROCESSING

### Development and optimization of osmotically dehydrated carrot tuity fruity and powder

Experiments were conducted with carrot for developing value added product such as carrot tuity-fruity and powder. Freshly harvested carrots, procured from Shillong markets, were washed with clean water, peeled and sliced into three different thickness of sizes *viz*. 4x10x10 mm (Length x breadth x width), 6x10x10 mm, 8x10x10 mm, 10x10x10 mm, 12x10x10 mm and 5x10x10 mm. The slices were subjected to different temperatures of blanching i.e. 5, 10, 15, 20 and 25 min. Blanched slices were then subjected to boiling in 50% sugar syrup for 30 minutes. Different quality parameters *viz*., hardness, colour and sensory were evaluated. Among different treatments, carrot slices of 10x10x10 mm followed by 15 minutes blanching recorded maximum sensory score (8.2) and also medium soft texture. Carrot peels and uneven slices were also blanched for 10 minutes followed by drying at 50ºC for 4 hrs in the cabinet air drier. These dehydrated carrots were then grinded to obtained carrot powder.

**Fig 9 Optimized osmotically dehydrated carrot tuity-fruity**

## SOCIAL SCIENCES

### Estimation of cost of cultivation of paddy in Meghalaya

Cost of cultivation data of paddy from Meghalaya were collected. It was found that in rice production, application of FYM consume the major share in the total cost of cultivation of paddy in low altitude localities (Table 1).

**Table 1 Cost of cultivation of paddy in Meghalaya (2011-12)**

| Sl. No. | Operation | Inputs | Rates/Unit | Cost (₹/ha) |
|---|---|---|---|---|
| 1 | Nursery bed preparation and raising of seedlings | 4 Man days | 110 | 440 |
| | Cost of seeds | 80 kg/ha | 25 | 2000 |
| 2 | Land preparation | | | |
| | Primary tillage (Power tiller) | | 1500 | 1500.00 |
| | Puddling | 15 Man days | 110 | 1650.00 |
| 3 | Layout and formation of irrigation channels and bunds | 10 Man days | 110 | 1100.00 |
| 4 | FYM | | | |
| | Cost of FYM | 5 tonnes | 2000 | 10000.00 |
| | Labour Charges | 4 Man days | 110 | 440.00 |
| 5 | Fertilizers | | | |
| | Nitrogen | 80 kg/ha | 12.35 | 988.00 |
| | Phosphorus | 60 kg/ha | 40.75 | 2445.00 |
| | Potash | 40 kg/ha | 11.21 | 448.40 |
| 6 | Transplanting | 25 Man days | 110 | 2750.00 |
| 7 | Gap filling/Interculture operations/insect management | 6 Man days | 110 | 660.00 |
| 10 | Harvesting and threshing | 25 Man days | 110 | 2750.00 |
| | Miscellaneous | | | 1500.00 |
| | Above Total | | | 29111.40 |
| | Interest on working capital | For 6 month | 12% per annum | 1746.68 |
| | TOTAL | | | 30858.08 |

### Role of agro-met advisory service in improving livelihood of rural farmers in Meghalaya

To study the impact of Agro-met Advisory Service (AAS) data were collected from the fields of farmers of both AAS and non-AAS categories on specified time schedules. The economic impact assessment was crop specific, region specific and season specific. Case studies of specific operations have also been cited with the gain/loss in economic terms. Given below are the detailed analyses of each crop undertaken by the 15 units. The results are based on impacts of AAS on (a) cost of cultivation, (b) net returns, (c) yield.

### Paddy

AAS units undertaking the study on rice were in Byrnihat, Mauhati and Bhoirylbong

### General information of the crop

Rice is grown in both *rabi* and *kharif* season in Ri-bhoi district. Yields in *rabi* are higher than *kharif* due to higher nitrogen use efficiency in view of abundant availability of solar radiation. In Byrnihat paddy is grown under both direct sown and transplanted condition.

### Weather sensitive farm operations

All farm operations sensitive to paddy growth viz., sowing raising of seedlings; transplanting, irrigation, fertilizer application, plant protection and harvesting were studied (Tables 2 & 3)

**Table 2 Weather sensitive crop growth stages of rice in Ri-Bhoi District, Meghalaya**

| Crop growth stage | Std. Met. Week | Important weather parameters related to respective crop growth | Effects of weather parameters |
|---|---|---|---|
| Emerging phase | 25 | Rainfall | Deficit or excess rainfall affect the emergence |
| Seedling phase | 26-28 | Rainfall & Sunshine | Deficit rainfall increased the weed growth |
| Transplanting phase | 29 | Rainfall | Deficit rainfall hampered the transplanting |
| Tillering phase | 30-33 | Rainfall | Excess rainfall decreased the tiller production |
| Vegetative lag phase | 34-35 | Cloudiness | Reduced biomass and photosynthesis |
| Reproductive phase | 36-38 | Rainfall | Reduced pollination |
| Grain ripening phase | 39-42 | Sunshine | Increased fertile spikelets |

**Table 3 Impact of AAS**

| Station | Crop | Decrease (%) on paddy cultivation | | Increase (%) | |
|---|---|---|---|---|---|
| | | Cultivation (₹/acre) | Gross returns (₹/acre) | Net returns (₹/ acre) | Yield |
| Bhoirylbong | Paddy | 12.3% | 12.0% | 25.8% | 10.3% |
| Byrnihut | Aman Paddy | 11.2% | 23.0% | 21.0% | 14.2% |
| Mauhati | Paddy | 5% | 8.1% | 19.1% | 21.3% |

**Development of food production in NE Region**

The region III of ICAR including Assam has a total food-grains requirement of 8125.11 thousand tonnes against the population of 46.3 million in 2012 (Table 4). During the past 2 years 2010-11 and 2011-12 substantial increase in production and productivity of food-grains has reduced the deficiency of food-grains from 23% in TE 2010 to 8.33% in TE 2012. During the last 10 years rice production of this region increased up to 21.28% (from 5396.2 thousand tonnes in TE 2003 to 6544.4 thousand tonnes in TE 2012) with a compounded growth rate of 3.16% over the last 5 years. The increase in production and productivity of food-grains is being achieved because of replacement of high yielding varieties and quality seed materials and timely supply of improved seeds. Among the NE states, Tripura has the highest productivity of food-grains (2.62 t/ha) and highest cropping intensity (184%). Similarly, in organic farming Sikkim is leading state especially in spices crops. The package and practices of organic farming for different crops provided by the ICAR, SAUs, CAU and state agricultural research stations has given better organic food in nutrient status. The National Horticultural Mission/ Technology Mission in horticulture have played an important role in increasing fruits and vegetables production. All the states have increased fruits production significantly i.e.from 2839.7 thousand tonnes in 2007-08 to 3955.89 thousand tonnes in 2011-12 with an annual compound growth rate (CGR) of 3.39%. In case of vegetables including Assam, the production in 2007-08 was 5670.6 thousand tones and in 2011-12 it was 4787.77 thousand tones. This indicates the market complexities in terms of vegetable production and productivity in remote areas. However in vegetables, excluding Assam, production was 1196.4 in 2007-08 thousand tones and 1742.2 thousand tones in 2011-12 with CGR 4.04%.

Fish has increased from 219.70 thousand tonnes in TE 2003 to 255.34 thousand tonnes in TE 2012 though this region is still deficient (57.63 %) at present. Egg production has been increased from 8305.00 lakh in TE 2003 to 10099.41 lakh in TE 2012. Milk production has increased from 1173.00 thousand tonnes in TE 2003 to 1201.35 thousand tonnes in TE 2012. Meat production has increased from 206 thousand tonnes in TE 2010 to 220.78 thousand tonnes in TE 2012 (72.48% increase). Except Tripura (-82.12%) and Sikkim (-22.36%), all the other states have increased meat production substantially particularly Nagaland (164.06%) and Arunachal Pradesh (132.04%).

**Table 4 Production and requirement of food grains, fish, milk, egg and meat in NE Region in 2012**

| States/Human population in 2012 (Estimated) | Commodity | Production (TE ending period 2001 to 2003) in '000' | Production (TE ending period 2010 to 2012) in '000' | Increase (% ) in production during 2001 to 2012 | Requirement in ('000) as per 2012 popln | Surplus/ Deficit in '000 | Per cent Surplus/ Deficit |
|---|---|---|---|---|---|---|---|
| **Arunachal Pradesh (Population 1406115)** | | | | | | | |
| | Rice | 134.00 | 234.93 | 75.32 | 220.8 | 14.17 | 6.0 |
| | Cereals | 227.20 | 325.27 | 43.16 | 222.2 | 103.10 | 31.7 |
| | Pulses | 7.40 | 9.77 | 31.98 | 25.7 | -15.89 | -61.9 |
| | Food grains | 234.70 | 335.03 | 42.75 | 246.4 | 88.61 | 26.4 |
| | Fish | 2.40 | 2.51 | 4.58 | 18.3 | -15.77 | -86.3 |
| | Milk | 49.00 | 27.20 | -44.48 | 153.9 | -126.77 | -82.3 |
| | Egg | 86.00 | 401.80 | 367.21 | 2109.2 | -1707.4 | -80.9 |
| | Meat | 9.20 | 21.35 | 132.04 | 15.47 | 5.88 | 27.5 |

*Contd...*

| States/Human population in 2012 (Estimated) | Commodity | Production (TE ending period 2001 to 2003) in '000' | Production (TE ending period 2010 to 2012) in '000' | Increase (%) in production during 2001 to 2012 | Requirement in ('000) as per 2012 popln | Surplus/ Deficit in '000 | Per cent Surplus/ Deficit |
|---|---|---|---|---|---|---|---|
| **Assam (Population 31699149)** | | | | | | | |
| | Rice | 3905.00 | 4529.59 | 15.99 | 4976.8 | -447.17 | -9.87 |
| | Cereals | 3921.00 | 4605.89 | 17.47 | 5008.5 | -402.58 | -8.74 |
| | Pulses | 63.20 | 67.75 | 7.20 | 578.5 | -510.76 | -88.3 |
| | Food grains | 3984.00 | 5020.03 | 26.00 | 5555.3 | -535.24 | -10.7 |
| | Fish | 159.80 | 184.21 | 15.27 | 412.1 | -227.9 | -55.3 |
| | Milk | 751.00 | 780.67 | 3.95 | 3471.1 | -2690.4 | -77.5 |
| | Eggs | 5067.00 | 4674.60 | -7.74 | 47548.7 | 42874.0 | -90.0 |
| | Meat | 22.40 | 33.54 | 49.71 | 348.69 | -315.16 | -90.48 |
| **Manipur (Population 2768025)** | | | | | | | |
| | Rice | 378.00 | 477.53 | 26.33 | 434.58 | 42.95 | 8.99 |
| | Cereals | 375.70 | 514.14 | 36.85 | 437.35 | 76.79 | 14.94 |
| | Pulses | 3.00 | 19.42 | 547.22 | 50.52 | -31.10 | -61.56 |
| | Food grains | 378.70 | 533.56 | 40.89 | 485.10 | 48.46 | 9.08 |
| | Fish | 15.50 | 17.52 | 13.05 | 35.98 | -18.46 | -51.30 |
| | Milk | 77.00 | 78.00 | 1.30 | 303.10 | -225.1 | -74.27 |
| | Eggs | 902.00 | 1146.08 | 27.06 | 4152.1 | -30096 | -72.40 |
| | Meat | 22.00 | 24.31 | 10.48 | 30.45 | -6.14 | -25.27 |
| **Meghalaya (Population 3014395)** | | | | | | | |
| | Rice | 184.00 | 210.06 | 14.16 | 473.26 | -263.20 | -55.61 |
| | Cereals | 225.20 | 238.74 | 6.01 | 476.3 | -237.53 | -49.87 |
| | Pulses | 3.40 | 3.64 | 7.06 | 55.01 | -51.37 | -93.38 |
| | | | | 6.08 | 528.3 | | -54.12 |
| | | | | -23.26 | | | |
| | Food grains | 228.50 | 242.38 | 5.02 | -285.89 | | |
| | Fish | 4.70 | 3.61 | | 39.19 | -35.58 | -90.80 |
| | Milk | 75.00 | 78.77 | | 330.08 | -251.31 | -76.14 |
| | Eggs | 902.00 | 1008.39 | 11.79 | 4521.6 | -3513.2 | -77.70 |
| | Meat | 35.60 | 37.67 | 5.81 | 33.16 | 4.51 | 11.97 |
| **Mizoram (Population 1109561)** | | | | | | | |
| | Rice | 99.30 | 55.69 | -43.92 | 174.20 | -118.51 | -68.03 |
| | Cereals | 127.10 | 59.78 | -52.97 | 175.3 | -115.53 | -65.90 |
| | Pulses | 4.50 | 5.97 | 32.74 | 20.25 | -14.28 | -70.50 |
| | Food grains | 131.60 | 72.83 | -44.66 | 194.45 | -121.62 | -62.55 |
| | Fish | 2.90 | 2.88 | -0.80 | 14.42 | -11.55 | -80.06 |
| | Milk | 16.00 | 10.73 | -32.92 | 121.5 | -110.76 | -91.17 |
| | Eggs | 289.00 | 382.39 | 32.31 | 1664.3 | -1281.9 | -77.02 |
| | Meat | 8.70 | 9.92 | 14.04 | 12.21 | -2.28 | -23.02 |
| **Nagaland (Population 2014272)** | | | | | | | |
| | Rice | 199.00 | 334.69 | 68.19 | 316.24 | 18.45 | 5.51 |
| | Cereals | 354.00 | 461.07 | 30.24 | 318.26 | 142.81 | 30.97 |
| | Pulses | 30.40 | 35.25 | 15.96 | 36.76 | -1.51 | -4.28 |
| | Food grains | 384.40 | 496.32 | 29.12 | 353.00 | 143.32 | 28.88 |
| | | 5.00 | 5.79 | 15.87 | 26.19 | -20.39 | -77.88 |
| | Fish | 67.00 | | | | | -77.88 |
| | Milk | | 78.92 | 17.79 | 220.56 | -141.6 | -64.22 |
| | Eggs | 540.00 | 811.28 | 50.24 | 3021.00 | -2209.7 | -73.15 |
| | Meat | 26.20 | 69.18 | 164.06 | 22.16 | 47.03 | 67.97 |

*Contd...*

| States/Human population in 2012 (Estimated) | Commodity | Production (TE ending period 2001 to 2003) in '000' | Production (TE ending period 2010 to 2012) in '000' | Increase (%) in production during 2001 to 2012 | Requirement in ('000) as per 2012 popln | Surplus/ Deficit in '000 | Per cent Surplus/ Deficit |
|---|---|---|---|---|---|---|---|
| **Sikkim (Population 618018)** | | | | | | | |
| | Rice | 22.40 | 22.06 | -1.52 | 97.03 | -74.97 | -77.26 |
| | Cereals | 92.10 | 100.07 | 8.65 | 97.65 | 2.42 | 2.42 |
| | Pulses | 6.30 | 10.22 | 62.28 | 11.28 | -1.06 | -10.32 |
| | Food grains | 98.40 | 110.26 | 12.05 | 108.31 | 1.95 | 1.77 |
| | | 0.10 | 0.16 | 60.00 | 8.03 | -7.87 | -98.01 |
| | Fish | 49.00 | 43.72 | -10.78 | 67.67 | -23.95 | -54.79 |
| | Milk | 97.00 | 133.57 | 37.70 | 927.03 | -793.46 | -85.59 |
| | Eggs | 4.00 | | | | | |
| | Meat | | 3.11 | -22.36 | 6.80 | -3.69 | -54.31 |
| **Tripura (Population 3733439)** | | | | | | | |
| | **Rice** | 535.50 | 686.94 | 28.28 | 586.15 | 100.79 | 14.67 |
| | Cereals | 574.10 | 691.50 | 20.45 | 589.88 | 101.62 | 14.70 |
| | Pulses | 5.40 | 5.23 | -3.09 | 68.14 | -62.90 | -92.32 |
| | Food grains | 579.50 | 696.73 | 20.23 | 654.29 | 42.45 | 6.09 |
| | Fish | 29.30 | 43.69 | 49.11 | 48.53 | -4.84 | -11.09 |
| | Milk | 89.00 | 103.34 | 16.11 | 408.81 | -305.47 | -74.72 |
| | Eggs | 607.00 | 1541.31 | 153.92 | 5600.16 | -4058.8 | -72.48 |
| | Meat | 128.00 | 22.88 | -82.12 | 41.07 | -18.19 | -79.48 |
| **Total NE (Population 46362977)** | | | | | | | |
| | Rice | 5396.20 | 6544.39 | 21.28 | 7278.99 | -734.60 | -11.22 |
| | Cereals | 5896.10 | 6996.45 | 18.66 | 7325.35 | -328.90 | -4.70 |
| | Pulses | 123.70 | 157.26 | 27.13 | 846.12 | -688.87 | -81.41 |
| | Food grains | 6019.80 | 7500.03 | 24.59 | 8125.11 | -625.08 | -8.33 |
| | Fish | 219.70 | 255.34 | 16.22 | 602.72 | -347.38 | -57.63 |
| | Milk | 1173.00 | 1201.35 | 2.42 | 5076.75 | -3875.4 | -76.34 |
| | Eggs | 8305.00 | 10099.41 | 21.61 | 69544.47 | -59445.0 | -85.48 |
| | Meat | 128.00 | 220.78 | 72.48 | 509.99 | -289.2 | -56.71 |

**Impact assessment of technologies demonstrated for turmeric and ginger under TSP in northeast region**

Yield, cost of cultivation, production increase of ginger and turmeric were collected from the 50 beneficiaries of Ri-bhoi district. The highest net income from specific technology was ₹ 255000/- from the ginger followed by turmeric (₹ 202500/-). In farmers' practice it was worked out to be ₹ 159000/- from the Ginger than turmeric (₹ 74250/-). Out-put ratio was highest in turmeric with improved technologies (4.06). Whereas, in traditional practice it was 3.00. The highest net income as well as output-input ratio was found in ginger due to higher price of the produce (Table 5).

Varieties developed by the ICAR were found widely adopted by the farmers. The post-harvest management was found as the second preferred technology. Water management technology was found least preferred technology. Most of the farmers expressed unwillingness for use of chemical fertilizer (Table 6).

**Table 5 Economics of traditional practices vs. improved technology**

| Crop | Yield (kg/ ha) | Cost of cultivation (₹/ha) | Gross income (₹/ha) | Net income (₹/ha) | Output/input ratio |
|---|---|---|---|---|---|
| Traditional practices | | | | | |
| Ginger | 8800 | 65000 | 224500 | 159000 | 3.05 |
| Turmeric | 9100 | 61500 | 135750 | 74250 | 2.96 |
| Improved practices with modern technology | | | | | |
| Ginger | 16000 | 78500 | 333500 | 255000 | 3.00 |
| Turmeric | 26000 | 70800 | 273300 | 202500 | 4.06 |

**Table 6 Ranking of technology on the basis of preference of the farmers**

| Crop | Variety | Seed rate | Fertilizer management | Plant protection | Water management | Post-harvest management |
|---|---|---|---|---|---|---|
| Ginger | I | IV | III | V | VI | II |
| Turmeric | I | III | IV | V | VI | II |

### *Jhum* area of NE Region

In Arunachal Pradesh, 54.66 % reductions in abandoned *jhum* area was found during the period 2005-06 to 2009-10, however, the current *jhum* area had been increased from 496.22 $m^2$ to 1025.07 $km^2$, which showed an increase of 106.58%. Out of the total cropped area of 27600 $km^2$ in 2009-10 the percentage of area covered under current *jhum* was found to be 3.71% which was 1.86% in 2005-06 (Table 7).

**Table 7 Status of *jhum* in Arunachal Pradesh**

| Paramerter | 2005 -06 | 2009 -10 | Difference | Difference (% ) |
|---|---|---|---|---|
| Abandoned *jhum* area ($km^2$) | 1116.91 | 506.39 | -610.52 | -54.66 |
| Current *jhum* area ($km^2$) | 496.22 | 1025.07 | 528.85 | 106.58 |
| Total cropped area ($km^2$) | 26600 | 27600 | 1000 | 3.76 |
| % of *jhum* area to the total cropped area | 1.86 | 3.71 | | |

In Assam, during the period from 2005-06 to 2009-10 both abandoned (-81.78 % ) and current (-95.42%) *jhum* area were reduced significantly. In 2009-10 the contribution of *jhum* area (160.15 $km^2$.) to the total cropped area (409946 $km^2$.) of the state was 0.04% (Table 8).

**Table 8 Status of *jhum* in Assam**

| Paramerter | 2005 -06 | 2009 -10 | Difference | Difference (% ) |
|---|---|---|---|---|
| Abandoned *jhum* area ($km^2$) | 435.89 | 79.41 | -356.48 | -81.78 |
| Current *jhum* area ($km^2$) | 3495.08 | 160.15 | -3334.93 | -95.42 |
| Total cropped area ($km^2$).) | 394904.0 | 409946.0 | 15042.0 | 3.81 |
| % of *jhum* area to the total cropped area | 0.89 | 0.04 | | |

In case of Manipur too, both abandoned (-97.29 %) and current (-32.82 %) *jhum* area were reduced significantly during the said study period and area coverage of current *jhum* area was found to be 3.21% of the total cropped area of 23400 $km^2$. during 2009-10 (Table 9)

**Table 9 Status of *jhum* in Manipur**

| Paramerter | 2005 -06 | 2009 -10 | Difference | Difference (% ) |
|---|---|---|---|---|
| Abandoned *jhum* area ($km^2$) | 3697.14 | 100.1 | -3597.04 | -97.29 |
| Current *jhum* area ($km^2$) | 1119.54 | 752.1 | -367.44 | -32.82 |
| Total cropped area ($km^2$).) | 22500 | 23400 | 900 | 4.00 |
| % of *jhum* area to the total cropped area | 4.98 | 3.21 | | |

In Meghalaya, 34.73 % of abandoned *jhum* area was increased during the period 2005-06 to 2009-10. However, during the same period the current *jhum* area had been reduced from 627.21 $km^2$ to 291.87 $km^2$ which results a reduction of 53.45 %. Out of the total cropped area of 33641 $km^2$ in 2009-10 the percentage of area covered under current *jhum* was found to be 0.87 % which was earlier 2.44 % in 2005-06 (Tabble 10).

**Table 10 Status of *jhum* in Meghalaya**

| Paramerter | 2005 -06 | 2009 -10 | Difference | Difference (% ) |
|---|---|---|---|---|
| Abandoned *jhum* area ($km^2$) | 116.62 | 157.12 | 40.5 | 34.73 |
| Current *jhum* area ($km^2$) | 627.21 | 291.87 | -335.34 | -53.47 |
| Total cropped area ($km^2$) | 25750 | 33641 | 7891 | 30.64 |
| % of *jhum* area to the total cropped area | 2.44 | 0.87 | | |

Mizoram state showed 44.64 % and 10.32 % reduction in the area of abandoned and current *jhum* respectively during the mentioned period with 8.38% contribution of *jhum* area to the total cropped area of the state in 2009-10 (Table 11).

**Table 11 Status of *jhum* in Mizoram**

| Paramerter | 2005 -06 | 2009 -10 | Difference | Difference (% ) |
|---|---|---|---|---|
| Abandoned *jhum* area (km$^2$) | 2870.46 | 1589.03 | -1281.43 | -44.64 |
| Current *jhum* area (km$^2$) | 1146.95 | 1028.53 | -118.42 | -10.32 |
| Total cropped area (km$^2$) | 8312 | 12286 | 3974 | 47.81 |
| % of *jhum* area to the total cropped area | 13.80 | 8.37 | | |

*Jhum* area was found to be increased in Nagaland during the period from 2005-06 to 2009-10 with 98.26% in abandoned area and 10.97% in current area of *jhum*. Out of the total cropped area of 48640 km$^2$ in 2009-10 the percentage of area covered under current *jhum* was found to be 2.55% which was earlier 2.89 % in 2005-06 (Table 12).

**Table 12 Status of *jhum* in Nagaland**

| Paramerter | 2005 -06 | 2009 -10 | Difference | Difference (% ) |
|---|---|---|---|---|
| Abandoned *jhum* area (km$^2$) | 801.3 | 1588.65 | 787.35 | 98.26 |
| Current *jhum* area (km$^2$) | 1116.6 | 1239.09 | 122.49 | 10.97 |
| Total cropped area (km$^2$) | 38679 | 48640 | 9961 | 25.75 |
| % of *jhum* area to the total cropped area | 2.89 | 2.55 | | |

In Tripura, 49.34% of abandoned *jhum* area was increased during the period 2005-06 to 2009-10. However, during the same period the current *jhum* area had been reduced from 284. km$^2$ to 89.28 km$^2$, indicating reduction (68.66 %). Out of the total cropped area of 26673 km$^2$ in 2009-10 the percentage of area covered under current *jhum* was found to be 0.33 % which was earlier 1.01 % in 2005-06 (Table 13).

**Table 13 Status of *jhum* in Tripura**

| Parameter | 2005 -06 | 2009 -10 | Difference | Difference (% ) |
|---|---|---|---|---|
| Abandoned *jhum* area (km$^2$) | 110.37 | 164.83 | 54.46 | 49.34 |
| Current *jhum* area (km$^2$) | 284.89 | 89.28 | -195.61 | -68.66 |
| Total cropped area (km$^2$) | 28000 | 26673 | -1327 | -4.74 |
| % of *jhum* area to the total cropped area | 1.01 | 0.33 | | |

**Breeds of livestock reared**

From the data collected, in breeds of pig, 39 per cent was found to be improved and 61 per cent native which is highest rate of adoption among cattle, poultry and pig. The lowest improved breed was observed in cattle (5%). The adoption of poultry shows an adoption rate of 12.5 per cent, which is comparatively better than the latter.

Out of the total individuals interviewed 90 per cent families grew crops. The variety of crops grown consisted of ginger (87.5%), rice (50%), French bean (22.5%), maize (17.5%), sweet potato (15%), strawberry (15%), chilli (12.5%), cauliflower (10%), brinjal (7.5%), mustard (5%), cabbage (5%) and others (2-4%).

**Extension services**

Among the extension methods high preference was given to demonstration, the localities lagged behind in communication as their only lingua-franca is the *khasi*. This method gave them a good learning opportunity up to maximum extent. Discussion was preferred by a handful of people who are fairly educated (40 %) and 35 per cent gave preference for on farm trial while only 15 per cent preferred awareness programme. Several reasons were cited for not availing the extension services which shortage of time, inconvenient to attend at the venue, included no prior notice and lack of timely extension services.

**Constraints in adoption of improved livestock technology**

Some constraints faced by the farmers in adoption of improved livestock technology are enlisted under broad heads of resource, technology, financial, social, infrastructure, market and environment. In winter there is shortage of feed and fodder, vaccines are not available at veterinary clinics, reduced human labour and the present depleting resources of grazing lands are posing difficulty in improved livestock rearing. In technological field, problems arise involving lack of availability of improved breeds, high risk of survival and lack of information. The financial drawbacks are high cost of technology and availability of cash and credit. Distribution of land and labour shortage or migration was constraints faced socially. Infrastructural constraints like lack of irrigation facilities, electricity and village roads are also counted. Markets are not available in some of the villages and genuine price to the product was difficult to achieve. Water quantity

and quality in the villages created inconvenience also is the degrading soil fertility is of great concern to the farmers.

**Major problems perceived by the respondents**

Some of the major areas affecting and hindering the realization of the potential for high economic growth and personal empowerment were unhygienic processing, lack of value addition enterprises and technologies, non-availability of superior breeds of piglets and high quality semen for Artificial Insemination (AI) in pigs, poor accessibility to the veterinary dispensaries, non-availability of balanced feed at right time, etc. were the problems faced by the dairy owner in adopting improved cattle production technologies. In case of breeding practices, the nonfunctioning of AI centre, ill equipped AI Centre was being always seen as a major problem by maximum female respondents (65.64%) followed by distance of Veterinary hospital from the village (58.29%) while lack of good breedable bulls for natural service was never being seen as major problem by many of the respondents. For feeding practices, non-availability of feed materials at right time was more important and regular problem viewed by the respondents (62.83%) than the lack of grazing fields. In health care and management, lack of awareness about vaccination schedule (32.27%) was perceived by the respondents as major problem.

Less scope for the permanent asset building in the existing social system was the major constraint perceived by 34.24% of female respondents. Under infrastructure, high cost of pig shed for improved rearing by majority of the respondents.

## TRANSFER OF TECHNOLOGY

**FLD under DBT's Rural Bio-resource Complex in northeast India**

Thirteen commodity interest groups were organised for cultivation of Megha Turmeric 1 (Fig 1) on 15 ha area. An average 1.9-2.0 t/ha yield was recorded. All together 134 farmers were benefited from the Tyrso, Liarbang, Umran, Umdohbyrthih, Rilong, Pahambirlum, Mawrong, Pahamskhen, Thadnongiaw, Mawtneng villages in Ri-Bhoi District, Meghalaya. Seven farmers' interest groups were organised for FLD on *khasi* mandarin on 6.25 ha area. All together 80 farmers were benefited from the Pahambirlum, Nongladaw, Umdohbyrthih, Tyrso, Lumdiengjri, Pahambirthem and Raitongvilleges in Ri-BhoiDist of Meghalaya.

**Fig 1 FLD on Megha Turmeric 1**

**Training and Demonstration**

Three days training programme was organized on 6th – 8th March 2013 at Mawpun village, RiBhoi district, Meghalaya on "Improved Production Technology of Tuber and Rhizomatous Crops" in which presentations and lectures on production and cultivation of different tuber crops like colocasia, sweet potato, *Amorphophallus* were delivered . On farm demonstrations on cultivation of *Amorphophallus* and Colocasia were also conducted. Planting materials and plant protection chemicals were distributed to all the farmers after the training programme in the presence Director, ICAR Research Complex for NEH Region, Umiam, and other scientists (Fig 2).

**Fig 2 Training and Demonstration on tuber crops**

### Adaptability studies on Murrah buffaloes under agro-climatic conditions of Meghalaya

An attempt was made to introduce Murrah buffaloes at Umiam Meghalaya in March 2012 to evaluate the feasibility of Murrah buffaloes as a component of Integrated Farming System(IFS) along with crop and fish production system of north east with the rationale of combating acid soils of the region. The SWOT analysis of the study revealed that integration of Murrah buffaloes under IFS may enhance income for small and marginal farmers of this region along with nutritional security.

Considering the changing climatic conditions of the region and potential of buffaloes to adjust to a wide range of agrarian and diversified agro –climatic situations, the studies showed a marked loss of body score and weight loss up to 12-15% in the initial 30 days. They recovered well in the 30-60 days period with improved feeding and management. The buffalo calves showed an average daily weight gain over and above 500 g/day during first 6 months period. The lactating buffaloes resumed reproductive cyclicity in 100-120 days post –partum even in the months of June and July in contrast to the buffaloes in their home tract in north India where they show higher incidence of summer anestrus during these months.

### Development of low cost climate resilient environment-affinitive pigpen model

Innovative integrated low-cost pigpen was designed (Fig1) and developed with locally available natural resources for high rainfall mid and high altitude temperate region. The pig housing model was evaluated and compared with conventional concrete floor pig housing in term of micro-environment, physiological adaption, performance, water use efficiency, animal welfare and behavior. The results revealed that the temperature and humidity of the developed pigpen maintain within the normal range as compared to the conventional concrete pigpen during winter as well as rainy season. In winter, temperature of conventional concrete pigpen recorded average of 62.7ºF and floor temperature was 56.3ºF. The low temperature in the conventional concrete pen causes stress and energy loss to the pigs during winter. However, the saw dust-floor in developed pigpen provided warm and comfortable environment to pigs. In rainy and summer season, the conventional pigpen

**Fig 1 A low cost climate resilient environment-affinitive pigpen model**

has always wet floor and recorded significantly ($P$<0.01) higher humidity and temperature-humidity index (THI) as compared the developed pen, which causes stress to the pigs.

The floor in developed pigpen maintains dry and clean due the high moisture absorption capacity of sawdust floor, leading to low range of THI. The physiological parameters like heart rate, respiration rate, pulse rate within normal range during winter as well as summer/rainy season in the developed pigpen. Similarly these tress hormone, cortisol level was recorded within the normal range in developed pigpen, which is significantly ($P$<0.01) higher in the conventional concrete pigpen. The microenvironment of the invented pigpen maintains within the comfort zone and well suited for physiological adaptation during extreme weather events. Since the bad odor is mainly emitted from dung, manure, urine, and waste water in the pig shed, which is absorbed immediately by the sawdust floor in the invented pen. Thus the improved pig pen and its surroundings had considerably less odor. The daily body weight gain and feed conservation efficiency of the pigs reared in the developed pen were significantly higher as compared to conventional pen (Table1). The cross bred pigs reared in the invented pigpen attained the body

**Table 1 Efficiency of the pigs reared in the developed pen**

| Age | Body weight (kg) | |
|---|---|---|
| | Developed model | Concrete floor |
| 3 months | 9.75 | 9.36 |
| 6 months | 70.67 | 56.83 |
| 9 months | 106.83 | 76.28 |
| Average daily weight gain | 0.545 | 0.386 |

weight of 148-157 kg within one year. The diseases incidence was significantly($P$<0.01) lower in the developed pen and the method floor construction keep the floor dry and clean, hoof/nails grow normally and leg injury and leg lesion are completely nil. Similarly bacterial load in the floor of developed pen was very low and showed less incidences of diarrhoea and respiratory diseases. In conventional pen, the leg lesion, higher incidence of diarrhoea and respiratory diseases were common problem.

**Water harvesting and efficient water productivity**

The surface area of the roof of each shed was 72 sq.feet. According to the surface area of the roof and rainfall, total of 1.2 lakh liter was harvested/year/shed. Since there was no cleaning in the developed model, the water requirement in the developed pigpen was 7-10 liter/day/pig. Therefore water requirement per years was 3600 liter/pig. Water requirement per kg of pork production in the developed model was 20-30 litters against the 10-12 thousand litters water requirement in conventional concrete floor pig housing model.

**Manure production**

The manure production in the developed pen and the conventional concrete pen was 4,100 and 1,460 kg, respectively. The manure production in the developed pen was 2-3 times higher as compared the conventional concrete pen.

However, the quality of manure obtained in the developed model was significantly lower due to the inclusion of sawdust (Table 2). Thus the litter material has been treated in the vermicompost to improve the quality. The improved quality of litter material after vermin-compose are shown in the table 2.

**Table 2 Composition of composed deep-litter materials**

| Manure type | N (%) | P (%) | K (%) |
|---|---|---|---|
| Pig dung | 2.8 | 2.4 | 2.1 |
| Deep-litter | 1.2 | 0.7 | 0.7 |
| Deep-litter after vermicompost | 2.2 | 1.45 | 1.32 |

**Investigation on physical properties of pig bristle and innovative value addition**

Pig hair, called "bristle" is completely unutilized and burn during the conventional slaughter process (singeing) or dumped as slaughter waste on the ground, which resulted in environmental pollution as it is highly stable keratinized protein, takes long time in bio-degradation. Division of Animal Production has investigated the bristle properties, their processing and finally developed pig bristles into useful value added products in the country.

The bristle has special unique physical, mechanical and chemical properties as compared to other animal fibres. The bristles are very hard flexible coarse fibres with diameters of 210-320 µm. The tensile strength of the bristle is 4-5 times higher as compared to human hair and other animal fibres. Local indigenous pigs have long (5-7 inch) and dense (150-188/cm square of skin) bristles with special mechanical property as compared to the exotic pigs, this is one of the unique traits of indigenous pigs for protection against extreme cold in this region (Fig 2). The modulation index was varied from 0.72-0.88 depending on the breed.


**Fig 2 Pig bristles from different breeds**

An in-house methodology for bristle processing has been developed to a) remove dirt, epithelial scales and wax, b) to destroy microbes and parasitic eggs and c) bleaching for softening and colour removal before dyeing. After processing, different products have been developed using the pig bristle with manual method (Figs 3-6); 1) Coat/Jacket cleaning brush, 2) Cloth washing brush, 3) High quality shoe brush, 4) Soft carpet cleaning brush, 5) Hard carpet cleaning brush, 6) Furniture/equipment dusting brush, 7) Hair Comb/ brush and 8) Air comb for pet dogs.

The bristle requirement for each product varied depends on the size of the products (small comb/brush: 20-30g, medium brush: 50-70g and large size brush: 100-120g). Similarly the cost of production also varied depends on the size (small size brush: INR 80, medium brush: INR 100 and large size brush: INR150). Since

Fig 3 Coat and jacket cleaning brush

Fig 4 Cloth washing brush

Fig 5 Shoe brush

Fig 6 Soft carpet cleaning brush

the manual method of processing is time consuming, labour cost was the major cost involved in the production cost. A trained person could make 4-5 medium size brushes/day using manual method.

**Success rate, genetic improvement and monitory benefit of artificial insemination of pigs**

The study investigated the success rate, genetic improvement and monetary benefit of artificial insemination (AI) technology in smallholder backyard pig production system in the tribal region of north-east India. Initially, the study evaluated the pig production system and the breeding constraints and compared the performance of the cross bred upgraded pig and local pigs under tradition smallholder backyard pig production system. The performance of cross bred pigs was significantly ($P$<0.01) higher in the terms of litter size at weaning and growth rate as compared to non-descriptive local pigs. However, non-availability of superior germplasm to produce crossbred pigs and high mating cost are the major constraints observed in the study, in addition to indiscriminate mating. To produce crossbred piglet and genetic improvement of non-descriptive local pigs, AI delivery mechanism was developed with participatory mode including farmers, village leaders and key persons in the selected villages (n=36).The information system was designed in such a way that AI was carried out at the doorstep of the farmer upon the request. A total of 367 oestrus sow/gilts were inseminated at farmer doorstep. The study obtained the farrowing rate of 78.44 and mean litter size of 7.86±0.65 following AI, which did not differ significantly from natural service. However, the growth rate of crossbred piglets obtained following AI was significantly higher than that of natural service under the smallholder traditional production system. The tribal farmer benefited in many ways; i) timely availability of superior germplasm to produce crossbred piglets, ii) saved the mating cost of INR 1000-1200 and transport of cost (INR 300-400) of female to the boar premises and iii) controlled mating to prevent inbreeding. The study clearly demonstrates the feasibility and potential benefit of AI technique to smallholder backyard pig production in tribal rural area. In addition to genetic improvement and to produce the crossbred pigs with non-descriptive local pig, this technology can overcome the breeding constraints in the smallholder backyard pig production for increasing productivity.

**Fertility assessment of frozen-thawed boar semen**

To assess the fertility of the frozen-thawed boar semen, those straws having more than 50% post-thaw sperm motility pooled in a sterilized beaker and diluted with BTS at the rate of 2.5 billion motile sperm in 80 ml volume/dose. After dilution transferred into 100 ml washed bottle and inseminated intra-cervical using golden pig catheter (IMV technologies, France). The study obtained a pregnancy rate of 47% and farrowing rate of 38%. Two pigs were aborted during mid-gestation.

**Soil-Plant-Animal Continuum in relation to mineral status and fertility of dairy cattle in Meghalaya**

**Mineral status of blood samples of dairy cattle in Meghalaya:** A total of 416 blood samples were collected from all the seven districts of Meghalaya and were analyzed for mineral contents using atomic absorption spectrophotometer. Blood samples were analyzed for macro (Ca, P, Mg) and micro (Zn, Cu, Fe, Mn) minerals. The average concentration of Ca and phosphorus was found to be 5.90 ± 0.18 and 3.87 ± 0.14 mg/dl, respectively which were lower than the normal values (9-12 and 5-8 mg/dl, respectively). Similarly Mg concentration in blood samples was also found to be lower (1.07 ± 0.87 mg/dl) than the normal values (1.70 – 2.50 mg/dl). The level of Cu, Zn, and Mn were found to be 65.74 ± 12.87, 15.32 ± 3.79 and 1.17 ± 0.58mg/dl as against their normal range of 50 – 120, 80 – 150 and 1.5 – 2.5 mg/dl. Maximum deficiency was reported in the level of Zn. However, the average Fe concentration was found within the normal range (102.49 ± 15.65 mg/dl). Out of total serum samples analyze, 40, 57 and 32 per cent samples showed the deficiency of Ca, P and Mg, respectively. While Cu, Zn, Fe and Mn deficiency was reported in 36, 77, 21 and 12 per cent serum samples, respectively.

**Mineral status of composite fodder samples in Meghalaya:** A total of 226 fodder samples were collected from all the seven districts of Meghalaya and their proximate composition and mineral status was evaluated. Calcium content of composite fodder samples was found below the critical level in all the districts of Meghalaya (0.23 ± 0.01 vs 0.30 %). Sixty five per cent of fodder samples showed Ca deficiency. Similarly Zn was also found to be highly deficient in all the districts of Meghalaya (5.01 ±0.21 vs 30 %). Eighty five per cent of composite fodder sample showed Zn deficiency. However, the values of Mg, K, Cu, Fe, Mn was found within the normal range.

**Status of mineral availability in the soils of Meghalaya:** A total of 387 soil samples, collected from different districts of Meghalaya were analyzed for soil pH, and mineral status. Soils of Ri-Bhoi (pH 4.52) and East Khasi Hills (4.68) were most acidic while Garo Hills' soils were relatively higher in pH (5.37). Available N content averaged across the state was 239 kg/ha, with the East Khasi hills soils showing a mean availability of 275 kg/ha and RiBhoi 212 kg/ha. N availability in West Khasi, Ri Bhoi, Jaintia Hills and Garo Hills were 222, 237 and 250 kg/ha. P availability in East Khasi, West Khasi, Ribhoi, Jaintia Hills and Garo Hills were 21.1, 8.8, 17.8, 19.2 and 12.3 kg/ha, respectively. Available K in these soils were 165, 98, 126, 172 and 283 kg/ha, respectively. Status of exchangeable Ca in the respective soils was 0.73, 0.65, 0.57, 0.73, and 3.61 meq/100g, and that of Mg was 0.43, 0.55, 0.34, 0.27 and 1.04, respectively. Available S was found more or less similar in all the districts with a mean availability of 10.1 kg/ha.

Exchangeable Al ranged between 1.04 to 1.86 meq/100g, with the lowest values being associated with Garo Hills soils and highest values with Jaintia Hills soils. Available B in East Khasi, West Khasi, RiBhoi, Jaintia Hills and Garo Hills were 0.40, 0.56, 0.46, 0.48 and 0.42 ppm, respectively. On average, DTPA extractable Zn was found to be 1.7 ppm, but while categorizing the soils for Zn availability, it should be noted that the usually considered critical value of DTPA extractable Zn (*i.e.* 0.6 ppm) does not hold good in acidic soils of Meghalaya. Thus despite showing high Zn status, a majority of the soils studied may fall under the deficient category based on the regional assessment of the critical limit of DTPA extractable Zn in acidic soils. DTPA extractable Cu was 0.97, 0.21, 0.30, 0.16, and 0.21 ppm in the soils of East Khasi, West Khasi, Ribhoi, Jaintia Hills and Garo Hills, respectively. Status of DTPA extractable Fe in the respective soils was 56.2, 61.3, 67.3, 52.2 and 60.2 ppm, while that of Mn was 5.3, 8.5, 5.8, 4.4 and 5.32 ppm, respectively.

**Correlation between mineral status of soil, fodder and blood:** Significant positive correlation was found between soil and fodder (r =0.91), fodder-blood (r =0.82) and soil-blood (r =0.71) in case of Ca. Similarly highly significant correlation was found between soil-fodder (r=0.87), fodder-blood (r =0.78) and soil-blood(r =0.76) in case of potassium. Cu was found significantly correlated between soil-fodder (r=0.71), fodder-blood (r =0.65) and soil-blood (r =0.83). Zn was also found to be positively correlated with fodder-blood (r =0.89) and soil-blood (r =0.56).

Fe was also found to be positively correlated with soil-fodder (r =0.83) and fodder-blood(r =0.76). On the basis of above findings, the area specific mineral mixture can be formulated in order to improve the productive and reproductive performance of dairy cattle in Meghalaya and incidence of infertility in dairy cattle can also be reduced.

**Phenotypic and productive traits of Assam Hill Goat breed in the home tract**

In total 57 villages over six districts of the home tract of the Assam hill goat were surveyed. The farmers interviewed in a pre-set format and the data were recorded. The results revealed that the breed was originated and developed in the Khasi hills, then spread to other hilly region particularly Naga hills, Luchai hills and its adjacent area.

Thus highest density pure breed population was distributed in the Sora (Cherrapunji), Mawphlang, Pynursula, Mawsynram, Smit, Markasa, Amlarem, Mylliem, Dawki, Mawkyrwat and Laitlyngkoi area of East Khasi Hills. The recent survey indicated that only 10-15% goats in the Khasi hills are pure breed and remaining 15-20% were crossbred either with Assam local goat (in the Assam Plan) or Black Bengal. In Naga Hills and Luchai Hills, 5-10% of pure bred goat population and 10-15% crossbred goat population were found. Most of goat farmers (78.3%) were small holders with the flock size of 3-5, while 19.5% farmers maintained medium flock size of 10-25 and remaining 2.5% farmers maintained with the flock size of 25-37.

The predominant goat population (40%) had white colour, followed by white with black patches (30%), white with brown (20%) and complete black (10%). The goat has medium size head with length of 8.12 ±0.17 inch. Usually the horns is straight shape and slightly bend at end with upward and backward horn orientation, but some males had upward, backward and slightly outward with pointed end. The horn is very thick and broad base with a diameter of 9-11 cm and 16-27 cm long in male which is unique feature of the breed (Fig 7). The ears are predominantly horizontal amongst the goat population with length of 4.32-5.56 inch. Prominent, well developed beard is present in both adult male and female with long hair (9.33±1.58 cm). Nuzzle color was either black or pink or pink with black spot in female, while it is completely black colour in male**.** Assam hill goat is a medium size breed with the body length of 15.45 in female and 18.33 inch in male, while height at withers was 20.17 and 18.32 inch in male and female, respectively. One of the

**Fig 7 Assam Hill Goats**

specific features of the breed is short legged (Fore leg: 10.83 inches & hind leg: 12.16 inches) and able to climb hilly terrain. Another feature of the breed is high density (237-367 number / $cm^2$) and long hair (3.1- 12.7 inches) in the body which is one of the unique climatic resilient traits of the breed for protection against extreme cold in this region. Thus greasy hair and clean hair yield significantly higher when compared to other goat breeds. The meat of the Assam Hill Goat is famous for tenderness and taste and the meat considered being high quality as compared to other goat meat in the region, thus the cost of the meat is higher than other goat meat. Average bone and meat ratio was 1: 3.75. Skin also has high value for its softness and superior quality. The early sexual maturity (215 days), short inter kidding interval and high twining percentage are the unique traits of the goat. The breed is considered to be a highly prolific goat in the region. The breed is well adapted to high rainfall mid and high altitude hill eco-system. The survey revealed that this breed is considered to be resistant to various parasitic diseases in the high humid region of hill eco-system.

**Growth performance of pig and fish under integrated pig-fish system**

In order to find out the most suitable combination and ratio of fish species (composite fish culture) under pig-fish integrated system, the fish pond of Livestock Production Division was stocked with Catla (20%, silver carp (20%), grass carp (40%) and tilapia (20%). The fingerlings were stocked @8000 per ha pond area. Before stocking of fingerlings, the pond was prepared by applying cow dung and lime @ 5000 kg and 1200 kg per ha, respectively after removing the top layer of mud and dried organic matter from the bottom of the pond. Fifteen days after applying the lime, the pond was filled up to the height of 1.5 meter. Weaning piglets were integrated with fish culture @ 30 pigs/ha water area. For 0.05 ha pond area, 2 piglets were integrated. The pig was fed with standard ration in recommended quantity and the growth rate was recorded based on

the monthly body weight throughout the study period. Pig dung and floor washing was not allowed to fall directly in to the pond instead 5-10 kg of pig dung was poured directly into the pond twice weekly. The pig was offered 1, 2, 2.5 kg of concentrate feed per day at 2 -4, 4-6 and 6-8 months of age. Growth performance of pig (Table 4)and fish (Table 3) was studied at monthly interval.The fish production in 6 month was 51.25kg (0.05 ha area). Economics is given in Table 5.

**Table 3 Weight gain of fish reared under pig-fish integrated system**

| Parameters | Catla | Silver carp | Grass carp | Telapia |
|---|---|---|---|---|
| Initial weight | 4.25 | 5.04 | 5.53 | 3.51 |
| Weight at 1 month | 21.56 | 25.45 | 18.56 | 16.54 |
| Weight at 3 months | 75.45 | 65.45 | 82.54 | 49.55 |
| Weight at 6 months | 170.54 | 165.54 | 175.65 | 134.28 |
| Absolute growth | 166.29 | 160.50 | 170.12 | 130.77 |
| Daily body wt. gain (g/fish/day) | 0.92 | 0.89 | 0.94 | 0.72 |

**Table 4 Growth performance of crossbred Hampshire pig in pig-fish integrated system**

| Parameters | Initial body weight (kg) | Monthly absolute body weight gain (kg) | Body weight gain (g/day) |
|---|---|---|---|
| Initial body wt. at 5 months | 41.25 | - | - |
| 6 months | 49.56 | 8.31 | 277.00 |
| 7 months | 55.12 | 5.56 | 185.33 |
| 8 months | 64.58 | 9.46 | 315.33 |
| 9 months | 75.44 | 10.86 | 362.00 |
| 10 months | 81.51 | 10.07 | 335.66 |
| 11 months | 92.56 | 11.05 | 368.33 |

**Table 5 Economic of pig fish integrated system**

**Expenditures:**

**1. Non-recurring**

a. Construction of fish pond: Nil
Construction of pig sty: ₹. 5000

Pig sty will be constructed using low cost, locally available material like wooden plank, bamboo and tin etc.

**2. Recurring**

a. Pond preparation including liming: ₹. 5000
b. Cost of 400 fingerlings ((@ 8000 fingerlings per ha)& Rs. 3.0 each: ₹. 1200
c. Cost of 3 piglets (5 months) @ ₹ 4000/- each ₹ 12000
d. Cost of feed @ 18/kg
(i) Between 5-6 month @ 1.5 kg/day= 18x30x1.5 ₹. 810
(ii) Between 7-11 months @ 2.0 kg/day= 2x18x150 ₹ 5400
e. Medicine: ₹. 500
f. Harvesting of fish ₹. 500

**Total recurring expenditure: ₹ 25410**
**Total Expenditure (Non- recurring + Recurring ) ₹ 30,410**

**Income:**

(i) By sale of 3 pigs of 90 kg live weight @ ₹. 140 per kg live weight(3x90x140) ₹. 37,800
(ii) Sale of fish @ ₹ 100 per kg (51.25 x 100) ₹ 5125

**Total Income: ₹ 42,925**

**Net profit: 42,925 – 30,410 = 12,515**

**Input : Output ratio of pig-fish system = ₹ 30,410 : ₹ 42,925 = 1 : 1.41**

## POULTRY SCIENCE

### Development of value added poultry products

Experiments were conducted to standardize the methodology for preparation of chicken and turkey nuggets utilizing spent chicken and turkey hens' meat. Nuggets were formulated incorporating different levels of vegetables and oils (Table 1). The processing method of nuggets has been standardized and presented in Fig.1.Nuggets so prepared were subjected for sensory evaluation for their consumer acceptability. Results of the sensory evaluation revealed favorable consumer acceptability for all the groups (Table 2). Although there was no significant difference between the groups, but overall better acceptability values were recorded for both the chicken and turkey nuggets prepared by incorporating 5 per cent carrot and 5 per cent refined vegetable oil.

**Preparation of chicken nuggets:** The flow chart for preparation of chicken nuggets has been presented in Fig 1

### Studies on the performance of emu in Meghalaya

The performance of Emu (*Dromaius novaehollandiae*) chicks in terms of growth rate and feed consumption was recorded during the growing period of 3-12 months in the reared in the institute farm (Fig 2). The average monthly body weight recorded were 4.55±0.21, 8.05±0.06, 10.90±0.53, 12.87±0.76, 14.61±0.51, 17.07±0.50, 19.73±0.42, 22.40±0.65, 25.04±0.69 and 26.93±1.88 kg at the age

## Table 1 Recipe for preparation of nuggets

| Ingredients | Level of incorporation (%) | | | | | |
|---|---|---|---|---|---|---|
| | Chicken nuggets | | | Turkey nuggets | | |
| | Control-1 | T1 | T2 | Control-2 | T3 | T4 |
| Minced chicken meat | 100* | 100* | 100* | - | - | - |
| Minced turkey meat | - | - | - | 100* | 100* | 100* |
| Refined wheat flour | 10 | 10 | 10 | 10 | 10 | 10 |
| Refined vegetable oil | 10 | 5 | - | 10 | 5 | - |
| Carrot | - | 5 | 10 | - | 5 | 10 |
| Ice flakes | 7 | 7 | 7 | 7 | 7 | 7 |
| Common salt | 2 | 2 | 2 | 2 | 2 | 2 |
| Spice mixture | 3.5 | 3.5 | 3.5 | 3.5 | 3.5 | 3.5 |
| Sodium benzoate | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 |

*Only the minced meat percentage added up to 100% while the percentages of all ingredients are related to minced meat.

## Table 2 Organoleptic qualities of nuggets

| Qualities | Chicken nuggets | | | Turkey nuggets | | |
|---|---|---|---|---|---|---|
| | Control-1 | T1 | T2 | Control-2 | T3 | T4 |
| Color | 4.56±0.50 | 6.11±0.31 | 4.67±0.55 | 4.89±0.20 | 5.11±0.39 | 4.56±0.34 |
| Flavor | 5.00±0.33 | 5.22±0.28 | 4.56±0.34 | 5.33±0.33 | 5.78±0.22 | 5.00±0.17 |
| Juiciness | 5.11±0.42 | 5.11±0.26 | 5.00±0.33 | 4.89±0.26 | 5.44±0.24 | 4.33±0.23 |
| Tenderness | 5.67±0.37 | 5.33±0.33 | 5.00±0.62 | 5.22±0.22 | 5.44±0.58 | 4.89±0.39 |
| Overall acceptability | 5.11±0.42 | 5.33±0.41 | 4.67±0.47 | 5.00±0.24 | 5.56±0.34 | 4.56±0.38 |

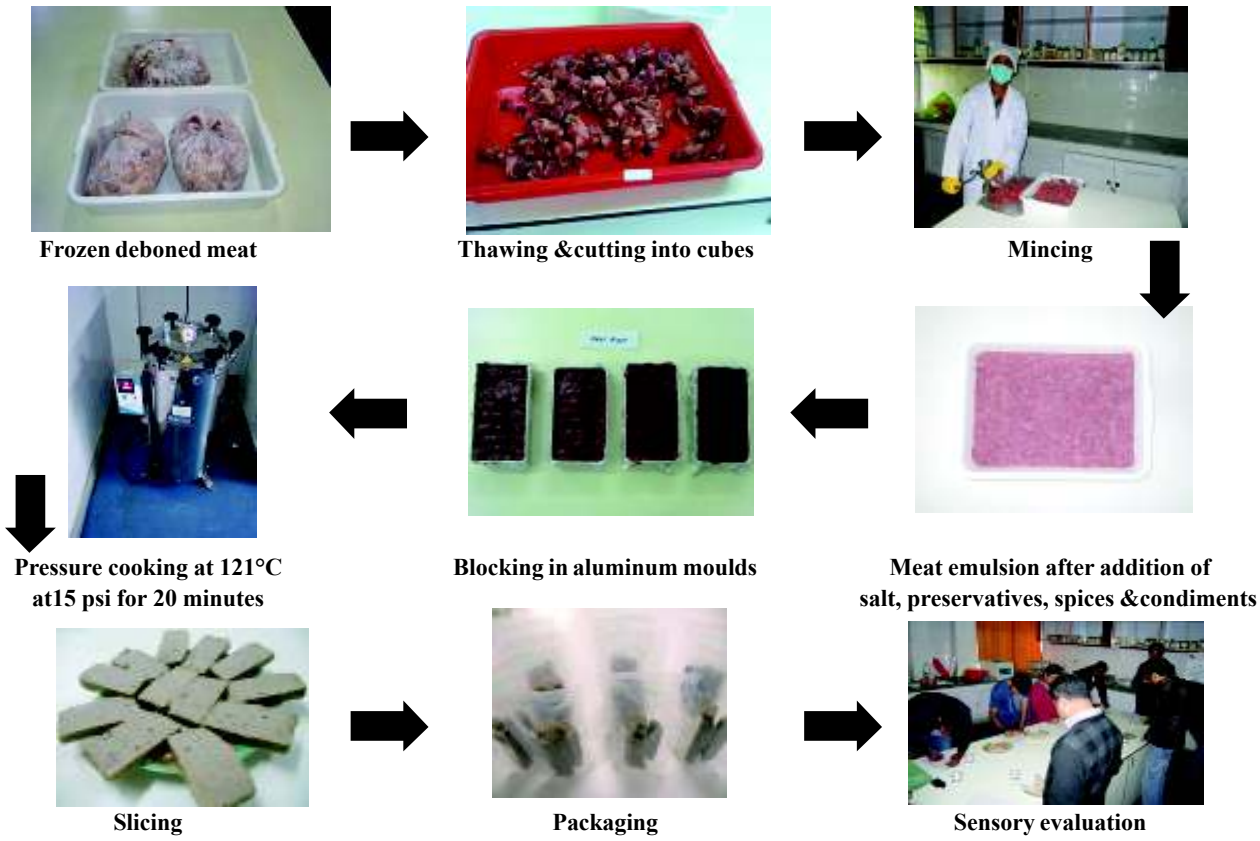



**Fig 1 Flow chart processing of chicken nuggets**

of 3, 4, 5, 6, 7, 8, 9, 10, 11 and 12 month, respectively. The average daily feed consumptions at the age of 3rd and 12th months were recorded as 650 g and 365 g per bird respectively. The performance of emu chicks in terms of growth rate is recorded to be optimum in the agro-climatic condition of Meghalaya.

**Fig 2 Emu birds in the institute farm**

**Studies on the effect of seasons on the performance of different chicken varieties in Meghalaya**

An experiment was conducted to evaluate the comparative performance of Vanaraja, Gramapriya and Indigenous chickens in different seasons under deep litter system of rearing. A total of 900 numbers of straight run day-old chicks, 100 chicks from each variety in each season i.e. pre-monsoon (Mar-May), Monsoon (Jun-Aug) and post monsoon (Sep-Nov) were allotted for the experiment during the year 2012. After 3 weeks of brooding in battery brooder, the chicks were reared in deep litter under standard management conditions up to 18 weeks of age. The average environmental temperature, relative humidity and rainfall values were recorded for the experimental period (Table 3). The performance of chicks in terms of growth rate, FCR and mortality were recorded, compiled and presented in two phases i.e., starting (0-8 weeks) and growing (9-18 weeks) (Tables 4 & 5). The results revealed better performance of Vanaraja chicks followed by Gramapriya and Indigenous in terms of growth rate and FCR irrespective of seasons. Moreover, irrespective of types of chicks, in pre-monsoon, the chicks performed better in terms of growth rate and FCR during chick stage (Figs 3 & 4). It was also noted that maximum chicks mortality took place during pre-monsoon and post-monsoon in which

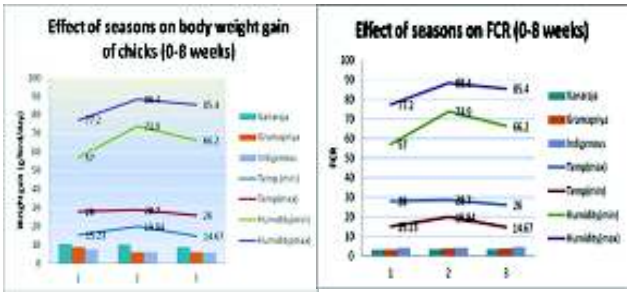



**Fig 3 Effect of seasons on body weight and FCR (0-8 (0-8 weeks)**

**Table 3 Average seasonal values for environmental temperature, relative humidity and rainfall during the experimental periods**

| Seasons | Temperature (°C) | | Humidity (%) | | Rainfall (mm) |
|---|---|---|---|---|---|
| | Maximum | Minimum | Maximum | Minimum | |
| Pre-monsoon (Mar-May) | 15.28 | 28.00 | 57.00 | 77.20 | 138.00 |
| Monsoon (Jun-Aug) | 19.84 | 28.70 | 73.90 | 88.40 | 336.00 |
| Post-monsoon (Sep-Nov) | 14.67 | 26.00 | 66.20 | 85.40 | 210.00 |

**Table 4 Performance of chicks in different seasons from 0-8 weeks**

| Varieties | Traits | Pre-monsoon (Mar- May) | Monsoon (Jun-Aug) | Post monsoon (Sep- Nov) |
|---|---|---|---|---|
| Vanaraja | Growth rate (g/b/d) | 10.67 | 10.11 | 8.89 |
| | FCR | 3.07 | 3.35 | 3.53 |
| | Mortality (%) | 9.76 | 3.99 | 10.30 |
| Grampriya | Growth rate (g/b/d) | 8.84 | 6.24 | 6.16 |
| | FCR | 3.25 | 3.77 | 3.82 |
| | Mortality (%) | 10.44 | 2.15 | 11.25 |
| Indigenous | Growth rate (g/b/d) | 7.51 | 6.10 | 5.98 |
| | FCR | 4.04 | 4.18 | 4.45 |
| | Mortality (%) | 9.65 | 2.77 | 10.06 |

**Table 5 Performance of chicks in different seasons from 9-18 weeks**

| Varieties | Traits | Pre-monsoon (Mar- May) | Monsoon (Jun-Aug) | Post monsoon (Sept- Nov) |
|---|---|---|---|---|
| Vanaraja | Growth rate (g/b/d) | 19.45 | 20.26 | 18.99 |
| | FCR | 3.21 | 3.00 | 3.67 |
| | Mortality (%) | 2.50 | 2.25 | 2.30 |
| Grampriya | Growth rate (g/b/d) | 17.80 | 18.86 | 16.50 |
| | FCR | 3.24 | 3.17 | 3.88 |
| | Mortality (%) | 0.67 | - | 0.67 |
| Indigenous | Growth rate (g/b/d) | 12.32 | 12.51 | 10.06 |
| | FCR | 3.25 | 3.39 | 4.12 |
| | Mortality (%) | 3.89 | 3.89 | 2.61 |

average temperature and humidity were lower compared to monsoon.


**Fig 4 Effect of seasons on body weight and FCR (9-18 weeks)**

## FISHERIES

### First succesful breeding of Grass carp in mid hill condition

Grass carp (*Ctenopharyngodon idella*) is an important fish species for aquaculture in hill states. A few adult Grass carp procured from the state of Assam were reared in fish farm complex of ICAR, Barapani for maturation. They were fed *ad libitum* with a mixture of rice polish, mustard oil cake and fish meal for 6 months prior to induced breeding. In addition, fishes were also fed with locally available banana leaf regularly. The first successful breeding trial was conducted on 31st May 2012 under mid hill condition when the water temperature and pH ranged between 27 to 29 and 6.5- 6.8 $^0$C respectively. The female brood fish of grass carp weighing 2.5 kg received 1.3 ml of Ovaprim hormone for successful spawning with 94 % fertilization and 89% hatching.

### Advance fingerling production in pond based cage culture during winter months

Amur common carp and local strain common carp with *Labeo gonius*- an important indigenous minor carp were stocked in pond based PVC- nylon net cages (size 2X2X1.5 mt) at a stocking density of 20 nos. per cu.mt for advance fingerling production under cage condition during winter months (Fig. 1) (September to December, 2012). Fishes were fed *ad libitum* with locally available rice bran and oil cake at 1:1 ratio every morning. In cage -1, 100 nos. of fry of Amur common carp were stocked with 20 nos. of *Labeo gonius*. Similarly in cage -2, Local common carp (100 nos) + *Labeo gonius* (20nos.) were stocked to evaluate the performance of each species under pond based cage condition for a period of 90 days (Fig 2). Amur registered a better percentage weight gain (136%) than the local common carp (85%) - a difference of 51%, whereas the *Labeo gonius* (Fig 3) registered percentage weight gain of 126% and 121% in cage -1 & 2 respectively (Table 1).

**Fig 1 Fingerling production on PVC-nylon net cages**

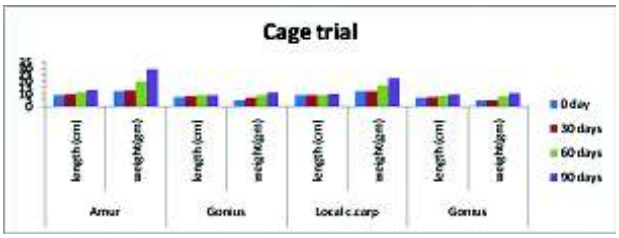



**Fig 2 Results of cage trial on different species**

**Table 1 Growth of Amur common carp, local common carp with *Labeo gonius* in cage rearing.**

| Days | Cage 1 | | | | Cage 2 | | | |
|---|---|---|---|---|---|---|---|---|
| | Amur | | Gonius | | Local C.carp | | Gonius | |
| | Length (cm) | Weight(g) | Length (cm) | Weight(g) | Length (cm) | Weight(g) | Length (cm) | Weight(g) |
| 0 | 9.20 | 12.56 | 7.47 | 4.93 | 9.02 | 12.25 | 7.45 | 4.92 |
| 30 | 9.75 | 12.80 | 8.48 | 7.12 | 9.16 | 12.58 | 7.80 | 5.33 |
| 60 | 11.13 | 20.17 | 9.04 | 9.22 | 9.33 | 16.73 | 8.55 | 8.33 |
| 90 | 13.2 | 29.66 | 9.49 | 11.15 | 10.37 | 22.76 | 9.87 | 10.89 |

**Fig 3 Showing the growth of two common carps and *Labeo gonius***

**Fig 4 Brood and juveniles of *Channa stewartii***

**In-situ seed production of *Channa stewartii* (Play fair)-an indigenous ornamental fish of northeast under mid hill altitude**

*Channa stewarde* locally known as *Chengeli* under the family Channidae is an important air-breathing fish inhabiting in wet land, pond and rice field of Northeast India. The fish is consumed as food fish locally, however in recent years, the species is also considered as one of the most important ornamental fish species of northeast due to its colouration, behaviour and demand in the global ornamental fish market. Although it is known to be a warm water fish, a successful maiden attempt was made during 2012-13 to breed the species under mid hill condition in a concrete fish pond having soil bottom. The inner walls with 1:1.5 slopes of the ponds have several cracks and crevices. Five pairs (male and female) of *Channa stewartii* of average size 12- 13 cms long were introduced in to the ponds in January and fed regularly with a mixture of rice polish, mustard oil cake and dry fish powder. The temperature and pH of the fish pond during the period ranged between 20- 26.9 $^0$C and 6.5 to 7.7 respectively. The number of eggs per body weight was observed to be low (38 to 54). The fish was found to breed in the months of June- July. Several juveniles could be observed swimming near the cracks and crevices and corners of the fish pond with parents guarding them (Fig 4). They were later collected with the help of a net for further rearing and also to avoid cannibalism.

**Evaluation of growth performance of Gold fish under low cost poly house condition**

Gold fish, *Carrasius auratus* is one of the most popular ornamental fish having local demand. Although the species breeds several times in a year, high percentage of juvenile mortality is recorded every year during winter due to low water temperature in the wet lab condition where in the water temperature drops down to 6-7 $^0$C (Fig 5).

Therefore, a maiden attempt was made to rear the juveniles under poly house condition where a favourable water temperature could be maintained during the winter months. The experimental tank water temperature under the polyhouse ranged between 19.76- 22.62 °C in November and 16.27 -18.3 °C in December.

The juveniles of gold fishes were reared for 60 days in cement tanks ( size: 2X1.5X0.75 m) under polyhouse at two different stocking densities of 170 nos and 200 nos/m$^2$. Better performance was recorded at a stocking density of 170 nos/ m$^2$with an average survival percentage of 88%, while the stocking density of 200 nos/m$^2$ resulted in a survival percentage of 67. However, there were no significant differences in the growth of juveniles during the study period.

**Fig 5 Performance of Gold fish under low cost poly house condition**

### TSP Activities

Fish seed is the basic input for aquaculture and most fish farmers of the hill states of the northeast region depend on Assam and other neighbouring states for supply of fish seeds. In an effort to make the fish seeds available locally, 10 portable FRP carp hatcheries were procured from the CIFA, ICAR, Bhubaneswar for distribution to selected farmers of five viz., northeast hill states, Arunachal Pradesh, Meghalaya, Manipur, Nagaland and Tripura under the Tribal sub plan. The selected farmer seed producers were given on the job training on operation of the hatcheries (Fig 6).

**Fig 6 Training of farmers on hatchery practices under TSP**

## ANIMAL HEALTH

### Screening of serum, blood and tissue samples for porcine viruses

The Division of animal health was involved in routine screening of serum/tissue /swab samples for PRRS virus (porcine reproductive and respiratory syndrome), PCV (Porcine circo virus), CSFV (Classical swine fever virus) and PPV (porcine parvo virus fig 3). Initial identification of this virus was done at the ICAR Research Complex for NEH by RT PCR. Large scale screening of samples were done by RT PCR for PRRS. Subsequently the OIE approved kits for detection of PRRS were procured and antibody screening was facilitated. Work on two other porcine viral agents causing post weaning multisystemic wasting syndrome was initiated. A total of 361 serum samples were screened and 10 samples were positive for Porcine circo virus, 17 samples were positive for porcine parvo virus and 115 were positive for CSFV (Tables 1& 2).

Screening of PRRS by PCR from Kyrdemkulai Govt. Pig farm showed 24 sample positive out of 43 tested. Porcine sera samples screened with Idexx PRRS Ab ELISA kit (OIE approved) revealed 270 samples positive out of 441 examined.

The following serum and tissue samples were screened for CSFV and other viral infections by RT PCR. These samples were cloned and sequenced. It was observed that some of the random as well as archieved samples were in the 2.1 genogroup and the samples from outbreaks were in the 2.2 genogroup. Sequencing of 5'-NTR and E-2 regions have been carried out for CSFV and molecular epidemiological analysis is underway. Expression of CSFV surface glycoproteins has also been initiated. The expressed glycoprotein could be useful in development of ELISA based diagnostic protocols for the serological monitoring of CSFV.

**Table 1 Porcine sera samples screened for CSFV Antigen by PCR**

| State | Sample no. | Results(+) |
|---|---|---|
| Mizoram | 16 | 9 |
| Meghalaya | 123 | 39 |
| Arunachal Pradesh | 64 | 24 |
| Nagaland | 41 | 10 |
| Total | 244 | 82 |

**Table 2 Porcine tissue samples screened for viral diseases by PCR**

| Place | Total samples | CSFV (+) | PCV-2(+) | PPV(+) |
|---|---|---|---|---|
| Meghalaya | 80 | 26 | 8 | 12 |
| Assam | 30 | 5 out of 10 screened | 2 out of 5 screened | 5 out of 5 screened |
| Arunachal Pradesh | 2 | 2 | Not checked | Not checked |
| Mizoram | 5 | Nil | Nil | Nil |
| Total | 117 | 33 | 10 | 17 |

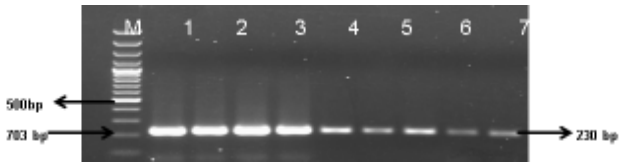



**Fig 3 Standardization of PCR protocol for identification of PPV based on VP-2 gene**

### Comparison between agarose gel and PAGE for detection of rotavirus

Rotaviruses are the most important cause of severe dehydrating diarrhoea in young ones of many animal species. The extracted dsRNA of rotavirus from 5 positive faecal samples were subjected to SDS-PAGE (separating gel 7.0%, 8.5% and 12.5%) and agarose gel (0.8%, 1.2%, 1.6% and 2.0%). The bands of the

RNA segments were clearly separated on 7.0% and 8.5% separating gel of PAGE and 0.8% and 1.2% agarose gel. However, initial 4-5 segments of rotavirus were not visualized in PAGE (Table 3). Moreover, the agarose gel method was easy to perform, less laborious, economical and time saving (2-3 h) than the SDS-PAGE method (6-7 h), as it is complicated, laborious and needs expert to perform. Both the methods detected dsRNA at very low concentration of 100ng. However, while screening the stool samples of children and fecal samples of piglets, agarose gel method detected maximum no. of isolates (38 human + 3 porcine) than that for SDS-PAGE (34 human + 3 porcine). Thus, it was concluded that agarose gel method was superior, rapid and sensitive than the SDS-PAGE method (Figs 4 & 5).

**Table 3 Rotavirus detection by PAGE and agarose gel electrophoresis**

| Species | No. of samples | No. positive by SDS-PAGE | No. positive by Agarose |
|---|---|---|---|
| Human | 100 | 34 (10 short pattern) | 38 |
| Piglets | 42 | 3 | 3 |
| VP7 gene (primer) giving 1062 bp product: | 30 | 8 | 8 |
| VP4 gene (Con3 Con2 primer) giving 876 bp product | 30 | 6 | 6 |

A comparison of two primers for RT PCR based detection of rotavirus was carried out. It was seen that VP7 gene primers were more sensitive than the VP4 gene primers.

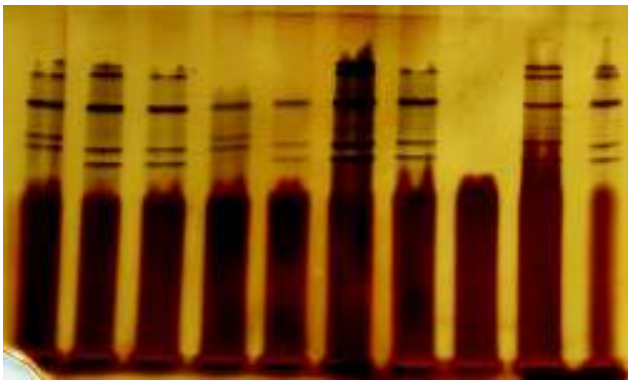


**Fig 4 Strands of dsRNA of rotavirus in SDS-PAGE**

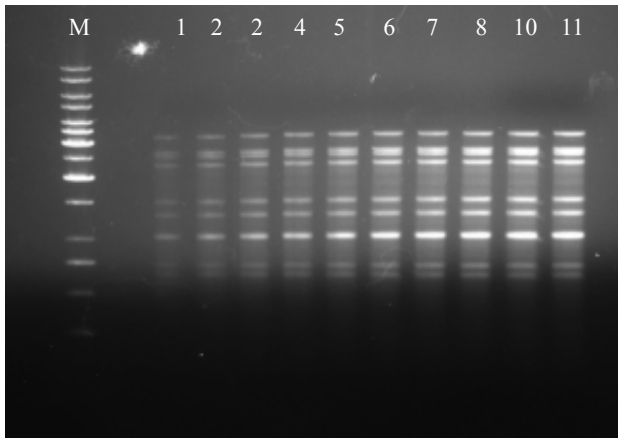



**Fig 5 Strands of dsRNA of rotavirus in 0.8% Agarose Gel**

**Investigation of livestock diseases under PD ADMAS**

a) **Bird flu virus:** There was a heavy mortality of birds in Tripura in January, 2012. Different samples from the affected and dead birds were collected and sent to the HSADL, Bhopal for bird flu confirmation. The samples were found to be positive for bird flu.

b) **Swine fever:** There were three different outbreaks of swine fever at Kyrdemkulai farm, Ri Bhoi district of Meghalaya. Samples (oral swab, nasal swabs, serum, blood, tissue) were collected from affected pigs as well as from dead pigs. All these samples were tested by polymerase chain reaction by targeting 5'NTR gene and were found to be positive for CSF.

c) **Colibacillosis :** Forty eight faecal samples collected from cows and calves from in and around Shillong, were processed for isolation of *E. coli*. However, 42 *E. coli* organisms were recovered from these samples which were then confirmed by morphological and cultural characteristics. Molecular characterization of *E.coli* isolates were done using polymerase chain reaction to find out virulent genes. It was found that 25 isolates were positive for *stx1* gene and 12 for *stx2* gene. Meanwhile serotyping of *E. coli* isolates were carried out at National *Escherichia coli* and Salmonella centre, Kasauli, Himachal Pradesh. All together 30 *E.coli* isolates were serotyped into 12 serogroups as O5, O6, O14, O56, O59, O76, O89, O95, O101, O108, O167 and O172 with 5 untypable and 1 rough strain. Majority of the isolates belonging to O95 (4 isolates) and O108 (4 isolates) serogroups. There was an outbreak of colibacillosis in goats of ICAR farm, Umiam. Twenty six faecal

samples were collected from diarrhoeic goats. All the samples were positive for *E. coli* and *est* gene was detected in 8 isolates. A total of 56 cloacal swab samples were collected during different outbreaks of colibacillosis in poultry farm of ICAR, Umiam. Al these samples were processed for isolation of pathogen. Fifty two *E.coli* isolates could be recovered from these samples and two samples were positive for *Salmonella* spp. The *E. coli* isolated were sensitive to ceftriaxone, gentamycin, tetracycline and chloramphenicol.

**d) Rotavirus infection in livestock:** A total of 113 faecal samples from piglets (66), goats (17) and poultry (30) were collected from different farms located in and around ICAR, Barapani and screened for detection of rotavirus. Additionally, 12 faecal samples were collected from childrens admitted to the two different hospitals in Shillong. The dsRNA of rotavirus from faecal samples were extracted by phenol:chloroform:isoamyl alcohol method or using Qiagen extraction kit and then subjected to SDS-PAGE. A total of 6 samples from piglets and 5 samples from children were found to be positive for rotavirus by SDS-PAGE and agarose gel.

e) **Result of the serum analysis :** A total of 44 serum samples comprising goats (11), pigs (23) and cattle (10) collected from four different villages viz. Ranikor,(West Khasi Hills) Mawngap Mawsmai(East Khasi Hills), Moobakhan (Jaintia Hills) and Mawkangi(Ri-Bhoi) of Meghalaya were sent to PD_ADMAS Hebbal Bangalore for screening of antibodies against Brucellosis, IBR and CSF by ELISA kit and the result are given below;

- *Brucella* antibodies: Three cows from Ranikor and two cows from Mawngap Mawsmai were found to be positive for *Brucella* antibodies.
- IBR antibodies: Four cows from Ranikor and two cows from Mawngap Mawsmai were found to be positive for IBR antibodies.
- CSF: Four pigs each from Mawkangi and Moobakhan and two from Mawngap Mawsmai were found to be positive for CSF.

**f) Livestock disease outbreak report 2011-12:** The data on the livestock disease outbreaks, attack and mortality in the State of Meghalaya were compiled from the monthly Animal Health information report on the incidence of specific and nonspecific diseases collected from the Disease Investigation Office and Disease Surveillance Office and published by the Directorate of Animal Husbandry and Veterinary, Government of Meghalaya.

**Establishment of archive for bacterial cultures, recombinant clones, bovine and porcine sera**

Considering the importance of proper storage and banking of isolates, biological samples, etc. an archive of bacterial cultures, recombinant clones, bovine and porcine sera have been established in the Division of Animal Health with participation of all scientists. The archive is backed up by a computerized database maintained in the division. At present the archive houses 173 pathogens, 12 lactic acid bacteria, 90 recombinant clones, 149 bovine sera, 1144 porcine sera, etc.

**Characterization of *Listeria monocytogenes***

Isolation, identification and characterization of *L. monocytogenes* from food of animal origin were carried out. A total of 228 samples comprising pork, fish, chicken- intestine and milk products were screened and *L. monocytogenes* was isolated from pork and fish samples with an overall isolation rate of 2.5%. All the isolates were found to be positive for virulence genes *hly*A and *iap* whereas *plc*A and *plc*B were positive only in 50% of the isolates. Standardized a duplex PCR method for serotyping by using sets of primers (D1, D2, FlaA & GLT) that allow strains to be easily classified into phylogenetic divisions (Fig 6).

**Table 4 Overall district-wise outbreaks of livestock and poultry diseases in Meghalaya**

| Species | Disease | Jaintia | Ri-Bhoi | East Khasi | West Khasi | East Garo | West Garo | South Garo |
|---|---|---|---|---|---|---|---|---|
| Cattle | FMD | 57 | 24 | 51 | 32 | 1 | 54 | 0 |
| | HS | 0 | 0 | 2 | 1 | 0 | 42 | 0 |
| | BQ | 0 | 0 | 1 | 8 | 0 | 44 | 0 |
| Swine | SF | 0 | 1 | 89 | 3 | 0 | 70 | 0 |
| | FMD | 1 | 0 | 7 | 0 | 0 | 0 | 0 |
| Caprine | FMD | 13 | 0 | 22 | 1 | 0 | 3 | 0 |
| Avian | RD | 1 | 2 | 24 | 18 | 0 | 49 | 0 |
| | Fowl pox | 22 | 4 | 27 | 8 | 0 | 7 | 0 |

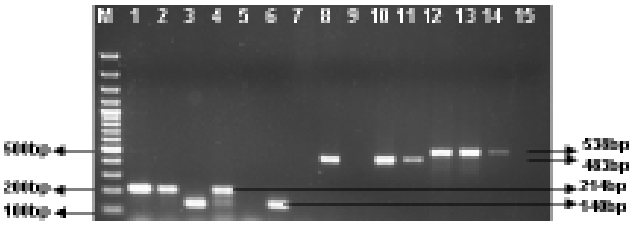



**Fig 6 PCR amplification results of *L. monocytgenes*. Lane M, 100 bp ladder; Lanes 1, 2, 4, D1 positive strains; Lane 3 and 6, D2 positive strains; Lanes 8,10,11, GLT positive strains; Lanes 12,13 and 14, FlaA positive strains; Lanes 5, 7, 9 and 15, NTC for D1, D2, GLT and FlaA genes, respectively**

By employing these primers, isolates can be identified as serotype 1/2a or 3a, 1/2b or 3b and 4b or 4d. The results indicated that the serotypes responsible for human infection are also prevalent in food and environment samples.

### Epidemiology of antimicrobial resistant *E. coli*

A total of 187 *Escherichia coli* isolates from cattle (37), pigs (95), goats (34) and chickens (21) were investigated for their resistance to 14 different antimicrobial agents. Multi-resistance was found in all the isolates from all the species under study (resistance to >2 antibiotics). Various resistance patterns were recorded from different isolates of different species. Resistance was highest in the isolates from chickens, followed by pigs, cattle and goats. The isolates were subjected for PCR detection of antibiotics resistant genes ($bla_{TEM,}$ *sul*I, *sul*II, *tet*A, *tet*B,) using specific primers. Overall, $bla_{TEM}$ was the commonest genotype, 22.88% isolates were positive for bla TEM, 21.81% for Sul II, 18.18 % for Sul I and 1% *tet*B. The results indicated that multi-drug resistant *E. coli* is prevalent in pigs, goats, cattle and chickens in north east India and there was variation in the rates and patterns of resistance.

### Characterization of *E. coli* pathotypes from diarrhoeic piglets

The serotyping results of the *E.coli* isolates revealed that these *E. coli* isolates belonged to 21 different serotpyes with serotype O90 being the most prevalent serotype followed by O43 whereas, O20 and Rough serotypes constituted the least number of isolates. The isolates were checked for single pathotype specific PCRs for detection of *stx*1, *stx*2, *eae*, *H*7, *elt*, *est* and developed multiplex PCR was used for the detection of various genes *(estI, eltI, stx* and *eaeA*) representing most prevalent *E. coli* pathotypes (ETEC, AEEC and STEC) from diarrhoeic piglets. Total 152 *E. coli* isolates were screened for the presence of these genes by using this multiplex PCR as well as simplex pathotype specific PCRs. Out of these 152 isolates, 18 isolates belonged to STEC, 23 isolates belonged to ETEC and only 2 isolates belonged to AEEC. The developed multiplex PCR found to be useful for detection of pathogenic *E.coli* in diarrhoeic piglets (Figs 7-9).

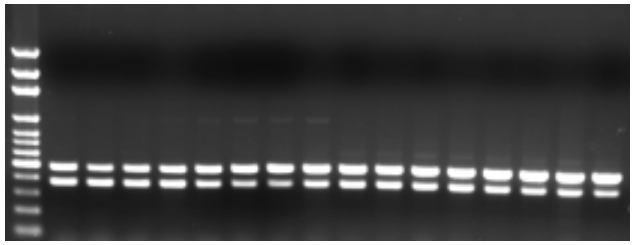


**Fig 7 PCR amplification result of *E. coli*. Lane M, 100 bp ladder; Lanes 1 to 16, *eae* (384bp) and *hly*A (534bp) gene positive strains**

Faecal samples of livestock and poultry were screened for *E. coli* infectiones statenise results of faecal samples of pigs presented in Table 5 and results of other animals presented in Table 6.

**Table 5 Results of screening of faecal samples of diarrhoeic piglets for *E. coli***

| State | Nos. of faecal samples screened | Nos. of *E.coli* positive (%) |
|---|---|---|
| Meghalaya | 117 | 105 (89.74) |
| Mizoram | 49 | 45 (91.84) |
| Nagaland | 14 | 14 (100) |
| Total | 180 | 164(91.11) |

**Table 6 Results of screening of faecal samples for *E. coli* in other animals**

| Species | No. of isolates | No. of *E. coli* detected |
|---|---|---|
| Goat | 30 | 28 (93.33%) |
| Cattle | 38 | 38 (100%) |
| Poultry | 50 | 47 (94%) |
| Total | 118 | 113 (95.76%) |

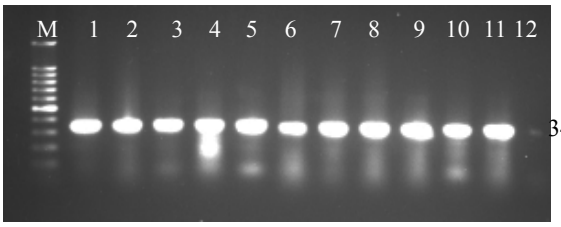



**Fig 8 PCR showing *stx 1* positive *E. coli* isolates recovered from clinical samples**

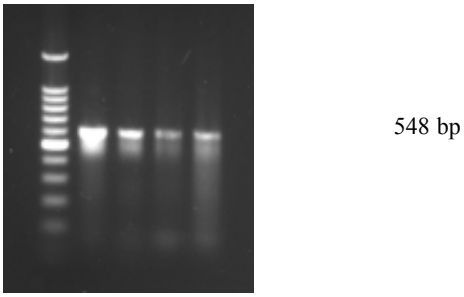



**Fig 9 PCR showing *stx 2* positive *E. coli* isolates recovered from clinical samples**

### Isolation and identification of *Aeromonas* spp. from food, water and animals from Meghalaya

In this study a total of 62 Aeromonas isolates were obtained from 500 samples comprising food, water, animal and human samples from Meghalaya. Isolates were speciated using Phoenix 100 automated system. Results indicated overall incidence of 12.4% of *Aeromonas* spp. The entire set of isolated aeromonads comprised of *A. caviae* – 33.8%, *A. sobria* – 32.3%, *A. veronii* – 16.1% and *A. hydrophila* – 17.7% (Fig 10).

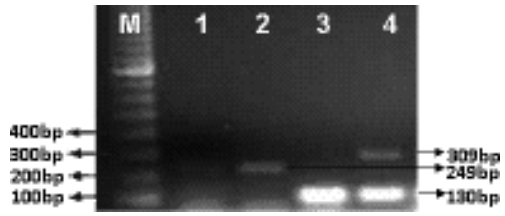



**Fig 10 Amplification of virulence genes (*aer*A, *ahh*1 & *asa*1) of *A. hydrophila* by PCR, Lane- 100bp Ladder, Lane (1-4) - *A. hydrophila* isolates**

### Immunomodulatory effects of CpG *inovo* in chickens

The work on immunomodulation was carried out by optimizing the protocol for the estimation of IgA and IgY by indirect ELISA. The level of IgY and IgA in the CpG treated groups and non-treated control on different day post challenge were recorded as shown in the figures 11 and 12. The treated groups of Vanaraja as well as Gramapriya birds were showed significantly higher titre as compared to non- treated control. The response of the treated groups was comparatively higher than the vaccinated groups.

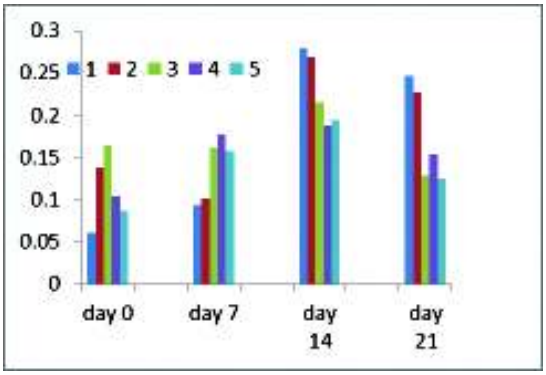



**Fig 11 IgA response against NDV challenge**

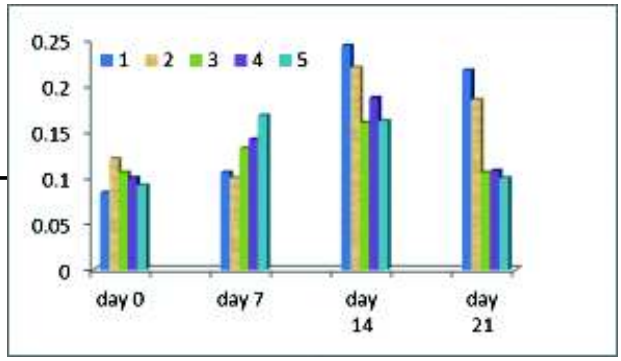



**Fig 12 IgY response against NDV challenge**

Grp 1, Gramapriya with CpG;Grp 2,Vanaraja with CpG;Grp 3,Control without CpG; Grp 4,Vaccinated without CpG;Grp 5,Placebo control

### Microbiocidal effects of Roselle extracts

Roselle plant (*Hibiscus sabdariffa*) extract has been scientifically proven to possess high antioxidant activity, anti- proliferation and anti-carcinogenic properties. The study of the aqueous and methanolic extract of Roselle plant @100mg/ml (w/v) to see the microbiocidal effects (pour plate method) of some common pathogens like *E. coli, Staphylococcus aureus* and *Klebseilla pneumonia* revealed that up to 2nd dilution (25mg/ml) shows complete growth inhibition of both gram positive and gram negative bacteria. It was concluded that Roselle extract in higher conc. can

inhibit the growth of both gram +ve and –ve bacteria. The result was encouraging and suggested the potential to explore the therapeutic use of this plant which is an indigenous food ingredients.

**Prevalence of Gid in goats**

Gid is the infection of the brain by the larval stage of *Taenia multiceps* characterized by signs like blindness, circling movement, head pressing and bulging of the head in goat. The case of gid in a herd of 21 goats in an organized farm at Ri-Bhoi districts of Meghalaya was reported when one of the animals showed signs of neurological disorder like circling movement, tremor of the muscles, weakness, blindness, dehydration and anorexia but no signs of bulging of the skull. The goat was treated for nervine disorder and was given Neurobion @ 5ml intramuscularly to improve the nervous function and Intacef @ 15mg/kg body wt. to prevent secondary bacterial infection, DNS @ 30ml/kg body wt. to check dehydration, initially there was a slight improvement but later on the condition worsened and ultimately died. The post mortem examination revealed Taenia cyst in the brain (cerebellum).The cyst and heart blood was collected aseptically. The cyst was triturated with 1% Phosphate Buffer Saline and serum was separated from the heart blood. AGPT was done using the cyst material as antigen and serum collected from other goats showed positive results. The remaining goats in the farm were given Fentas plus @ 5mg/kg body weight on the next day and it was repeated after 21 days. Blood was collected from all the animals after the treatment and serum was separated .The serum samples were subjected to AGPT using the cyst as antigen. All the samples were found to be negative indicating that the animals were cured from tapeworm infection. The case warrants creating massive awareness programme for proper deworming of animals and also to prevent the zoonotic spread keeping in mind the dietary preference of meat in the region.

**Characterization of *Pseudomonas aeruginosa* isolated from poultry**

*Pseudomonas aeruginosa* are gram negative bacteria causing infections and various diseases in humans. They are very rarely reported from animals. In order to assess their role in animal diseases an investigative study was undertaken to isolate and characterization of the isolates for their virulence potential. Thirteen *P. aeruginosa* were isolated from lungs of dead poultry birds in collaboration with Institute of Animal Health & Veterinary Biologicals, Kolkata. All birds were suffering from respiratory illnesses. No other pathogenic bacteria could be recovered from these birds. Characterization of these isolates for two virulence genes revealed that 83.3% of the isolates harboured *oprL* gene while 66.7% of the isolates possessed *eta1* gene (Fig 13). Isolates were resistant to various antimicrobials as detected by Phoenix automated IDAST system (Fig 14). Screening of isolates targeting tetracycline resistance genes indicated that 25% of the isolates carried *tetA* gene (Fig 15). Results of the study highlighted the role of *P. aeruginosa* in poultry disease.

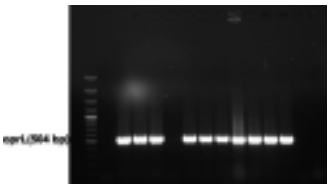


**Fig 13 PCR for *oprL* gene in *P. aeruginosa* isolates**

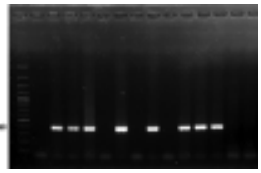


**Fig 14 PCR for eta I gene in *P.aeruginosa* isolates**

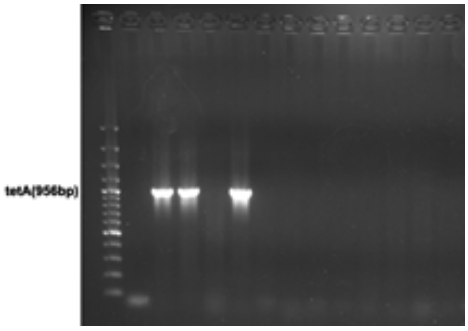



**Fig 15 PCR for *tetA* gene in *P. aeruginosa* isolates**

**Detection of New Delhi metallo-betalactamase and extended spectrum beta-lactamase genes in *Escherichia coli* isolated from mastitic milk samples**

In the present study, eight *Escherichia coli* isolates were obtained from milk samples of dairy cattle suffering from clinical/sub-clinical mastitis. Isolates were characterized phenotypically and genotypically (PCR and sequencing) for antimicrobial resistance traits and virulence genes. Results revealed that one isolate was harbouring New Delhi metallo-beta-lactamase gene ($bla_{NDM}$) (Fig 16). Cloning, and sequencing of the PCR amplicon confirmed the identity of the gene (GenBank Accession No. KC769583) having 100% homology with $bla_{NDM-5}$ (Gen Bank Accession No. JN104597.1) and this isolate was

susceptible to colistin, chloramphenicol, and tetracycline only. Moreover, one other isolate carried extended spectrum beta-lactamase (ESBL) gene ($bla_{CTX-M}$) (Fig 18) and all isolates possessed ESBL gene ($bla_{TEM}$) (Fig 17). Occurrence of New Delhi metallo-beta-lactamase ($bla_{NDM}$) in one *E. coli* isolate and ESBL genes in other isolates pose a potential threat to human health following possible entry and spread through food chain.

**Fig 16 PCR for blaNDM (New Delhi metallo-beta-lactamase) gene in *E. coli***

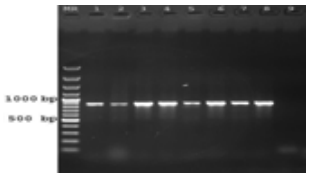


**Fig 17 PCR for blaTEM (ESBL) gene in *E. coli***

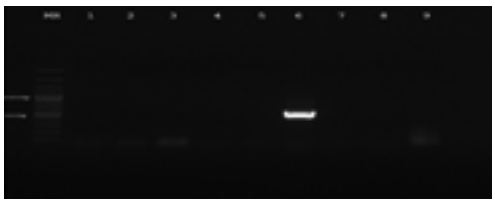


**Fig 18 PCR for blaCTX-M (cefotaxime resistance) gene in *E. coli***

**Detection of Lactic Acid Bacteria in fermented foods from NE region**

- Eighteen bacterial species were identified, among the bacteria isolated from various fermented foods. Prominent Lactic Acid Bacteria isolated included *Lactobacillus delbrueckii* ssp *lactis*, *Lactococcus lactis* ssp *lactis*, *Lactococcus raffinolactis*, *Leuconostoc mesenteroides* ssp *cremoris*, *Leuconostoc pseudomesenteroides*, *Pediococcus acidilactici*, *Pediococcus pentosaceus*, etc.
- Pathogens identified included, *Staphylococcus aureus*, *Staphylococcus capitis* ssp *capitis*, *Staphylococcus hominis*, *Staphylococcus warneri*, *Streptococcus mitis*, and *Turicella otitidis*.
- Identification of *Turicella otitidis* is unusual because it usually found in human ear canal and its identification clearly indicated possible unhygienic practices during handling of fermented food.
- Isolates have been characterized for their drug resistance profiles and various resistance markers were identified. Resistance markers included 'methicillin resistance' and 'high level mupirocin resistance.
- Assessment of foodsafety parameters viz. for fermented food samples revealed wide variability (6.4 X $10^5$ c.f.u. / g to 2.46 X $10^9$ c.f.u. / g) among these products. Since there is no microbiological standard available for these products it is recommended that one be evolved for correct interpretation of experimental data.

**DBT Network project on Brucellosis**

Two hundred and seventy one samples were collected from West Garo Hills District (Selsella, Zikzak), Ribhoi district (Umiam, Umran), East Khasi Hills district (4th Mile, Nongpyor, Mawkhan) and Jaintia Hills district (Khliehkyrshi). Samples were obtained from cattle, buffalo, goat and pig. Samples were examined by RBPT and STAT for observing serological evidence of brucella infection. Serological evidence of brucella infection in animals by RBPT and STAT showed 0.76% swine were positive.

**Detection of Bovine Viral Diarrhoea virus (BVDV) in NE region**

An investigation to assess the incidence of BVDV in NE region was undertaken. BVDV specific ELISA of 197 samples collected from NE region revealed that 12% of all samples were positive for BVDV antibodies.

**Assessment of water quality of East Khasi Hills and Ri Bhoi District, Meghalaya**

A total of 43 water samples were analysed for assessment of potability by MPN technique. Results revealed high (Fig 19) MPN count in many of the water samples. Considering the BIS standards for drinking water results were worrying indicating poor potability index of the waters used for various purposes in the East Khasi Hills (Fig 20).

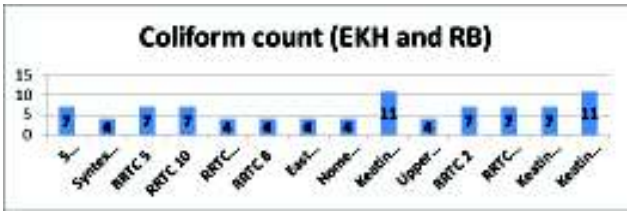



**Fig 19 MPN count of water samples from East Khasi Hills and Ri Bhoi District**


**Fig 20 Quality of water samples from East Khasi Hills and Ri-Bhoi District**

**Diagnostic services**

**a) Diagnosis of diseases in pig from an outbreak of Umiam:** In animal nutrition farm, of the Institute, there was an outbreak of swine erysepelothrix in October 2012. Out of a total of 12 pigs, four weaned piglets (Hamshire crossed) were found dead after showing symptoms of anaemia, diarrhoea, fever, purplish discoloration of the skin of hind limb and abdomen. Post mortem examination revealed multiple haemorrhage lesions in intestine, subcutaneous tissues, kidney, spleen etc (Fig 21A & B). Tissue smears of spleen showed bacillus which shows the possibility of *Erysipelothrix* infection and was confirmed by PCR amplification of 16sRNA (Fig 22).

A) B)

**Fig 21 PM lesion of the animal (P7) with confirmative diagnosis of *Erysipelothrix rhusiopathiae* showing A) Skin hemorrhage; B) Petechial hemorrhage in kidney**

**b) Diagnosis of diseases in pigs from an outbreak of Upper Shillong area:** There was an outbreak of heavy pig mortality in the Meghalaya Govt. state pig farm at upper Shillong. The outbreak started on Jan, 2013 and within a span of 1 month the farm observed death of 95 pigs (78 piglets, 15 growers and 2 adults). The clinical symptoms in piglets and grower were that of diarrhoea, lethargy and sudden death and wherein in 2 adults were that of arthritic lesions in limbs. The investigation was concluded to be of mixed infection of Classical Swine Fever

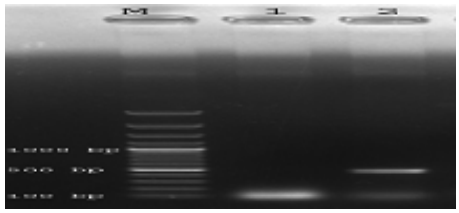



**Fig 22 PCR for 16sRNA specific for *Erysipelothrix rhusiopathiae* - M: 1 kb Ladder, Lane 2 PCR showing positive band at 440 bp**

Virus (CSFV) with antibiotic resistant *E.coli.* The CSFV was confirmed through amplification of 241bp nested PCR specific for 5' NTR region of CSFV (Fig. 23) and *E.coli* was isolated on specific culture media and its confirmation and resistance pattern was further confirmed by BD phoenix 100.

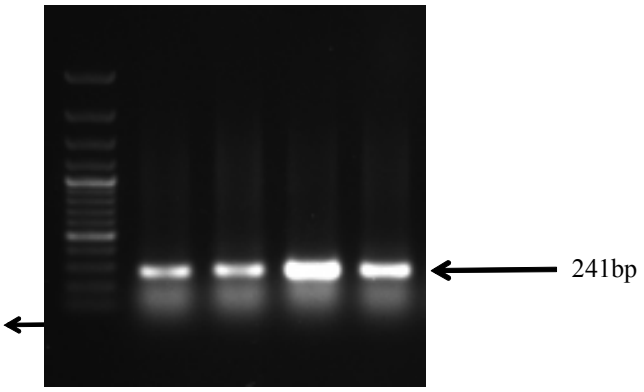



**Fig 23 Showing amplification of 241bp nested PCR specific for 5' NTR region of CSFV**

**c) Bovine babesiosis in ICAR RC Umiam:** Out of a total of 22 cows, 3 cows suffered from clinical babesiosis showing signs like haemoglobinurea, fever, diarrhoea, anorexia and anaemia. Out of 22 blood samples that were screened for babesiosis by PCR, 6 blood samples from heifers were positive for babesiosis. The affected cows were treated successfully with Diminazene aceturate @ 5mg/kg body weight deep intramuscularly.

**d) Detection of *E.coli* virulence genes from Japanese quail:** The mortality of Japanese quail from organized farms in Ri-bhoi district of Meghalaya was investigated. The birds were reported dead without much apparent clinical signs. The post mortem examination revealed changes in the liver, intestine, stump of ovaries and oviduct impacted with eggs. Samples were collected and organism were isolated which was identified as *E. coli*. The samples were subjected to isolation of DNA to detect the virulence genes. The amplified product

of 680 bp (Fig 24) corresponded to cvaC, while 760 bp and 620 bp (Fig 25) indicate ISS and TSH genes respectively. Detection of virulence associated genes like ISS for resistance to immunological defenses, TSH for adherence and cvaC responsible for complement resistance by PCR indicates the pathogenicity of the organism.

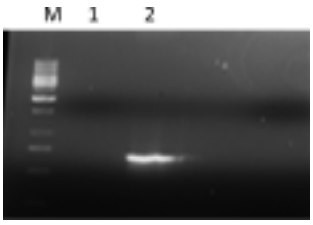



**Fig 24 Detection of cvaC (lane2)**

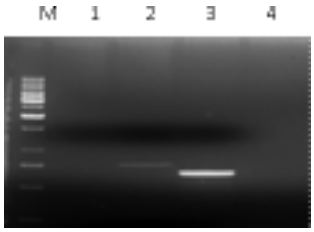



**Fig 25 Detection of iss (lane 2) and tsh (lane3)**

Antibiogram results were observed as follows: resistant to ampicillin, tetracycline, ciprofloxacin, colistin, penicillin-G, oxytetracycline, neomycin amikacin, ofloxacin ampicillin/salbactam, enrofloxacin, chloramphenicol, co-trimoxazole, norfloxacin, streptomycin, trimethoprim and sulphafuraxole. Sensitive to gentamicin, ceftriaxone and ceftazidime. The pattern of antibiogram in the isolates suggested growing resistance against most of the antibiotics currently available in the market.

**Detection of haemoprotozoan infections in animals of northeastern region**

For detection of haemoprotozoan infections in animals of northeastern of India, a total of 155 blood samples of cattle and buffaloes were collected from different organized farms and slaughter houses. *Babesia bigemina* infections were detected in 1.34% cattle after examination of Giemsa stained blood smears and in 4.02% cattle after molecular diagnosis using polymerase chain reactions (Fig 26). Blood samples of dogs were also collected. *B. canis* (Fig 27) and *B. gibsoni* infections were detected in 9.52% and 19.04% dogs, respectively using PCR and in microscopical examination detected 4.76% blood samples of dogs as positive for both these species (Fig 28).

**Phylogenetic relations of *Babesia* spp. isolated from this region**

Cloning and sequencing of PCR product generated from *B. bigemina* found in a cow of Umiam,

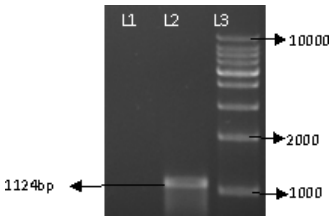



**Fig 26 *B. bigemina* (expected PCR product1124 bp)**

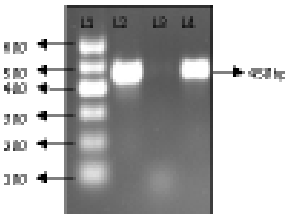


**Fig 27 *B. canis* (expected PCR product 450 bp)**

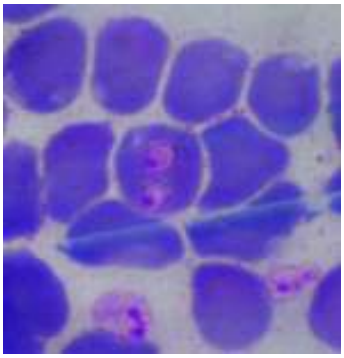


**Fig 28 *B. canis* in RBC of a dog**

Meghalaya, was done. BLAST analysis showed that sequence of PCR product generated with *B. bigemina* primers had 99% nucleotide identity with many sequences of 18 S ribosomal gene of *B. bigemina* (EF458191, EF458200, DQ785311). The Indian isolate (Umiam) of *B. bigemina* showed the close relation with Argentinian isolate and distinctly placed away from the isolates of neighbouring country China (Fig 29).

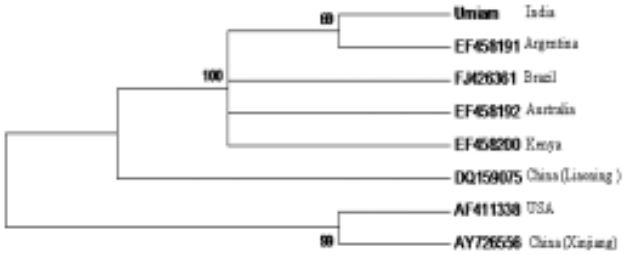



**Fig 29 NJ tree showing the 18 S rRNA gene based phylogenic relationship among the *Babesia bigemina* isolates and other *Babesia* spp. from different countries. The Indian isolate of *B. bigemina* is showing the close relation with Argentinian isolate and distinctly placed away from the isolates of neighbouring country China**

Cloning and sequencing of two PCR products (No.105 and 239) generated from *B. canis* isolated from dogs of Assam was done. BLAST analysis showed nucleotide sequence of *B.canis* is having

93% sequence (18S rRNA gene) identity with *B. canis vogeli* (strain TWN2, GenBank HQ148664, Taiwan). Therefore, it is likely that the organism is sub-species of *B. canis vogeli*. Phylogenetically, No.105 and 239 are very closely related and they are also very closely related to strain SK-013, which is from Saint Kitts and Nevis (Caribbean) islands.

**Epidemiological studies on gastrointestinal parasitism in Meghalaya and other north-eastern States**

The epidemiological studies on G.I. parasitism were undertaken in different N.E. States like Meghalaya, Nagaland, Manipur and Mizoram. Faecal samples of cattle, goats, pigs and poultry from these states were collected. Post mortem examination of gastrointestinal tracts of goats was done to determine the prevalence of G.I. helminthes. Overall prevalence of G.I. parasites has been presented in Table 7.

**Table 7 Overall prevalence of gastrointestinal parasites during 2012-13**

| Animal | State | Positive (%) |
|---|---|---|
| Goat | Meghalaya | 35.43 |
| Pig | Meghalaya | 38.82 |
| | Nagaland | 44.44 |
| | Mizoram | 45.37 |
| | Manipur | 76.92 |
| Cattle | Meghalaya | 33.47 |
| | Manipur | 40.67 |
| Poultry | Manipur | 38.88 |

In Meghalaya, *Strongyle* spp. (74.01%), *Strongyloides* spp. (44.61%), *Eimeria* spp. (38.80%), *Trichuris* spp. (14.87%) and *Moniezia* spp. (11.45%) were detected in faecal samples of infected goats. In pigs, *Ascaris suum* were predominant (73.41%) followed by *Strongyle* sp. (51.56%), *Eimeria* spp. (29.24%), *Trichuris* spp. (19.53%) and *Strongyloides* spp. (18.95%). In cattle, Strongyle spp. were predominant (73.31%) followed by *Strongyloides* spp. (24.93%), *Eimeria* sp. (24.93%), *Moniezia* spp. (15.71%), *Trichuris* spp. (9.72%), *Toxocara vitulorum* (7.48%), and *Nematodirrus helvetianus* (4.98%).

In Nagaland, the percentage of infections of different parasites as recorded in pigs were *Ascaris suum* (21.69%), Strongyle spp.(16.93*%), Strongyloides* spp.*(* 5.29*%), Trichuris* spp.*(* 8.99*%) and Eimeria* sp. (14.28*%).*

In Manipur, the percentage of infections of different parasites as recorded in pigs were *Ascaris suum* (81.25%), *Strongyle* spp. (25.00*%), Strongyloides* spp.(8.75*%), Trichuris* sp.(3.75*%), Eimeria* spp. (40.00*%)* and *Isospora* spp. (58.75%). The eggs of the following parasites were recovered from faecal samples of cattle: *Strongyle* sp. (93.75*%) Eimeria* spp. (22.91%), *Nematodirrus* spp. (6.25%), *Moniezia* spp. *(*6.25%) and Amphistome (10.42%). In Poultry, the percentage of infections of different parasites as recorded were *Ascaridia galli* (14.28%), *Heterakis* spp. (28.57*%), Capillaria* spp. (42.85%) and *Eimeria* spp. (42.85*%).*

In Mizoram, faecal samples of pigs revealed the presence of, *Ascaris suum* (35.18%), Strongyle spp. (16.66*%), Trichuris* spp. (11.11*%), Eimeria* spp. (42.59*%)* and *Isospora* spp. (7.40%).

**Parasitological study of GI tracts of slaughtered goats of Meghalaya**

Post mortem examination of GI tracts of goats revealed the presence of G.I. parasitic infections in 67.03% goats. The presence of *Haemonchus contortus* (85.24%), *Oesophagostum* spp. (65.57%), *Trichuris* spp. (44.26%), *Moniezia* spp. (11.47%) and Amphistomes (11.47%) were recorded.

**Detection of mange infestation in pigs of Meghalaya**

Skin scrapings of 47 numbers of suspected pigs were collected for detection of mange (*Sarcoptes scabiei* var. *suis*) infestation. Out of these 4 (8.51%) pigs were found infested with *S. scabiei* var. *suis* after microscopical examination of skin scrapings.

**Characterization of immunogenic proteins of *Cysticercus tenuicollis* of goats**

The larval stage of the canine tapeworm *Taenia hydatigena* inside their intermediate host is known as *Cysticercus tenuicollis*. The cysts of *C. tenuicollis* were collected from the mesentry of small intestine of goats after slaughter. The polypeptide profiles of cystic fluid antigens and whole cyst lysate antigens as resolved by SDS-PAGE have been shown in fig 30. A total of eight polypeptides of *Mr* 149.4 kDa, 92.9 kDa, 74.2 kDa, 63.5 kDa, 36.2 kDa, 23.9 kDa, 15.7 kDa and 9.6 kDa were resolved by SDS-PAGE from each samples with minor variations. Out of these, three polypeptides of *Mr* 36.2 kDa, 23.9 kDa and 9.6 kDa were recognized as immunodominant polypeptides after western

blotting in both cystic fluid antigens and whole cyst lysate antigens. All of them could be considered as major polypeptides.

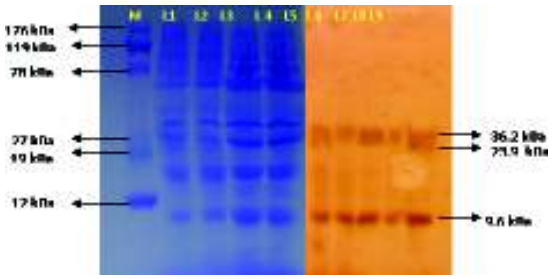


**Fig 30 Polypeptide profiles of cystic fluid antigens (L1&L2) and whole cyst lysate antigens (L3&L4) prepared from *C.tenuicollis,* resolved in 10% SDS-PAGE and stained with CBB (Left Portion). Western blot analysis of the same (Right Portion). Lane L5 to L7 whole cyst lysate antigens; L8 & L9 cystic fluid antigens Lane M-Standard Molecular Weight Marker**

***Balantidium coli* infection in pigs:** During the examination of faecal samples of pigs maintained in pig farms of ICAR Research Complex for NEH Region, Umiam, *Balantidium coli* infection was detected in 16.7% pigs. The infected animals were treated successfully with metronidazole and tetracycline.

## Tribal Sub Plan

During the year 2012-13, four animal health cum awareness camps were held by the Division of Animal Health, ICAR Umiam, under the project Tribal Sub Plan in four villages viz.Khrang village, Sohra (East Khasi Hills) on 14th June 2012;Mawpynhong village, Mawphlang (East Khasi Hills) on 16th June 2012; Nongrahvillage, Umroi (RiBhoi) on 11th January 2013&LaitMawsiang village, Cherrapunjee (East Khasi Hills) on 14thMarch, 2013 wherein 100% of the population of these villages are STs.Animal health awareness about scientific methods of rearing and prevention of the prevalent diseases of livestock and poultry was given by delivering lectures by the subject experts and also by displaying charts, posters and distributing leaflets to the farmers. In all these animal health camps, there was an interaction session between the expert scientists and the farmers where the animal health problems faced by farmers were discussed and suitable solutions were advised to the farmers. Many piglets and poultry birds were distributed to the low income group farmers in presence of village head man to start their piggery and poultry farming. Animal health coverage was also done by distributing medicines (free of cost) in the form of herbal appetizers, mineral mixtures, anthelmentics, vitamins and antibiotics for treatment of their sick animals and debilated animals.

### Animal Health Camp report

An Animal Health cum vaccination camp was organized on 11th January 2013 in Nongrah Village, Umroi under the Scheme Tribal Sub Plan (TSP) by the Division of Animal Health, ICAR RC for NEH region, Umiam, Meghalaya. Sixty farmers attended the animal health awareness programme. During the Health camp a total of 30 piglets were distributed to 15 beneficiaries (2 piglets each) and a total of 80 chicks were distributed to 40 beneficiaries (2 birds each). All the piglets were vaccinated against swine fever at the time of distribution. 31 farmers having pigs and poultry, have received medicines for treatment of their animals.

**Fig 31 Health awareness programme**

A sass vaccination programme against swine fever and goat pox was held in RRTC, Umran on 27th February 2013 by the Division of Animal Health, ICAR RC for NEH region, Umiam, Meghalaya. A total of 90 pigs and 7 goats were vaccinated against swine fever and goat pox respectively during the programme.

## ANIMAL NUTRITION

### Development of feeds and fodder

**Parai fodder production:** In fodder demonstration plot of Animal Nutrition Research Farm, *parari* (*Scheflera wallichi*) plants (Fig 1) have been established for 11 years with density of 2500 plants/ha. About 1 kg FYM was applied to each plant at the end of April, 2012.

**Fig 1 Parai fodder plants with native grasses in plain lowland area**

In the plain lowland individual plant on average yielded 64.3 kg (n=20) fresh foliage having approximately 67% edible part comprised of leaves-petiole and bark/stem peel and 33% nonedible woody stem. Nevertheless total foliage yield was less with 23.5 kg (n=20) from the plants on sloppy upland. In addition 32.15 t/ha biomass having ~15% DM and 9% CP from native grasses grown within the inter space provided extra fodder in 3-4 cuttings during monsoon and up to October. Some of the nutritional parameters of edible portion of *parari* foliage are given in the Table 1.

**Table 1 Nutritional parameters (%, DM basis else mentioned) of *parari* foliage**

| Parameters | Leaves-petiole | Bark/ stem peel | Overall |
|---|---|---|---|
| Parts of total foliage (fresh basis) | 49 | 18 | 67 |
| DM | 32.95 | 28.42 | 31.73 |
| OM | 87.64 | 90.10 | 88.30 |
| CP | 8.87 | 4.71 | 7.75 |
| CF | 26.35 | 37.45 | 29.34 |
| EE | 2.24 | 2.25 | 2.24 |
| NFE | 50.18 | 45.69 | 48.97 |
| Ash | 12.36 | 9.90 | 11.70 |
| GE (kcal/kg) | 4125 | 3955 | 4079 |

**Fodder production from terraced upland area:** Mono cultivation of soybean, rice bean cowpea, maize, sorghum, job's tear and bajra (non-legume) at 60-65d respectively yielded 19.95, 21.43 and 19.54, and 40.85, 31.20, 27.69 and 37.85 t/ha green fodder during the *kharif* season. Crops of sorghum and job's tear provided three cuts.

**Fodder production from plain lowland area:** From cultivable plain lowland area, the improved varieties of perennial grasses viz., hybrid Napier, Congosignal, Napier, Hamil and Guinea collectively yielded 51.17 t/ha fodder with average DM content of 14.25% in four cuttings.

**Sorghum production in terraced upland**: Multicut sorghum yielded 31.2 t/ha in 1st cut at ~70d. Subsequent 2nd cut yielded 18.6 t/ha at 60d and 3rd cut 11.3 t/ha during January. It can be tried as perennial crop (Fig 2) as same had survived winter dry conditions and it is under observation during current year. Perhaps, it could provide better yields of fodder in 1st cut than first year on application of FYM.

**Fig 2 View of sorghum at early growth (L), before 1st harvest (C) and during winter (R)**

**Groundnut fodder production under the tree shed in lowland plain area:** Ten year after the establishment of perennial groundnut (*Arachis pintoi*) under the trees in plain lowland yielded 35.71 t/ha with average 20.43% DM in 4 cuttings. Besides providing excellent quality fodder, it can also be grown on the risers of terraced land to check the soil erosion and aiding nitrogen fixation.

**Effect of intercropping of non-legume and legume fodder crops during *kharif* season:** Under the acidic soil conditions in the terraced upland in mid altitude of Meghalaya, mono and intercropping of non-legume crops viz., maize, bajra, sorghum and job's tear and, legume crops viz., soybean, rice bean and cowpea (Fig 3.) with furrow application of 0.5 t/ha lime and 10 t/ha FYM was studied during *kharif* season.

**Fig 3 View of intercropping of maize (L) and sorghum (R) with legume fodder crops**

Data of fodder production from different combination were obtained at 65d after sowing. Highest yields of green fodder were observed from maize and cowpea in monocropping while maize + cowpea in intercropping (Table 2). Other combinations also produced better yields.

**Table 2 Fodder yield parameters (average) of mono and intercropping during *kharif***

| Particulars of fodder crop(s) | | DM (%) | CP (%) | Yields (t/ha) | | |
|---|---|---|---|---|---|---|
| | | | | Fresh fodder | DM | CP |
| ***Monocropping*** | | | | | | |
| Non-legume | Maize | 22.75 | 9.73 | 45.12 | 10.26 | 1.00 |
| | Bajra | 22.86 | 9.13 | 40.76 | 9.27 | 0.85 |
| | Sorghum | 23.61 | 8.62 | 39.88 | 9.07 | 0.78 |
| | Job's tear | 20.06 | 9.06 | 31.57 | 7.18 | 0.65 |
| | ***Ave*** | ***22.32*** | ***9.14*** | ***39.33*** | ***8.95*** | ***0.82*** |
| Legume | Soybean | 19.07 | 19.81 | 19.95 | 4.54 | 0.90 |
| | Rice bean | 16.06 | 16.74 | 22.51 | 5.12 | 0.86 |
| | Cowpea | 17.86 | 20.02 | 24.39 | 5.55 | 1.11 |
| | ***Ave*** | ***17.66*** | ***18.86*** | ***22.28*** | ***5.07*** | ***0.96*** |
| ***Intercropping*** | | | | | | |
| Maize+ | Soybean | 22.52 | 12.31 | 41.95 | 9.54 | 1.17 |
| | Rice bean | 24.61 | 10.98 | 38.49 | 8.76 | 0.96 |
| | Cowpea | 22.75 | 12.96 | 40.28 | 9.16 | 1.19 |
| | ***Ave*** | ***23.29*** | ***12.08*** | ***40.24*** | ***9.15*** | ***1.11*** |
| Bajra+ | Soybean | 25.06 | 11.51 | 36.71 | 8.35 | 0.96 |
| | Rice bean | 22.06 | 10.21 | 35.65 | 8.11 | 0.83 |
| | Cowpea | 20.08 | 11.87 | 38.00 | 8.65 | 1.03 |
| | ***Ave*** | ***22.40*** | ***11.20*** | ***36.79*** | ***8.37*** | ***0.94*** |
| Sorghum+ | Soybean | 22.68 | 10.37 | 35.31 | 8.03 | 0.83 |
| | Rice bean | 25.19 | 10.46 | 33.54 | 7.63 | 0.80 |
| | Cowpea | 24.61 | 11.22 | 35.82 | 8.15 | 0.91 |
| | ***Ave*** | ***24.16*** | ***10.68*** | ***34.89*** | ***7.94*** | ***0.85*** |
| Job's tear+ | Soybean | 23.44 | 11.33 | 31.64 | 7.20 | 0.81 |
| | Rice bean | 23.69 | 11.58 | 30.77 | 7.00 | 0.81 |
| | Cowpea | 26.18 | 11.77 | 33.67 | 7.66 | 0.90 |
| | ***Ave*** | ***24.44*** | ***11.56*** | ***32.03*** | ***7.29*** | ***0.84*** |

**Safflower as fodder during winter lean period:** Safflower (*Carthamus tinctorius* L., Hindi-Kusum), the NEH region, especially Meghalaya which suffers chronic shortage of green fodder during the lean period i.e., December to April. An attempt thus, was made to grow safflower (Fig 4) for fodder in the terraced upland after the harvest of soybean using 5t FYM/ha with plant density of 40-60 plants/$m^2$ during mid of January.

Limited extent of feeding to Assam local hill goats showed good palatability of safflower fodder. The production parameters and chemical composition (Table 3) also indicate potential of safflower as fodder crop in Meghalaya conditions.

**Fig 4 Safflower plants grown in terraced upland**

**Table 3 Average yield and chemical composition (% DM basis, else indicated) of safflower fodder at different stages of growth**

| Particulars | Stages of growth | | |
|---|---|---|---|
| | 40 days (stem elongation) | 50days (branching) | 60 days (pre flowering) |
| Fresh yield (t/ha) | 10.8 | 12.7 | 14.7 |
| DM yield (t/ha) | 1.1 | 1.6 | 2.1 |
| DM (%) | 10.11 | 12.61 | 15.97 |
| fresh basis | | | |
| OM | 85.20 | 86.15 | 87.30 |
| CP | 20.84 | 16.40 | 13.80 |
| EE | 2.15 | 1.94 | 2.18 |
| CF | 24.20 | 29.48 | 33.64 |
| Ash | 14.80 | 13.85 | 12.70 |
| NFE | 38.02 | 38.33 | 37.68 |
| GE (Kcal/kg) | 3913 | 3892 | 3862 |

**Effect of higher dose of FYM on oats fodder production:** Previous study involving production of oats fodder indicated better yields on use of lime (furrow application @ 500 kg/ha; 10% of LR) and FYM @5 t/ha. Together with lime, in present study FYM at 5 and 10 t/ha was applied. Higher dose of FYM with similar dose of lime resulted in enhanced fodder yields (t/ha) with 24.51 Vs 21.03 in first cut at 45d and 32.11 Vs 29.64 in subsequent 2nd cut at 70d.

**Berseem and Lucerne fodder production:** Growth of berseem and lucerne at initial stages remains low which correspond to low yields of fodder on 1st cutting. Chinese cabbage due to rapid growth may enhance the forage yield in 1st cut. Therefore, intercropping of Chinese cabbage with berseem and lucerne was tried at the research farms at Animal Nutrition and Agronomy Divisions. Crops were sown during 1st week of November with application of lime (@ 500 kg/ha, furrow) and FYM @ 5 t/ha. The crops were under moisture stress due to almost negligible rains during entire growing period. Though intercropping of Chinese cabbage provided additional fodder (23%) in 1st cut, it failed to allow proper growth of berseem and lucerne as well (Fig 5) in the terraced uplands. Unless proper nutrient and irrigation management applied above cropping may not be possible under similar conditions.

**Fig 5 Berseem and lucerne fodders grown without lime (L) and with chinese cabbage intercropping (R) in 2nd cut from the Agronomy farm**

**Use of effluent from cattle shed for mixed fodder production during winter:** Dairy shed effluents being rich in nutrients, have potential for use for the cultivation of fodder during winter scarcity period. Mixed/intercropping of Chinese cabbage, oats and berseem was attempted in the field receiving the washings/drainage from the dairy shed. Chinese cabbage was harvested (single cut) as major fodder after the 40d of sowing and the oats and berseem (Fig 6) were harvested subsequently after 15-20d interval.

**Fig 6 Mixed/intercropping of fodder crops during winter. Chinese cabbage and oats were ready to harvest in 1st cut (L), and oats and berseem in subsequent cuts (R)**

**Performance of dairy animals**

About 30 crossbred cattle (cows-9 and heifers & calves-21) and 14 Murrah buffaloes (buffaloes-7 and heifers & calves-7) were maintained on the fodder crops/grasses produced from 0.6 ha area and purchased fodders like- grass, paddy straw and concentrates. Out of total area under fodder, improved perennial grasses and other annual fodder crops each were grown in 0.3 ha area. Among the milch animals, a HF crossbred cow #43 (Fig 7) emerged best performer. It produced total 5191.5 kg milk during 305d (average-17 kg/d) of previous (2nd) lactation. During first 201 days of current 3rd lactation, a total of 4301 kg milk with peak yield of 27 kg/d has already been obtained from the same animal.

Overall trend and lactation performance of dairy herd has been depicted in the Fig 8 and Table 4. During

**Fig 7 Best performing hf crossbred dairy cow #43**

the period of January to March, 2013 all the animals were almost exclusively maintained on paddy straw as sole roughage apart from concentrate feeds.


**Fig 8 Trend of milk production by lactating cows and *mrrah* buffaloes at dairy unit**

**Table 4. Milk yield (MY) and herd performance of lactating animals at dairy unit**

| Particulars | Crossbred cattle | | Murrah buffaloes | |
|---|---|---|---|---|
| | Total MY (kg) | Ave MY (kg/ animal) | Total MY (kg) | Ave MY (kg/ animal) |
| Total MY (kg) | 27695.0 | - | 9595.5 | - |
| Ave MY (kg/month) | 2307.9 | 312.1 | 799.6 | 124.1 |
| Herd Ave (kg/h/d) | 7.8 | - | 3.8 | - |
| Wet Ave (kg/h/d) | 10.2 | - | 4.5 | - |

## Goat nutrition

**Effect of improved pasture on goat production:** Few years back, sloppy upland area was developed for pastures in the premises of Animal Nutrition Research Farm. Congo-signal grass was grown in whole area while, perennial groundnut was added in half (~400 $m^2$) of area (Fig 9). Over the years, other native grasses in a small proportion have also mingled in the same pasture.

**Fig 9 View of established pasture with perennial groundnut on sloppy upland**

Six goats (Assam local hill) with 2-5 parity were distributed in two groups of 3 each. Every animal offered 100 g concentrate (16% CP, 65% TDN) daily and allowed to graze on Congosignal or perennial groundnut improved pasture for 4 days a week by individually tying with ~6m long nylon cord. Remaining days, all goats were allowed free grazing on mixed jungle grasses. Feeding continued for the period of May to November 2012 subsequently, all animals were stall fed on *parari* fodder. Findings (Table 5) of this observation hint a potential of goat rearing on perennial groundnut improved pastures under the village conditions, especially the degraded/abandoned *jhum* lands.

**Table 5 Performance of goats on perennial groundnut improved pasture**

| | Particulars | Type of pasture | |
|---|---|---|---|
| | | Congosignal (C) | C + Perr. Groundnut |
| Pasture-Goats- | Ave CP (%) | 8.05±1.02 | 12.03±1.15 |
| | Ave BW (kg) on 1.5.12 | 16.97±0.18 | 16.93±0.32 |
| | Ave BW (kg) on 1.1.13 | 17.70±0.94 | 18.87±1.11 |
| Kids- | Total kids born | 4 | 6 |
| | Type of birth | 2 single, 1 double | 1 each of single, double & triple |
| | Sex | 4 Female | 4 Female, 2 Male |
| | Ave birth W/kid (kg) | 1.17±0.09 | 1.13±0.09 |
| | Mortality | nil | nil |
| | Ave birth W of kids (kg) /goat | 1.50±0.25 | 2.17±0.49 |

***Parari* and Lucerne feeding in growing kids:** Growth of kids is not properly supported by sole feeding of *parari* foliage during winter lean season. Three groups of 3 kids each with average 4.6 kg BW offered roughage based diets with *parari* and lucerne in proportion of 100:0, 50:50 and 0:100 (DM basis). On calculation basis, average intake of CP (g/d) was 16.2, 25.2 and 34.2, and TDN (g/d) was 90, 102 and 114 in respective groups. The average daily gain of kids was highest (33.3 g) on 100% lucerne, followed by mixture (28.6 g) and sole *parari* (19.1 g) feeding.

**Feeding of tree leaves based complete feed blocks:** Often, tree leaves during the winter lean season provide good fodder for goats, however consumption

of some tree leaves remain inadequate. Complete feed blocks (CFB) not only improve palatability, intake and digestibility but also allow easy transportation, handling and storage. Using tree leaves, total mixed ration (TMR; 12%CP, 60%TDN) was prepared with 60:40 roughage to concentrate ratio. The roughage comprised of 10 parts each of leaves from guava (*Psidium guajava*), makari sal (*Schima wallichii*), ficus (*Ficus hookeri*) and jackfruit (*Atrocarpus heterophyllus*) and 20 parts of maize stover. Nine kids were evenly distributed in 3 groups. Each animal daily received 100 g chopped oats fodder in the morning followed by feeding of 200 g berseem fodder with green sorghum (*ad lib)* in control (C), TMR in mash form (M) and TMR in CFB form (B). At the end of 3 week experimental feeding there was improvement in growth performance of kids on CFB with ADG of 32.2, 33.7 and 37.1 g/d in respective groups. The beneficial effect of incorporation of tree leaves could also be implicated by 60-80% reduction of total faecal egg count in the kids fed TMR in mash (M) and block (B) form over the control feeding (C).

**Dairy cattle nutrition**

**Effect of feed supplement on milk yield in cattle:** A milk enhancer (100 ml) liquid feed supplement was given daily for a period of 10 days in the concentrate feed to individual HF crossbred cows (n=4, 2-4 parity, 90-120 days of lactation). The milk yield and composition of combined samples of 10d corresponding to preceding, supplementation and post supplementation periods were monitored. Average daily milk yield was 12.4, 12.9 and 12.8 kg during respective periods, which correspond to 3.9 and 3% increase in milk yield during the supplementation and post supplementation periods. A detailed study on nutrient utilization is required on such supplementation in lactating animals.

**Mixed jungle grass based complete feed block feeding in dairy animals:** Matured mixed jungle grasses are generally not relished by dairy cattle due to low palatability. This biomass after proper processing such as in the form of compressed complete feed blocks (CFB) can provide better feeding of ruminant animals during winter scarcity period. Mature mixed grasses were collected from the jungle area inside the institute during 1st week of December. The material was sun dried and chaffed. Using 50:50 roughage to concentrate ratio diets were formulated with calculated ~12% CP and 60% TDN.

In first experiment, eight HF crossbred calves (ave. 125.4 kg BW) were distributed in 2 groups of 4 calves each. Chaffed grass and water soaked concentrate mixture in *mash* form was given in one group (T-1) while same ration was given in the form of CFB in other group (T-2) of animals. Additionally all animals were given one kg green fodder daily. The experimental feeding was continued for 28d followed by digestibility trial of 7d. Results revealed that feeding a diet containing 50% mature mixed jungle grasses in the form of CFB has improved the intake of total DM (4.48 Vs 3.27 kg) and ADG (486 Vs 429 g/d) in growing calves.

In other experiment six lactating crossbred cows (ave. 367 kg BW, 10.13 kg MY, 2-4 lactation) were distributed in 2 groups depending upon milk yield and BW. Besides above mentioned similar treatments, animals were given 2 kg green fodder daily and experiment lasted for 21d with 14d adaptation feeding followed by 7d collection period. The average values of parameters viz., DMI (kg/d), DMD (%) and MY (kg/d) were 10.26, 60.35 and 10.6; 10.65, 62.51 and 11.0 on mash and CFB feeding respectively indicated advantage of feeding of CFB.

**Buffalo feeding**

**Feeding adaptation under the Meghalaya conditions:** Whilst introducing an animal breed in diverse agro- attention therefore needed for satisfying the animal's dietary requirements as nutrition is foremost important component for every livestock rearing. Milch *murrah* buffaloes upon arrival during March, 2012 from native tract (Distt- Rohtak, Haryana) at dairy unit faced intricacy in feeding on paddy straw (PS) which was only available roughage. As palatability of PS was low (<4 kg/h/d), animals were put on high concentrate (~9 kg/h/d) diet on conventional feeding. Through several modifications in fodder processing and ways of feeding viz., chaffing, water soaking, supplementation with jaggery etc and *sani*, animals could consume greater quantity of PS. By dipping intact PS in the water with concentrate (Fig 10) buffaloes can consume ~15 kg DM with 2/3rd from PS alone during the dry period.

**Effect of feeding on body weight changes in buffaloes:** Seasonal availability of fodders affect the growth or body weights (BW) of animals. Apart from receiving optimum level of concentrate animal given roughage comprised of grass+PS, grass and PS during the respective period of 0-90, 90-160 and 160d onwards. Growing buffalo calves gained BW at 316 g/d during entire period with 373 and 222 g/d during the availability of grass and PS respectively indicating

**Fig 10 Feeding of paddy straw in *Murrah* buffaloes**

that feeding of green grasses produced higher growth. More or less similar trend was also observed in adult buffaloes during lactation or otherwise (Fig 11).

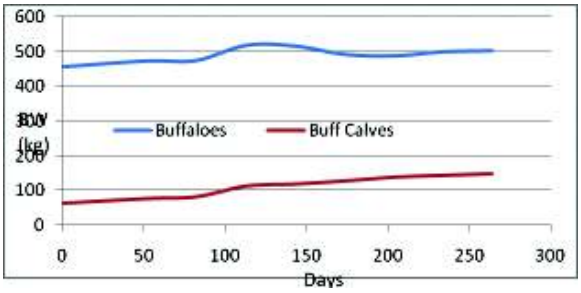
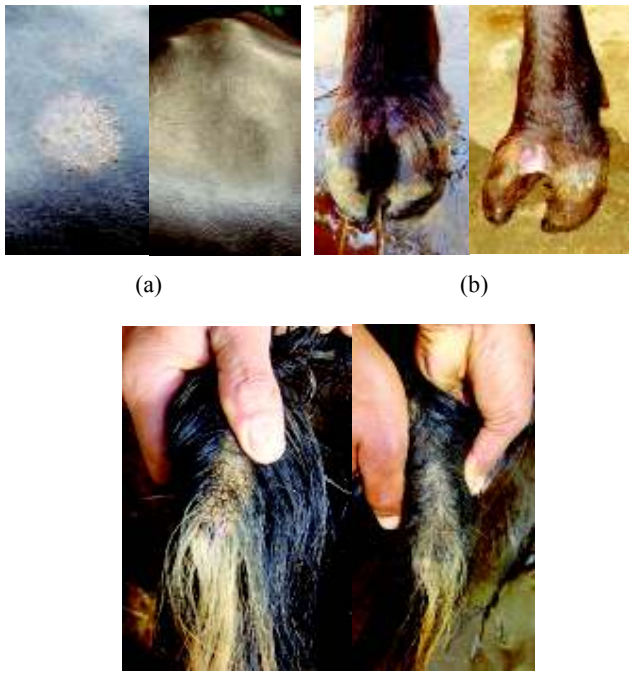



**Fig 11 Trend of body weight change in buffaloes on grass and paddy straw feeding**

**Nutritional management of Degnala in buffaloes fed on paddy straw:** Adult buffaloes exhibited classical symptoms of *Degnala* on paddy straw (PS) feeding as sole roughage with conventional concentrate during the winter lean period. Lesions appeared on the skin, hooves and tail within a month of PS feeding, which aggravated in next 15d. Moreover, similar symptoms were not observed in young buffalo calves under 1 year age. Unlike buffaloes, cattle never showed such symptoms under similar feeding regimen. After collecting fodder and blood samples for the analyses for Selenium and *Fusarium* sp., animals were given *Degcure* (formula source: NDRI Karnal). After 30d of *Degcure* use on similar diet, noticeable improvements (Fig 12) were observed in all affected animals. Further in depth biochemical studies may be required for elucidation of etiology.



(a) (b)

(c)

**Fig 12 Views of affected body parts viz., skin (a), hoof (b) and tail (c) of buffaloes before (L) and after (R) the use of *Degcure* mixture**

## Pig nutrition

**Preparation of legume silage for pigs:** Owing to higher protein content legume fodders offer an attractive alternative to expensive concentrate feeds in pig rearing. Besides their seasonal availability, bulkiness, low energy, presence of high fiber, moisture, and incriminating factors, hampers their application in pig feeding. Preparation of silage from legume fodders could provide a solution.

Wilted and chaffed fodders of soybean, rice bean, cowpea, jack bean, Crotalaria and Flemengia were ensiled without supplementation, with 4% maize flour, lactobacillus culture and combination of maize flour with lactobacillus under laboratory conditions for 21d. Depending on the pH, CP and aroma, cowpea with use of Lactobacillus and maize flour produced best quality silage followed by similar treatment of rice bean soybean, crotalaria, jack bean and flemengia. For feeding of finisher pigs, mixed silage from cowpea, rice bean and soybean fodder (DM-35.9%, pH-3.5, CP-16.4%) was prepared in the polythene lined HDPE bags (Fig 13).

**Fig 13 View of silage bags**

**Fermented squash for animal feeding:** Farm produced squash fruits are alternate feed resources for pig feeding. However presence of oxalates makes these fruits less utilizable and cooking is generally practiced for feeding them to pigs. The preservation of squash as silage could turn them into better feedstuff. Squash were chopped into small pieces, and mixed with 4% maize flour and probiotic inoculums containing Lactobacillus with *Saccharomyces cereviceae*. The contents were then anaerobically sealed into a plastic drum for 21d. The fermented product or silage (Fig 14) is high moisture (~85%) with pleasant aroma of organic acids, pH of ~3.6 and live lactobacillus. Preliminary feeding to pigs and poultry birds indicated high palatability however, detailed study is required.

**Fig 14 Squash fruits, chopped and fermented product**

**Probiotics supplementation**

Fecal isolates of lactobacillus strain were tested for *in vitro* probiotic characteristics. One isolate of Lactobacillus having probiotic potential was grown on large scale on MRS broth and used for feeding in different species.

**Probiotics supplementation in goats**: Eight, 2 week old suckling kids *(Assam local hill goat*) were allotted to 2 groups and allowed willful intake of feeds. In one group, individual kid was given 10 ml of mixed culture of Lactobacillus isolate with *Saccharomyces cereviceae* orally twice a week for 2 months. The observation of BW revealed higher growth (23.5 vs. 20.8 g/d ADG) in probiotics administered group. In another experiment, 6 multiparous goats (19.2 kg ave BW) were given 100 g concentrate (16%CP, 70%TDN) and native grasses *ad lib* with a group of 3 goats each on similar treatments 3 weeks which include 2 weeks preliminary feeding followed by one week metabolism trial. The nutritional status of probiotics supplemented group was better than non-supplemented group and the respective values were 521 and 511 g/d DMI, 65.79 and 63.16% DM digestibility, 66.82 and 64.45% CP digestibility, and 58.66 and 54.21% CF digestibility. Nevertheless blood biochemical parameters remained similar in both groups of adult goats.

**Probiotics supplementation in pigs**: Two groups of 3 crossbred female piglets each (21 kg Ave BW) were used for this study. All animals allowed recommended daily ration. One group was given probitics mixture in feed while other without probiotics, served as control. Piglets supplemented with probiotics performed better as average weight gain (kg), ADG (g/d) and FCR were 36.8, 428 and 4.02, and 40.5, 471 and 3.62 in control and supplemented groups, respectively. For evaluation under the field conditions, probiotics supplement was given to farmers in Kyrdem village. The performance of supplemented pigs was better (Table 6) than non-supplemented ones.

**Table 6 Growth performance of crossbred pigs under the farmer's field in Kyrdem village**

| Particulars | Without probiotics | With probiotics | | |
|---|---|---|---|---|
| | Female (n=6) | Female (n-6) | Male (n=3) | Overall (n=9) |
| Initial BW (kg) | 9.58 | 10.00 | 10.67 | 10.27 |
| Final BW (kg) | 20.28 | 23.60 | 22.40 | 23.12 |
| Days of feeding | 129.5 | 133.00 | 133.0 | 133.00 |
| BWG (kg) | 10.70 | 13.60 | 11.73 | 12.85 |
| ADG (g/d) | 82.21 | 102.26 | 88.22 | 96.64 |
| Mortality | 1 | nil | nil | nil |

**Probiotics supplementation in poultry**: One faecal isolate of *Lactobacillus* having probiotic potential with *Saccharomyces cereviceae* was grown on large scale and used for feeding in Vancobb broiler chicks (Fig 15).

Velvet beans (Mucuna) are rich source of protein but same time these also have several incriminating factors which affect the animal production if consumed in larger proportions. However, same can also be used for its benefits as *ayurvedic* literature indicates its utility as a drug particularly as mood enhancer/stress alleviator in humans. In some studies probiotic microbes were also demonstrated to offset some

**Fig 15 Dietary probiotic supplementation studies in Broiler birds**

negative effects. Six diets for broilers having 20% CP and 3000 Kcal/kg ME were formulated using yellow maize, soybean meal, groundnut cake, fishmeal, mineral mixture, DCP, and salt. The diets of G1, G2 and G3 were probiotic free and G4, G5 and G6 were supplemented with probiotics (*Lactobacillus* plus *Saccharomyces*). Further, diets of G1 and G4, G2 and G5, and G3 and G6 contain *Mucuna* meal at a level of 0, 2 and 4% respectively (*source: Dr K.P. Mohpatra*). The production data on 55d experimental feeding (Table 7) imply the utility of mucuna meal at 2% level and synergistic efficacy of probiotics supplementation even though the mechanism needs to be investigated.

## National Initiative on Climate Resilient Agriculture (NICRA)

### Change in monsoon rainfall pattern at North Eastern Region

- In general, the average amount of monsoon rainfall recorded has decreased from 900-3000 mm (1951-90) to 850-2350 mm (1991-07), indicating an average reduction of 18% rainfall during the recent time (1991-2007). Significant ($P<0.01$) decrease in amount of rainfall in Ukhrul and Senapati districts of Manipur and Phek, Zunheboto and Wokha districts of Nagaland has been observed.

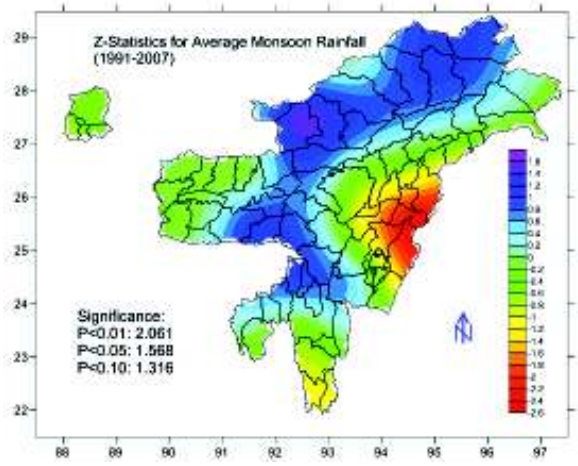
**Table 7 Average values of production parameters of broiler birds on diet containing graded levels of mucuna beans without or with probiotics supplementation**

| Particulars | Without probiotics | | | With probiotics | | |
|---|---|---|---|---|---|---|
| | G1 | G2 | G3 | G4 | G5 | G6 |
| Level of mucuna meal (% in diet) | 0 | 2 | 4 | 0 | 2 | 4 |
| Initial BW (g) | 82 | 81 | 76 | 85 | 83 | 80 |
| Final BW (g) | 1620 | 1810 | 1528 | 1742 | 1867 | 1615 |
| BW Gain (g) | 1538 | 1729 | 1452 | 1657 | 1784 | 1535 |
| ADG (g/d) | 27.96 | 31.44 | 26.40 | 30.13 | 32.44 | 27.91 |
| FCR | 2.59 | 2.31 | 2.75 | 2.41 | 2.22 | 2.61 |
| Mortality | 1 | 2 | 4 | 1 | 1 | 4 |

Evaluation of probiotics supplement in Vanraja chicks under the field conditions was carried out in Kyrdem village. The performance of supplemented birds was better (Table 8) than non-supplemented ones.

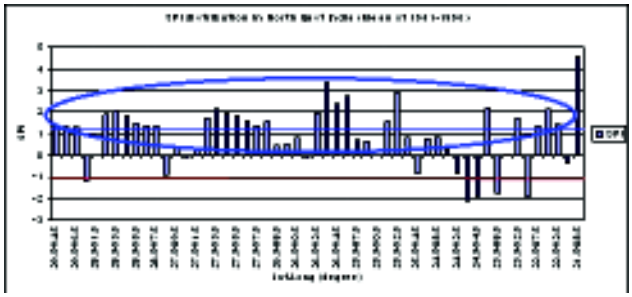
**Table 8 Performance of Vanraja chicks on probiotics supplementation under farmer's field**

| Production parameters | Without probiotics | With probiotics |
|---|---|---|
| No. of units (30 chick each) | 13 | 10 |
| Initial BW (g) | 78.5 | 69.0 |
| Final BW (g) | 1118.8 | 1556.3 |
| Days of feeding | 130.4 | 130.4 |
| BWG (g) | 1029.4 | 1486.3 |
| ADG (g/d) | 7.8 | 11.5 |
| No. of units with high mortality | 5 | 2 |




- Similarly, the range of rainy days reduced from 65-91 days (1951-90) to 57-85 days (1991-2007) indicating an average reduction of 9% rainy days over the region. The reduction is significant ($P<0.01$) for all the districts of Nagaland; upper Assam districts of Tinsukia, Dibrugarh; and Tirap, Changlang, Lower Dibang valley districts of Arunachal Pradesh.

- The traditionally wet north eastern region has shown a tendency of moving towards a drier monsoon regime in the recent time as evidenced through standardized precipitation index. More locations in the region moved to the negative side of SPI indicating occurrence of water stress of varying degrees during the *kharif* crop season.



- Preliminary crop modeling study in DSSAT platform indicates increase in upland rice productivity at Umiam, Meghalaya and Lamphalpet, Manipur by 6-7 and 3-4.5%, respectively, if maximum temperature rose by 2 $^0$C above current normal and level of $CO_2$ concentration increased to 450 ppm from present 392 ppm. For that purpose, two locally developed and commonly cultivated high yielding rice cultivars *viz*. Bhalum-1 (145-150 days duration) and RCPL 1-142 (115-120 days duration) were used after proper calibration. Both the cultivars have potential to produce over 4 t/ha of grain yield.

### Crop Improvement

- A total of 600 rice genotypes were screened under three temperature regimes. Seventy eight genotypes could register about 80% germination at 40 $^0$C, and 27 genotypes at 45 $^0$C. No growth of seedlings was found at 50 $^0$C. After heat treatment of those 27 genotypes at 40 $^0$C and 45 $^0$C, 18 genotypes successfully recovered at 40 $^0$C and 9 at 45 $^0$C. These nine genotypes are RCPL 1-136, RCM 17, RCPL 1-74, RCPL 1-188, RCPL 1-185, RCPL 1-132, RCPL 1-460, RCPL 1-409 and RCPL 1-186. The 18 genotypes which recovered after 40 $^o$C treatment were also tested for drought tolerance at flowering stage. RWC was highest in RCPL 1-132 (60.01) followed by RCPL1-136 (48.58) and Deku (45.11). Both RCPL 1-132 and RCPL 1-136 also showed recovery after exposure of seedlings to 45 $^0$C. Out of 600 rice genotypes tested for heat tolerance RCPL 1-136 and RCPL 1-132 were found most tolerant against high temperature exposure at 45 $^0$C (72% spikelet fertility on recovery) with tolerance for drought (RWC 48.6).
- Total 83 *jhum* and 259 upland rice germplasm from north-eastern region were screened for drought tolerance under managed stress screening following IRRI protocol. Based on grain yield and other traits, the promising drought tolerant genotypes RCPL 1-128, Bhalum 3, Berain 2, Full Badam and Kataktara were identified in Tripura.
- Preliminary screening of 132 maize genotypes for heat tolerance led to identification of sixteen tolerant genotypes. Further investigation was done for pollen grain viability of these sixteen heat tolerant maize genotypes. The pollens were exposed to selected temperatures of 25 (control), 35, 38, 40 and 42 $^0$C under moist (100% humidity) as well as dry conditions (40-50% humidity). At the end, three genotypes (RCMGP 63, RCMGP 105 and RCMGP 47) were found with high pollen viability and germination even at 42 $^o$C, under both dry and wet conditions.
- Thirty eight genotypes of tomato were evaluated under poly-house condition at 20-30 $^0$C at three levels of moisture stress (90±2.3%, 80±2.3% and 70±2.3% moisture stress) by irrigating at 15, 10 and 5 days intervals. The ranges of temperature and relative humidity at poly-house were 20-38 $^0$C and 22-45%, respectively. Out of 38 genotypes, Megha Tomato 3 performed best at low moisture condition.

## Soil moisture conservation

### Suitable land use model for NEH region of natural resource conservation

To conserve soil and water resources, improve carbon sequestration and land productivity in sloppy land (30-40% slope), a land use model (Fig1) involving diversified components *viz*. natural forest, fodder crops, leguminous cover crops, intercropping of maize + legume under different resource conservation technologies (RCT) measures were evaluated for climate resilient hill agriculture. After harvest of *kharif* crops, the residues were retained on the surface and *toria*, French bean and lentil were grown under zero tillage with residual soil moisture. The cropping sequence adopted along the slopes from top to bottom were as: natural pine forest with catch pits followed by- fodder crops, cover crops, maize + legume intercropping and finally rice at foot hills. Among the different cropping systems, fodder crop based system

**Fig 1 Cultivation in topo-sequence with soil & water conservation measures**

registered maximum soil organic carbon (1.80%) and SOC stock (29.7 t/ha) accumulation followed by cover crop based system (1.61 %, 26.8 t/ha), at the end of three cropping cycles. Soil loss in water was found least in fodder blocks (ranged from 0.85 to 1.78 t/ha), followed by blocks under cover crops (1.95 to 2.86 t/ha). Residue retention resulted 10% higher soil moisture content than under no residue practice under dry-season French bean cultivation.

**Soil and water conservation measures in *jhum* fields**

Bench terraces were made in a portion of *jhum* field (28-32% slope) at Sonidan village of Ri Bhoi district of Meghalaya with fixed vertical interval of 1m. The bench terraces were made covering an area of 2281.1 $m^2$. Ginger was sown in the terraces with receipt of early spring showers during April, 2013. The improved techniques, such as, pre-sowing treatment of planting materials, application of biofertilizers etc were followed. In another *jhum* field at Khatweimer village, *buns* (a kind of raised bed) were made across the slope for ginger cultivation, whereas, in normal practice *buns* are raised along the slopes. This was done to have a comparative study between these two methods of *jhuming*. Improved rice cultivation practices including evaluation of varieties, intercropping with legumes, nutrient management etc. are also undertaken in Sonidan.

**Fig 2 Bench terrace making**

**Fig 3 Bun across the slope for ginger**

**Understanding the unique traits in indigenous pig and poultry**

Unique traits of indigenous pigs on NEH region:

- Extensive study on unique traits of the indigenous pigs of north eastern region have revealed special features like thin bristled skins, shows early sexual maturity, able to digest high fiber diets, possesses long canine teeths, special leg and hoof placement patterns with pot belly and strong disease resistance.
- They possess several climate resilient traits against extreme heat and cold. Lower skin thickness (1.6mm) and subcutaneous fat (5.83mm) in indigenous pig help in heat dissipation (heat exchange). Whereas, long (5-7 inch) and dense (150 to 188/$cm^2$ of skin) bristle helps the pigs to protect themselves against extreme cold in the region. Higher number of hair follicle and sebaceous gland helps them to keep the skin oily and lively to prevent various skin diseases.

**Low cost climate resilient environment- affinitive pig house model**

Innovative integrated low cost pig pen was developed with locally available natural resources for high rainfall mid to high altitude region. The housing model has got better micro environment leading to improved physiological adaptation and performance. This pig house model was also integrated with rain water harvesting mechanism and vermicompost unit for water conservation and production of quality manure, respectively.

**Mucuna beans and probiotics supplementation for chicks to mitigate winter stress**

*Mucuna pruriens* meal at 2% level with or without probiotic supplementation (*Lactobacillus* + *Saccharomyces* sp.) to the vencobb commercial chicks showed winter stress tolerance under Meghalaya condition. Average daily grown rate of chicks was more at 2% level of *Mucuna* beans without (31.44 g/day) and with probiotics (32.44 g/day) and with FCR of 2.31 and 2.22, respectively.

**Identification of unique traits of indigenous poultry**

The indigenous poultry are medium sized, active and having multi-colored plumage. Majority of the birds were normally feathered however, frizzled and naked neck types are also observed in many areas. The frizzled and naked neck types of indigenous poultry are more tolerant to heat due to their capacity of more heat dissipation from the body. The birds possess single comb, red earlobe and white non-feathered shank.

**Epidemiological study of pig and poultry diseases and correlation with climatic variables**

Viral and bacterial disease occurrence was very high during summer and rainy season in pig and poultry. Major diseases observed were swine fever, swine pneumonia, parasitic infections, viral and bacterial infections for pig. Different breeds of pigs viz., upgraded Hampshire, Large black, Mali, Ghungroo and Duroc were compared for physiological adaptation and their performances were demonstrated in different agro-climatic condition of NEH region through participatory mode.

In poultry, Ranikhet Disease, Bacillary White Diarrhoea, Non- specific bacterial diarrhea, chronic respiratory disease, Fowl pox, Fowl cholera and Parasitic infestations were observed. Improved breeds of Poultry viz., Vanaraja, Giriraja and Grampriya were evaluated under low input production system and demonstrated (Fig).

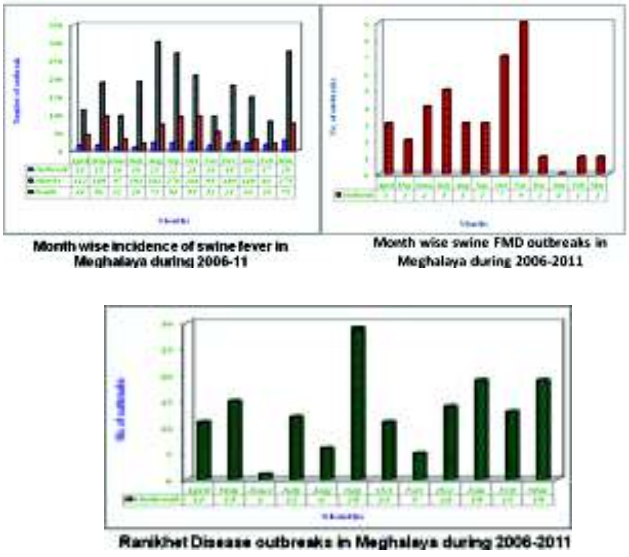



**Fig Epidemiological study of common pig diseases**

## TECHNOLOGY DEMONSTRATION

The Institute has recently started strategic research and technology demonstration for climate resilient agriculture to tackle the issues of climate change under NICRA Scheme. Under this scheme, institute has demonstrated several technologies in the Farmer's field at Nongthymmai Village, Ri-bhoi district, Meghalaya.

### 1. Crop Production

### a. Zero tillage of pea in rice fallows

Pea seed (var. Arkel) were distributed (120 kg) for demonstration in the farmers' field. The crop was planted in the rice fallow in an area of 1 ha under zero tillage and residue retention. A follow up and individual farm visit were taken up for expert guidance in terms of improved intercultural operations. The crop was planted with the available rice crop biomass and sufficient moisture. Field pea was harvested with well developed pods with average yield of 3-4 t/ha

### b. Zero tillage of rapeseed in rice fallows

Rapeseed (var. M 27) were distributed for demonstration (25 kg) in the farmers' field. The crop was planted in the rice fallow in an area of 2 ha with the available rice crop residues and residual moisture (Fig 4). A follow up and individual farm visit were taken up for expert guidance in terms of improved intercultural operations. Crop yield was 0.6 to 0.7 t/ha as compared to the traditional varieties under traditional practice (0.2 t).

**Fig 4 Zero tillage toria in farmers field**

Before the demonstration, farmers gave least importance to the pulse crops and presently, they have realized the importance of pulse and oilseed crops which greatly enhanced the year round production and improved the soil fertility due to inclusion of legume in cropping systems.

### c. Vegetable cultivation

Three polyhouses have been constructed for off-season vegetable production and for raising vegetables seedling. Potato seed tubers *(*var. Kufri Jyoti and Kufri Giriraj) 2.5 t were distributed for demonstration in the farmers' field. Likewise, tomato hybrid seed var. Rocky (100 packets) and Cucumber hybrid seed (var. Malini) (300 g) were also distributed for demonstration in the farmers' field. These crops were cultivated in the raised bund after rice cultivation in an area of 1 ha each to ensure irrigation efficiency and nutrient efficiency. The performance of the crops was better in comparison to the local crops with traditional practices without nursery management (Fig 5).

**Fig 5 Vegetable cultivation in Mawlangkhar village**

**2. Livestock production**

a) The improved breed of pig (*T & D)* 2-3 months old and having an average weight of 10 kg were provided to farmers. With the balanced feeding of 50% rice bran, kitchen waste and garden waste + 50% concentrate, improved healthcare management and heeding to improve resistance and performance under stress conditions, the body weight of the piglets has increased to average weight of 25 kg in 2 ½ months in comparison to the local breeds and traditional method of rearing (Fig 6).

**Fig 6 Demonstration of improved livestock rearing under NICRA**

b) The improved breed (Assam Hill Goat) of 4-6 months old were provided to farmers. The goat kids were of free grazing type and fed with 50% concentrate. Goat kids of Assam Hill goat breed performed well with a body weight of 30 kg average increased in 7 months and female goats have given birth to one goat kid each, a total of 8 goat kids showing improved performance under given climate conditions and farmers became aware of goat rearing through the demonstration which may supplement meat requirement of the village in case of increased temperature.

c) The Kuroiler as well as Vanaraja birds were of free range type and of 6 months old having an average weight of 350 g. Both male and female birds respectively developed a body weight of 2.90 kg and 2.50 kg approximately and the mortality due to very low temperature is reduced to greater extent because of improved housing, mineral supplementation and low cost healthcare management in comparison to broiler or local strains.

**3. Vermicomposting**

A total of 10 numbers of vermicomposting unit of 10 x 3 x 2 ft were constructed with low cost fabricated tanks along with thatch roof and 15 kg of earthworm culture was released @ 1.5 kg per tank for supplementation of organic manure and efficient use of available bio mass and crop residues etc, subsequently, enhancing carbon cycling. Awareness increased to 90% about vermicompost production and about 4 tonnes composts already produced to meet 20 kitchen gardens requirement.

**4. Rain water harvesting and preparation of Jalkund**

Field demonstration of rain water harvesting structure such as farm pond (one new pond 20 x 20m x 1.5 m, one renovated 30 m x 18m x 1.5 m), micro rain water harvesting structure *jalkund* (5 x 4 x 1.5 m) were demonstrated in farmers field for promoting lifesaving irrigation during dry season and diversifying farm activities. It will be possible to cultivate high value vegetables and *rabi* crops with harvested water in farmers field. Moreover numbers of farmers are increasing day by day for cultivation of off-season vegetables in the kitchen garden and also farmers are willing to prepare more number of *jalkund*.

**5. Farmers' training programme on Climate Resilient Agricultural technologies**

Three number of farmers training programme on 'Zero tillage of pea cultivation', 'Cultivation of tomato' and 'Improved production technologies of *kharif* crops' was organized at Nongthymmai Village during 28th November, 2012, 17th Jan, 2013 and 25th March, 2013. More than 75 farmers with large number of women participated in the training programme (Fig 7). The training programme focused on various approaches for providing resilience to agriculture in stress condition.

**Fig 7 Training and demonstration of improved technologies**

**6. Custom Hiring Centre**

A custom hiring center was established and implements with equipment's necessary for day to day

agricultural activities (Fig 8). The farmers from the Noghthymmai village will be able take the benefit of using those equipment's for their agricultural work with prior permission from the Assistant Headman after paying a minimum pre-decided amount. Necessary guidance in the form of posters for operating these implements are provided.

**Fig 8 Custom hiring centre in Noghthymmai village**

**Livelihood improvement of rural poor through sustainable farming systems- NAIP-III**

The NAIP, Component- III sub project on *"Livelihood improvement and empowerment of rural poor through sustainable farming systems in north east India"* have contributed tremendously in improving the livelihood of small and marginal farmers of the disadvantaged districts through various site specific technological interventions such as integrated farming system for effective natural resource management, agro-forestry for rehabilitation of degraded land, resource conservation technologies viz. system of rice intensification (SRI), integrated crop management (ICM), zero *tilla*ge, poly-house technology for nursery and year round vegetables production, composite pisciculture, introduction of seeds/breeds of high yielding crops/livestock breeds/fish, multiple cropping to increase cropping intensity, scientific cultivation and value addition of spices and horticultural crops, usage of farm implements, subsidiary income generation activities, etc. Some of the successful site specific technological interventions are:

**SRI and varietal intervention in rice in Dhalai (Tripura) and South Garo Hills, (Meghalaya)**

A total of 700 farmers in Maracherra and Balaram cluster under Dhalai district (Tripura), were provided rice seeds of Pusa-44, Samba Mashuri and Naveen @ 1kg/kani (0.16 ha) for SRI cultivation (Fig 1). Similarly, a total of 250 farmers were provided with Ranjit variety of paddy in South Garo Hills (Meghalaya). The average productivity of high yielding rice varieties under SRI/ ICM in Dhalai and South Garo Hills were 4.7 t/ha and 3.8 t/ha, as against 2.4 t/ha and 1.75 t/ha with local variety and local practice, respectively. Due to the introduction of HYV rice + SRI technology in the two sites (Dhalai & South Garo Hills) farmers could earn a net income of Rs. 37,000/ha/year.

**Fig 1 SRI and varietal intervention in rice**

**Zero tillage *toria* cultivation in rice fallow for crop intensification and resource conservation in Tamenglong, Manipur**

In Tamenglong, zero tillage toria cultivation in rice fallows has been a success in the cluster villages viz. Noney, Reangkhong, Awangkhul and Tupul Charoi Chagotlong. About 59.5 ha area was brought under rice cultivation covering 197 households (HH) whereas, 116.8 ha was brought under toria cultivation covering 322 HH. The average productivity of RC Maniphou 10 (Fig 2) was 3.8 t/ha as compared to low average productivity of 2.6 t/ha of local variety (Moirangphou). Whereas, the average yield of *toria* was recorded at 0.71 t/ha. Farmers could earn a net income of ₹ 15,000/ha from toria only. Apart from this Apiculture was also integrated with toria (4 bee hives/ha) which is giving on an average ₹ 2000/ha as additional income to the farmers (Fig 3).

**Fig 2 A good crop of rice in farmers' field**

**Fig 3 M 27 under zero tillage + Apiculture at Tamenglong, Manipur**

**Fish based integrated farming system in South Garo Hills and Dhalai**

Fish based integrated farming system has been a successful livelihood intervention in South Garo Hills

and Dhalai. In South Garo Hills and Dhalai a total of 73 and 24 household, respectively benefitted from fish based farming system which has in turn increased the income of the farmers substantially (Figs 4 & 5). The farm resources were effectively recycled through the complementary interaction of crop-livestock-fishery components. The farmers could earn a net income of Rs. 35,000/- by selling fishes, eggs, piglets, vegetables, fruits etc.

**Fig 4 Fish based farming system in South Garo Hills, Meghalaya**

**Fig 5 Fish based farming system in Dhalai, Tripura**

### Terracing for *panikheti* in Mon

Terracing for *panikheti* gave encouraging results in Mon as assured water availability has provided the opportunity to the beneficiaries for round the year cultivation. All the beneficiaries are also interested to increase the area under wet land terrace cultivation. In terraces the average productivity of high yielding rice varieties (Lampnah and Shahsarang-1) was 3.9 t/ha as against 1.2 t/ha with local variety (Fig 6). Farmers could earn a net income of ₹ 19,400/ha/yr. This intervention has changed the mindset of the farmers of the area as the beneficiaries having terraces have significantly stopped the shifting cultivation to a great extent and a small area is being cultivated under *jhum* by them for cultivation of some tuber crops like colocasia and tapioca, spices, sesamum and fox tail millet. Terracing is gaining popularity among the other farmers of the village and important nutritient rich crops are being cultivated by them.

**Fig 6 Lowland rice in terraces**

### Production and processing of turmeric at Saiha, Mizoram

In Saiha, 148 farmers of the two villages viz. East Kalcho and Maubawk were selected for cultivating turmeric covering an area of 70 ha with an average of 0.5 ha/HH. High yielding variety of turmeric (Lakadong) was cultivated organically under rainfed conditions. The crops are harvested within 8-9 months time during January - February by digging using a spade. The average yield under sole crop was about 10.5 t/ha (without mulches) and under mixed cropping 12.5 t/ha (approx.) and with mulches about 13.7 t/ha. During processing one kg of freshly harvested turmeric after curing and drying gives about to 230g, which after processing it comes to nearly 200 g in powdered form. Depending upon the availability of dried turmeric rhizomes for making turmeric powder, 200 – 400 kg of powder was processed per month. Turmeric powder is sold at a wholesale price of ₹ 20/100 g packet.

# ARUNACHAL PRADESH CENTRE

## WEATHER REPORT

The period from April 2012 to March 2013 recorded a normal rain except September and October when high rainfall was recorded within a few rainy days, with high intensity. Following were the variations in weather parameters recorded (Table 1) at Agromet Observatory, Gori, Research Farm, at Basar.

The mean monthly maximum temperature varied from 17.8°C in the month of January to 29.1°C in August. The mean monthly minimum temperature varied from 6.4 °C in the month of January, 2013 to 22.7°C in the month of July, 2012. Highest maximum temperature recorded for a single day was 35.1°C on 12th August 2012 and lowest temperature recorded was 3.0°C on 25th January, 2013.The total rainfall recorded at Basar was 2567.6 mm which was above normal value of 2361.3 mm. The total number of rainy days was 117 days which was below normal value of 142 days. The peculiarity of the rainfall in October, 2012 was that within the first six days of the month 269.3 mm rain was recorded. The highest rainfall recorded on a single day was 163.8 mm on 1st October, 2012.

## CROP PRODUCTION

### RICE

**Residue management in rice for improving soil and crop productivity**

The different residue management treatments *viz.,* 100% crop residues, 100% weed biomass, 50% crop residues + 50% weed biomass, 50% crop residues and 50% weed biomass were assigned to main plots and two microbes (fungi) *Trichoderma* and *Pleurotus* were applied in sub plots. Growth and yield attributes of rice (var. Ranjit) were the highest with application of 100% weed biomass followed by 50% crop residues + 50% weed biomass. The highest seed yield under residue management was obtained with 100% weed biomass (3582 kg/ha) and was comparable to 50% crop residues + 50% weed biomass (3572 kg/ha). The lowest seed yield was recorded with 100% crop residues (3223 kg/ha). The decomposing agent *Trichoderma* was found better than *Pleurotus* and showed 9.85% higher seed yield.

Mustard (var. TS 38) was sown with imposed treatments. Mustard followed the similar trend to rice. The growth and yield attributes of mustard were the highest with 100% weed biomass followed by 50% crop residues + 50% weed biomass. The highest seed

**Table 1 Monthly weather data from April 2012 to March 2013 and their comparison with normal**

| Months | Mean max. temp. (°C) | Normal max. temp. (°C) | Mean min. temp. (°C) | Normal min. temp. (°C) | Monthly rainfall (mm) | Normal monthly rainfall (mm) | Total rainy days | Normal rainy days |
|---|---|---|---|---|---|---|---|---|
| April | 22.6 | 22.6 | 15.4 | 14.9 | 152.7 | 158.6 | 14 | 5 |
| May | 28.3 | 25.8 | 18.1 | 17.5 | 156.8 | 213.3 | 9 | 11 |
| June | 27.1 | 27.5 | 21.9 | 20.4 | 429.8 | 428.4 | 18 | 11 |
| July | 28.9 | 28.1 | 22.7 | 21.6 | 453.6 | 485.6 | 18 | 14 |
| August | 29.1 | 28.8 | 22.3 | 21.2 | 315.7 | 321.8 | 11 | 15 |
| September | 25.9 | 27.9 | 20.9 | 20 | 501.7 | 317.5 | 16 | 20 |
| October | 24.8 | 26.3 | 16.5 | 17.4 | 326.7 | 132.6 | 8 | 21 |
| November | 21.3 | 23.5 | 10.6 | 11.4 | 42 | 41.3 | 4 | 15 |
| December | 18.4 | 19.7 | 9.4 | 8.2 | 32.6 | 26.4 | 4 | 15 |
| January | 17.8 | 16.9 | 6.4 | 6.8 | 21 | 48.0 | 4 | 8 |
| February | 22.6 | 17.4 | 7.8 | 8.9 | 37.5 | 84.6 | 2 | 4 |
| March | 23.6 | 20.1 | 12.2 | 11.1 | 97.5 | 103.2 | 9 | 3 |
| Mean/Total | | 23.7 | | 15.0 | 2567.6 | 2361.3 | 117 | 142 |

yield was recorded with 100% weed biomass (954.2 kg/ha). 100% crop residues recorded 21.6% lower seed yield (785.0 kg/ha) followed by 50% crop residues (12.4%). Similarly, mustard straw yield followed the trend of seed yield and recorded the highest straw yield with 100% weed biomass and lowest with 100% crop biomass. *Trichoderma* had little edge over *Pleurotus* and recorded 7.7 and 7.0% higher seed and straw yield, respectively.

**Rice-legume intercropping for maximization of crop production**

Rice var. Bali (red) which is largely grown on *jhum* and upland was intercropped with cowpea (CP04), groundnut (ICGS 76) and soybean (JS 335). It was recorded that the seed yield of rice was 3.57 t/ha when it was grown solely. Among the intercrops grown solely were harvested with 1.42 t/ha groundnut, 1.45 t/ha soybean and 4.02 t/ha green pod of cowpea. But, the rice equivalent yield (REY) was highest with sole groundnut (4.95 t/ha) followed by sole soybean (4.01 t/ha). On the other hand, among row proportions, 8:4 ratio (Fig 1) had higher REY (4.16 t/ha) followed by 8:2 (3.79 t/ha). The land equivalent ratio was measured 1.12 when groundnut was intercropped with rice with 8:4 row proportions. Similarly, monitory advantage index was higher when rice was intercropped with groundnut and soybean with 8:2 and 8:4 row proportions. However, 8:4 row proportion had little edge over 8:2 row proportions. These clearly indicate that by adopting intercropping land and other available resources can be judiciously used.

**Fig 1 Row proportion (8:4) for rice and groundnut**

**Performance of seed priming with moisture conservation measures in upland rice**

The rice var. Bali were hydro primed (Fig 2) for 0, 6, 12, 18 and 24 hours and sown in main plots and in-situ moisture conservations like no furrow, continuous furrow, furrow after alternate row and furrow after four rows were formed in sub plots and replicated thrice.

It was recorded that germination and crop establishment were better with 18 hours hydro priming but was close to priming with 24 hours. However, crop growth and yield attributes were highest with hydro priming for 24 hours but statistically similar to priming with 18 hours. Among the furrows, furrow after alternate row had better growth and yield attributes and finally led to higher yield. The highest seed yield was recorded with hydro priming of 18 hours along with alternate furrow followed by 18 hours hydro priming and continuous furrow. Among the in-situ soil moisture conservation measures, it was noticed that growth and development were better under furrow with alternate rows followed by furrow at every row than the control. Growth and yield attributes were better under hydro priming at 18 and 24 hrs and in-situ moisture conservation with alternate rows. It was recorded that rice with hydro priming enhanced the root growth, helped the plant to sustain against moisture stress and avoided lodging up to certain extent. It was also noticed that rice plants were early established with seed priming at 18 and 24 hrs, and had less growth of weeds. Similarly, with in-situ soil moisture content passing of furrow twice with every row followed by alternate row reduced weed growth than no furrow.

**Fig 2 Hydro-priming for 18 hours with alternate furrow**

## DISEASES

**Study on epidemiology factors of rice blast disease**

Rice blast disease caused by *Pyricularia oryzae* (Fig 3) was observed up to 2000 m m.s.l. at Basar (660 m m.s.l.). The disease first appeared on foliage by the end of April or beginning of May and remained till the end of this month. Quick build-up of the diseases on foliage occurred in the beginning of June and attained the proportion of epiphytotic by the end of the month. Rainfall has further been found to influence the initial infection. Result indicated that at least 6-7 numbers of rainy days were essential even with congenial temperature and humidity. Further, rise in temperature, humidity and rainfall increased in the incidence of disease. Data revealed that crop sown on 15$^{th}$ March had minimum foliage blast severity (40%) while a gradual increasing trend was recorded in subsequent dates. The, highest severity of 74.8% was found in

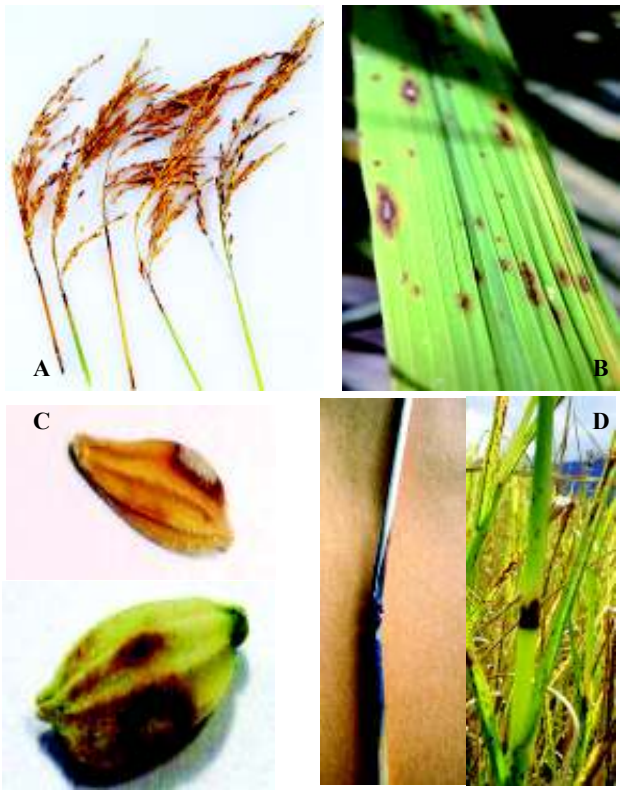



**Fig 3 Typical symptoms of Neck blast (A), Leaf blast (B), Seed blast (C) & Node blast (D)**

15th May sown crop. Earlier sowing escaped infection for longer duration than later dates. As it is evident, the crop sown between 15th March and 15th April did not show foliage blast for initial one month while crop sown in last part of May got infected immediately after germination and severity reached the peaks almost at the same time as in earlier sowing. Epiphytotics on foliage prevailed during June within the temperature range of 24 to 28$^0$C combined with the relative humidity of 90% and above.

**Reaction of paddy varieties against Rice Tungro Disease (RTD)**

Rice tungro disease (RTD) is caused by the co-infection of rice tungro bacilliform virus (RTBV) and rice tungro spherical virus (RTSV). Results (Table 1) revealed that out of six tested varieties under natural condition of infection, only RCPL1-300 showed moderately resistant reactions, while RCM 11, CAUR-1, SARS 66 were moderately susceptible and Ranjit, SARS 6 were susceptible to RTD in WRC paddy. It was observed that almost all the varieties were infected with tungro virus. None of the variety got score more than 8. Among the varieties, percentage of hill infection was higher in SARS 6 (Table 2 & Fig 3). For screening, data on disease index (DI), disease severity (%), plant height reduction (%), Plant tillers reduction (%) and disease reaction of tungro were recorded. All the DI scales and disease reactions were obtained by following a standard evaluation system (IRRI, 1996), where the index values were: 0 to 1 = HR (highly resistant), 2 = R (resistant), 3= MR (moderately resistant), 4 to 6 = MS (moderately susceptible), 7 = S (susceptible) and 8 to 9 = HR (highly susceptible).

**Fig 4 Symptom of Rice Tungro Disease (RTD)**

**Table 2 Reaction of Rice Tungro Disease (RTD) in different varieties in WRC paddy under natural condition of Basar**

| Var | Hill infection /Disease severity (%) | Disease index (%) | Average number of tillers /hill | | Plant tillers reduction (%) (H-D/H x100) | Average height of tiller/hill (cm) | | Plant height reduction (%) (H-D/H x100) | Disease reaction |
|---|---|---|---|---|---|---|---|---|---|
| | | | H | D | | H | D | | |
| SARS 6 | 80.00 | 08.00 | 34.40 | 32.40 | 05.81 | 89.00 | 31.50 | 64.61 | S |
| Ranjit | 75.00 | 07.00 | 33.80 | 15.60 | 53.85 | 65.62 | 30.08 | 54.16 | S |
| SARS 66 | 45.00 | 04.25 | 20.40 | 19.60 | 03.92 | 106.60 | 39.02 | 63.40 | MS |
| CAU-R-1 | 50.00 | 05.00 | 33.00 | 10.40 | 68.48 | 62.60 | 21.84 | 65.11 | MS |
| RCM 11 | 40.00 | 04.00 | 28.20 | 08.80 | 68.79 | 63.50 | 22.00 | 65.35 | MS |
| RCPL1-300 | 40.00 | 03.00 | 25.33 | 09.00 | 64.47 | 56.33 | 47.00 | 16.56 | MR |

*D: diseased; H: healthy

**Table 3 Diseases of WRC Paddy and their occurrence period in Basar**

| Disease | Causal organism | Period of occurrence |
|---|---|---|
| Blast | *Pyricularia oryzae* Cavara | March - November |
| Brown spot | *Bipolaris oryzae* | May - November |
| Stem rot | *Sclerotium oryzae* Catt | June - July |
| Sheath blight | *Rhizoctonia solani* Kuhn | June - July |
| False smut | *Ustilaginoidea virens*(Cke.) Thkahasi | August - September |
| Leaf scald | *Microdochium oryzae* | July - August |
| Sheath rot | *Sarocladium oryzae* | August-September |
| Rice Tungro Disease (RTD) | RTBV (Badnavirus) & RTSV (Waikavirus) | June-July |

## INSECT PEST

### TORIA

Sowing of *toria* was done on 4th December 2012 to study the presence insect fauna, insect-pests and their infestation level. Among beneficial insects, Syrphid fly was found abundant. The honey-bee population was as high as 3 to 4 per square meter during 10.00 to 12.00 AM in flowering season. Among pests, mustard sawfly were observed as much as one larva per plant and remained so up to the maturity of the plant. After the plant got matured, the larvae were found scattering away from the field in search of suitable place for pupation. Also, abundant population of painted bugs was observed (2 to 3 bugs per plant). Aphids were rarely observed may be due to the late sowing of the crop in December.

### MAIZE

**Evaluation of maize varieties under mid hill condition**

Fourteen varieties of maize were evaluated under mid hill condition, it was recorded that yield attributes like no. of cobs/ plant, no. of seeds/ row, no. of rows/ cob and test weight were recorded highest with Vivek hybrid 21 (Fig 1) followed by Vivek QPM 9. However lowest yield attributes were recorded with local check. Similarly, highest yield was harvested with Vivek hybrid 21 (8425.9 kg/ha) followed by Vivek QPM 9 (6944.5 kg/ha). However, lowest yield was harvested with local check (2777.8 kg/ha).

**Fig 1 Vivek hybrid 21**

**Evaluation of maize-French bean- mustard cropping system under land configuration and mulching**

Four land configuration viz. flat bed (FB); raised bed (RB), ridges and furrow (R&F) and broad bed and furrow (BBF) were allotted to main plots and two mulches viz., no mulch and paddy straw mulch (at 4.0 t/ha) were placed in sub plots and whole treatments were replicated thrice. Maize was dibbled in given land configuration and mulches. It was recorded that highest seed yield was harvested with BBF (Fig 2) (4430.0 kg/ha) followed by R&F (3979.2 kg/ha). However lowest seed yield obtained with FB (3312.5 kg/ha). Straw yield of maize followed the similar trend of seed yield and harvested highest straw with BBF (5850.8 kg/ha) followed by R&F. It was recorded that mulch had registered 4107.1 kg/ha, which was 14.2% higher seed yield than no mulch. After maize, French bean seeds were dibbled with the same treatments imposed to maize and maize stubbles were used as mulch for mulching to French bean. The highest pod yield of 3581.7 kg/ha with BBF which was 35.3% higher than the FB followed by R&F (3359.0 kg/ha). Stover yield was followed the similar trend of pod yield and registered 9.3% higher yield than FB. Similarly, mulch had registered 12.5% higher pod and 9.0% stover yield than no mulch. After French bean, mustard was dibbled with same land configuration and French bean stover was used as mulch at 2.0 t/ha on dry weight basis on mulched treatments. It was observed that BBF had 967.8 kg/ha seed yield which was 28.2% higher followed by R&F (885.0 kg/ha) than FB (755.0 kg/ha). However, mulched plot recorded 904.2 kg/ha which was 12.4% higher seed yield than no mulch (804.8 kg/ha).

**Fig 2 Maize under BBF**

In all three crops, weed parameters and water contents were measured, it was recorded that method of planting had no significant effect on weed parameters, but among the mulches, weed dry matter was recorded lower with mulched treatments for French bean and mustard. Similarly, moisture content was higher in BBF and R&F over FB. However, mulched plot conserved more moisture than no mulch.

## OILSEEDS

### SOYBEAN

**Evaluation of locally available mulches and phosphorus solublizing and potassium mobilizing bacteria on soybean and pea**

An experiment on soybean (Fig 1) where phosphorus solublizing bacteria (PSB) and potassium mobilizing bacteria (PMB) were assigned in main plot and seven different mulches *viz.,* no mulch, maize stubbles, weed biomass, Fern (*Dryopteris*), *Imperata cylendrica*, *red jutli* and *Altingia excelsa* in sub plots and replicated thrice. Prior to these, maize with 14 varieties were grown in the same land with recommended management practices. Soybean seeds were dibbled without tilling the land. The growth, yield attributes and highest seed yield were recorded with PMB followed by PMB. The highest growth and yield attributes and yield of soybean were recorded on mulched with weed biomass followed by *A. excelsa*.

However, lowest growth and yield parameters were recorded with no mulch. After shedding of leaves, pea variety Azad pea 1 (used for green pod purpose) was dibbled. Same treatment of soybean was imposed on pea. The highest pod yield was recorded with PMB followed by PMB. Similarly, growth and yield attributes were highest when mulched with weed biomass followed by *A.excelsa*. The lowest yield was obtained with no mulch.

**Fig 1Soybean under locally available mulching and PSB and PMB**

### MUSTARD

**Effect of planting methods and mulches on growth and yield of mustard**

Mustard var. TS 38 was sown in split plot design. Main plot were assigned to planting methods viz. flat bed, ridges and furrow, broad bed with three rows and broad bed with six rows and sub plots were allotted for mulching viz. no mulch (hand how was run at every rows at 25 DAS) and mulching with groundnut haulm @ 4.0 t/ha. It was recorded that the growth and yield were recorded highest when mustard was sown with broad bed with three rows followed by six rows (Fig 1 & 2) and lowest seed yield with flat bed. However, seed yield was recorded higher with mulching @ 4.0 t/ha with groundnut haulm. Weed dry weight was recorded during the experiment and it was found that, broad bed at three rows had lower weed biomass followed by six rows and higher weed biomass was recorded with flat bed. Among the sub plot treatments, interesting results were obtained, no mulching with one hand how at 25 DAS recorded least weed biomass than mulching of groundnut haulm @ 4.0 t/ha.

**Fig 1 BBF with six rows and mulch**

**Fig 2 BBF with three rows and mulch**

## DISEASES

### Disease reactions of groundnut germplasm against rust and *tikka* disease

Disease reactions of 10 diverse genotypes of groundnut were recorded against rust and *tikka* disease under natural condition of infection. Among 10 genotypes; GIRNAR 2, GG 7 and TG 37-A recorded the highest terminal disease intensity (TDI) against rust (*Puccinia arachidis*), early (*Cercospora arachidicola*) and late leaf spots (*Phaeoisariopsis personata*), respectively (Table 1).

**Table 1 Diseases reaction of different groundnut germplasm and their terminal disease intensity in Basar, West-Siang District of Arunachal Pradesh**

| Variety | Terminal Disease Intensity (%) | | | Yield (q/ha) |
|---|---|---|---|---|
| | Rust | Leaf spot / *Tikka* disease | | |
| | | Early | Late | |
| ALR 2 | 20.00 | 00.00 | 02.00 | 08.50 |
| ICGS 76 | 15.00 | 00.00 | 05.00 | 11.30 |
| ICGS 5 | 30.00 | 00.00 | 10.00 | 09.50 |
| GIRNAR 2 | 35.00 | 05.00 | 08.00 | 07.20 |
| SG 99 | 20.00 | 02.00 | 04.00 | 06.50 |
| GG 22 | 30.00 | 05.00 | 08.00 | 09.25 |
| M 13 | 10.00 | 10.00 | 05.00 | 08.20 |
| Co 2 | 15.00 | 05.00 | 10.00 | 07.50 |
| TG 37-A | 18.00 | 00.00 | 30.00 | 10.25 |
| GG 7 | 08.00 | 30.00 | 00.00 | 07.50 |

## FRUITS

## APPLE

## DISEASE

### Survey of apple diseases

A systematic apple orchards survey was undertaken to identify the major disease problem of apple orchards in Arunachal Pradesh. The survey, showed the presence of apple scab disease (Fig 1) in all the areas ranging from 0.3% at Shergaon state horticulture farm to 2.5% at Tawang on foliage while on fruits it was least at Dirang (1.0%) and highest (10.05%) at Tawang. Varietal variation indicated highest severity in Red Gold (2.5%) on foliage and 10.5% on fruits followed by Royal Delicious, Maharaji and Golden Delicious. Red Delicious, Jonathan, Maling-9 and Red June had mild severity (Tables 1 & 2). The disease was practically absent in Fanny, Baldwin and Mclntosh.

**Fig 1Typical symptom of Apple Scab disease on fruits**

**Table 1 Apple scab severity on leaf and fruit at different locations of West Kameng and Tawang district of Arunachal Pradesh**

| Location | Per cent scab severity | | | |
|---|---|---|---|---|
| | Leaf | | Fruit | |
| | Mean ± S.E. | C.V.(%) | Mean ± S.E. | C.V.(%) |
| Tawang | 02.50±00.97 | 66.19 | 10.05±04.36 | 75.24 |
| Dirang | 01.05±00.21 | 45.17 | 01.00±00.43 | 99.01 |
| Salary farm, Bomdila | 00.90±00.14 | 66.74 | 05.45±00.40 | 30.45 |
| State Horti. farm, Shergaon | 00.30±00.15 | 151.54 | 02.00±00.35 | 49.72 |

Apple scab severity was found to be influenced by tree age. Trees below five years were healthy, while severity increased with age of the tree. The highest leaf infection of 2.50% on foliage and 6.09% on fruits was recorded in the trees above 15 years age. Increase in altitude had positive influence on scab severity (Table 1). Disease at 1200 m altitude was least which

**Table 2 Apple scab severity on different varieties of apple in West Kameng and Tawang district of Arunachal Pradesh**

| | | Apple Variety | | | | | |
|---|---|---|---|---|---|---|---|
| | | Red June | Red Delicious | Red Gold | Royal Delicious | Golden Delicious | Maharaji |
| Per cent scab severity | On leaf | 00.50 | 00.10 | 02.50 | 00.80 | 00.10 | 00.50 |
| | On fruit | Trace | Trace | 10.50 | 03.50 | 06.50 | 01.50 |

increased gradually at higher elevations. Maximum severity (2.8%) on foliage and on fruits (5.035%) was recorded at an altitude of 2500m and above. The powdery mildew (*Podosphaeraleucotricha* (E.&E.) Salm) infection was observed (10 to 80%) in different varieties. Higher severity was in Mclntosh. Leaf spot showed a maximum (30%). Stem black canker (*Sphaeropsismalorum* Berk) disease could be seen in very old trees only. White root rot (*Dematophoranecatrix*Hartig) ranged from 8 to 15 per cent, powdery mildew (07 to 30%), leaf spots (10 to 20%), lichens (10 to 20%) and fly speck (trace) at Wangho village of Bomdila.

## CITRUS

## INSECT PEST

### Standardization of integrated approaches for the management of fruit drop in *khasi*mandarin (*Citrus reticulata* Blanco)

The citrus orchard was observed highly infested with trunk borers where every fifth tree in the orchard was found with hole at the base with the presence of saw-dust. Heavily infested trees were found wilting and dying. The earlier recommendation of applying Bordeaux paste was not proving its best because the bores found their place below the ground level and started boring from there. Hole treatment and drenching the base with Dichlorvos 5ml/10litre recovered trees from wilting and which were otherwise going to die from wilting and drying.

## DISEASE

### Disease reaction of citrus germplasm against scab disease

Citrus germplasm existing at the centre were scored (1-9) against citrus scab disease (Fig 1) under natural condition of infection, results revealed that Hill Mandarin, Kinnow orange, Nagpur Santra, King Theppi mandarin, Para malta, Rubimalta and Wilking mandarin were resistant; *khasi* mandarin, Sikkim mandarin, Majuricamalta, Mosambi Australia, Daccusmalta, Whittwarmalta, Malta orange, Exliermalta, Citrange and C*itrus latipes* were moderately resistant whereas *Citrus volkamariana*, *C. zigardia*, Karnakhatta, *C. taiwanica*, Rough lemon, Valencia newton, Vanilamalta, Rubi blood red, Italian large and Kamala Australia were susceptible to citrus scab disease (Table 1).

**Fig 1 Typical symptoms of Citrus scab (*Elsinoe* spp.) disease on leaves and fruit**

**Table 1 Disease reaction of citrus germplasm against scab (*Elsinoe* spp.) disease under natural condition of Basar**

| Citrus germplasm | PDI (Scale 1-9) | Citrus germplasm | PDI (Scale 1-9) |
|---|---|---|---|
| *Khas*i mandarin | 05.50 | Nagpur Santra | 02.40 |
| Valencia newton | 08.60 | Hill mandarin | 00.80 |
| Washington malta | 08.50 | Kinnow orange | 01.50 |
| Vanilamalta | 08.60 | Wilking Orange | 02.50 |
| Rubimalta | 03.10 | King Theppi | 02.50 |
| Exceliermalta | 06.10 | Sikkim mandarin | 05.60 |
| Malta orange | 06.80 | *Citrus zigardio* | 08.50 |
| Rubi Blood Red | 08.90 | Soh-niangriang | 04.50 |
| Whittwarmalta | 06.80 | Para malta | 03.20 |
| Majuricamalta | 06.10 | Mousambi Australia | 06.20 |
| Italian large | 11.50 | Cleopatra mandarin | 08.60 |
| Daccusmalta | 05.10 | Kamla Australia | 11.50 |
| Trifoliate orange | 02.10 | *C. volkameriana* | 07.60 |
| Rough lemon | 09.50 | *C. latipes* | 06.20 |
| Citrang | 05.30 | Karnakhatta | 13.00 |
| *C. taiwanica* | 10.50 | | |

## BANANA

### Productivity maximization in Tissue culture banana var. Grand Naine

High density planting of 1053 plants tissue culture banana var. Grand Naine (Fig 2) was done at 1.5x2.0 m and different treatments like INM, mulching and trenching were tried. Control recorded significantly less growth parameters than other mulching treatments. Black polythene mulch induced early flowering (312 days) followed by local grass mulching (349 days), paddy straw mulching (364 days) and *Toko* leaves (375 days). The soil and leaf samples are being analysed.

**Fig 2 Growth of TC banana variety Grand Naine with different soil & water conservation measures**

## VEGETABLES

### Yield, weed dynamics and soil moisture content influenced by mulching in winter vegetables

The winter crops like mustard, pea, potato, cabbage, cauliflower and knoll khol were sown/transplanted and all the crops had mulch (paddy straw @ 4.0 t/ha) and no mulch. Each crop was harvested at 10 points with 2 x 2 m area. During the winter the crop was fully dependent on rainfall and no additional irrigation was provided, except, water was provided for crop establishment. It was recorded that mulched plot had 27.6-51.3% higher yield of crops (Figs 1 & 2). However, highest yield was harvested with knoll khol and lowest with potato. The cabbage, knoll khol, cauliflower, mustard, pea and potato recorded 19.71, 17.02, 13.69, 1.03, 2.27 and 24.53 t/ha, respectively with paddy straw mulch. However, no mulch has harvested with 13.51, 11.25, 9.25, 0.73, 1.66 and 19.23 t/ha, respectively. During the experiment, on an average 41.5% increment of crop yield was recorded with mulched plot with respect to crops taken. Mulched plot had higher soil moisture content throughout the crop growth period and lower weed density per unit area as compared to no mulched.

**Fig 1 Potato under mulch**

**Fig 2 Mustard under mulch**

## INSECT PESTS

### Study on status of insect-pests on cruciferous plants

Cut-worms were found on up to one month old cabbage plants. Infestation was recorded on two vars. i.e. Rareball and Purple grown in the farm. The plants were cut by the insects at their ground portion and fallen down on the ground were made on count to estimate the infestation. An infestation level of 32% was found on the var. Rareball while the level of infestation was up to 45% in 'Purple' variety. This infers more susceptibility of 'Purple' variety the reason of which need to be investigated. The infestation of cabbage by *Pieris rapae* was found, but the level of infestation was not above the economic injury level (one to two larvae per 10 plants). The larvae observed were light green in colour with a yellow line on the mid-dorsum. Flea beetle was also found in some farmers' field. Dusting with wood-ash and apply of Dichlorvos 1 ml/2 litres were found effective.

## SPICES

## GINGER

### Growth and yield performance of ginger under land configuration and mulching

Ginger was grown under broad bed and furrow (BBF), ridge and furrow (R&F) and flatbed (FB), and crops were imposed with four mulches @ 4 t/ha, *Imperata cylendrica (IC)*, Pine needle (PN), Paddy straw mulch + weed biomass (PSM) and no mulch (NM) Yield attributes like no. of rhizome/plant, no. of primary and secondary rhizome and yield/plant were recorded highest with BBF followed by R&F. However the lowest values for yield attribute was obtained with FB. Among the mulches, all the yield attributes were higher with PSM followed by PN. However, lower values for yield attribute were obtained with no mulch. Rhizome yield was recorded significantly higher (43.3%) with BBF, followed by R&F (31.55 %). However, lowest rhizome yield was harvested with FB (17.81 t/ha). Among the mulches, highest rhizome yield (38.9%higher) was obtained under PSM than the NM. Similarly, PN and IC registered 24.0 and 14.4 per cent, respectively, higher rhizome yield than no mulch.

BBF was the land configuration where lowest weed density recorded at 60 and 120 DAS. However, the highest weed density were recorded with FB (95.5 and 74.2%, respectively), followed by R&F (20.4 and 16.3%, respectively), than BBF. Correspondingly, weed dry weight was 65.0 and 50.2%, respectively, higher with FB followed by R&F (14.6 and 10.7%, respectively). Weed dry weight followed the trend of weed density at both the sampling time. Weed control efficiency was 57.9% with BBF followed by R&F (52.6%) and FB (33.7%). However, weed index (1.48%)was recorded with BBF and (9.59%) with R&F. Among the mulches, the weed density was 280.8 and 255.3% lower with PN at 60 and 120 DAS respectively, followed by IC (243.2 and 190.1%, respectively), over NM. PSM recorded lower weed density (171.9) than NM (173.0%). Weed dry weight followed the trend of weed density and recorded 211.4 and 190.2 per cent reduction of weed dry weight with PN at 60 and 120 DAS, respectively.

## TURMERIC

### Performance of turmeric under land configuration and mulching

Turmeric was grown under broad bed and furrow (BBF), ridge and furrow (R&F) and flat bed (FB) and crop were imposed with four mulches *Imperata cylendrica (IC)*, Pine needle (PN), Paddy straw mulch+ weed biomass (PSM) and no mulch (NM). Growth and yield attributes were recorded higher with BBF followed by R&F over FB. Among, mulches, PSM recorded higher growth and yield attributes followed by PN than NM. It was also observed that highest rhizome yield was harvested with BBF (28.81 t/ha) followed by R&F (25.79 t/ha). However lowest yield was recorded with flat bed (19.15 t/ha). Among the mulches, the highest rhizome yield was recorded with PSM (29.72 t/ha) followed by PN (25.67 t/ha) while, lowest yield was obtained under no mulch (19.69 t/ha). Water use efficiency (WUE) was recorded highest with BBF followed by R&F. BBF registered 25.2% and R&F had 19.5% higher WUE than FB (21.2 kg/ha/mm). Among the mulches, PSM has 26.4% higher WUE over NM, whereas, IC and PN had 4.7 and 1.1% reduction of WUE than NM (23.16 kg/ha/mm). Weed parameters were comparatively lower with BBF followed by R&F than FB. However, weed control efficiency (WCE) was highest with BBF (57.7%) followed by R&F (55.0%). Similarly, PSM has 66.3% WCE followed by PN (64.8%) and IC (62.6%). These clearly depicts that planting of turmeric with BBF has better rhizome yield, water use efficiency and weed control. Similarly, placement of mulch improves the rhizome yield, water use and WCE.

### Flagship programme on Improvement of *jhum* through horticulture interventions

Under this project distribution of banana (600 Nos.), *Khasi* mandarin (5000 Nos.), potato (10 t) and vegetable seeds (1000 kits) to about 500 farmers at NAIP site, Ziro, Mechukha, Daring, AaloBasar and sago covering about 100 ha *jhum* area were completed. Planting of banana (970 Nos.), pineapple (2600 Nos.) and two numbers of tuber blocks with Elephant foot yam (2 Nos.), Tapioca (3 Nos.), Sweet potato (3 Nos.), *Diascorea* (3 Nos.) and *Colacasia* (17 Nos.) were completed with various soil and water conservation measures like trenching & mulching in the *Jhum* land. Plant growth parameters and soil sampling are continued in banana, pineapple and tuber crops.

### Flagship programme on temperate fruits for the improvement of productivity and rejuvenation of senile orchards

Three days training progarmme on budding, grafting and pruning of temperate fruits was organized at Regional Apple Nursery, Dirang for 25 Nos. of extension functionaries and progressive farmers in collaboration with CITH, Srinagar. Mother blocks for apple, kiwi, william pear, walnut, peccan nut and apple rootstocks were established at Research Farm, Gori for production of budded and grafted plants of temperate fruit crops. Five farmers'fields were identified for the establishment of mother blocks and standardization of production technologies of apple, pear, kiwi, walnut and pecan nut at Menchukha. Apple varieties like Tydeman's Early, Golden Delicious, LalAmbri, Ambred, Mollies Delicious, Oregon Spur, Cooper-IV, and Gala Mast were introduced at Research Farm, Gori and Menchukha. Clonal Apple rootstocks like vars. M 7, M 9, MM 106, MM 111 and

**Fig 1 Kiwi mother block at Research Farm, Gori**

**Fig 2 Apple mother block at Research Farm, Gori**

conventional apple rootstock were also introduced. Kiwi vars. viz., Allison (Female), Allison (Male), Monty, Hayward and Bruno; Pecan nut, William Pear and Walnut were also included.

### Technology Mission (MM-1)

*Khasi* mandarin rootstocks (10000 Nos.), banana TC plants (5000 Nos.), strawberry (2000 suckers), pineapple (3000 suckers) and tuber crops were produced. Different value added processed products were prepared from banana, *Taktir*, peach, pineapple, and other vegetables and training to SHG were also imparted.

## MUSHROOM

## DISEASE

### Survey of mushroom

Fungal forays were undertaken in the forests and markets of Basar. Ten wild specimens were collected which included *Schizophyllum commune* Fr., *Auricularia delicata,*(Fig 1) *A. auricula-judae, A. auricula, Termitomyce s*spp., *Termitomyces microcarpus, Clavulinopsis* spp., *Lenzites* spp., *Boletus* spp. and *Ganoderma* spp. The mushrooms were collected from different habitats such as forest, decaying wood, rotting plant parts etc. The fungi were also collected from markets where the local inhabitants collected from nature and sale. The site of their collection and other related information was ascertained from the seller and even local men and women. The identification of each sample was done with the help of standard manuals. Preliminary market survey of Basar revealed that state is rich in wild edible mushrooms. There are few local mushrooms name and selling was observed in the month of April-May (*INDE, INYAK, BUGLUK, TAKEK MAREK)* and June- July (*IMBUK, AATAR, HUBSI, LOLOM*). Each pack of *S. commune*. had approximately 40g humid weight and was sold for Rs. 10.00.

**Fig 1 Fruiting bodies of *Auricularia delicata***

## AGRO FORESTRY

### Planting geometry of *Gmelina arborea* influenced the *Dryopteris* spp.: Soil moisture content and solar radiation interception

Ten planting geometry viz. 2 x 3; 2 x 4; 3 x 3; 3 x 4; 4 x 3; 4 x 4; 5 x 3; 5 x 4; 6 x 3 and 6 x 4 m were planted with randomized block design and replicated five times. It was recorded that the highest tree density was recorded with 2 x 3 m spacing followed by 2 x 4 m. However, lowest tree density was obtained with 6 x 4 m. Basal area of tree followed the similar trend to tree density and recorded highest basal area with 2 x 3 m followed by 2 x 4 m. *Dryopteris* density was highest with 6 x 4 m followed by 6 x 3 m, whereas, lowest density was recorded with 2 x 3 m. Similarly, *Dryopteris* dry weight followed the similar trend of its density and associated positively. As *Dryopteris* density increases dry weight of it increases linearly with $R^2$= 0.99. Similarly, *Dryopteris* dry weight was positively linear related with solar radiation transmission with $R^2$= 0.92. This explained that as solar radiation transmission (SRT) increases the *Dryopteris* density linearly increase. SRT was recorded highest with 6 x 4 m spacing followed by 6 x 3 m. However, lowest transmission of solar radiation was recorded with 2 x 3 m. SRT to ground from canopy was higher with thin tree density, whereas, thick density has least SRT. Soil moisture content (SMC) at 0-25 cm was recorded highest with 2 x 3 m spacing followed by 2 x 4 m. However lowest SMC was obtained under 6 x 4 m.

**Fig 1 *Dryopteris* under *Gmelina arborea***

## NATURAL RESOURCE MANAGEMENT

### Characterization of variability in soil quality parameters under different land use system in mid-hills

Four locations in west Siang district were sampled (Table 1) under different cropping system and with three depth 0-15, 15-30, and 30-45 cm and analysed in laboratory for their physico-chemical analysis and found *jhum* land having high pH, low electrical conductivity and low organic carbon in comparison

**Table 1 Soil parameters in different cropping systems**

| | Depth 0-15cm | | | Depth 15-30cm | | | Depth 30-45cm | | |
|---|---|---|---|---|---|---|---|---|---|
| **Cropping System** | **pH** | **EC** | **OC (%)** | **Ph** | **EC** | **OC (%)** | **Ph** | **EC** | **OC (%)** |
| *Jhum* | 4.4 | 0.086 | 1.29 | 4.5 | 0.061 | 1.05 | 4.5 | 0.056 | 0.81 |
| Agroforestry | 4.9 | 0.090 | 3.18 | 5.1 | 0.048 | 0.93 | 5.2 | 0.021 | 0.90 |
| Guava | 4.6 | 0.070 | 2.37 | 4.8 | 0.048 | 1.38 | 4.8 | 0.040 | 1.35 |
| Pine apple | 4.4 | 0.052 | 2.28 | 4.5 | 0.046 | 1.86 | 4.8 | 0.020 | 1.80 |
| Settled *Jhum* | 5.0 | 0.182 | 1.08 | 5.1 | 0.078 | 0.81 | 5.2 | 0.048 | 0.42 |

with agro forestry, pineapple and guava. However, high organic carbon was found than settled *jhum* land at 0-15 cm depth of soil.In general, all the parameters were higher at 0-15 cm of soil depth than 15-30 and 30-45cm except pH which change are with soil depth.

## NAIP

### Improvement of cropping system in *jhum* land

In soil and water conservation after harvesting of rice panicle the straw were slashed and spread on ground along with weed biomass grown at site as mulch materials and in-situ fertility maintenance. Sequence cropping of pea (3.00 ha), French bean (1.50 ha) and soybean (1.00 ha) were done after rainy season crops and harvested with 2.50, 3.20 and 0.75 t/ha, respectively. It wasobserved that these crops were not only source of income but conserve the soil and improved soil fertility being leguminous in nature. The available farm residues along with weeds were kept in pit for preparation of compost and the compost were recycled to crop plants. High yielding varieties of cereal (rice and maize), pulses (blackgram), oilseeds (sesame in rainy and mustard in post rainy season) and vegetables (okra, tomato, brinjal, chilli, cucurbits like, pumpkin, cucumber, ridge gourd, bitter gourd, sponge gourd and ash gourd) were sown. It was recorded that among cereals, rice and maize recorded 21.8 and 40 per cent, respectively, higher yield over traditional varieties and practices. Similarly, among the pulses, blackgram, French bean, pea and soybean registered absolute growth, as these crops were earlier not grown by farmers. However, sesame registered 45.5 per cent higher yield. Similarly, vegetable crops sown in *jhum* recorded the higher yield of okra (44.2%), tomato (22.0%), brinjal (12.0%) and chilli (71.6%). However, cucurbits recorded 49.0 per cent higher yield than the traditional practices and varieties grown on *jhum*. It was observed that with the present *jhum* cultivation practices increased the employment to the farmers by 40.9% and land was used 77.3% more by growing sequential crops, with the additional crop yield from per unit area. Integrated weed, insect and disease management was done for poly-culture in *jhum*.

Due to the introduction of improved method of rice cultivation and variety, overall crop yield increased from 25.11 to 56.05% and income up to 23.55 to 26.50% and employment on their own field increase up to 30%. Similarly the land use efficiency was recorded 38 % higher than the traditional method of rice cultivation. Overall in the *jhum* land about 46% of high yielding varieties, 24% of hybrids and 30% of local varieties were used. Seven *jalkund* were setup at Kuporijo, Lida, Riddi and Belo. Each *jalkund* stores 45000 litres of water and provided life seving irrigating to approximately 1 ha of farm. The net income from a single poly house (100m$^2$) was ₹ 11,125/- in a single year compared to hardly about ₹ 750/- from open cultivation of vegetables.

Farmers were provided DOC chicks along with some feeds and medicines. Total six poultry units were distributed comprising of 50-100 birds per unit. In the field conditions, the average age and weight at laying was at 24-26 weeks and around 2.8-3.45 kg, respectively. Number of eggs laid by per bird in 30 days was found to be 12-15 numbers. The average body weight at 2 months 1.72 ±0.58 kg. About 17% of the

total households of project area (55 households) were provided with 60 numbers of improved piglets (75% Hampshire, Large black, Ghungroo and Crossbreed pigs). On an average ₹ 13,500/- is enhanced in each piggery unit with an annual gross income of ₹ 22, 500/-. Overall 729 numbers of farm families were benefited in 12 Villages of Upper Subansiri district of Arunachal Pradesh.

## NICRA

## CROP SCIENCES

### Effect of tillage and residue management on moisture conservation and carbon sequestration in maize based cropping system

Maize was grown under three tillage *viz.,* conventional (CT), minimum (MT) and no tillage (NT) in main plots and residue removal and residue retention in sub plots. The experimental findings clearly depicts that CT gave the highest seed yield (3943.3 kg/ha) followed by MT (3852.7 kg/ha). However, lowest yield was recorded with NT (3004.8 kg/ha). Similarly, stover yield followed the same trend of seed yield and recorded highest yield with CT (7048.3 kg/ha) followed by MT (6943.0 kg/ha). CT registered 31.2 and 24.8 per cent higher seed and stover yields, respectively, over NT. Between residue removal and residue retention, residue retention recorded 10.5 and 8.9% higher seed and stover yields, respectively, with 3780.2 and 6824.6 kg/ha, respectively over residue removal.

Same treatments were imposed for mustard and recorded that MT 28.3 per cent higher seed yield (956.7 kg/ha) than NT, whereas, CT had 24.8 per cent higher seed yield (930.8 kg/ha). However, between residue removal and residue retention, residue retention recorded 20.2 per cent higher seed yield with 958.3 kg/ha over residue removal (797.2 kg/ha). It was also observed that chlorophyll a, b and total chlorophyll content followed the trend with CT>MT>NT. Whereas, chlorophyll stability index (CSI) were higher with NT followed by MT and CT. Membrane damage (MD) has registered highest with CT>MT>NT. Residue retention recorded higher Chl a, b and total with higher CSI and lower MD.Relative water content (RWC) and hydration (%) was higher with NT>MT>CT whereas, relative saturation deficit (RSD) was higher with CT. Residue retention has registered higher RWC and hydration with low RSD. Among the tillage, CT has registered highest broad leaf weeds and NT registered highest grasses. However, MT recorded relatively higher sedges. This clearly indicated that there are significant shift of weed density with respect to tillage. But, residue retention recorded comparatively lower weed biomass than residue removal. It was also recorded that, during *rabi* season the performance of crop under residue retention was better by providing congenial conditions like reduced weed growth, better soil moisture content etc.

### Soil moisture wise contingency crop planning to enhance climate resilience in West Siang district of AP

Soil samples were collected from different circles of West Siang district of Arunachal Pradesh from selected villages for three season viz. pre monsoon, monsoon and winter. Soil from each village was collected from wet land rice cultivation (WRC), terrace land, upland and *jhum* land up to 60 cm at 10 cm intervals. Season-wise analysis and comparison was done and documented in proper database. Among the land forms during monsoon season the highest soil moisture content was recorded with WRC followed by terrace. However, least moisture content was recorded with *jhum* land. This might be due to stagnation of water on WRC and terrace, whereas, *jhum* land provides good drainage. Therefore, water content was recorded lower in *jhum*. It is confirmed that as depth increased from surface moisture content decreased gradually in WRC, whereas water content was almost constant with *jhum*. Terrace showed interesting trend and recorded higher moisture in surface and gradually decreased upto 30 cm and thereafter water content was almost constant. It was also noticed that moisture content of soil profile during pre monsoon varied with place and least variation with Aalo to Basar and highest variation at Daring was recorded. The results clearly reflect that as move from foot hills towards hills the variability decreased. On the basis of soil moisture content at various seasons, contingent crop planning and crop calendar was prepared to had better understanding of weather situation and to know how soil moisture behaves with respect to season. So that, farmers, extension functionaries and policy makers may take appropriate decision at various time intervals with respect to various weather abnormalities.

### Identification of Indigenous technology knowledge for soil and water conservation measures

Soil and water conservation measures of different land forms viz., *jhum*, wetland, terrace etc were

**Fig 1Placement of lopping across the slope (Soil and water conservation)**

collected from the indigenous people (key informant) of the area. The information about the technologies was collected through interview and discussion with various groups of peoples of different age. Replies of the informants were recorded and cross checked and examined. As per the final comments and merits and demerits of the methods followed in different land forms were documented. Among the different soil and water conservation practices ten very popular indigenous methods are identified for the area. Six methods are used in *jhum* and two in terrace and two in wetland condition. The technologies are very effective in hilly areas as per the indigenous farmers. According to the different group of people interviewed, the techniques are very much prevalent in the area and nearby similar area for maintaining optimum level of water in the field and to prevent surface runoff. The materials required for its construction are mainly the forest and agriculture by-products such as bamboos, woods, straw, etc. which was available on their vicinity. As per the claim of the villagers the technologies are proved effective in flood and erosion control also.

**Fig 2 Placement of weed biomass on lopping (in-situ fertility management)**

**Surface drainage on rice influenced crop productivity and soil behaviour at mid hill of eastern Himalaya**

Rice variety RCM 11 was grown with randomized block design and replicated thrice, with treatment details are continuous drainage (CD), surface drainage (SD) at maximum Tillering (DT), SD at panicle initiation stage (DPI), SD at booting stage (DBS), SD at flowering stage (DF), SD at milking stage (DM), 15 days intermittent SD (ID) and continuous flooding (CF). Growth parameters did not followed any trends. However, all the growth parameters were recorded highest with CF. However, leaf area and leaf area index were reduced 294.6 and 131.2 per cent in CD and ID correspondingly than CF. Similarly, total dry matter was 102.9 and 51.4 per cent reduced with CD and ID respectively over CF. Yield attributes like panicle length, no. of grains/panicle and filled grains/panicle, yield/hill and test weight of CF and DT were statistically comparable. However, panicle weight was recorded highest with DT (2.83 g/panicle) which was higher (11.9) than CF. Yield/hill and test weight were 13.6 and 3.5 per cent lower in DT than CF. No. of filled grains were 6.1 per cent lower with DT than CF. Correspondingly, no. of grains was highest with CF followed by DT, but the % of chaffy grain was lowest with DT (5.1%) followed by CF (5.2%). However, highest chaffy grains were recorded with CD (94.9%) and ID (37.2%) than CF.

The highest seed yield 3406.7 kg/ha was harvested with CF, followed by DT (3083.3 kg/ha). However, lowest seed yield obtained with CD (1216.7 kg/ha). CD has recorded 180% reduction of seed yield followed by ID (119.3%). The lowest reduction of 10.5% seed yield with DT. As, growth stages progresses and crop plants were imposed with SD, there was reduction of crop yield. DPI reduced 30.9%, DBS (39.8%), DF (45.65) and DM (46.0%) of seed yield than CF. The highest water was used with CF (1147 mm) followed by DPI (997 mm). However, the lowest water use was recorded with CD (882 mm). Overall the water use ranges from 882-1147 mm during rice growing period. SD at rice with different growth and developmental stages reduced the water use from 15.1 – 30.0%. However, lowest water use was recorded at DPI and highest with CD and rests were lying in between these. Water use efficiency (WUE) was recorded highest with DT (3.10 kg/ha/mm) followed by CF (3.16 kg/ha/mm). However, the lowest WUE was obtained with CD (1.38 kg/ha/mm).

Maximum root length was recorded highest with CD (33.3 cm). However, lowest root length was recorded with CF (20.3 cm). Similarly, root volume, root diameter and root dry weight followed the trend of maximum root length and secured highest values with CD and lowest with CF. Root density was highest with DPI (0.479 (g/cc) but was close to CF, DF, DB and Father highest RWC was recorded with CF throughout the sampling time, however lowest RWC was recorded with CD and as growth stages progresses

Fig 3 Rice under continuous drainage

Fig 4 Rice under continuous flooding

Fig 5 Surface drainage imposed on rice var. RCM 11

the RWC decreased gradually. The highest leaf rolling score was recorded at CD and ID at tillering stage, as growth stages progresses leaf rolling scores were also increased gradually and recorded highest values with CD followed by ID. The least or no leaf rolling was obtained with CF. The cracking length, width, number of cracks and cracking surface area of soil were recorded highest with CD followed by ID. However, soil cracking behaviour was not observed with CF.

**Study the carbon sequestration potential of ten agroforestry tree species under mid hill condition**

In present scenario of enhanced atmospheric carbon dioxide ($CO_2$) coupled with the rise in temperature, it becomes essential to have accurate and realistic estimates of carbon stock in trees for determining their role in mitigating global warming and climate change. The present study was conducted to assess carbon sequestration potential and its allocation in different tree-components of ten important agroforestry tree species viz. in eastern Himalayan region of India. On an average branch and stem wood are the major contributors of carbon content. Allocation of carbon content was highest in *Pinus kesiya* with 45.52% followed by *Pinus walliciana* (44.85%). However, the lowest carbon content was found with *Cinnamomum camphora* (42.12%). Above and below ground biomass and total biomass was recorded highest with *P. kesiya*, it sequestrates the highest carbon (252.82 kg tree$^{-1}$). The $CO_2$ removal followed the similar trend to carbon sequestration and highest with *P. kesiya* (61.79 kg tree$^{-1}$ year$^{-1}$) followed by *P. walliciana* (44.46 kg tree$^{-1}$ year$^{-1}$). However, the lowest $CO_2$ removal was obtained with *Parkia roxburghii* (4.46 kg tree$^{-1}$ year$^{-1}$).

## ANIMAL SCIENCE

**Pig farming practices and adoption level of pig farmers in West Siang district of Arunachal Pradesh**

A total of 14 circles out of 20 circles were surveyed from district of West Siang. Data were collected by through interview schedules. The farmers were asked to give their opinion about adoption of feeding practices on four point continuum scale and scores were allotted. The perceived constraints were categorized and based on frequency, ranking was done. It was found that 87.5 percent reared on scavenging system, 7.7 percent semi intensive and 4.8 percent intensive system. Cent percent of the farmers kept the hog (castrated male) in intensive system. 95.2 percent farmers used locally available materials for preparation of *kuccha* (Fig 1) house and 4.8 percent cemented type. Flooring materials used were 77.3 percent bamboo, 17.9 percent wooden planks and only 4.8 percent made of cement flooring. Average height, length and breadth of traditional pig housing was 1.09 ±0.389 m, 2.53±0.21m and 1.967 ±0.02m. All farmers provided stall feeding for fattening purpose. Scavenging cum evening ration provided by 88 per cent and remaining 11.9 percent stall feeding. 97.6 percent provided household waste and locally available feeds out of which (96.7%) constitute rice husk, (68.2%) rice brew and (41.9 %) wild leaves ,tapioca ,colacasia etc. Majority of the farmers (95.2 %) never did vaccination of pigs. Only 10.1 percent practiced deworming of pigs using indigenous products. Around (89.13%) sold 2-3 months old piglets @ ₹ 1500 to 2000/piglet and 62 percent had income between ₹ 6000-8000/annum from sale of pigs. In Adoption of different practices, feeding practice was highest adopted 57.50 % and least adopted was health care (12.50%). The major constraints were non-availability of medicine and vaccine 89.17% and high cost of feeds 87.6% in the study area.

Fig 1 Low cost pig housing

**Identification of the unique traits in indigenous pigs and poultry which make them resilient to climate change and development of data base**

Collection of primary data from state department of animal husbandry and veterinary sciences, and

department of department of economics and statistics of Govt. of Arunachal Pradesh was done. Three districts *viz.,* Papum Pare, West Siang, Tirap district was purposively selected. Three villages were randomly selected from each district. Twenty farmers (20) farmers were surveyed from each villages making a total of 180 farmers .Data collection was done through structured questionnaires w.r.t to general managemental practices and morph metric characteristic. It was found that 100percent made *kuccha* houses out of which 63.33 percent made from bamboo and 36.67 percent from wooden planks and 82.3 per cent roof of *toko* leaves.

The indigenous *desi* pigs (58.67 %) had black coat colour and 41.44 percent with black coat colour and white strips in the forehead and legs region were observed. Cent percent had pointed snout and hoof line. Around 86.67 % had erected ears, 71.66 % had concave top line and 77.66 percent had long bristle (length 4-7cm). Average ear, body length, front girth, hind girth & tail length for piglets was 6.2 ± 0.21 (cm), 41.79 ±0.53 (cm), 38.38 ± 0.57 (cm), 41.42 ± 0.02 (cm) and 10.72 ± 0.71 (cm). Average ear, body length, front girth, hind girth and tail length for sow was 8.7 ± 0.33 (cm), 67.9 ± 1.32 (cm), 80.3± 1.62 (cm), 83.3 ± 1.42 (cm) and 25 ± 0.23(cm).

The *desi* bird showed plumage color variation, predominant being black, and various shades of brown. Comb colour was light pink with black eye .Wattle was poorly developed. Ear lobe and shank was brown. Majority (69%) of the respondents reported average egg production about 60 – 70 eggs/year.

On farm trial revealed performance of Ghungroo breed at 9 months of age around 49.9 ± 1.07 kg, Hampshire 45.5± 2.07 kg and Arunachal local was 22.25± 1.35 kg in semi intensive system with balance ration (Fig 2). A total of 380 Vanaraja chicks were procured. Out of these 200 were reared in farm condition and remaining 180 were distributed in farm field to evaluate the performance and its adaptability

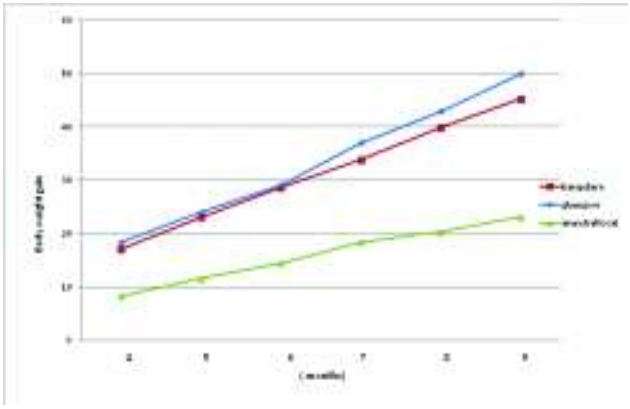


**Fig.2 Performance of Ghungroo, Hampshire and Arunachal local breeds of pigs**

in different altitudes i.e. Likabali, Basar and Menchuka region. The average day-old weight was 32.3 gram and mean body weight at 6,12, 20,24 weeks of age was 612.23 ± 3.23 and 543.5± 5.33gm, 1.56 ± 0.31 and 1.03 ± 0.78 kg, 2.57 ± 0.027 kg and 2.06 ± 0.43 kg, 2.61 ± 0.0.057 and 2.23± 0.0.045 kg respectively for male and female birds (Table 1).

In field conditions the overall mean body weight of Vanaraja birds at Basar was higher compared to Likabli and Menchuka.

## Tribal Sub Plan

Improved seed potato 9.5 t (var. Kufri Jyoti) was distributed amongst farmers (189 nos.) of West Siang and Upper Subansiri district under TSP, it covered about 4.5 hectares of land. The average total yield observed was around 7.39t/ha. Nyodou village performed much better than others.

Forty farmers attended the training programme on poultry under TSP organised during 4 - 5$^{th}$ April 2012 at Basar. Each farmer was provided one unit of poultry chicks of improved Vanraja/Kroiler along with some feeds, vaccines and medicines. In addition, improved pig breeds viz., Ghungroo, TMD and Hampshire along with some medicines were distributed to farmers of Menchuka.

**Table 1 Body weight (kg) of poultry in field conditions**

| Particulars | Likabali | | Basar | | Menchuka | |
|---|---|---|---|---|---|---|
| Age (weeks) | Male | Female | Male | Female | Male | Female |
| 8 | 0.57± 0.31 | 0.43± 0.23 | 0.63± 0.21 | 0.52± 0.32 | 0.523± 0.23 | 0.42± 0.027 |
| 12 | 1.12± 0.037 | 0.72 ± 0.021 | 1.23± 0.041 | 0.83± 0.021 | 1.17± 0.050 | 0.88± 0.045 |
| 16 | 1.42± 0.039 | 1.06± 0.013 | 1.62± 0.017 | 1.37± 0.019 | 1.49± 0.012 | 1.05± 0.012 |
| 20 | 1.97± 0.073 | 1.68± 0.025 | 2.27± 0.074 | 1.83± 0.036 | 2.01± 0.053 | 1.57± 0.023 |
| 24 | 2.13 ± 0.045 | 1.71± 0.021 | 2.52± 0.074 | 2.27± 0.019 | 2.23 ± 0.0 72 | 1.82± 0.033 |

## Extension Activities

A 2- days training cum exposure visit of farmers from Papum Pare district under Horticulture Mission was organised. It was inaugurated by Dr. R. Bhagawati, Joint Director. He emphasized on scientific cultivation of sub-tropical horticultural crops and also encouraged the women farmers for secondary agriculture. Sh. Raghuveer Singh, Scientist (Plant Pathology) delivered a presentation on "Disease management of important sub-tropical horticultural crops and demonstrated the mushroom production technology. Total 35 farmers attended the training cum exposure visit. A Farmers'-Scientist interaction was also organized. The scientists participated in the district level farmers' training under ATMA at Aalo wherein, 150 farmers attended the training programme.

The centre also organised 2-days training cum input distribution programme under NICRA at Jairampur. The programme was inaugurated by Sh. Setong Sena, Hon'ble Minister of Agri-Horti, Govt. of A.P. He encouraged the young entrepreneurs engaged in farming activities. He also suggested for adoption of scientific technologies for commercial crops and backyard poultry. Dr R. Bhagawati, Joint Director, highlighted the vagaries of climate change in farming sector and possible mitigation strategies. The farmers were distributed seeds 0.6 t rice (Ranjit), maize 1.5t (DMH 849) , soybean 0.6t (JS 335),okra 0.18t (Arka Anamika), 500 saplings of tissue cultured banana (Grand Naine), 4000 nuclear seedlings ( *khasi* mandarin), 50 kg oyster mushroom spawn, 1000 day old chicks (Vanaraja),and feeds and medicines. In addition, 3 rolls of 200 µm UV stabilized poly film; 3 rolls of shade net and 5 rolls of Silpaulin for construction of protected structures and *jalkund* were also provided.

# MANIPUR CENTRE

## WEATHER REPORT

**Table 1 Agro-meteorological data (monthly average) from April 2012 to March 2013**

| Month | Temp (°C) | | Relative Humidity (%) | | Wind direction (deg) | | Wind speed (km/h) | Cloud Cover (Okta) | | Total Rainfall (mm) |
|---|---|---|---|---|---|---|---|---|---|---|
| | Max | Min | 700h | 1300h | 700h | 1300h | | 700h | 1300h | |
| April | 28.0 | 15.5 | 82.0 | 64.5 | 176.7 | 288.2 | 5.1 | 7.3 | 5.1 | 151.3 |
| May | 32.7 | 18.6 | 77.0 | 62.1 | 160.5 | 257.3 | 4.8 | 4.6 | 3.8 | 102.3 |
| June | 31.9 | 21.9 | 84.9 | 73.6 | 91.3 | 231.3 | 3.7 | 6.9 | 6.5 | 213.8 |
| July | 32.3 | 22.8 | 89.0 | 70.5 | 141.5 | 234.0 | 4.2 | 7.4 | 6.8 | 209.0 |
| August | 31.5 | 22.4 | 86.4 | 70.9 | 133.4 | 253.5 | 3.6 | 7.1 | 6.2 | 113.0 |
| September | 29.8 | 21.7 | 88.4 | 70.9 | 184.5 | 228.7 | 3.4 | 6.9 | 6.1 | 180.6 |
| October | 29.4 | 17.5 | 87.7 | 68.5 | 161.3 | 192.9 | 2.8 | 5.5 | 3.8 | 161.5 |
| November | 26.6 | 12.0 | 86.5 | 67.8 | 158.2 | 215.0 | 2.5 | 4.9 | 3.0 | 88.3 |
| December | 22.8 | 4.9 | 88.7 | 56.2 | 188.9 | 242.1 | 1.8 | 4.9 | 2.0 | 0.0 |
| January | 23.1 | 3.0 | 82.7 | 34.8 | 183.4 | 248.2 | 1.7 | 2.5 | 1.5 | 0.0 |
| February | 28.0 | 7.7 | 79.3 | 32.0 | 147.1 | 218.4 | 1.8 | 3.7 | 3.0 | 1.7 |
| March | 29.0 | 10.7 | 79.5 | 36.6 | 153.1 | 262.1 | 3.8 | 3.7 | 3.7 | 31.8 |

The mean maximum and minimum temperature was 28.8°C and 14.9°C, respectively. The maximum daily temperature (36.4°C) was recorded on 3rd and 9th July, 2012; whereas, the minimum daily temperature (-0.5°C) was recorded on 11th January, 2013. Total annual rainfall observed during the year 2012-13 was 1253.3 mm. The maximum total monthly rainfall was received in the month of June, 2012 (213.80 mm) whereas, there was no rainfall in December, 2012 and January, 2013. The average maximum and minimum relative humidity during 2012-13 was 84.34% and 59.03%, respectively. Average daily wind speed of 3.27 km/hr was observed during the period.

**Fig 1 Rice variety RC Maniphou 12**

**Fig 2 Release of RC Maniphou 12 by Agriculture Minister of Manipur, Manipur**

## CROP SCIENCES

### RICE

#### Rice variety RC Maniphou 12

One newly developed short duration rice variety RC Maniphou 12 (Fig 1) was released by the State Sub-committee on Crop Standard Notification and Release of Varieties, Govt. of Manipur in October, 2012. The ceremonial release of the variety was done by Hon'ble Minister of Agriculture of Government of Manipur (Fig 2). RC Maniphou 12 (RCM 13/IET No. 22828) is a derivative of the cross Leimaphou x Akhanphou. The variety takes 75 days to reach 50% flowering and matures in about 90-105 days in summer (March-April sowing) under the valley condition of Manipur. Hence, the variety is suitable for the first crop of the double cropping rice as well as for different cropping system. The variety is 100 cm tall and 50-200 spikelet were obtained per panicle. It has desirable soft cooking (low amylose content-11.70%) quality characters preferred by the people of north eastern hill region. It has very low amylose content. The yield potential ranges between 4.5-5.0 t/ha.

#### Rice breeding for higher yield and disease resistance in *kharif* season

Five advanced lines of rice along with three local checks were evaluated in replicated trials for their comparative performance under low land transplanted conditions of Manipur valley. MC 34-10-9-35-35-2 line flowered in 93 days which was shorter in comparison

to all three checks namely, Lungnilaphou, KD 2-6-3 and RCManiphou 7. However, MC 34-10-3-30-16-1 showed shorter height (123.9 cm) than local check RCManiphou 7. The lines namely, MC 34-7-5-2-75-33-19 and MC 34-10-9-35-35-2 recorded 7.5 t/ha and 7.2 t/ha yield, respectively. These two lines were superior over all three local checks.

**Rice breeding for higher yield and medium duration in *kharif* season**

Sixteen advanced lines of medium duration rice along with two checks were evaluated in replicated trials for their comparative performance under low land transplanted conditions of Manipur valley. Out of 16 lines, 5 lines viz., MC 34-5-10-2-38-02 (94 days), MC 34-5-14-2-5-16(94 days), MC 34-5-12-4-34-4 (95 days), MC 34-9-7-77-96-62 (95 days) and MC 34-5-8-2-19-95-26 ((97 days) showed early flowering in comparison to local check RC Maniphou 7 (98 days). Superior yield performance was recorded in the lines namely, MC 34-9-7-77-96-62 (9.0 t/ha), MC 34-7-7-17-94-60 (8.83 t/ha), MC 34-13-45-32-69-3 (8.33 t/ha) and MC 34-5-10-2-38-02-27-8 (8.25 t/ha).

**Rice breeding for paddy cum fish culture during *kharif* season**

In this trial, 11 entries along with two local checks were tested in low land transplanting conditions for paddy cum fish culture in *kharif* season. All entries were superior in yield performance over both local checks. However, in terms of yield, entries namely, MC 34-7-6-2-72-92-90 (8.41 t/ha), MC 34-4-3-9-31-18 (8.16 t/ha), MC 34-1-26-28-8-4 (8.16 t/ha) and MC 34-4-1-55-1-11 (7.75 t/ha) were found be higher than other entries.

**Research Complex Regional Trial (RCRT)**

**RCRT on low land Rice-1:** In this experiment, 18 entries including 3 checks were tested for comparative performance in low land conditions of Manipur valley during *kharif* 2013. Out of 18 entries, one entry namely, RCPL 1-167 performed exceptionally well and recorded 9.25 t/ha yield.

**RCRT on low land Rice-2:** This experiment comprising 14 entries along with two local checks namely, RCM 10 and RCM 21, were evaluated in lowland transplanted conditions in Manipur valley. Among them RCPL 1-145 revealed 7.11 t/ha yield which was better only over one local check *viz.,* RCM 21.

**RCRT on upland land Rice-1:** Ten entries including two checks *viz.,* RCM 5 and RCM 21 were evaluated for comparative performance under upland conditions of foot hills of Manipur during *kharif* 2012. RCPL 1-114 and RCPL 1-128 recorded better performance with mean yield 2.42 t/ha over the check *viz.,* RCM 5.

**All India Coordinated Trials on Rice -2012**

Twelve entries in one upland trials of AICRIP namely IVT-U- H were evaluated for their comparative performance under upland (direct seeded) conditions at Langol farm of ICAR Research Complex for NEH Region, Manipur Centre during *kharif* 2012. In IVT-U-H, shortest duration to reach 50% flowering was recorded in entry no. 3101 (69.5 days), followed by 3106 and 3102 (79 days); whereas, maximum duration was taken by entry no. 31012 (91 days). In terms of yield, entry no. 3106 was found to be the most promising (4.03 t/ha), followed by entry no. 31010 (3.71 t/ha) and 3108 (3.69 t/ha).

## DISEASE

**Evaluation of rice germplasm against neck blast disease**

Under the DBT Sponsored Project "Identification and Molecular Mapping of a Novel Neck Blast Resistance Gene(S) from Local Land Races and Introgression Lines of Oryza" 422 entries of rice germplasm were screened for their reaction to neck blast under field conditions on 0-9 SES scale . The neck blast reaction in different entries varied from 1 (Kerebe Phek, China-1, Taothabi, Ching Phouren, Allechisho, Haosil Mah, Rezose Phek, Shangshak Local, Remi, Jungu Phek, Maneh Jang(Wonder Rice), Im Satang Makokchung, Thekrulha, Ronga-1, Koya Jang, Meitidak, Akutphou, Rukhatang, Talong Maha, Bali White, Tengu Be Phek, Kuki Muso, Weshelora, Chingphou Angouba, Rulotsia, Hotung, Asupa, Masia Jang, Khangambra, Hokha Tsok, Yanjo Epya, Otsok Khira, Kimin, Mutruk, Ehunyo (Makhapui Kalay), Duikung Mei, Mesao Tsuk, Chandel Exhibition, Moirangphou Khongnembi, Ruchitra, Moirangphou, Ngonolashia, Leikhamumei, Zunheboto Ghisul, Kezu, Meche Tssok, Rcm-21, Chakhao Angoubi, Chandel, Chakhao, Tamenglong) to 3 (Kumta Mah, Matamaha, Chakhao, Mainong Kangbu, Dharam Phou, Azoghi, Chalh Tssia, Arunachal-1, Moir Angphou, Ching Chakhao, Moirangphou Khongnembi, Phouren Kaichang, Champraphou(Prakash Utlou), Et Saro,

Moirangphou Angouba, Kapang Rangla, Jaksemla, Pnal Jong, Chingphou, Kba Stem, Leimaphou, Ginphou, Chapali, Niphvthokpi, Mangghoomei, RCM-13, Changluima, Phouren Amubi, Rodziia Kakra, Lam Jang, Langphou(From Imphal West) to 5 (Thekrulaha, Bhuman Ccpur, Rcm-12, Meron Tssok, Pumpha Mah, Retu Masojang, Matruk Kiphre, Wr-1-9-1-1, Phatsen, Senebumap, Chakhao Local, Ereima, Chinapati, Rcm-10, Rcm-11, Pariphou, Japanphou, Rcm-9, Rcm-22, Langphou Angouba, Chakhao Amubi, KD-263, Athamah, Machang Kazik, Chingtui Makarei, Mukhok Mujeh, Khongmei Mah, Napthmei , Kheikhoma, Champrama, Moirangphou, Phouren, Mikrotho) to 7(Runya, Kong epya, Sumi special, Dzukemum, Meghalay lafara, Phouren, Sanayanbi, Maritchitpi, Changlei, Nagaphou, Nungshangphou, Nongrangphou, RCM-12, Langphou, Chakhao amubi from Thoubal) to 9 (RCM-10, RCM-16, Chinaching, Jakherpati, Charongphou, Charongphou, Chakhao poireiton from Thoubal, Chakhao from Ukhrul). Rests of the entries were free from neck blast. The leaf blast was observed only in entries Kba Jawai(1), Akutphou(1), Et Saro(4), Chakhao Local(4), Rulotsia(4), Yanjo Epya(4). 17 Near Isogenic Lines (NILs) namely DM-360(Pi9), BL-122(Pi1+Pi2), BL-142 (Pi1+Pi4), A57-115-4, C101Lac(Pi1), C101A51(Pi2), C101PKT(Pi4a), IRBL1-CL(Pi1), IRBL11-Zn(Pi11), IRBL12M(Pi12), IRBL8-CP4(Pi3) , IRBL5M(Pi5), IRBL9W(Pi9), IRBL9-C(Pia), IRBL6-B(Pib), IRBLI-F5(Pii) and IRBLKm-Ts(Pikm) were also screened under filed condition. The incidence of leaf or neck blast was not observed on any of the NILs.

**Screening of rice entries under National Screening Nursery (NSN–H) against multiple diseases**

Eighty two entries (NSN-H) sent by DRR Hyderabad were screened for multiple diseases. The leaf blast score was 1 in entries (2504), 2 (2610, KD 263, Vikramarya), 3 (2814), 4 (2908), 5 (Ajaya, Benibhog), 6 (2906, HR-12, Rasi), 7 (2603). The neck blast score in different entries varied from 1 (3104, 3106, 3109, 3112, 2610, 2804, 2702, 2704, KD 263, 2707, 3009, 2902, 2505, 2513, RP 2421, HPR-2143) to 3(KD 263, 2615, 2807, 2809, 2708, 2501) to 5(2606, 2609, 2808, 2812, 3001, 2908, 2504, 2511) to 7 (2601, 2613, 2906, IR 50, Rasi) to 9 (2811, HR 12). Rests of the entries were free from blast. All the entires were free from sheath blight and sheath rot and rice tungro diseases. The disease score for brown spot disease were 2 (KD 263, 2802, 2812), 3 (3104, HPR 2143), 4 (2611, 2814, IR 64, Ajaya), 5 (3004) to 6 (2902), 7 (3111, 3002). The remaining entries were free from brown spot infection. All the entries were free from leaf blast. The neck blast score varied from 7 in RASI and improved Samba Mahsuri to 5 in Vikramarya, CH45 and entry 3007 (VL31618) to 1 in entries 3510 (VL8094), 3009 (VL31577), 3306 (VL31726),and 3310 (SKAU 410). The Bacterial blight reaction in different entries varied from 9 in 3510 (VL 8094) to7 in entries 3508 (VL8051), 3604 (VL8292), KD 263, 3102 (HPR2589), 3108 (VL31450), HPR2143, Improved Sambha Mahsuri and RASI. The entries exhibiting score of 1 were 3509 (VL8116), 2801(HPR 2529-4), 2808 (VL31449), 3401 (VL7954), 3407 (VL7852), 3602 (VL8204), 3610 (HPR2645), 3206 (VL31401), 3207 (VL31348), 3004 (UPR3575-11-2-2), 3006 (VL31616), 3007 (VL31618), 3011(HPR2615), 3301(VL31724), 3304 (UPR3573-4-2-1), 3305 (VL31600), 3308 (VL31611), 3314 (HPR2612), 3105 (VL31452), Sukaradhan-1, Vivekdhan-154 and IR-50. The disease score for brown spot varied from 7 in entry HPR 2656 to 6 in HPR 2143 followed by 5 in HPR 2618 to 4 in entry RP2421 and KD 263. The remaining entries were either free from brown spot or exhibited a score of 1. All entries were free from sheath rot and *Rice tungro virus*.

## MAIZE

**Evaluation of maize genotypes for quantitative traits under foot hill conditions of Manipur**

Seventy one genotypes of maize along with one check DS 16 (Composite variety) were evaluated for agro-morphological and biochemical characters during *kharif* 2012. Among the different genotypes, RCMM 6 (62 days) and RCMM 26 (62 days) were recorded the shortest duration for days to 50% tasseling whereas the shortest duration for days to 50% silking was noticed in RCMM 6. RCMM 10 took the least period for maturity (96 days). A wide range of plant height was revealed among maize genotypes from 172.4 to 359.5 cm. The shortest plant height was measured in RCMM 1 (159.5 cm) followed by DS 16 (188.7 cm) and RCMM 9 (170.5 cm). All the genotypes were non-lodging except RCMM 34 (B). The highest number of cobs per plant were recorded in RCMM 1 (3.2) followed by RCMM 8 (2.7), RCMM 2 (2.6), RCMM 18 (2.3) and RCMM 29 (2.3). It was observed that more than 50 lines had more than one cob. The highest number of kernels/row was observed in RCMM 35(A) (40.6), followed by RCMM 4 (40.2), RCMM 41(A) (39.4) and RCMM 38 (B) (38.4). Wide variation was

observed for 100 seed weight. Maximum 100-seed weight was recorded in the RCMM 36 (A) (47.3g) whereas RCMM 1 showed the minimum 100-seed weight (10.1g) (Fig 3). It was observed that there was not uniformity for cob length and no regular seed formation in kernel rows. Hence, seed yield was low in majority of genotypes in comparison to check DS 16. In terms of seed yield, check variety DS 16 (5.51 t/ha) was found to be highest yielder, followed RCMM 13 (5.3 t/ha) and RCMM 3 (4.86 t/ha). Genetic parameters of variability were studied for 11 quantitative characters in 72 germplasm lines of maize. The phenotypic coefficient of variation (PCV) was higher in comparison to genotypic coefficient of variation (GCV) for all the characters under study. High magnitude of PCV was recorded for the characters *viz.*, plant height, number of cobs/plant, cob length, number of kernels/row, 100-seed weight and seed yield. GCV also showed similar trends.

**Fig 3 Diversity of maize cob in Manipur**

### Evaluation of maize germplasm for agro-morphological and biochemical analysis

Out of 71 lines 44 lines were observed as non-lodging and 21 lodging. It is interesting that all lines were free from banded leaf and sheath blight disease. Albeit majority of lines were infested by cob borer except RCMM 22 and RCMM 29, ranged from 20 to 100%. Grain analyses were done for 4 biochemical traits namely, protein, starch, oil and moisture in percent. Mean protein was revealed 10.38% and ranged from 7.9 to 13.4%. Maximum protein was achieved in the RCMM 8 (13.4%) followed by RCMM 42 (12.7%), RCMM 1 (12.2%) and RCMM 2 (12.2%) whereas the lowest protein (7.9%) was recorded in RCMM 12. The highest starch was noticed in RCMM 22 (77.5%) followed by RCMM 12 (73.6%), RCMM 24 (73.1 %), RCMM 20 (72.7%), RCMM 27 (72.7%), RCMM 25 (72.6%) and Sikkim primitive-2 (72.3%). Mean starch amount was recorded 70.55% and ranged 68.2 to 77.45%. A wide range was observed for oil (3.9-10.25%) in maize lines with mean oil quantity (5.3%). Maximum quantity of oil was observed in RCMM 5 (10.3%) whereas RCMM 16 showed minimum oil (3.9%). Moisture (%) varied from 9.6 to 13.5%. Highest moisture was found to be present in RCMM 5 (13.5%), whereas lowest moisture (9.6%) was revealed in RCMM 6. Mean moisture was 12.08%.

### All India Coordinated Trial on maize

Fifteen entries of hybrid maize including two local checks were evaluated for their comparative performance under foot hill conditions of Manipur during *kharif* 2012. Vivek QPM 9 registered shorest duration for 50% pollen shedding (58 days) and 60 days for 50% silk emergence. This entry matured in 94 days. The shortest plant height was measured in Vivek Maize Hybrid 43. CMH 08-337 exhibited superiority over both the local checks (RCMM-27 and RCMM-42) for cob length (20.5 cm), ear width (16.4 cm), dry cob weight/plot (7.6 kg) and 1000-grain weight (437.4 g). The entries *viz.*, CMH 08-337 (9.75 t/ha), KNMH 408710 (7.61 t/ha), Vivek Maize Hybrid 43 (7.28 t/ha), Vivek Maize Hybrid 25 (6.90 t/ha) and Vivek Maize Hybrid-23 (6.84 t/ha) performed well and recorded significantly higher yield than over both the local checks.

## PULSES

### Evaluation and advancement of segregating generations in interspecific crosses of pigeon pea

In the present investigation, $F_5$ progenies of two interspecific crosses along with their parents were screened against pod borers under natural field conditions. The progenies are derivative of interspecific crosses ICPL 88034 x *Cajanus scarabaeoides* and UPAS 120 x *Cajanus scarabaeoides*. The test material was kept free from any insecticidal spray throughout the crop season. A range of mean of percent pod damage among parents was revealed 1.8 to 42.9%. Least pod damage was recorded in *Cajanus scarabaeoides* (1.8%) with low seed yield/plant (10.9 g). Out of 18 $F_5$ individual plant progenies selected on the basis of yield and its attributing characters as well as pod borer infestation, 11 $F_5$ progenies were found promising from the cross ICPL 88034 x *C. scarabaeoides*. A promising progeny RCMP10131-1-2 showed good plant type with plant height (126 cm), primary branches/plant (6), pods in cluster, least pod damage (1.03%), pod length (4.9 cm), seeds/pod (4.2), no seed damage (0.0), undeveloped seeds/pod (0.4) and seed yield/plant (20.8 g). Another progeny RCMP1018-1-2 had the highest number of pods/plant (287) with seed yield/plant (86.15 g), less pod damage (1.74%), desirable pod length (5.42 cm)

and seeds/pod (4.6). A wide range was observed for the characters *viz.,* undeveloped seeds/pod (0.0-1.4), pod length (4.5 to 6.1 cm) and seed yield/plant (12.79-86.15 g). RCMP 10241-1-1 showed the highest seed yield/plant (50.83g) along with pod damage by pod borer (9.17%) and damaged seeds/pod (0.0) whereas undeveloped seeds/pod was observed (0.2). RCMP10239-2-2 revealed the desirable traits namely; plant height (159 cm), primary branches/plant (16), long branches, semi determinate type, pod damage by pod borer (5.13%), pod length (5.3 cm), seeds/pod (4.4), damaged seeds/pod (0.0), undeveloped seeds/pod (0.6) and seed yield/plant (31.6 g).

## VEGETABLES

### Tomato variety RC Manikhamenashinba 1

One newly developed high yielding tomato variety RC Manikhamenashinba1was released by State Sub-committee on Crop Standard Notification and Release of Varieties, Govt.of Manipur during October, 2012. The variety is a progeny of the cross Punjab Chhuhara x Marglobe and was bredwith the objective of developing HYV having resistance to biotic and abiotic stresses. The variety is suitable for rainfed / irrigated and paddy fallow (life saving irrigation). Good quality seed can be easily produced without any special problem sasitisopen pollinated variety. The variety has a yield potential of 4.25 t/ha under good management practices (Fig 4)..The fruits have smooth fruit surface, soft firmness, juicy pulp, 6.7°Brix TSS and good shelf life at proper storage condition. The variety is moderately resistant to bacterial wilt and tolerant to leaf curl disease. The variety has also been found to be tolerant to moisture stress; and hence it is relatively free from fruit cracking which is a major problem in tomato.

**Fig 4 Bearing plants and harvested fruits of tomato variety RC Manikhamenashinba 1**

### Tomato improvement programme for high yield and resistance to biotic and abiotic stresses

Four advanced lines of tomato along with one check were evaluated in replicated trials for their comparative performance under Manipur valley. In terms of yield, RCT-1 was found be most promising (48.27 t/ha), followed by RCT-2 (38.70 t/ha) and TMC-2 (34.74 t/ha); as compared to check variety DVRT-2 (33.76 t/ha).

### Taroimprovement programme for high yield and resistance to biotic and abiotic stresses

Ten high yielding clones of colocasia (RCMC-1 to -10) along with one check (Muktakeshi) were evaluated in replicated trial under terraced condition (Figs 5-7). Among the genotypes, maximum yield (37.05 t/ha) was recorded with RCMC-9; followed by RCMC-10 (35.25 t/ha) and RCMC-4 (33.93 t/ha) as compared to check variety Muktakeshi (19.70 t/ha).

**Fig 5 Taro clone RCMC-9**

**Fig 6 Taro clone RCMC-10**

**Fig 7 Taro clone RCMC-4**

### Screening of taro genotypes for *Phytophthora* leaf blight

A sizeable population comprising of 62 genotypes of taro genotypes has been collected from different parts of Manipur; ICAR-RC-NEHR, Nagaland Centre and RC CTCRI, Bhubaneswar. The genotypes were screened *in vitro* for *Phytophthora colocasiae* using cell wall glucan elicitor inoculation technique. Elicitor was prepared from the harvested mycelia mats of *Phytophthora colocasiae* Racib. through blending, filtering and homogenizing with chloroform, methanol and acetone. Ten microlitres of glucan elicitor was injected in the *Colocasia* leaves and the Hypersensitive Response (HR) was observed. The taro genotypes were screened based on the degree of HR (Fig 8).

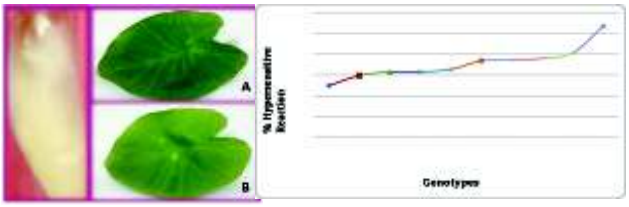


**Fig 8 Hypersensitive response in susceptible (A) and tolerant (B) genotype of taro**

### Spices improvement programme: Characterization of local turmeric and ginger germplasm of Manipur

**Turmeric:** Twenty eight turmeric germplasm were collected from different parts of Manipur. The germplasm were characterized at molecular level using 18 SSR primers. Clustering of the 28 germplasm using the dominant scoring (presence/absence) of bands based on UPGMA separated them into main groups at the Jaccards similarity coefficient – 0.77. Group A formed the major group within the dendogram by accommodating 14 lines of same geographical origin, in which a set of identical (synonymous) accessions were detected. An overview of the clustering pattern indicates that the grouping of the accessions was dependent of the place of collection. The genetic similarity coefficients among the 28 germplasm amplified using 18 SSR markers ranged from 0.35 to 1.0. The highest value (1.0) corresponded to (RCMT-8 and RCMY-9) accessions that generated identical fingerprints across the markers studied (Fig 9).

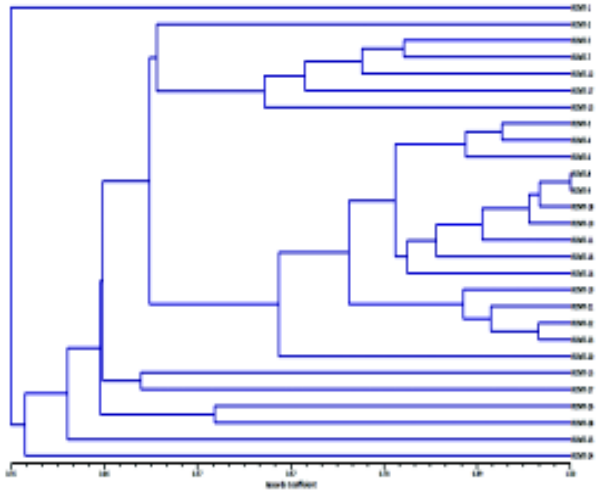


**Fig 9 Cluster analysis local turmeric germplasm based on pooled SSR markers**

**Ginger:** A total 18 local ginger germplasm were collected from different district of Manipur and characterized for their genetic diversity using 73 SSR primers. Clustering of the 18 ginger accessions using the dominant scoring (presence/absence) of bands based on UPGMA separated them into five main groups at the Jaccards similarity coefficient – 0.79. Group A comprised of one germplasm RCMG 1. Eight germplasm are combined in group B and become a major group within the dendrogram from same geographical origins. RCMG 9, -11, -29 and -22 are the collections of group C. RCMG 26 is most diverse species accession that the dendogram is showing. An overview of the clustering pattern indicates that the grouping of the accessions was by and small and dependent of the place of collection. The genetic similarity coefficients among the 18 accessions amplified using 73 SSR markers ranged from 0.15 to 1.0. Principle component analysis was also done to visualize genetic relationships among the elite breeding lines. The results were similar to UPGMA results (Fig 10).

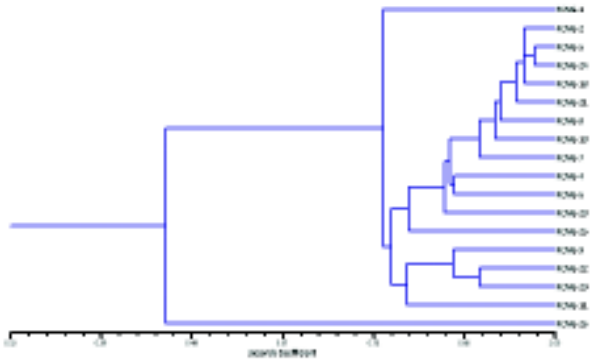


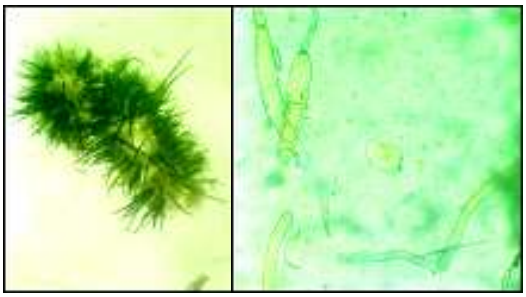
**Fig 10 Cluster analysis of local ginger germplasm based on Pooled SSR Markers**

## DISEASE

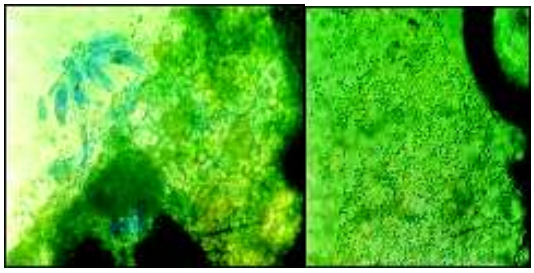
### Studies on diseases of King chilli (*Capsicum chinense*) and their management

The survey was carried out in localities around Imphal to assess the incidence of different fungal and viral diseases (Fig 11). The fungi isolated and identified from king chilli are *Cercospora capsici*, *Colletotrichum capsici*, *Glomerella cingulata*, *Corynespora cassicola*, *Phoma destructive*. The symptoms on infected plants were in the form of leaf spots, necrosis of leaves and dying back of twigs and branches.

There was sporadic occurrence of virus diseases in the field. The symptoms consisted of inward rolling of leaves, shoestring, yellow mosaic and necrotic rings on leaves. To identify the viral diseases, Direct



*Colletotrichum capsici* *Corynespora cassicola*



*Glomerella cingulata* *Phoma destructiva*

**Fig 11 Diseases of King chilli**

Antibody Sandwich ELISA(DAS-ELISA) was carried out using antisera against *Potato virus Y* (PVY), *Cucumber mosaic virus* (CMV) and *Bean common mosaic virus* (BCMV), *Tomato leaf curl virus*(TYLCV), *Tomato mosaic virus* (TomV), *Pepper veinal mottle virus* (PVMoV*)* and *Pepper mild mottle virus* (PMMoV) using both positive and negative controls (healthy samples). On the basis of comparison of the absorbance readings of the negative controls (healthy samples) with that of samples, none of the plants were infected with PVY, CMV, BCMV, TYLCV, TomV, PVMoV. The king chilli samples in wells B3-B10, C3-C10, D3-D10 had *Pepper veinal mottle virus* (PVMoV) infection as revealed by DAS ELISA.The crude virus extract of PVMoV infected samples subjected to Transmission Electron Microscopy revealed the presence of flexuous virus particles which means that the virus belonged to genus *Potyvirus* of family Potyviridae.

A field trial on evaluation of fungicides against fungal diseases of king chilli was laid in April 2012. The fungicides evaluated were Bayleton @ 1g/l, Section @ 2g/l, Derosal @ 1g/l, Antracol @ 3g/l and control. Four fungicide sprays were done at an interval of 15 days each. Three sprays of pestoneem were done for control of aphids. Bayleton was most effective in reducing the *Colletotrichum* fruit rot and increasing the yield. The yield and disease incidence was 10 t/ha and 18.51% respectively with 167.09% increase in yield and 54.01 % decrease in disease incidence as compared to control. It was followed by Derosal with productivity and disease incidence of 17.6 t/ha and 22.22%, respectively with 22.22% increase in yield and 44.79% decrease in disease over control. The viral disease incidence was low in plots (18.5%) which were surrounded by maize on all sides.

## INSECT PEST

### Impact of weather parameters on population build-up of aphids on cruciferous crops and their management

Field experiment was conducted at ICAR Research Complex for NEH Region, Manipur Centre, Langol Farm, Imphal during 2012 to study the "Impact of weather parameters on population build-up of aphids on cruciferous crops and their management". The experiment was laid out in randomized block design with nine treatments of biopesticides *viz.,* Racer (*Beauveria bassiana)* @ 5g/l, Lipel (*Bacillus thuringiensis)* 5g/l, Derisom (karanjin) @ 2ml/l , Derisom (karanjin WP) @ 2g/l, Anosom (Anonin) @ 2ml/l, Anosom (Anonin WP) @ 2g/l, Margosom (Neem 0.15% EC) @ 5ml/l and Margosom (Neem 0.15% EC) @ 10ml/l, including one chemical insecticide Imidacloprid 17.8% SL @ 0.5ml/lt of water and control.

***Mustard:*** There was no significant difference on aphid population days before spraying of pesticides. Significant differences were obtained in aphid population due to spraying of pesticides at different stages as compared to control. The significantly lower aphid population was recorded on 1st spraying under Neem 5% (0.9), *Bacillus thuringiensis* (1.9) and Imidcloprid (1.7) 1 DAS (days after spraying), 7 DAS and 14 DAS, respectively. In 2nd spraying, there were no significant differences in aphid population at 1 DAS and 7 DAS except 14 DAS. The significantly lowest aphid population was observed under Neem 10% (3.5) followed by Neem 5% (6.5) and AnoninWP (6.9) as compared to other treatments at 14 DAS. In 3rd spraying, Imidacloprid was significantly more effective to minimize the aphid population at 1 DAS, 7 DAS and 14 DAS as compared to other treatments. Among the biopesticides, neem 5% was more effective in reducing the aphid population in mustard.

***Broccoli:*** The significant differences were obtained in aphid population due to spraying of pesticides at different stages as compared to control. The significantly lower aphid population was recorded on 1st spraying under Neem 5% (0.9), 1 DAS (days after

spraying) and 7 DAS, while Imidacloprid recorded significantly lowest population at 14 DAS. In 2nd spraying, the significant differences in aphid population were recorded at 7 DAS and 14 DAS under Neem 10% except 1 DAS. In 3rd spraying, Neem10% was significantly more effective to minimize the aphid population at 1 DAS, 7 DAS and 14 DAS as compared to other treatments. Among the biopesticides, neem 10% was more effective in reducing the aphid population in broccoli.

***Cabbage:*** The significantly lower aphid population was recorded on 1st spraying under Imidachlorpid at 7 DAS (6.2) and 14 DAS (4.5) than other treatments. Application of Imidachlorpid on 2nd spraying at 1 DAS, 7 DAS and 14 DAS reduced the aphid population by 300.8%, 345% and 551%, respectively over control treatment. The aforesaid treatment was also significantly more effective than other treatment in 3rd spraying at 1 DAS, 7 DAS and 14 DAS. Among the biopesticides, neem 5% and 10% were more effective at 1st, 2nd and 3rd spraying after 1, 7 and 14 DAS in reducing the aphid population of cabbage.

***Cauliflower:*** *There* was no significant difference on aphid population days before spraying of pesticides. The significantly lower aphid population was recorded on 1st spraying, 2nd spraying and 3rd spraying under Imidachlorpid at 1 DAS, 7 DAS and 14 DAS than other treatments. Among the biopesticides, neem 10% was better in reducing aphid population as compared to other treatments.

***Impact of weather parameters on population build-up of aphids on cruciferous crops:*** Aphid population in cabbage, cauliflower and broccoli was negatively and significantly correlated with morning relative humidity and afternoon relative humidity. In mustard crop, there was no correlation with weather parameter and aphid population (Table 1).

**Organic production package for passion fruit based cropping system**

Planting of passion fruit on the ridges of the terraces at a distance of 5 m provides entire terraces for cultivation of intercrops without hampering the yield of main crop. Organic mulch and life saving irrigation through bamboo drip (3 l water/plant at 3 days interval) during lean season and 4 placing bee-box/ha was found to be effective in enhancing the productivity. Suitable intercrops have been identified for passion fruit based cropping system. Both main crop (passion fruit) and different intercrops were grown organically. In terms of yield, pineapple (39.15 t/ha) and ginger (22.89 t/ha) were found to be most suitable. However, in terms of economics, maximum gross return (₹ 14.54 lakhs/ha) was recorded with passion fruit + capsicum; followed by passion fruit + ginger ( ₹ 9.13 lakhs/ha). The bio-oragnic inputs have been standardized for passion fruit based cropping system. Among different combinations tried, application of Vermicompost (6.5 t/ha) + *Azospirillum* (20 kg/ha) + PSB (20 kg/ha) + AM (65 kg/ha) was found to be most suitable. This

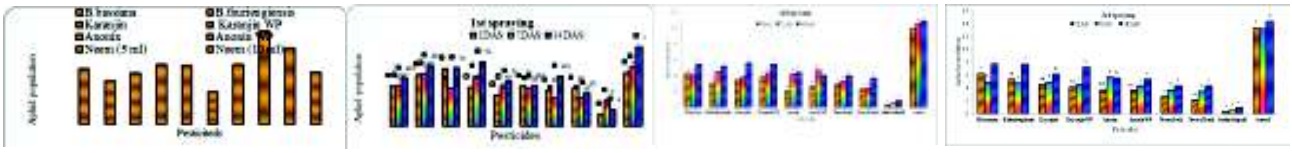


**Fig 12 Impact of weather parameters on population build-up of aphids on cruciferous crops**

Ranks are given based on DMRT test i.e. representing L.S.D. (P = 0.05) significance level of various treatments. For most effective treatments ranks are given a, b, c subsequently.

**Table 1 Impact of weather parameters on population build-up of aphids**

| Aphid Population | Temp (°C) | | R H (%) | | Wind Direction (Deg.) | | Wind Speed (km/hr) | CC (Okta) | |
|---|---|---|---|---|---|---|---|---|---|
| | Max | Min | 700h | 1300h | 700h | 1300h | | 700h | 1300h |
| Cabbage | -0.007 | -0.410 | -0.665* | -0.824** | -0.594 | 0.287 | -0.25 | -0.509 | 0.202 |
| Cauliflower | 0.237 | -0.483 | -0.809** | -0.878** | -0.315 | 0.155 | -0.348 | -0.720 | 0.016 |
| Broccoli | 0.067 | -0.563 | -0.663** | -0.825** | -0.467 | 0.112 | -0.347 | -0.599 | -0.035 |
| Mustard | -0.078 | -0.151 | 0.246 | -0.11 | -0.624 | 0.341 | 0.209 | 0.088 | 0.002 |

Note: *, ** Significant at 0.05 and 0.01 probability levels, respectively

bio-organic combinations resulted in maximum yield of passion fruit (23.63 t/ha), ginger (28.45 t/ha) and capsicum (9.27 t/ha); as well as enhance the quality of passion fruit (30% juice content, 16.30°B TSS, 17.50 mg/100 g Ascorbic acid, 4.75% reducing sugar and 8.43% total sugar. Application of Pyrethrum, *Pseudomonus fluorescence* and Bio-tarcel was found to be effective to control major insect-pests and diseases of passion fruit.

## Horticulture Mission for North Eastern and Himalayan States (Mini Mission I)

### Standardization of horticulture based sustainable cropping model for small and marginal farmers of Manipur

Horticulture based sustainable cropping system models were standardized under foothill condition of Manipur. Of the cropping models tested, relay cropping sequence in vegetables *i.e.,* Spinach-Radish-Cabbage-Onion-Tomato-Carrot-Okra-Bittergourd-Garlic has registered highest B:C ratio (6.4) with 9 fold increase in cropping intensity. However, the B:C ratio in mono cropping and double cropping system was observed to be in the range of 1.3 to 6.4.

### Standardization of spacing and fertilizer dose in sweet potato var. Gauri under foothill condition of Manipur

A trial was undertaken on sweet potato *var.* Gouri with two level of spacing *viz.*60x20 cm ($S_1$) and 60x30 cm ($S_2$) under three fertilizer doses ($F_1$:60:40:60; $F_2$:75:50:75; $F_3$:90:60:90). The tuber yield was recorded to be highest in the treatment combination $S_1F_2$ (33.0 t/ha) followed by $S_2F_3$ (32.7 t/ha) and $S_2F_1$ registered lowest yield (19.82 t/ha).

### Selection of suitable varieties of onion and garlic for Manipur condition

Two experiments were undertaken for selection of suitable onion varieties for Manipur (Fig 13). In the present study, eight varieties of onion were evaluated along with local check. In terms of yield, Agrifound Light Red (34.63 t/ha) has been found to be the most suitable for Manipur condition, followed by Bhima Raj (34.41 t/ha) and Bhima Super (34.12 t/ha). Similarly, among the five garlic varieties, Yamuna Safed 4 has been found to highest yielder (18.65 t/ha), followed by AF White (13.99 t/ha).

**Fig 13a.Sweet Potato var. Gouri**


**13b. Onion var. Agrifound Light Red**


**13c. Garlic var. Yamuna Safed 4**

### Use of botanicals for eco-friendly pest management in cabbage under Manipur condition

Cabbage butterfly (*Pieris brassicae*) and Diamond back moth (*Plutella xytostella*) are two major insect pests of cabbage which cause considerable loss to the crops. Given this backdrop, the experiment has been undertaken to assess the effectiveness of six bio-insecticides in reducing the prevailing insect pest population in cabbage under Manipur condition. The bio-insecticides include three plant extracts (*Lantana camera, Artemisia nilagirica* and *Melia azedarach*), two commercial botanical formulations (Pestoneem and Eliminix) and cow-urine extract. The plant extracts and cow-urine extract was applied @ 25 ml/l of water; whereas Pestoneem (*Azadirachta indica*) and Eliminix *(Vitex negundo*) was applied @ 2 ml and 3 ml per litre of water, respectively. Chemical insecticide Imidacloprid @ 1ml/l of water was included as control. Recommended package of practices was followed to manage the crop. Among the different botanicals tried, maximum yield (33.42 t/ha) was associated with the spraying of Imidacloprid; closely followed by Pestoneem (33.35 t/ha).

### Standardizing the dose of arbuscular mycorrhiza and microbial inoculants for vegetable crops in Manipur valley

The experiment was undertaken to identify the most suitable bioorganic inputs for broccoli (*Brassica oleracea* var. *Itlica*), bell pepper (*Capsicum annuum*) and false coriander (*Eryngium foetidum* L.) grown as intercrop in grape plantation under naturally ventilated polyhouse (Fig 14).

Different combination of vermicompost, *Azospirillum*, Phosphate Solubilizing Bacteria and Potash Solubilizing Bacteria were applied during planting. No chemical fertilizer was applied to the crops. Among the different bio-organic combinations tried, application of Vermicompost (6.25 t/ha) + *Azospirillum* (1.0 l/ha) + Potash Solubilizing Bacteria

**Fig 14 Broccoli, capsicum and false coriander intercropped in grape plantation under natural ventilated poly-house**

(250 ml/ha) + Arbuscular Mycorrhiza (2 tablets/plant) was found to be most suitable for broccoli (21.00 t/ha), bell pepper (7.30 t/ha) and false coriander (24.50/ha).

**Multimedia module on pineapple and passion fruit**

Two multimedia modules on pineapple and passionfruit were developed in collaboration with LB-Institute of Technology and Management, Imphal (Figs 15 & 16). The user friendly modules are windows based applications for disseminating the scientific production package of the crops in an attractive way. The modules can be effectively used in Expert Systems Software and ICT kiosks.


**Fig 15 Multimedia Modules on 'Pineapple'**


**Fig 16 Multimedia Modules on 'Passionfruit'**

**National network on integrated development of jatropha**

Under the R&D programme, local exploration was conducted for collection of local genotypes of Jatropha in Manipur. All total 21 local germplasm (MNJ 001 to MNJ 021) have been collected, out of which, three accessions (MNJ 001, MNJ 006 and MNJ 017) were found promising in terms of seed oil content (> 40%). Field evaluation of 16 local genotypes of Jatropha was carried out. Based on seed yield and seed oil content, accession MNJ 001 (1.05 t/ha seed/ha and 40.77% oil content), MNJ 002 (0.99 t/ha seed/ha and 40.87% oil content) and MNJ 006 (0.974 t/ha seed/ha and 40.34% oil content) were found to be promising. The results indicate a large scope for exploitation of superior accessions of Manipur for further improvement. Different trials namely progeny trial, zonal trial, multi-locational trial, national trial I, national trial III and local trial are being conducted and promising accessions have been identified.:

Oil content of different accessions was analyzed at NOVOD Board Laboratory. Maximum oil content (46.55%) was recorded in accession PJ 01, followed by JIP 15 (44.12%). The plants under multilocational trial and national trial III are still at vegetative stage. In addition, research was undertaken to standardize the package of practices for jatropha under Manipur condition. Under spacing trial, planting distance of 2m x 3m was found to be mostsuitable under hill slope of Manipur (1231.67 kgs fruits/ha and 0.81 t/ha seed/ha). The plants under pruning trial are still at vegetative stage. However, pruning height of 100 cm was found to be the most suitable in terms of number of branches and collar diameter tested over 7 genotypes. In fertilizer trial, application of Urea, SSP and MOP @ 150, 250 and 50 g/plant respectively resulted in maximum collar diameter, whereas maximum number of branches was recorded with Urea, SSP and MOP @ 100, 250 and 50 g/plant respectively. The plants are yet to flower to draw any conclusion. The horti-silvicultural trial has been conducted to select the suitable intercrops for jatropha plantation. Among the different crops evaluated, sweet potato (Gouri), tomato (Megha Turmeric) and soybean (JS335) have been found to be the most suitable intercrops for jatropha under foothill condition of Manipur.

## NATURAL RESOURCE MANAGEMENT

**Biomass management in cropping systems for enhancing productivity and resource use efficiency under hill regions of Manipur**

The present experiment was laid out in split-split plot design with combinations from four pre *kharif* green manuring treatments (control, cowpea, greengram and sesbania) in main plots. Three cropping systems *viz*., maize sole, groundnut sole and maize + groundnut (additive series) in sub plots and their residue recycling *(kharif)* treatments of maize/groundnut and maize + groundnut (without residue and with residue) in sub-sub plots and replicated thrice (Figs 17 & 18). Amongst the green manuring, sesbania followed by cowpea recorded significant effect on maize and groundnut yield under sole as well as intercrop than control. Under cropping system, maize + groundnut (additive series) gave significantly 14 and

**Fig 17 Green manuring of cowpea, green gram and sesbania**

**Fig 18 Sole maize, sole groundnut, maize + groundnut intercropping**

172% higher grain equivalent yield than sole groundnut and sole maize, respectively. Effect of pre-*kharif* residual green manuring and residue recycling (*kharif*) [maize/groundnut/and maize + groundnut] had significant effect on dry pod yield of pea. Green manuring with sesbania gave highest dry pod yield (2.05 t/ha) followed by cowpea green manuring (1.96 t/ha) than control (1.86 t/ha) treatment. Amongst the residue recycling (*kharif*), maize + groundnut residue increased 24% dry pod yield over control.

**Standardization of balanced nutrient management for improving productivity of maize in acidic hill soils**

An experiment was initiated in 2011 to determine the effect of organic manure (FYM) and fertilizers including micronutrients (Zn and B) on performance of maize (*cv* Pusa Composite 3). The experiment was repeated during the reporting period (2012-13) for validation. There were eight treatment combinations: control ($T_1$), 10 t FYM/ha ($T_2$), 100% NPK ($T_3$), 100% NPK Zn B ($T_4$), 100% NPK Zn B + 10 t FYM/ha ($T_5$), 100% NPK Zn B + 5 t FYM /ha ($T_6$), 50% NPK Zn B + 10 t FYM/ha ($T_7$) and 50% NPK Zn B + 5 t FYM/ha ($T_8$). 100% NPK Zn B represented 120 kg N; 80 kg $P_2O_5$; 60 Kg $K_2O$; 5 kg Zn; 1 kg B/ha. The results showed that different combination of organic and inorganic nutrient sources significantly increased maize grain yield over the control; mean magnitude of increase being 33.8% over the control. Similar increase in yield was also recorded in the first year (36.4%). The highest yield was recorded with $T_5$ (6 t/ha) followed by $T_4$, $T_6$, $T_3$, $T_7$, $T_2$, $T_8$ and $T_1$ (control) in decreasing order and the highest stalk yield was recorded with $T_5$ (11 t/ha) followed by $T_6$, $T_4$, $T_3$, $T_7$, $T_8$, $T_2$ and $T_1$. The results thus indicated that the integration FYM and mineral fertilizers including Zn and B was more beneficial in increasing maize yield as compared to only either FYM or inorganic fertilizers. The efficiency of balanced fertilization was also supported by higher values of yield related characters such as number of grain/row in cob, number of grain/cob and 100 grain weight and harvest index with those treatments ($T_3$-$T_8$).

**Soil test based fertilizer recommendation for targeted yield of rice in acid soils of Manipur**

Fertilizer adjustment equations were developed (Table 2) for direct seeded upland rice using the basic data. Based on these equations, fertilizer recommendations were prescribed in the form of ready reckoner for desired target yield of 30 and 40 q/ha of direct seeded rice with different combination of NPK under rainfed upland situation of Manipur. The targeted yield equations for direct seeded rainfed upland rice and fertilizer recommendations were validated by conducting experiments in the farmers' field. The targeted yield equations for direct seeded rainfed upland rice (RC Maniphou 6) in Manipur is as given in table 2.

**Table 2 Basic data and fertilizer adjustment equations for targeted yield**

| Basic data | N | P | K |
|---|---|---|---|
| Nutrient requirement (kg/q) | 2.75 | 0.20 | 3.53 |
| Oil efficiency (%) | 9.63 | 12.15 | 21.34 |
| Fertilizer efficiency (%) | 52.92 | 13.73 | 126.04 |
| ***Fertilizer adjustment equations*** | | | |
| **FN** = 5.19T – 0.18SN | *SN, SP and SK, soil available nitrogen, phosphorus and potassium (kg/ha); FN, FP and FK, fertilizer nitrogen, phosphorus and potassium required (kg/ha)* | | |
| **FP** = 1.48T – 0.89SP | | | |
| **FK** = 2.80T – 0.17SK | | | |

## ANIMAL SCIENCE

### Monitoring and surveillance of antibiotic resistant pathogens from livestock and its byproducts

Three hundred and fifteen samples *viz.,* chicken meat (n=50), beef (n=10), pork (n=20), milk (n=50), faecal samples from pig (n=100), cattle (n=80) and diarrhoeal dogs (n=5) were collected from various locations of Imphal West District. Using chromogenic media's, *Escherichia coli* (n=90), *Klebsiella* spp. (n=30), *Staphylococcus aureus* (n=20), *Aeromonas* spp. (n=20), *Enterococcus* spp. (n=50) and *Salmonella* spp. (n=5) were isolated. Antibiotic sensitivity assay of the entire organism revealed that majority of the isolates were resistant to penicillin, methicillin, streptomycin and clindamycin, and sensitive to nitrofurantoin, gatifloxacin and imipenem. Minimum inhibitory concentration using five antibiotics ampicillin, chloramphenicol, streptomycin, sulfisoxazole and tetracycline for all the isolates ranged between 0.0018 µg/ml to 1.024 µg/ml, 0.02 µg/ml to 2 µg/ml, 0.001 µg/ml to 3 µg/ml , 2.0 µg/ml to >240 µg/ml and 0.01µg/ml to 1.0 µg/ml, respectively. VRE Alert Kit detected Vancomycin-Resistant Enterococcus (VRE) in sixty percent (n=30) of the *Enterococcus* spp.

## POULTRY

### Poultry Seed Project

At present 471 nos. of second batch parent stock at the age of 69 weeks and the third batch foundation stock (16$^{th}$ weeks old) of 2077 nos. (Vanaraja 1267 & Gramapriya - 810) are being maintained in the Institute's farm. The supply of quality germplasm was increased by 143 % over previous year. Performance on various traits revealed that Vanaraja attained average body weight (g) of 41.98, 421.44, 1591.51, 2356.45, 2469.81, 2775.39 and 2922.63 at day 1 and subsequently at 6, 16, 24, 32, 40 and 58 weeks of age, respectively. While at the same age, Gramapriya was 39.13, 332.25, 1213.30, 1691.62, 1964.05, 2216.95 and 2843.55, respectively. Mortality was 10.15 % and 13.99 % in Vanaraja and Gramapriya, respectively up to 24 weeks of age. The average age of sexual maturity (ASM) was 169±2 and 163±2 days, respectively. The egg weight (g) at 28, 40 and 50 weeks were 44.89, 50.86 and 51.35 g in Vanaraja while in Gramapriya it was 48.52, 52.73 and 52.94 g respectively.

***Performance under backyard conditions (Farmers' field):*** The village records showed that an average weight of 352.71 g and 339.46 g was achieved by male and female chicks, respectively at four weeks. The average survivability up to the end of 6 weeks was 87.57 % (Vanaraja 88.73 % and Gramapriya 86.42 %). The average age at sexual maturity (ASM) for Vanaraja and Gramapriya birds was 169 and 172 days respectively, from the records of 125 adults and the average body weight of female at the corresponding age was around 1529.41 and 1274.91 g respectively. The birds laid on an average of 20 eggs (246 birds) per month with tinted brown colour during peak period. The egg weight (g) at 28, 40 and 58 weeks of age were 45.24, 47.61 and 50.76g in Gramapriya while 41.77, 44.39 and 48.36 g in Vanaraja, respectively. The above level of production was achieved by providing 50 percent of daily requirement through home-made feed mixtures of ground maize, rice bran, oilcakes, household waste, agricultural by-products with supplementary feeding of shell of snails, lime powder etc. as source of calcium during laying period in the semi-intensive rearing systems in the villages.

**Fig 19 Performance of poultry under bakyard farming**

## FISHERIES

### Standardization of breeding and culture techniques for potential indigenous ornamental fishes of Manipur for commercialization

***Pangio pangia:*** The eel-loach or Kulhi loach, *Pangio pangia* known as *Nganap* in Manipuri is an important ornamental fish. It is bottom feeder, omnivorous and eat worms and insect larvae. *P. pangia* juveniles were collected from Khumbong, Imphal west of Manipur in the month of October, 2011. The fishes were transported in oxygenated bags and maintained in the laboratory in FRP tanks having water capacity of 3 t with water recirculation system. The fishes were fed with live feeds (worms, daphnia, Cyclops) and formulated pelleted diet. Induced breeding of *P. pangia* were carried out successfully in utility tray (360 mm×310mm ×130 mm size) with a water depth of 8 cm in the laboratory. The water temperature, dissolved oxygen, pH and total alkalinity of the breeding trays were maintained at 25 ± 3.0 °C, 6.0 ± 2.0 ppm, 7.5 ± 0.2 and 110 ppm, respectively. Aeration was given continuously during breeding operation. Three different doses of Wova-FH were tested i.e. 0.5 ml, 0.7 ml and 0.9 ml/kg body weight on the dorsal muscles above the lateral line near the dorsal fin. Three sets of brood stocks were selected at the ratio of 1:2 (female: male) dose of hormone was given to each set. After the injection, the breeding sets were released in different utility trays in duplicate manner. Spawning occur after 21 hrs of injection. After spawning, fecundity of each female was determined by randomly taking representative samples of eggs. A varied degree of response of different doses of Wova-FH was observed. Spawning response varied from 19-21 hrs. The highest rate of fertilization was obtained in fish set given Wova-FH dose @ 0.7 ml/kg body weight. Fertilized eggs were slight yellowish in colour, spherical, translucent and demersal measuring to 0.6-0.7 mm in diameter. Unfertilized eggs were paler and opaque. Within 1½ hrs twitching movement of the embryo was observed. Hatching was preceded by movement of the larvae inside the egg shell. Fertilized eggs were hatched out after 3 hours of fertilization. The newly hatched larvae were measured at 0.7- 1.5 mm long (Fig 20). The young ones did not take exogenous food for about 48 hrs at 25 °C. From the results, it is evident that highest spawning of *P. pangia* occurred at dose 0.7 ml/kg. At lower dose at 0.5 ml/kg, spawning was moderately low. Very few eggs were released in fish set given @ 0.9 ml/kg. Fertilization rate (40%) and hatching rate (45%) were also lower in set that were given @ 0.7 ml/kg and 0.5 ml/kg body weight, respectively. From these results, it is evident that the doses of hormone affected the spawning, percentage of fertilization and hatching rate. The young ones were dark brown in colour and very active swimming in their environment. About 1"-2 of the bottom of the rearing tanks were filled with fine sand. Well aerated clean water was maintained. Fishes were fed with worms, tubifex and sinking type pellets. The fishes can attained body weight of 1.0 g in 2 months.

**Fig 20 a. Hormone injection**

**Fig 20 b. Fertilized egg**

**Fig 20 c. 10 days old juvenile**

**Fig 20 d. 15 days old juvenile**

***Schitura fasciatus****:* It is known as *Leingoiphon or Ngatup* in Manipur were collected from Izei river, Tamenglong district of Manipur in the month of June, 2011. *S. fasciatus* is a community fish, and lives well with other non-aggressive community fish like guppies, neons, platys and other bottom dwellers. These fishes are bottom dwellers, but they also swim in the middle of the tank and to the top occasionally. They make very fine additions to any community aquarium. They are schooling fish and like to be kept 4-5 individual together in a tank. Sex were differentiated. Males were having swollen anterior body, triangular head and faintly coloured vertical bars especially visible from the middle of the dorsal fin to the base of the caudal fin, whereas females have well distinct marked vertical bars. The dorsal surface of males is straight horizontally and with a well develop prominent dorsal adipose crest. The anterior dorsal profile of females are well arched and the adipose dorsal crest not

prominent as in male. Ratio of male and female brooder was 1:1. Plastic tanks (360×310×130 mm) having water depth of 8cm. Water quality of the spawning tray was analyzed by using water testing kits Aquacheck (Renkem). The breeding tanks were maintained at temperature, 25±3.0 °C; pH, 7.5±0.2; dissolved oxygen, 6.0±2.0 ppm and carbon dioxide at 0.0ppm. A mild current of water was arranged inside the tanks using aerators. Three sets of brooder were selected for the breeding experiment. Three different doses of Wova-FH i.e. 0.5 ml, 0.7 ml and 0.9 ml/kg body weight were given to each set. After the injection, the breeding sets were released in three breeding tanks. Spawning occured after 21-23 hrs of injection. After spawning, effective fecundity of each female was determined by randomly taking representative samples of eggs in a 10 ml graduated measuring cylinder from the total eggs in 1ml was counted and multiplied with total volume of egg released. The fertilization rate of egg was determined by randomly taking a sample of approx. 45 eggs. Fertilized eggs were slight yellowish in colour, spherical, translucent and demersal measuring to 0.7-0.8 mm in diameter (Fig 21). Unfertilized eggs were paler and opaque. Within 5 hrs twitching movement of the embryo was observed. Hatching was preceded by movement of the larvae inside the egg shell. Fertilized eggs were hatched out after 8-9 hrs of fertilization. The hatchlings were yellowish in colour. The newly hatched larvae measure 0.8- 1.5 mm long. The young ones did not take exogenous food for about 48 hrs at 25 °C.

**Fig 21 a. Breeding tank**

**Fig 21 b. Fertilized egg**

**Fig 21 c. 4 days old embryo**

**Fig 21 d. 5 days old spawn**

***Danio dangila:*** Forty five numbers of *Danio dangila* commonly known as Moustached Danio were collected from a hill stream from Barapani, Meghalaya and maintained at ICAR Manipur centre, Imphal. Breeding of *D. dangila* is one of the easiest egg scatterers to breed. These fish is sexually mature when they reach 2.5" and will spawn only when kept in schools. A good ratio for spawning was 2 males and 1 female with lots of plant. For this experiment 2 males weighing 2.76 g and body length of 5.6 mm and one female having body weight 3.5 g and 5.9 mm in length were selected. Fishes were injected hormone Wova – FH @ 0.05 g/100g fish. Latency period was 24 hrs. The fishes bred eggs after 24 hrs of hormone injection at 26 °C. About 300 eggs were laid and scattered by a female. Hatching was preceded by movement of the larvae inside the egg shell. Hatching takes approximately 36 hours and the fry should be free swimming after 5 days. The newly hatched larvae measure 0.5- 6.5 mm long Fig 22). The young ones did not take exogenous food for about 48 hrs at 26 °C. The fries were fed with brine shrimps and micro worms.

**Fig 22 a. *Danio dangilla***

**Fig 22 b. Fertilized egg**

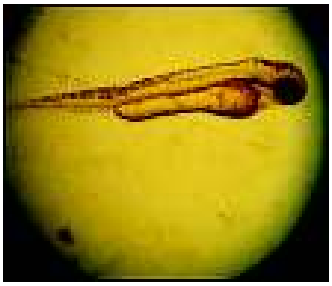


**Fig 22 c. 4 days old embryo**

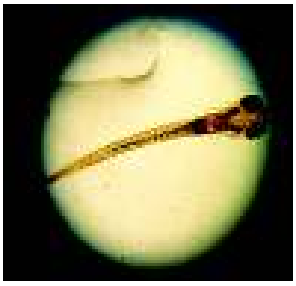


**Fig 22 d. 2 days old spawn**

## SEED TECHNOLOGY

### Participatory development of rice, maize and rapeseed quality seed production practices for seed village

The project involving KVKs and famers' participatory approach aimed at developing a suitable seed production system for the NEH region in major important crops (Fig 23) was taken up in five different


**Fig 23 Maintenance breeding of locally released varieties of rice and other recommended crop varieties**

districts *viz*., Imphal West, Imphal East, Churachandrpur, Tamenglong and Chandel. In the first year it was successful in the first three districts only. Altogether twenty four famers were involved. The quality of seed produced with this programme could reach the Indian Minimum Seed Certification Standards. In rice 95%, in maize 80% and in rapeseed 92% could attain the standards. Continuous monitoring and involvement were required at the initial stage. In rice, varieties RC Maniphou 7 and RC Maniphou 10, the off-types could be reduced to 0.05% (in both varieties) as compared to 3.75% under farmers' field conditions. In maize the purity of the variety could be maintained to certification standard. Seed produced from Pusa Composite-3 with time isolation by *rabi* sowing in Churachandpur district and Imphal West was maintained by IMSCS to certifying level quality. In rapeseed, M 27, September to October sowing with zero tillage technique (time isolation) could avoid bee outcrossing. Seeds stored under desiccated condition in low cost RC Seed bin maintained the seed moisture throughout. Seed moisture in RC-Seed Bin was maintained at 10.5% in rice, 10.7% in maize and 8.25% in rapeseed.

**Table 3 Rice RC Maniphou 10 seed quality level under farmers' participatory seed village**

| Standards under Indian Minimum Standard | Seed produced under supervision | Check |
|---|---|---|
| Purity (grow out 99.80%) | 99.95% | 96.25% |
| Pure seed (98%) | 99.00% | 94.15% |
| Inert matter (2.5%) | 0.58% | 3.75% |
| Weed Seed (10/Kg) | 1.10 | 12.15 |
| Germination (80%) | 88.25% | 79.15% |
| Moisture content (13%) | 10.85% (seed bin) | 13.45% |

Rice varieties released from the centre are being maintained through panicle row selection and basic seeds are being produced every year. Seeds were supplied to the framers either directly under different demonstration programmes or through state department for seed production programme. Two rice varieties for pre *kharif* are RC Maniphou 4 and 5 and main *kharif* varieties RC Maniphou 6, 7, 10 and 11 were taken up (Fig 24). During the year, altogether 7.74 t basic and 7.4 t labelled seeds in rice were produced. In *kharif*, RC Maniphou 7 and RC Maniphou 10 were raised getting 99.98% and 99.95% purity, respectively. Similarly, in RC Maniphou 6, purity was 99.67%.


**Fig 24 Maintenance breeding of released rice varieties**

**Development of seed production packages for important crops**

In wetland rice, repeated sowing and planting of the same variety for 3 years reduced the off-type level to 0.001% as compared to 0.02% by growing different varieties. In other self pollinated crops like peas, soybean and groundnut, varietal contamination was negligible. But, it was clear in rapeseed and maize. As the holding sizes are small, time isolation was found to be better to maintain the purity level. In upland crops like soybean and groundnut, rain poss the biggest uncertainty in quantity and quality. Almost all standard seed production practices are adopted for seed source, site selection, roguing, handling and storage. In outcrossed crops like maize (*rabi*, December-January sowing), rapeseed and mustard (Aug to Oct., depending on soil moisture), time isolation was more practicable than distance isolation. Thus, maize needs irrigation

water and rapeseed M 27 can be sown with zero tillage to catch the earliness. For pre-*kahrif* rice seed production, studies in wetland rice found that the spacing of 20 cm×10 cm with a gap of 0.5 m after every 1.5 m favours ease in interculture and rouguing giving a seed yield of 4.2 t/ha. In pre *kharif,* yield of RC Maniphou 6 was 3.75 t/ha, RC Maniphou 4 (3.54 t/ha), RC Maniphou 5 (3.15 t/ha). In *kharif* varieties, higher yields of RC Maniphou 7 (4.25 t/ha), RC Maniphou 10 (4.75 t/ha) and RC Maniphou 11 (4.45 t/ha) were also recorded. In maize, good seed under *rabi* sowing was obtained as intercrop with field pea (Rachana). Seed yield in pea was negligible due to the poor *rabi* rains. In rapeseed, early zero tillage sowing (Aug-Sept) in the hill gave a yield of 0.45 t/ha. In the valley, zero tillage sowing during Nov-Dec gave better crop stand and seed yield (0.5-0.75 t). In soybean (JS 335), spacing of 40 cm×30 cm was found better over closer spacing. In groundnut, early sowing during first pre-monsoon (Apr-May) was favourable for better seed health and quality (Fig 25).


**Fig 25 Seed Production of Soybean (JS 335) and Groundnut (ICGS 76) at Langol Hill Research Farm, ICAR-Manipur Centre**

## SOCIAL SCIENCE

### Role of mass media in farm technology dissemination among the farmers in Manipur state

The study was undertaken to explore the media contribution in dissemination of agri-allied technology in the context of Manipur and to analyse the extent of adoption of technology by the valley and hill farmers disseminated through mass media in Manipur. The specific objective was to analyze the socio-economic conditions, information utilization, and to investigate the relationship between independent variables with extent of adoption. The findings were intended to enhance the dissemination system of agriculture and allied activities through mass media. Two valley districts (Imphal west and Thoubal) and two hill districts (Ukhrul and Churachandpur) were selected for analysis. Two villages from each district with the sample size of 15 each totalling to 120 samples was done randomly for investigation. Due consideration was taken to include women respondents in the investigation. The interview schedule incorporated the agricultural programme disseminated via All India Radio, Doordarshan in six months duration between Jan to June, 2011 was taken for analysis. The interview schedule was pre-tested to the size of 10 % of the sample in Imphal West district. Majority (64 % in valley and 68 % in hills) of the farmers were in age group of 30-50 years in both hills and valley districts. 85% of the farmers know Manipuri and 75% know English. Majority (73%) of the farmers have farming experience of more than 10 years. The information utilisation of the farmers is Radio followed by Family members >T.V> Friends and neighbor > training by valley farmers where as Radio, friends and neighbour > KVK-ICAR > family members > Demonstration is the information source utilized by hill farmers.The preference of mass media varied for valley and hill farmers. The valley farmers prefer Radio >T.V.>Newspaper>Mobile and in case of hills the preference is Radio > Radio + farmers club > Mobile. The regression analysis revealed that the extent of adoption of technology is contributed by 68 % of the variables. Further, the variables namely power supply, information sources, listening/viewing/reading of agricultural programme are positively and significantly contributed for the extent of adoption at 1 % level. The variables *viz*., education and farmers club are negatively contributed for the extent of adoption at 5 % and 1%, respectively. It means that irrespective of education and the members of farmers club the adoption of technology is similar.

## TRIBAL SUB-PLAN 2012-13

***Enhancing farm income of tribal farmers in Manipur through seeds of crops and animals*:** Efforts were given to sustain the own saved seed production at tribal farmers' level. Altogether, 8 major crops were taken up in *rabi* and *kharif* seasons of 2012-13 in 5 (Five) different hill and one valley districts of Manipur. During the *rabi* programme, quality seed production of lentil, rapeseed and pea were taken up on the farmers' fields in the districts during 2012-13. Under this project, more than 400 tribals farmers covering 271 ha area in 5 district of the state were covered and around 805.83 t seeds of different crops were produced through participatory approach. Regarding animal seed production, 35 farmers were involved and all total 44 male and 88 female piglets were produced.

**Fig 26 Outreach Activities under Tribal Sub-Plan**

## NATIONAL AGRICULTURAL INNOVATION PROJECT (NAIP III)

During the *kharif* season, 2012-13 the progamme "Quality Saved Seed Production" was taken up in the four cluster villages *viz*., Noney, Reangkhong, Awangkhul and Tupul Charoi Chagotlong in rice, groundnut and soybean. The average yield of RC Maniphou 10 during the season ranged from 3.0 t/ha in Awangkhul village to 4.0 t/ha in Noney village against the local check yield of 2.9 t/ha. The recorded yield of groundnut (var. ICGS 76) was 1.25 t/ha cultivated in 1 ha adopting 10 total no of farmers. Soybean gave a satisfactory yield of 1.87 t/ha. Though agriculture in the district was mono-cropped, keeping the lands mostly fallow during the *rabi* season, zero tillage technique in rapeseed M 27 allows farmers to plant 15 days earlier than usual. Since the cost of land preparation is nil, it generated higher net income. During *rabi* 2011-12 rapeseed M 27 under zero tillage was in 180 ha area in four villages of the cluster by 249 farm families. Thirty eight bee boxes were also distributed to the farmers in order to generate additional income to the farmers and to increase the oil yield. Potato was also cultivated in a total area of 31 ha adopting 301 farm families in the three cluster villages of Project sites. 120 farm families were adopted pea cultivation in 5.70 ha area and crop performed good under minimum tillage practices in cluster villages. An area of 2.0 ha for cabbage cultivation *var.* Rareball was adopted by 43 farm families with an average yield of 9.28 t/ha. In the model mini polyhouse established at 3 cluster villages with farm families, 110 nos. of capsicum plants (var. California Wonder) and 90 nos. tomato plants (var. Nidhi) were planted. Nine training programme on different topics were conducted at different villages of NAIP cluster villages by the scientist of ICAR RC, Manipur Centre for the benefits of the farmers.

**Pig, goat and poultry farming:** ***A tool to promote sustainable livelihood in Tamenglong District of Manipur:*** A total of 21 farm families of four cluster villages *viz*., Marangching, Noney, Reangkhong and Awangkhul have been selected. The adopted farmers started rearing cross breed Hampshire piglets with initial body weight of 7.0 to 8.0 ± 2.0 kg where the distribution were made @ 3 piglets (2F + 1M) to each beneficiary. An average net return of Rs 65,438.00 per farm family could earn through rearing of improved Hampshire pigs and improved the livelihood of poor farmers. A total of 60 nos (one male and two female kids per beneficiary) of Black Bengal goats (4-5 months old) were distributed with a body weight approximately 5-7 kg. Average daily weight gain was 29.25g. Dressing percentage was 45.00 ± 0.50 and average milk yield/day was 0.30 kg. A minimum of two kids were achieved from goat with a litter size of 2 kid/kidding. Distribution of the farmer's income according to their annual rearing through goat husbandry was that half (50%) of the farmers had earned more than ₹ 8500/year through goat husbandry. The farmers annually earning up to ₹ 5000/- through goat husbandry were 30%. Remaining 20% farmers

earned ₹ 5001 to ₹ 8500/year. A total of 600 Vanaraja chicks (4-5 weeks age) were introduced with 20-25 chicks per family in four villages. The result in field conditions indicated that Vanaraja male attained average body weights of 0.90 kg, 1.60 kg, 2.75 kg, 3.15 kg while Vanaraja female attained 0.82 kg, 1.15 kg, 2.25 kg, and 2.60 kg at the ages of 8 weeks, 10 weeks, 20 weeks and 40 weeks, respectively. The average age of sexual maturity was 171 days and average egg production of 147 eggs/hen /annum with an average egg weight of 58g. The pullet weight was 2.55 kg. The percentage of fertility and hatchability was 71.13% and 72.7%, respectively. Farmers could generate incomes between Rs.10,000-15,000/- per farm family by selling of Vanaraja eggs and birds (Fig 27).

**Fig 27 Farming system activities under NAIP-III in Tamenglong**

## NATIONAL INITIATIVE ON CLIMATE RESILIENT AGRICULTURE (NICRA)

### Effect of submergence tolerance on growth and yield of rice

Submergence tolerance study was continued on five rice varieties *viz.*, RC Maniphou 6, RC Maniphou 4, RC Maniphou 7, Taothabi and Akutphou, during *kharif,* 2012. The varieties with 60, 50, 35 and 25 days old seedling were half submerged for 5, 10 and 15 days and full submergence for 5, 10 and 15 days. For grain yield (kg/plant), 60 days old seedling RC Maniphou 6 gave the highest grain yield of 0.041 kg/plant under half submerged condition for 15 days. However, RC Maniphou 7 and Taothabi had the higher average rate of survival. For plant height, Taothabi had the highest plant height of 136.0 cm followed by RC Maniphou 4 with 135.0 cm in 60 days old seedlings half submerged for 15 days. In RC Maniphou 4, the longest panicle was found in 15 days half submerged condition in 60 days old seedlings. Full submerged 50 days and 60 days old seedling had almost similar panicle length. In most of the varieties, 50 days old seedling had longer panicle length than 60 days old seedlings in both half and full submerged conditions. Longest panicles (27.3 cm) were found in Taothabi with 5 days half submerged 50 days old seedling, followed by 15 days half submerged 50 days and 60 days old seedlings (25.7 cm and 25.0 cm, respectively). Highest tiller number was reported in Taothabi under 5 days half submerged 50 days old seedlings.

### Screening of local maize genotypes for cold tolerance

In order to find out the suitability of maize varieties for early sowing to adjust with the untimely rains, molds tolerance study was carried out with 11 local genotypes with Pusa Composite 3 as check. The genotypes collected from Ukhrul (*viz., Tharathei, Khamathei white, Khamathei yellow, Khamanuthei, Angjianchu* and *Vekla*), Chandel (*viz., Chechata* and *Kumpuchecha)* and *Churachandpur (viz., Vaiminphei, Vaiminmaan* and *Kaunvok*), were sown on three different early dates with an interval of 5 days after each sowing. Among the genotypes *Tharathei, Khamathei white, Khamathei yellow, Angjianchu and Vaiminmaan* sown on 28$^{th}$ Dec, 2011 (late sowing) had higher plant height than early sowing on 19$^{th}$ and 23$^{rd}$ Dec, 2011. *Khamathei yellow* was the tallest (228.0 cm) followed by *Tharathei, Vaiminphei, Chechata and Vekla.* Vekla required shortest duration (102 days) to reach 50% flowering; whereas, *Kumpuchecha* requires the longest duration (167 days to reach 50% flowering). *Angjianchu* was earliest to 50% silking (102 days), followed by *Khamathei white* (122 days); while the longest 50% silking was recorded with *Kumpuchecha* in all the sowing date. In terms of ear length (cm), *Vaiminmaan* has the shortest ear (10.52cm) while *Kaunvok* had the longest (23.46 cm) ear followed by *Vekla (21.94 cm).Vaiminmaan* had higher number of kernels per diameter (18.2), but had the lowest no. of kernels per row. Kaunvok had the highest no. of kernels per row higher than the check Pusa Composite-3. *Kumpuchecha* had the longest duration with 204 days, 202 days and 199 days sown on 19$^{th}$, 23$^{rd}$ and 28$^{th}$ Dec, 2011, respectively. All the other local varieties are almost in the similar maturity range of 170-185 days. The germplasms *viz.*, *Khamatheiwhite*, *Vaiminphei and Chechata* were found better suited for cold conditions.

From the study, germplasm *Khamathei white*, *Vaiminphei* and *Chechata* were found to give the higher grain yields (3.38, 2.29 and 2.47, respectively) over other varieties under the minimum temperature ranges of 1.9 to 11.5 °C in the first sowing, 2.1 to 11.5 $^0$C in second sowing and under 1.0 to 11.5 $^0$C in third sowing.

**Impact of climatic factors on production and productivity of tomato**

The experiment was undertaken with 10 tomato genotypes under three growing conditions *viz.*, natural field condition (exposure to frost), low-cost poly house condition (exposure to drought) and 50% agro shade net condition (exposure to low light intensity) to study the different growing conditions on tomato as well as to identify suitable genotypes under different growing conditions. The high temperature and drought condition under poly house resulted 37.21% decline in fruit yield as compared to natural field condition. During *rabi* season, tomato varieties Manikhamnu and Manileima (1.96 & 1.95 kg/plant) were found to be tolerant against frost condition; whereas, Kashi Hemant (2.53 kg/plant) performed better over other genotypes under low light condition. Tomato var. RC Manikhamenashinba 1 (Selection 9A) showed tolerance to drought and high temperature. During *kharif* season, tomato var. Manikhamnu (1.75 kg/plant) was found to be suitable under natural field condition, followed by Selection 11 (1.70 kg/plant). RC Manikhamenashinba 1 (Selection 9A) showed tolerance to drought and high temperature (1.30 kg/plant); whereas, under agro-shade net condition, Kashi Anupam (2.04 kg/plant) was most suitable (Fig 28).

**Fig 28 a. Manileima**

**Fig 28 b. Kashi hemant**

**Fig 28 c. Kashi anupam**

**Fig 28 d. Selection 9a**

## TREND ANALYSIS OF EXTREME WEATHER VARIABLES OF IMPHAL REGION

**Evaluation of production potential, profitability and quality vis-à-vis accumulated heat unit requirement of groundnut (*Arachis hypogaea* L.) cultivars in acidic soils of eastern Himalayan region**

The treatments consisted of 43 groundnut cultivars, which were replicated thrice in randomized block design. Among all the cultivars, ICGS 76 followed by ICGV 86590 were the best performing varieties in acid soils and recorded significantly higher dry pod yield (3.4 t/ha), protein yield (0.82 t/ha) and oil yield (1.68 t/ha). From the results it was observed that some cultivars used heat more efficiently. Under NEH Region, heat tolerant cultivar K 134 (1.8) and ICGV 86590 (1.8) had significantly highest HUE followed by ICGS 76 (1.7) than other cultivars. The lowest HUE was observed in Somnath (0. 6) and B 95 (0.7).

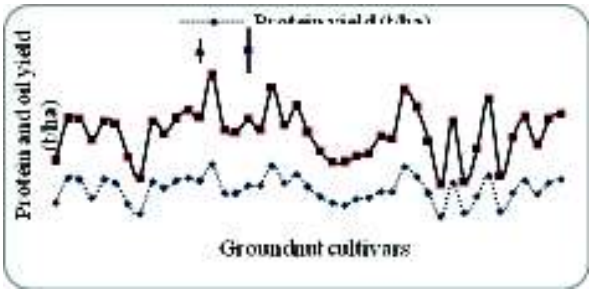



**Fig 29 Protein and oil yield of groundnut cultivars**
(*Vertical bar represents L.S.D. (P = 0.05) significant level)*

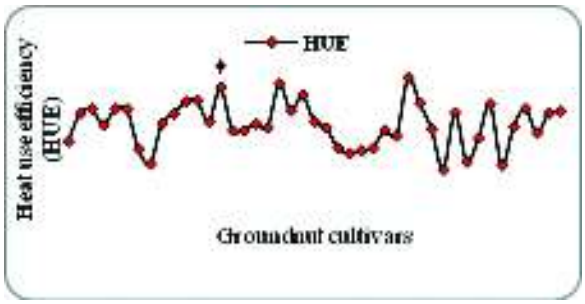



**Fig 30 HUE of various groundnut cultivars**
(*Vertical bar represents L.S.D. (P = 0.05) significant level)*

**Evaluation of production potential, profitability and quality of maize (*Zea mays* L.) cultivars in acidic soils**

Among all the cultivars, Vivek QPM 9 followed by Prakash was the best performing variety (Fig 31) in acid soils and recorded significantly higher grain yield (5.15 t/ha). The quality parameters (protein, oil and starch content) were analyzed by *FOSS grain*

*analyzer (Infratec-1241)*. The oil content was highest in Vivek QPM 9 (4.8%) followed by HQPM-4 (4.65%) than other cultivars. The protein content was highiest in Pusa composite 3 (10.15%) followed by HQPM 4 (9.55%) than other cultivars. However, the starch content was maximum in Vijay composite (73.95%) followed by HQPM-5 (73.45%) (Fig 32).

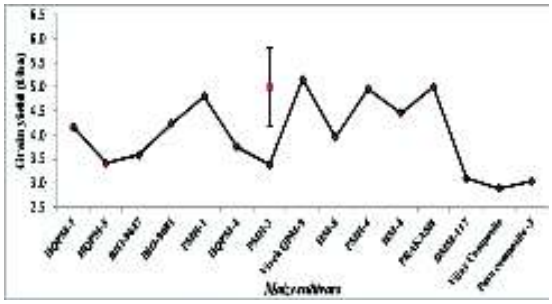


**Fig 31 Grain yield of various maize cultivars**
*(Vertical bar represents L.S.D. (P = 0.05) significant level)*

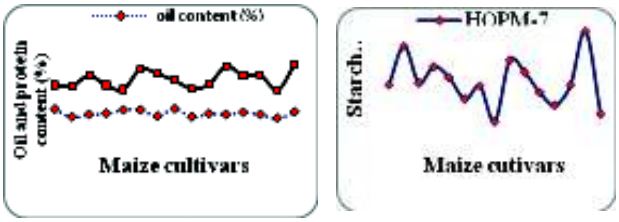



**Fig 32 Quality of various maize cultivars**
*(Oil, Protein and starch content)*

### Studies on breeding behavior of *Channa punctata* and *Pangia pangio* in different temperature regime

Breeding of *Channa punctata* is generally occurring in the month of April to June with the onset of monsoon. An experiment was conducted to study the breeding behavior, fertilization and hatching of this fish species in different temperature levels. The matured brooder (male and female) were collected from the rearing tank. Prior to breeding, they were fed with pelleted feeds containing 50% protein. On the 11 day they were injected with 0.7 ml/kg dose of Wova-FH. Injection was given intramuscularly into the dorso-lateral region of both males and females and released in fibre glass tanks having different water temperature i.e. 24 °C, 26 °C and 28 °C using thermostat heaters. The fishes show different latency period 8 to 10 hours. Rate of fertilization and number of fertilized eggs were different in different temperature. Hatching occurred after 48 hrs of spawning and highest survival rate were obtained in fishes maintained at 26 °C and 28 °C, respectively. Breeding and hatching performance of *P. pangio* were studied in different temperature i.e. 22 °C, 24 °C, 26 °C and 28 °C. Matured *P. pangio* brooders having body weight of 2.5±0.2 g (male) and 1.7±0.2g (female) were selected at the ratio of 2:1 (Male: female). A series of plastic tanks having (360×310×130) mm with a water depth of 8cm were taken in duplicate and maintained temperature at 24 °C, 26 °C and 28 °C respectively. Water quality such as temperature, pH, dissolved oxygen, carbon dioxide, nitrates, nitrites, phosphates etc of the spawning tray were analyzed by using water testing kits Aquacheck (Rankem). Fishes were given hormone injection at same dose of 0.05ml/100g of fish. A good chasing behavior was observed among the brooders kept in the temperature 24 °C, 26 °C and 28 °C. The fishes maintained at 22 °C showed no active movement or courting. The fishes remain hided in shaded areas of the tank. Highest number of eggs released and fertilization were observed in fish kept at 26 °C. Fishes maintained at water temperature of 28 °C released low number of eggs and fertilization rate was also low i.e, 45% of total eggs released. From the results, it is evident that normal spawning of *P. pangio* occurred at close 26 °C a lower temperature such as at 22 °C, no spawning was observed. Again a higher temperature of 28 °C, a very low spawning was seen. The percentage of fertilization and hatching rate of *P. pangio* were influenced with the range of temperatures. Highest percentage of fertilization (97.8%) was noticed in *P. pangio* at 26 °C.

## EXTENSION ACTIVITIES

### Popularization of tuber crops in Manipur through training, demonstration and entrepreneurship development

An attempt was taken to popularize the advanced tuber crops technologies through training, demonstration and development of entrepreneurship in Manipur. Under this programme, about 90 (Fig 1) farmers in the village Thoyee, Riha and Khonglo in Ukhrul district have been trained with scientific cultivation of different tuber crops. Quality planting materials of cassava and taro distributed amongst the progressive farmers for successful demonstration of these two important tuber crops (Fig 2). Training programmes for the extension functionaries and entrepreneurs were organized for scientific management, value addition and commercialization of tuber crops based products in the state. A tuber crop growers' association comprising of 100 progressive

farmers, 50 SHG members and 25 RYs has been constituted for successful production, value addition and marketing of tuber crop products for higher profitability.

**Fig 1 Dissemination of tuber crops technologies through training to farmers, SHGs and extension functionaries**

**Fig 2 Distribution of quality planting materials of cassava and colocasia at Thoyee village of Ukhrul**

### Animal Health Camp

The "Animal Health Camp cum Awareness Training Programme" was held in six different villages covering five districts of Manipur. During this programme, medicines, vitamins and mineral supplements,

**Outreach activities under Horticulture Mission (MM-I)**

| Sl. | Title of the Programme | Training | FLD | Others |
|---|---|---|---|---|
| 1. | Improved production and rejuvenation package for Khasi mandarin, Kachai lemon and Heiribob | 1 | 5 | — |
| 2. | Improved production technology of Kiwi fruit | — | 1 | — |
| 3. | Scientific production technology for high value vegetables and off-season vegetable farming | 1 | 7 | — |
| 4. | Mushroom production technology | — | 5 | — |
| 5. | Improved production package of turmeric and ginger | — | 1 | — |
| 6. | Value addition of fruits and vegetables | 6 | — | — |
| 7. | Farmers' Field Day on oyster mushroom | — | — | 1 |
| 8. | Farmers' Fair | — | — | 1 |
| | **Total** | **8** | **19** | **2** |

**Outreach programmes under Horticulture Mission (Mini Mission-I)**

anthelminthics were distributed to the farmers. Besides, vaccination programmes were conducted and livestocks and pet dogs were vaccinated against important diseases.

| Location | No. of Partici-pants | No. of animals vaccinated | | | | | |
|---|---|---|---|---|---|---|---|
| | | Cattle | Buffalo | Pig | Sheep | Goat | Dog |
| Marangching village, Tamenglong District | 60 | 30 | 10 | 100 | 4 | 20 | 45 |
| Laiphrakpam village, Imphal West district | 100 | 25 | 3 | 90 | - | - | 30 |
| Lungshang Aze village, Ukhrul district | 80 | 5 | - | 95 | - | - | 30 |
| Japhou village, Chandel district | 60 | 80 | 10 | 70 | 2 | 10 | 20 |
| Pearsonmun village, Churachandpur district | 80 | - | - | 80 | - | - | 60 |
| Kokchai village, Mayang Imphal, Imphal West district | 80 | 50 | - | 200 | - | - | 50 |
| **Total** | **460** | **190** | **23** | **635** | **6** | **30** | **235** |

**Carp seed production**

| Species | Spawn production (laks) | Fingerlings (No.) |
|---|---|---|
| *Cyprinus carpio* | 18 laks | 60,000 |
| *Ctenopharyngodon idellus* | 10 laks | 40,000 |
| *Osteobrama belangeri* | 10 laks | 30,000 |
| *Bangana dero* | 1 laks | 15,000 |
| *Clarias magur* | 0.60 laks | 15,000 |
| Others | 12 laks | 40,000 |
| **Total** | **51.60** laks | **2,00,000** |

**Basic seed production in rice during 2012-13 at ICAR (RC) Manipur Centre**

| Rice Variety | Quantity (Kg) | | Total |
|---|---|---|---|
| | Basic Seed | Labelled Seed | |
| RC Maniphou 4 (RCM 7) | 420 | - | 420 |
| RC Maniphou 5 (RCM 8) | 310 | - | 310 |
| RC Maniphou 6 (RCM 5) | 150 | 300 | 450 |
| RC Maniphou 7 (RCM 9) | 3500 | 1100 | 4600 |
| RC Maniphou 10 (RCM 10) | 450 | 6000 | 6450 |
| RC Maniphou 11 (RCM 11) | 2200 | - | 2200 |
| RC Maniphou 12 (RCM 13) | 710 | - | 710 |
| **Total rice** | **7740** | **7400** | **15,140** |
| Soybean (JS 335) | 160 | | |
| Groundnut (ICGS 76) | 160 | | |
| Maize (Pusa Composite 3) | 140 | | |
| Rapeseed (M 27) | 600 | | |
| **Total other crops** | **1060** | | |

# MIZORAM CENTRE

## WEATHER REPORT

The weather of Mizoram during April 2012 to March 2013 (Table 1) showed that the mean monthly maximum temperature varied from 23.0 °C in January 2013 to 31.82 °C in May 2012. The mean monthly minimum temperature varied from 12.5 °C (January, 2013) to 23.7 °C (July, 2012). The total rainfall was 2887.2 mm distributed over 139 rainy days. Around 672.5 mm of rainfall was received during April, 2012 which contributed 23 % of total annual rainfall. The mean monthly maximum relative humidity was highest in August, 2012 (97 %). The minimum relative humidity varied from 31 % (March) to 80 % (July and September).

**Table 1 Average monthly weather data of Kolasib, Mizoram from April 2012 to March 2013**

| Months | Max T (°C) | Min T (°C) | Max RH (%) | Min RH (%) | Rainfall (mm) | No. of rainy day | Cloud cover |
|---|---|---|---|---|---|---|---|
| April | 28.4 | 19.8 | 80 | 55 | 647.5 | 24 | 1.5 |
| May | 31.8 | 22.3 | 86 | 64 | 268.4 | 16 | 3.9 |
| June | 30.6 | 22.9 | 95 | 78 | 471.9 | 20 | 6.1 |
| July | 30.3 | 23.7 | 96 | 80 | 312.0 | 20 | 5.7 |
| August | 30.8 | 23.4 | 96 | 79 | 515.0 | 24 | 6.2 |
| September | 30.3 | 23.3 | 97 | 80 | 526.5 | 17 | 5.4 |
| October | 29.9 | 22.1 | 95 | 74 | 108.2 | 12 | 3.9 |
| November | 26.7 | 18.6 | 88 | 71 | 24.8 | 4 | 3.0 |
| December | 24.6 | 14.2 | 84 | 61 | 0.0 | 0 | 1.0 |
| January | 23.0 | 12.5 | 83 | 57 | 0.0 | 0 | 0.7 |
| February | 28.9 | 17.7 | 64 | 40 | 5.1 | 1 | 2.4 |
| March | 31.3 | 22.5 | 58 | 31 | 7.8 | 2 | 2.3 |

## CROP PRODUCTION

### RICE

#### Evaluation of different rice varieties under upland conditions

Five varieties *viz*., Bhalum 1, Bhalum 2, Bhalum 3, Bhalum 4 and IURON 514 were tested under upland conditions with all agronomic practices (Fig 1). Bhalum 3 recorded significantly higher grain (2.52 t/ha) and straw yield (7.38 t/ha) followed by IURON 514 which recorded 2.38 t/ha grain yield and 6.26 t/ha straw yield (Table 2).

**Table 2 Evaluation of rice varieties under upland conditions**

| Varieties | Straw yield (t/ha) | Grain yield (t/ha) |
|---|---|---|
| Bhalum 1 | 4.94 | 1.87 |
| Bhalum 2 | 4.28 | 1.63 |
| Bhalum 3 | 7.38 | 2.52 |
| Bhalum 4 | 4.80 | 2.13 |
| IURON 514 | 6.26 | 2.38 |
| SEm± | 0.06 | 0.10 |
| CD (*P* = 0.05) | 0.56 | 0.44 |

#### Evaluation of local germplasm of rice under upland conditions

Seventy two upland indigenous rice varieties were collected from eight districts of Mizoram and were evaluated for their yield potential (Fig 3). The yield data depicted in fig 2 revealed that MZR 19 produced higher grain yield of 2.83 t/ha followed by MZR 53 (2.62 t/ha) and MZR 27 (2.55 t/ha), whereas lesser grain yield was recorded in MZR 58 (0.32 t/ha).

**Fig 1 Field veiw of upland rice varieties**

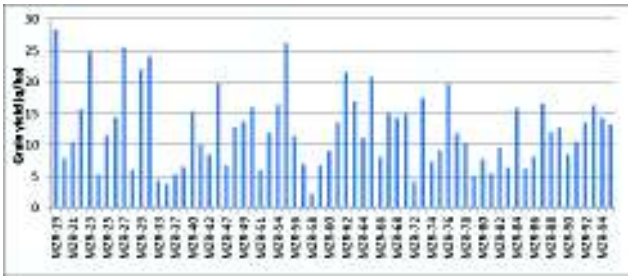


Fig 2 Grain yield (q/ha) of different local germplasm of rice during 2012-13

## Evaluation of different rice varieties under lowland conditions

Among 21 rice varieties tested (Table 3) under lowland conditions, Shasarang showed highiest grain yield (4.30 t/ha) followed by RCPL 1-408 (3.92 t/ha), whereas RCPL 1-111 recorded lowest grain yield (1.14 t/ha).


Fig 3 Different local germplasm of rice

**Table 3 Evaluation of rice varieties under lowland conditions**

| Varieties | Panicle length (cm) | No of panicle | Panicle weight (gm) | No of grains/ panicle | Test wt. (g) | Grain yield (t/ha) |
|---|---|---|---|---|---|---|
| RCPL 1-111 | 25.5 | 4.2 | 39.0 | 145.0 | 27.5 | 1.14 |
| RCPL 1-126 | 26.1 | 5.8 | 23.7 | 103.0 | 26.0 | 1.88 |
| RCPL 1-131 | 26.0 | 6.9 | 30.0 | 154.0 | 26.7 | 1.63 |
| RCPL 1-132 | 26.7 | 8.0 | 30.0 | 97.7 | 31.7 | 1.47 |
| RCPL 1-140 | 28.0 | 10.7 | 20.0 | 107.0 | 24.3 | 2.30 |
| RCPL 1-149 | 25.8 | 9.5 | 33.3 | 113.3 | 29.7 | 2.00 |
| RCPL 1-160 | 27.0 | 6.2 | 42.7 | 108.3 | 34.3 | 2.21 |
| RCPL 1-300 | 25.0 | 9.5 | 49.0 | 175.0 | 33.4 | 2.35 |
| RCPL 1-303 | 25.3 | 9.0 | 38.3 | 111.3 | 26.7 | 2.44 |
| RCPL 1-307 | 25.0 | 5.5 | 30.0 | 136.7 | 26.0 | 2.06 |
| RCPL 1-308 | 24.2 | 10.3 | 34.3 | 99.7 | 26.8 | 2.86 |
| RCPL 1-400 | 27.0 | 6.5 | 55.0 | 150.7 | 24.0 | 2.23 |
| RCPL 1-401 | 25.0 | 8.0 | 40.3 | 124.7 | 22.0 | 3.25 |
| RCPL 1-408 | 25.0 | 4.4 | 51.5 | 130.0 | 30.5 | 3.92 |
| RCPL 1-410 | 24.3 | 7.0 | 28.7 | 99.0 | 26.3 | 1.37 |
| RCPL 1-475 | 25.0 | 3.2 | 30.0 | 88.7 | 25.7 | 1.93 |
| Shasarang | 26.7 | 7.8 | 38.3 | 164.3 | 26.8 | 4.30 |
| IR 64 | 25.7 | 7.5 | 37.3 | 121.9 | 27.7 | 1.86 |
| RCM 9 | 26.2 | 7.7 | 37.8 | 143.1 | 27.3 | 2.36 |
| RCM 10 | 25.1 | 5.6 | 21.1 | 116.9 | 25.1 | 2.35 |
| RCM 11 | 26.7 | 7.1 | 38.3 | 164.3 | 26.8 | 3.05 |
| SEm± | 0.70 | 0.30 | 0.90 | 3.10 | 0.50 | 0.70 |
| CD ($P$ = 0.05) | 1.90 | 0.80 | 2.50 | 9.30 | 1.30 | 0.20 |

### Identification of drought or high temperature tolerant rice varieties

Three lowland rice varieties such as RCM 9, RCM 10 and RCM 11 (Fig 4) along with one local check were evaluated under different agro-climatic conditions of Mizoram *viz.,* Kawnpui (Kolasib district), Khawzwal and Champhai (Champhai district). Among the three varieties, RCM 10 recorded maximum yield in all the three locations *viz*., Kawnpui (4.0 t/ha.), Khawzwal (4.0 t/ha) and Champhai (3.8 t/ha), whereas local check recorded 2.19 t/ha in Kawnpui, 3.1 t/ha in Khawzwal and 2.9 t/ha in Champhai (Table 4). Leaf folder infestation was very high in RCM 9 and RCM 11, whereas RCM 10 was free from leaf folder infestation. However, local check was highly susceptible to leaf folder and ear head bug.

**Fig 4 Performance of different rice varieties viz., RCM 10, RCM 9 and RCM 11**

## MAIZE

### Evaluation of different varieties of maize during *kharif* 2012

Thirteen maize varieties collected from VPKAS, Almora and one local land race of Kolasib were evaluated for yield potentials. Results revealed that the cob length (21.47 cm), cob girth (16.93 cm) and grain yield (6.05 t/ha) were significantly higher in CMH 08-337 as compared to other varieties (Table 5).

### Evaluation of local germplasm of maize of Mizoram

Thirty three indigenous maize varieties collected from eight districts of Mizoram were evaluated for their yield potential (Fig 5 and 6). Among 33 indigenous

**Fig 5 Grain yield (t/ha) Thirty three land races of maize from Mizoram during 2012-13**

**Table 4 Performance of rice varieties under different climatic conditions of Mizoram**

| Varieties | Height of plant (cm) | No. of tiller | Panicle length (cm) | Yield (t/ha) | Remarks |
|---|---|---|---|---|---|
| **Kawnpui, (Lowland)** | | | | | |
| RCM 9 | 70.1 | 12 | 24.5 | 3.4 | High incidence of leaf folder in RCM 9 and RCM 11 |
| RCM 10 | 68.7 | 16.5 | 30.0 | 4.0 | |
| RCM 11 | 78.2 | 13.6 | 26.0 | 3.6 | |
| Local | 99.6 | 15.0 | 22.6 | 2.2 | High incidence of leaf folder and ear head bug |
| **Khawzwal (Lowland)** | | | | | |
| RCM 9 | 92.2 | 10.6 | 24.5 | 3.2 | NIL |
| RCM 10 | 100.2 | 12.2 | 22.7 | 4.0 | |
| RCM11 | 97.1 | 9.2 | 19.5 | 3.0 | |
| Local | 139 | 9.4 | 24.8 | 3.1 | |
| **Champhai (Lowland)** | | | | | |
| RCM 9 | 75.6 | 9.2 | 21.7 | 2.8 | Late panicle initiation in RCM 9 and RCM 11 due to low temperature |
| RCM 10 | 81.8 | 11.6 | 23.1 | 3.8 | |
| RCM 11 | 84.5 | 9.8 | 23.4 | 2.7 | |
| Local | 129.5 | 7.6 | 20.5 | 2.9 | |

**Table 5 Evaluation of different varieties of maize during *kharif* 2012**

| Varieties | Cob girth (cm) | Cob length (cm) | Lines per cob | No. of grains per line | Average grainwt. (g) | Grain yield (t/ha) |
|---|---|---|---|---|---|---|
| PEEHM 5 | 14.96 | 18.60 | 14.20 | 34.20 | 161.60 | 3.69 |
| Vivek QPM 9 | 15.99 | 17.19 | 15.67 | 33.13 | 151.40 | 3.41 |
| Vivek hybrid 9 | 16.36 | 17.67 | 15.40 | 34.87 | 161.13 | 5.16 |
| Vivek hybrid 21 | 15.29 | 16.25 | 13.60 | 32.60 | 139.73 | 2.35 |
| Vivek hybrid 23 | 15.98 | 19.35 | 14.00 | 34.27 | 169.13 | 1.77 |
| Vivek hybrid 25 | 17.45 | 21.43 | 15.20 | 37.80 | 218.13 | 4.46 |
| Vivek hybrid 33 | 16.70 | 18.63 | 16.00 | 36.40 | 176.60 | 4.77 |
| Vivek hybrid 39 | 16.63 | 20.20 | 14.93 | 37.67 | 195.27 | 3.98 |
| Vivek hybrid 43 | 15.91 | 18.43 | 13.73 | 35.87 | 208.87 | 3.57 |
| CMH 08-156 | 16.90 | 20.17 | 15.87 | 36.93 | 195.00 | 4.61 |
| CMH 08-239 | 16.73 | 20.53 | 14.53 | 37.33 | 204.13 | 3.48 |
| CMH 08-337 | 16.93 | 21.47 | 15.47 | 31.13 | 204.07 | 6.05 |
| KNMH 408710 | 16.85 | 18.55 | 15.20 | 34.80 | 176.00 | 4.84 |
| Local check (Mimban Dum) | 16.45 | 19.48 | 15.27 | 33.40 | 183.73 | 3.90 |
| SEm± | 0.94 | 0.63 | 0.39 | 1.11 | 10.65 | 0.32 |
| CD ($P$ = 0.05) | 1.92 | 1.29 | 0.80 | 2.27 | 21.81 | 0.67 |

**Fig 6 Local germplasm of maize**

maize varieties evaluated, four varieties had more grain yield which ranged from 2.5 to 3.0 t/ha. The highest grain yield was recorded in MZ 5 (2.6 t/ha) and MZ 31 (2.6 t/ha).

### Effect of mulching and earthing up on growth and yield of *rabi* maize

Maize cultivar RCM 76 was evaluated with nine treatments during *rabi* season. The highest plant height (176 cm), cob length (18.64 cm) and grain yield (4.16 t/ha) was recorded in furrow sowing + mulching + 2 earthing up method followed by line sowing + mulch + 2 earthing up method (Table 6).

### Integrated nutrient management in maize

In maize experiment, the plant height (213.6 cm) was significantly higher in 100 % recommended dose of fertilizer (RDF) followed by 50 % RDF along with 5 t of FYM (211.5 cm) compared to control (Table 7). The cob length was higher in 100 % RDF (21.10 cm) followed by 50 % RDF along with 5 t FYM (20.40 cm) and 50 % RDF along with 2.5 t vermicompost (19.63 cm). The grain yield was significantly higher in 100 % RDF (7,018 kg/ha) followed by 50 % RDF along with 5 t FYM (6747 kg/ha). The lower grain yield was observed in the control treatment. The stover yield was higher in 100 % RDF followed by 50 % RDF along with 5 t FYM compared to the control. The harvest index was not significantly influenced by the treatments (Table 7).

**Table 6 Effect of mulching and earthing up on growth and yield of *rabi* maize**

| Treatments | Plant height (cm) | Cob length (cm) | Cob weight (g) | Yield (t/ha) |
|---|---|---|---|---|
| Line sowing | 105 | 13.64 | 98.5 | 1.72 |
| Line sowing + mulching | 135 | 14.37 | 141.6 | 2.64 |
| Line sowing + earthing up | 115 | 13.86 | 136.7 | 2.36 |
| Line sowing + 2 earthing up | 145 | 14.82 | 164.2 | 2.77 |
| Line sowing + mulching + 1 Earthing up | 156 | 16.24 | 168.4 | 3.22 |
| Line sowing + mulching + 2 earthing up | 171 | 18.12 | 186.4 | 3.84 |
| Furrow sowing | 130 | 15.37 | 156.2 | 2.62 |
| Furrow sowing + earthing up | 165 | 17.67 | 175.0 | 3.38 |
| Furrow sowing + mulching + 2 earthing up | 176 | 18.64 | 186.4 | 4.16 |
| SEm± | 4 | 0.47 | 4.0 | 0.10 |
| CD ($P$ = 0.05) | 13 | 1.40 | 12.0 | 0.29 |

**Table 7 Effect of INM on growth, yield and yield attributes of maize**

| Treatments | Plant height (cm) | Cob length (cm) | Grain yield (kg/ha) | Stover yield (kg/ha) | Harvest index |
|---|---|---|---|---|---|
| $T_0$- Control | 145.6e | 15.90g | 5188d | 8980d | 0.32a |
| $T_1$- 100 % RDF | 213.6a | 21.10a | 7018a | 10410a | 0.36a |
| $T_2$- 50 % RDF | 199.4b | 19.00cd | 5878c | 9548bcd | 0.34a |
| $T_3$- 50 % RDF + 5 t FYM | 211.5ab | 20.40ab | 6747a | 9927ab | 0.35a |
| $T_4$- 50 % RDF+ 2.5 t vermicompost | 207.5ab | 19.63bc | 6392b | 9821abc | 0.35a |
| $T_5$- lime + FYM + vermicompost | 180.6c | 17.73ef | 5426d | 9165cd | 0.35a |
| $T_6$- 5 t FYM | 202.6ab | 19.06cd | 6116bc | 9623bcd | 0.36a |
| $T_7$- 2.5 t vermicompost | 184.7c | 18.16de | 5832c | 9226bcd | 0.35a |
| $T_8$- Lime alone | 162.6d | 16.90fg | 5321d | 9079d | 0.34a |

## GROUNDNUT

### Effect of different sources of boron on growth and yield of groundnut

The performance of bold seeded groundnut variety ICGS 76 was evaluated with different boron sources during *kharif*, 2012. The data presented in Table 8 revealed that maximum pod yield of 2.11 t/ha was recorded with three foliar application of Colemanite (2 kg/ha) followed by basal applications of borax (20 kg/ha) (2.06 t/ha) which was on par with boric acid (20 kg/ha) (2.04 t/ha) and Colemanite (20 kg/ha) (1.99 t/ha).

## MUSTARD

### Performance of mustard under zero tillage practice

The performance of mustard (cv. M 27) was evaluated under zero tillage (Fig 7) after harvest of lowland rice with five soil amelioration treatments. The crop was sown in mid November i.e. after the harvest of rice. A uniform dose of 60 kg N/ha in two split doses were applied in all treatments at the time of sowing and flowering. Among five treatments applied, vermicompost @ 2t/ha recorded significantly tallest plants (56.53 cm), more branches (4.33), highest pod length (6.37 cm), test weight (3.72 g) and grain yield (1.41 t/ha) followed by application of lime @ 2t/ha +

**Table 8 Effect of different source of boron on yield of groundnut**

| Treatments | Plant height (cm) | No. of branches /plant | No. of pods / plant | 100 pod wt. (g) | Pod yield (t/ha) |
|---|---|---|---|---|---|
| Colemanite @ 20 kg/ha as soil application | 27.73 | 8.90 | 20.29 | 179.5 | 1.99 |
| Colemanite @ 10 kg/ha as seed dressing | 22.04 | 8.15 | 17.38 | 166.2 | 1.70 |
| Colemanite as foliar spray (2 kg/ha) | 26.95 | 8.41 | 21.49 | 233.7 | 2.11 |
| Solubur @ 20 kg/ha as soil application | 25.03 | 9.44 | 15.64 | 134.7 | 1.52 |
| Solubur as foliar spray (2 kg/ha) | 26.63 | 8.83 | 17.86 | 137.5 | 1.73 |
| Borosol @ 20 kg/ha as soil application | 23.55 | 7.43 | 15.75 | 114.2 | 1.53 |
| Borosol as foliar spray (2 kg/ha) | 19.54 | 7.14 | 17.40 | 163.7 | 1.68 |
| Borax @ 20 kg/ha as soil application | 22.05 | 10.20 | 20.94 | 216.9 | 2.06 |
| Boric acid @ 20 kg/ha as soil application | 27.79 | 8.51 | 20.86 | 175.3 | 2.04 |
| Control (No boron application) | 19.89 | 6.86 | 14.08 | 116.5 | 1.38 |
| SEm± | 1.79 | 0.58 | 0.52 | 1.90 | 0.13 |
| CD (*P*=0.05) | 4.87 | 1.58 | 1.42 | 5.10 | 0.36 |

**Fig 7 Performance of different rice varieties viz., RCM 10, RCM 9 and RCM 11**

$P_2O_5$ (20 kg/ha) and SSP @ 20 kg /ha. However, the benefit cost ratio (1:1.51) was the highest for single dose application of SSP @ 20 kg/ha (Table 9).

## SOYBEAN

### Integrated nutrient management in soybean

In integrated nutrient management practices on residual crop of soybean (Table 10), the highest plant height was resulted in 100 per cent recommended dose of fertilizer (70.13 cm) followed by integrated nutrient management practices of 50 per cent recommended dose of fertilizer along with 5 t FYM (68.53 cm). The yield per pot was higher in the 100 per cent recommended dose of fertilizer (128.89 g/plot) followed by 50 per cent recommended dose of fertilizer along with 5 t FYM (120 g/plot).

## PEA

### Performance of pea varieties under zero tillage

Two varieties of pea viz., Arkel and Prakash were tested for their performance under residual soil moisture after the harvest of low land rice (Fig 8). Pre-soaked seeds as per treatment were broadcasted in the low land one day after harvest of rice. The mean germination and pod yield of Arkel found to be superior to Parkash (Table 11). Arkel recorded the highest crop

**Table 9 Performance of mustard under zero tillage practice**

| Treatment | Plant height (cm) | No of branches | Pod length (cm) | Test wt. (g) | Yield (t/ha) | BCR |
|---|---|---|---|---|---|---|
| SSP @ 20 kg / ha | 49.23 | 2.45 | 5.23 | 3.54 | 1.33 | 1 : 1.51 |
| Lime @ 500 kg / ha | 42.67 | 2.20 | 4.92 | 3.44 | 1.16 | 1 : 1.13 |
| Lime @ 20 kg/ha + SSP @ 500 kg / ha | 52.05 | 4.20 | 5.63 | 3.61 | 1.40 | 1 : 1.48 |
| Vermicompost @ 2 t/ha | 56.52 | 4.33 | 6.37 | 3.72 | 1.41 | 1 : 1.15 |
| Control | 38.24 | 1.82 | 4.24 | 3.01 | 1.05 | 1 : 1.12 |
| SEm± | 1.18 | 0.09 | 0.13 | 0.08 | 0.03 | - |
| CD ($P$ = 0.05) | 3.17 | 0.24 | 0.36 | 0.21 | 0.08 | - |

**Table 10 Effect of integrated nutrient management on growth, yield and yield attributes of soybean (2012-13)**

| Treatments | Different growth and yield parameters | | | |
|---|---|---|---|---|
| | Plant height (cm) | No of pods /plant | No. of clusters / plant | Yield (g)/plot |
| $T_0$- Control | 49.31d | 48.2f | 14.4d | 49e |
| $T_1$- 100 % RDF | 69.49a | 58.9a | 24.2a | 128a |
| $T_2$- 50 % RDF | 61.46c | 52.2bcde | 17.0c | 89bc |
| $T_3$- 50 % RDF + 5 t FYM | 66.67ab | 56.0ab | 23.6a | 120a |
| $T_4$- 50% RDF+ 2.5 t vermicompost | 64.64bc | 55.3abc | 20.8b | 100b |
| $T_5$- lime + FYM + vermicompost | 51.02d | 50.9def | 15.6cd | 70d |
| $T_6$- 5 t FYM | 63.64bc | 54.2bcd | 20.6b | 97bc |
| $T_7$- 2.5t vermicompost | 53.39d | 51.9cdef | 16.3cd | 85c |
| $T_8$- Lime alone | 50.71d | 49.7ef | 15.3cd | 61de |

**Fig 8 Field veiw of pea trail (A) Arkel and (B) Prakash**

**Table 11 Effect of pre-soaking on germination and yield of pea under zero tillage**

| Treatment | Arkel | | | Prakash | | |
|---|---|---|---|---|---|---|
| | Crop establish(%) | Green pod yield (t/ha) | Grain Yield (q/ha) | Crop establish (%) | Green pod Yield (t/ha) | Grain yield (t/ha) |
| 0 hours | 38.5 | 1.52 | 0.86 | 28.3 | 1.04 | 0.76 |
| 12 hours | 42.2 | 1.52 | 0.85 | 28.8 | 1.02 | 0.75 |
| 18 hours | 65.4 | 1.92 | 1.22 | 34.5 | 1.26 | 0.93 |
| 24 hours | 72.8 | 2.06 | 1.29 | 45.8 | 1.45 | 1.07 |
| 36 hours | 70.5 | 2.08 | 1.32 | 52.5 | 1.52 | 1.13 |
| 48 hours | 64.3 | 1.94 | 1.21 | 48.3 | 1.46 | 1.08 |
| Mean | 58.9 | 1.84 | 1.12 | 39.7 | 1.29 | 0.95 |
| SEm± | 1.6 | 0.30 | 0.02 | 1.2 | 0.02 | 0.02 |
| CD (*P* = 0.05) | 8.8 | 0.18 | 0.12 | 6.3 | 0.13 | 0.11 |

establishment percentage (72.8) when seed were soaked for 24 h., whereas Prakash recorded the highest crop establishment percentage (52.5) when seed were soaked for 36 hrs. The highest pod (2.08 t/ha) and grain yield (1.32 t/ha) recorded in Arkel when seed were soaked for 24 hrs. Whereas, Prakash recorded maximum pod (1.52 t/ha) and grain yield (1.13 t/ha) when seed were soaked for 36 hrs.

## LENTIL

### Effect of pre-soaking on germination and yield

Among six different treatments of pre-soaking of lentil seed (cv. BPL 15), the highest crop establishment (74.75%) and grain yield (1.24 t/ha) observed when seed were soaked for 24 hrs. (Fig 9 and Table 12)

**Fig 9 Field veiw of lentil under zero tillage**

**Table 12 Effect of pre-soaking of seeds on germination and yield of lentil under zero tillage**

| Treatments | Germination (%) | Yield (t/ha) |
|---|---|---|
| 0 hrs | 52.2 | 0.95 |
| 12 hrs | 58.0 | 1.07 |
| 18 hrs | 64.8 | 1.10 |
| 24 hrs | 74.8 | 1.24 |
| 36 hrs | 60.3 | 1.16 |
| 48 hrs | 56.2 | 1.02 |
| SEm± | 2.28 | 0.04 |
| CD (*P*=0.05) | 7.12 | 0.14 |

## FRUITS

## MANGO

### Canopy management of mango (*Mangifera indica* cv. Amrapali)

Treatments consisted of three spacing arrangements of plants 2.5 x 2.5 m, 3 x 2.5 m and 2.5 x 1.5 m accommodating plant densities: 100 (control), 1600, 1333 and 2666 plants per hectare, respectively. Plant vegetative growth parameters were evaluated after 6 months of planting. In general, high density planting caused reduction in vegetative and reproductive variables of individual mango trees (Table 14).

**Table 14 Vegetative growth of high density planted mango cv. Amrapali**

| Block &Spacing (m) | Leaves/ flush | Plant height (m) (mm) | Trunk diameter (cm) | Canopy diameter | Canopy height (m) shoot | No. of terminal apical shoots | No. of compressed |
|---|---|---|---|---|---|---|---|
| Block-I (2.5 x 2.5) | 9.24 | 0.68 | 6.91 | 25.49 | 0.84 | 1 | 1 |
| Block-II (3 x 2.5) | 12.14 | 0.72 | 7.32 | 27.18 | 0.87 | 1 | 1 |
| Block-III (2.5 x 1.5) | 10.18 | 0.61 | 6.19 | 22.98 | 0.74 | 1 | 1 |

## BANANA

### Introduction and evaluation of plantains (*Musa* sp.) in Mizoram

Nineteen genotypes of banana and plantains were collected from Banana Research Station (BRS), Kerala Agriculture University, Thissur, Kerala. All the genotypes responding very well under Mizoram conditions and are at vegetative stage (Fig 11). Among all the collections, Monthan (ABB), Nendran (AAB) and Kunnan (AB) are plantain types. List of plantains which were collected for evaluation in Mizoram is depicted in Table 15.

**Fig 11 Multiplication of banana genotypes**

**Table 15 List of genotypes collected and their genetic constitution**

| Genotypes | Genetic constitution | Genotypes | Genetic constitution |
|---|---|---|---|
| Padathi | (AAB) | Manoranjitham | (AAA) |
| Niyalipoovan | (AB) | Anaikomban | (AA) |
| Palayamkodan | (AAB) | Tongat | (AA) |
| Monthan | (ABB) | Pisang jaribuya | (AA) |
| Karpoorvalli | (ABB) | Pisang Lilin | (AA) |
| Sannachenkadali | (AA) | Rasthali | (AAB) |
| Robusta | (AAA) | Nendran | (AAB) |
| Chhakrakeli | (AAA) | Kadali | (AA) |
| Yangambi KM-5 | (AAA) | Kunnan | (AB) |
| Chenkadali | (AAA) | | |

## VEGETABLES

## FRENCH BEAN

### Identification of water deficit stress tolerant French bean genotypes for *rabi* season

Among all the genotypes, the highest no. of leaves was found in MZFB 48 (282) and the lowest in MZFB 47 (116) in well watered (WW) plants, whereas in water stressed (WS) plants, MZFB 38 (155) recorded maximum no. of leaves and the lowest in MZFB 45 (42) (Fig 12 and Table 16). Root collar shrinkage is one of the important parameter to visualise stress wherein in WW plants there was no significant shrinkage but in WS plants showed significant differences in collar diameter shrinkage. Maximum shrinkage was found in MZFB 40 (2.57mm) and lowest in MZFB 27 (6.55 mm). Under WW conditions, there was no significant difference in yield among all the genotypes. Contrastingly, in WS plants there were significant differences wherein MZFB 29 (52.23 g) gave the maximum pod yield, whereas, MZFB 32 and MZFB 43 recorded the lowest pod yield (6.80 g).

**Fig 12 Experiment on identification of water deficit stress tolerant French bean**

## TOMATO

### Evaluation of tomato genotypes

The field experiment was conducted to evaluate the performance of five tomato cultivars under chilling winter temperatures of Mizoram (Fig 13). Plant height was recorded significantly higher in Sel12 (75.66 cm) than all the other cultivars whereas stem thickness found to be highest in Pusa Rohini (Table 17). Number of fruits per plant found to be significantly higher in Pusa Rohini (38.66) and Dev NP 5081 (35.00) as compared to other cultivars. There was no significant difference in single fruit weight among all the tomato

**Fig 13 Evaluation of tomato genotypes**

**Table 16 Morphological and reproductive characters of French bean genotypes during well watered (WW) and water stressed (WS) conditions**

| Genotypes | No. of leaves | | Root collar diameter (mm) | | No. of pods/ plant | | Pod length (cm) | | Pod yield (g) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | WW | WS | WW | WS | WW | WS | WW | WS | WW | WS |
| MZFB 27 | 148 | 93 | 5.51 | 6.55 | 8.33 | 5.67 | 12.80 | 10.30 | 93.11 | 15.43 |
| MZFB 28 | 214 | 90 | 5.56 | 4.52 | 11.00 | 9.33 | 10.57 | 7.68 | 49.47 | 18.80 |
| MZFB 29 | 174 | 87 | 6.02 | 4.32 | 14.33 | 9.33 | 14.63 | 13.28 | 118.43 | 52.23 |
| MZFB 30 | 183 | 144 | 3.94 | 4.45 | 8.33 | 4.00 | 14.13 | 9.97 | 87.50 | 19.03 |
| MZFB 36 | 209 | 133 | 5.81 | 4.66 | 8.33 | 4.67 | 12.13 | 8.60 | 67.37 | 15.63 |
| MZFB 32 | 250 | 126 | 6.06 | 4.80 | 10.33 | 2.00 | 10.07 | 8.50 | 66.93 | 6.80 |
| MZFB 38 | 211 | 155 | 4.04 | 4.58 | 23.67 | 7.00 | 9.30 | 7.00 | 83.23 | 11.70 |
| MZFB 40 | 252 | 108 | 4.90 | 2.57 | 17.67 | 8.00 | 9.07 | 9.68 | 91.90 | 31.17 |
| MZFB 41 | 212 | 82 | 3.94 | 3.80 | 19.33 | 7.67 | 10.43 | 9.67 | 106.20 | 39.13 |
| MZFB 42 | 174 | 109 | 4.28 | 3.38 | 19.33 | 6.33 | 11.33 | 8.48 | 108.70 | 20.60 |
| MZFB 43 | 204 | 54 | 4.21 | 3.51 | 16.33 | 6.00 | 8.13 | 6.90 | 53.40 | 6.80 |
| MZFB 44 | 159 | 93 | 5.53 | 5.36 | 13.67 | 5.33 | 9.73 | 9.10 | 89.67 | 18.67 |
| MZFB 45 | 159 | 42 | 3.80 | 4.18 | 14.67 | 6.67 | 14.23 | 11.43 | 98.77 | 28.97 |
| MZFB 47 | 116 | 64 | 5.57 | 5.59 | 12.67 | 4.67 | 12.00 | 9.93 | 84.97 | 18.15 |
| MZFB 48 | 282 | 121 | 5.05 | 3.82 | 12.67 | 8.33 | 13.63 | 7.43 | 96.03 | 39.29 |
| MZFB 49 | 167 | 109 | 4.27 | 3.57 | 9.67 | 5.33 | 11.43 | 11.07 | 60.20 | 23.90 |
| MZFB 50 | 164 | 69 | 4.24 | 3.16 | 11.33 | 8.33 | 9.57 | 8.77 | 65.10 | 29.97 |
| MZFB 51 | 227 | 85 | 4.99 | 4.78 | 7.67 | 4.33 | 11.37 | 10.10 | 53.37 | 21.40 |
| MZFB 52 | 206 | 93 | 6.03 | 5.17 | 5.00 | 6.67 | 13.13 | 9.71 | 69.88 | 24.10 |
| MZFB 53 | 190 | 78 | 4.77 | 3.99 | 13.00 | 7.33 | 11.20 | 10.68 | 93.97 | 26.83 |
| MZFB 70 | 186 | 61 | 4.05 | 4.08 | 9.00 | 9.00 | 10.03 | 8.43 | 60.37 | 23.57 |
| MZFB 74 | 232 | 81 | 3.60 | 4.05 | 15.00 | 9.00 | 9.43 | 8.07 | 86.70 | 24.93 |
| MZFB 76 | 160 | 82 | 3.67 | 4.36 | 12.00 | 5.00 | 6.40 | 7.23 | 74.50 | 31.97 |
| SEm± | 27.46 | 17.08 | 0.67 | 0.59 | 2.57 | 1.86 | 1.01 | 1.39 | 16.38 | 7.22 |
| CD ($P = 0.05$) | 78.43 | 48.79 | N.S | 1.71 | 7.34 | N.S | 2.90 | N.S | N.S | 20.62 |

**Table 17 Performance of different tomato cultivars under winter conditions**

| Cultivar | Plant height (cm) | Stem thickness (mm) | Number of fruits / plant | Single fruit weight (g) | Fruit production (kg/ plant) | Healthy plant (%) | Disease reaction |
|---|---|---|---|---|---|---|---|
| Pusa Rohini | 29.63 | 12.41 | 38.66 | 47.66 | 1.85 | 90.33 | Free |
| Rocky | 27.80 | 12.12 | 23.33 | 46.33 | 1.10 | 80.66 | Free |
| Sel 12 | 75.66 | 11.42 | 21.00 | 41.33 | 0.85 | 78.33 | Bacterial Wilt |
| Dev NP 5081 | 24.93 | 10.42 | 35.00 | 50.00 | 1.75 | 85.33 | Free |
| Manithoibi | 27.57 | 12.11 | 20.00 | 43.00 | 0.85 | 79.00 | Blossom end rot |
| SEm± | 9.27 | 1.22 | 1.73 | 2.81 | 0.10 | 3.47 | |
| CD ($P = 0.05$) | 30.70 | N.S | 5.75 | N.S | 0.35 | N.S | |

cultivars. Significantly higher fruit production (kg/ plant) was recorded in Pusa Rohini (1.85) and Dev NP 5081 (1.75) as compared to other cultivars. Bacterial wilt and blossom end rot was recorded in Sel 12 and Manithoibi, respectively.

## SPICES

### TURMERIC

**Genotype × environment interaction on quality of turmeric**

The maximum yield was recorded for RCT 1(29.8 t/ha), followed by BSR 2 (28.8 t/ha), IISR Kedaram (27.6 t/ha). Moreover, dry matter content found to be highest in Rashmi (20.80 %) followed by Roma (20.13 %) and Duggeralia Red (20.06 %). The maximum plant height was recorded for IISR Allepy Superme (60.03 cm), followed by IISR Pratibha (57.82 cm) and BSR 2 (57.48 cm) The severity of leaf spot (*Colletotrichum curcumae* and *C. capsici*) was more severe than leaf blotch (*Taphrina maculans*). Leaf spot and blotch severity was recorded in four genotypes viz., Suranjana, Narendra Haldi, BSR 2 and Rajendra Sonia.

### GINGER

**Genotype × environment interaction on quality of ginger**

The average leaf length was highest for Nisapui (Local) (19.46 cm) which is at par with Varda (19.40 cm) and Mahima (18.96 cm). The maximum yield was recorded for Himgiri (15.4 t/ha) followed by Nadia (13.1 t/ha) and Mahima (12.5 t/ha). The highest plant height was recorded for Nisapui (Local) (41.336 cm) followed by Himgiri (40.76) and Mahima (40.66).

## DISEASE

**Surveillance for soft rot free areas in Mizoram**

The survey data revealed that the terrace type of cultivation observed more soft rot incidence than *jhum* cultivation (Table 18). The incidence of disease was higher when crop exposed to sun than shade areas. In Kolasib regions, the highest incidence of soft rot was recorded at Sihapui (39.76 %) followed by Kawnpui (36.30 %), Kawnpui (35.20 %). The least per cent disease incidence recorded from Runglei, (6.89 %), Thingdwal (7.23 %) and Nisapui (8.74%), where *jhum*ing type of ginger cultivation was pre-dominant.

**Management of soft rot pathogen in ginger**

Five treatments (Table 19 and Figs 14 and 15) were evaluated against soft rot causing pathogen, *Pythium* spp. in both pot culture and field experiments. In pot culture experiment, cent per cent disease incidence was recorded in untreated rhizome growing pots, whereas the minimum incidence and highest rhizome yield observed in treatment $T_4$ (4.00 % and 1.12 kg/pot) when

**Table 18 Soft rot incidence (%) at various farmer fields in *jhum* and terrace cultivation**

| Farmer's name | Locations | Types of cultivation | Soft rot incidence (%) |
|---|---|---|---|
| Pu Chawngchhuana | Kolasib | *Jhum* | 22.30 |
| Pi Lalremi | Kolasib | *Jhum* | 19.30 |
| Pi Hminglovi | Kolasib | Terrace | 33.70 |
| Pi Lallianmawii | Kawnpui | Terrace | 36.30 |
| Pu Lallawmma | Kawnpui | Flat | 35.20 |
| KVK, Kolasib | Runglei | *Jhum* | 6.89 |
| Pu Sanghuapa | Saihapui | Flat land | 39.76 |
| Pu Lalrinkma | Chemphai | Terrace | 22.30 |
| Mr. Hamingvarte | Thingdwal | *Jhum* | 9.63 |
| KVK, Khazhwal | Champhai | Terrace | 10.20 |
| Pu Thangmawia | Thingdwal | *Jhum* | 7.23 |
| Pu Zungdua | Bairabi | Flat | 26.84 |
| Mr. Bahadur | Nisapui | *Jhum* | 13.60 |
| Pi Himagaihi | Nisapui | *Jhum* | 8.74 |
| Pu Zarzoliana Ralte | Kawnpui | *Jhum* | 11.26 |
| Pu HC Lalhangliana | Sherkhan | *Jhum* | 10.63 |

treated with strobilurins (Pyraclostrobin 20%) @ 0.2 % rhizome for 30 min along with copper oxychloride (0.3 %) as soil application before planting. In field conditions, the minimum disease incidence (12.60 %) and highest rhizome yield (3.48 kg/plot) was recorded in treatment ($T_4$) (Fig 17). The highest soft rot incidence was observed in control with 96.89 per cent with lest yield of 0.44 kg/plot (Fig 16).

**Fig 14 Rhizome treated with $T_4$ and shade drying cv. Thinglaidum**

**Fig 15 Rhizome treated with $T_3$ and shade drying cv. Thinglaidum**


**Fig 16 Control ($T_1$)**


**Fig 17 Treatment $T_4$**

**Table 19 Observation on soft rot incidence and yield of cv. Thinglaidum in pot culture and field experiment**

| Treatments | Pot culture | | Field experiment | | |
|---|---|---|---|---|---|
| | Soft rot incidence (%) | Yield (kg/pot) | Soft rot incidence (%) | Yield (kg/plot) | Shoot borer incidence (%) |
| $T_1$ (control) | 100.00 | 0.00 | 96.89 | 0.44 | 2.12 |
| $T_2$ | 54.00 | 0.28 | 48.89 | 1.58 | 2.04 |
| $T_3$ | 15.00 | 0.66 | 29.33 | 2.04 | 1.16 |
| $T_4$ | 4.00 | 1.12 | 12.60 | 3.48 | 1.5 |
| $T_5$ | 35.00 | 0.62 | 62.66 | 1.12 | 0.48 |
| CD ($P = 0.05$) | 10.09 | 0.17 | 6.00 | 0.28 | 0.29 |
| CV (%) | 15.67 | 24.00 | 8.95 | 12.21 | 15.00 |

$T_1$- Apparently healthy rhizome planting (Control), $T_2$- HWT (47$^0$C) for 30 min followed by shade drying, $T_3$- HWT (47 $^0$C) for 30 min + Lantana @ 25% smearing followed by shade drying, $T_4$- strobilurins (Pyraclostrobin 20%) @ 0.2% rhizome treatment for 30 min + copper oxychloride (0.3%) soil application and $T_5$- HWT (47$^0$C) for 30 min + Trichoderma (2.5 kg/50kg FYM/ha, mixing in soil at planting time) + copper oxychloride (0.3%) soil application

## ANTHURIUM

## DISEASES

### Eco-friendly management of anthurium diseases under protected cultivation

A survey was undertaken to estimate severity and incidence of major diseases and insect pests from different anthurium growing areas of Kolasib and Aizawl districts of Mizoram during winter season 2012-2013. The anthurium plants were found to be associated with different type pathogens of fungi and bacteria such as *Pythium*, *Phytopthora*, *Rhizoctonia, Colletotrichum* and bacteria viz., *Xanthomonas* and *Ralstonia* (Table 20 and Figs 18 to 23). Among the diseases, the bacterial blight caused by *Xanthomonas axonopodis* pv. *dieffenbachiae* observed as major diseases and prevalent in almost all anthurium growing regions of Kolasib (67.0 %) and Aizawl (58.3 %) followed by *Colletotrichum gleosporides* (30.3 % and 35 %) and *Rhizoctonia* root rot (19 % and 25 %). The least root rot incidence (10 % and 15 %) recorded in *Phytopthora* and *Pythium* and suspected a bacterial wilt like disease also encountered only in Aizawl with 4.9 per cent incidence.

### Insect Pests

The major insect pests of anthurium were tobacco caterpillar (*Spodoptera litura*), Mosquito bug (*Helopeltis* spp.), grasshopper, caterpillar, scale insect and aphid found to be abundant during the dry periods of the year (Table 21 and Figs 24 to 26). All insect pests infested the economic parts of anthurium i.e. stalk, spathe and spadix, except aphids which found

**Table 20 Different diseases severity and incidence in anthurium**

| Name of diseases | Pathogens | Districts Disease (%) | | | |
|---|---|---|---|---|---|
| | | Kolasib* | | Aizawl@ | |
| | | Severity | Incidence | Severity | Incidence |
| Bacterial Blight | *Xanthomonas axonopodis* pv. *dieffenbachiae* | 67.0 | - | 59.3 | - |
| *Cercospora* leaf spot | *Cercospora* spp. | 23 | - | 26 | - |
| *Phytophthora/Pythium* root rot | *Phytophthora* spp.and *Pythium* spp. | - | 10 | - | 15 |
| Black nose disease | *Colletotrichum gloeosporioides* | - | 30.3 | - | 35 |
| *Rhizoctonia* root rot | *Rhizoctonia solani* | - | 19 | - | 25 |
| Bacterial wilt | *Ralstonia solanacearum* | - | - | - | 4.9 |
| Mean | | 45 | 19.77 | 42.65 | 19.97 |

*Mean of 100 plants each from14 farmers, @ Mean of 100 plants each from 9 farmers

Fig 18 Infested by bacterial blight

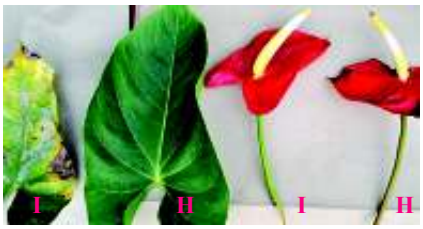



Fig 19 Infested (I) and healthy (H) leaves and flower

Fig 20 *Cercospora* leaf spot

Fig 21 *Phytopthora* and *Pythium* root rot

Fig 22 *Rhizoctonia solani* root rot

Fig 23 Black nose disease cv. "Fire"

Fig 24 Mosquito bug infested spathe and spadix of anthurium

Fig 25 Tobacco caterpillar, *Spodoptera litura* feeding on spathe

Fig 26 (A) Caterpillar (Unidentified) feeding on spathe, (B) scale insecton stem and (C) aphid infested leaf of anthurium at Hmarveng village, Kolasib district

only on leaves. *S. litura* recorded from both Kolasib and Aizawl district with high incidence of 55 and 35 per cent, respectively. The aphid encountered only in Kolasib district (5.5 %) with least incidence. The pest infested plants drastically reduced in both quality and marketability of flower.

**Table 21 Insect-pests of Anthurium recorded from Kolasib and Aizawl district of Mizoram**

| Pest | Scientific name | Infested part | Damage (%) | |
|---|---|---|---|---|
| | | | Kolasib* | Aizawl @ |
| Tabacco caterpillar | *Spodoptera litura* | Spathe and spadix | 55.0 | 35.0 |
| Mosquito bug | *Helopeltis* spp. | Stalk, spathe and spadix | 20.0 | 9.6 |
| Aphids | (unidentified) | Leaves | 5.5 | - |
| Caterpillar | (unidentified) | Spathe and spadix | 21.0 | 25.3 |
| Grasshopper | (unidentified) | Leaves, spathe and spadix | 8.3 | 10.4 |
| | | Mean | 21.96 | 16.06 |

*Mean of 100 plants each from14 farmers, @ Mean of 100 plants each from 9 farmers

## ANIMAL SCIENCE

## COWS

### Studies on bovine bacterial mastitis in Mizoram

A total number of 152 milk samples were examined in 6 different places of Mizoram using modified California mastitis test (MCMT) and 58 animals (38.16%) were found positive for sub-clinical mastitis (Table 22). Out of 152 numbers of animals examined using modified California mastitis test (MCMT), 9 animals (5.92%) were found positive for clinical mastitis.

### Isolation of causative organism from infected cases of mastitis

Out of 152 milk samples examined, 67 samples showed the presence of mastitis causing bacteria. The bacteria isolated from the samples were *Staphylococcus* (63), *Escherichia coli* (28) and *Streptococcus* (14) organism were isolated. *Staphylococcus* is the most dominant organism encountered in mastitis in dairy cows in Mizoram (Table 23).

### Treatment of mastitic cows by clinical and sub-clinical cases

Clinical cases were treated with Enrofloxacin in 10 nos of animals for 5 days and the animals recovered from the diseases and 10 animals were treated with Gentamicin for 5 days and the animals recovered from the diseases based on antibiogram. Sub-clinical cases were treated with Mastilept (Herbal medicine) in 10 nos. of animals and out of 10 animals 7 recovered from the diseases (Table 24 and Figs 27 and 28).

**Table 22 Incidence of mastitis in cows at different places of Mizoram**

| Place | Animal examined | | | Quarter samples examined | | | Presence of blind teat | |
|---|---|---|---|---|---|---|---|---|
| | No. | Positive | % | No. | Positive | % | No. | % |
| Saiha | 20 | NIL | NIL | 80 | NIL | NIL | NIL | NIL |
| Kolasib | 40 | 26 | 65.00 | 160 | 52 | 32.50 | 5 | 3.125 |
| Thingdawl | 25 | 12 | 48.00 | 100 | 30 | 30.00 | 1 | 1.00 |
| Durtlang | 24 | 11 | 45.83 | 96 | 42 | 43.75 | 4 | 4.17 |
| Sihphir | 23 | 14 | 60.87 | 92 | 48 | 52.17 | 2 | 2.17 |
| Sairang | 20 | 4 | 20.00 | 80 | 14 | 17.50 | NIL | NIL |

**Table 23 Occurrence of causative organisms in various locations of Mizoram**

| Place | *Staphylo coccus* | *Escherichia coli* | *Strepto coccus* |
|---|---|---|---|
| Saiha | NIL | NIL | NIL |
| Kolasib | 25 | 12 | 8 |
| Thingdawl | 11 | 4 | 1 |
| Durtlang | 10 | 6 | 3 |
| Sihphir | 14 | 3 | 2 |
| Sairang | 3 | 3 | - |

**Table 24 Treatment of mastitic cows by clinical and sub-clinical cases**

| Treatment | Date of treatment | No. of animals treated | No. of animals recovered | Control (%) |
|---|---|---|---|---|
| Enrofloxacin | 07.05.12 - 11.05.12 | 10 | 10 | 100% |
| Gentamicin | 22.05.12 - 26.05.12 | 10 | 10 | 100% |
| Mastilept | 04.06.12 - 10.06.12 | 10 | 07 | 70% |

**Fig 27 Treatment of the cow**

**Fig 28 Massaging of the mastitic cow**

## PIGS

### Studies on piglet diarrhea of bacterial origin in Mizoram

A total of 23 strains of *E. coli* isolated from Kolasib and Aizawl districts were subjected to antibiotic sensitivity test against piglet diarrhoea (Table 25). Ten isolates from Kolasib were equally sensitive to gentamicin and norfloxacin (76.9%), followed by enrofloxacin, cephotaxime and all the isolates were resistant to antibiotic, cloxacillin, nitrofurantoin, ampicillin, amoxycillin and sulphomethaxazole except four isolates from Kolasib showed resistant to cloxacillin.

### Serotyping of *E. coli* strains

Twenty three strains of *E. coli* were subjected to serotyping at Central Research Institute, Kasauli, Himachal Pradesh. Among twenty three strains of *E. coli,* only8 nos. of strains were typable i.e. 060 (2), 05, 036, 082, 092, 0103, 0154 and the rest of the *E.coli* strains were un typable (UT).

### Detection of toxin genes of *Escherichia coli* by PCR

Twenty three *E.coli* strains were screened for the presence of virulence genes viz., *stx*1, *stx*2, *elt*, *est,* and *hly* genes by PCR detection methods. Two different multiplex PCR protocols (one for *elt* and *est* genes and one for *hly*, *stx*1 and *stx*2 genes) were used. The *est* gene encoding for the thermostable enterotoxin could be detected in only 1 isolates. All the isolates were negative for *elt* gene encoding for thermolabile enterotoxin, *stx*1 (shiga toxin) and *hly* (haemolysin) gene. Four isolates showed the presence of *stx*2 (Table 26).

**Table 25 Antibiogram of *E.coli* strains isolated from piglet faecal samples**

| Antibiotics | Locations | | | |
|---|---|---|---|---|
| | Kolasib | | Aizawl | |
| | Numbers | Control (%) | Numbers | Control (%) |
| Enrofloxacin | 9 | 69.2 | 6 | 60.0 |
| Nalidixic acid | 7 | 58.8 | 4 | 40.0 |
| Norfloxacin | 10 | 76.9 | 6 | 60.0 |
| Nitrofurantoin | 10 | 76.9 | 6 | 60.0 |
| Cephalexin | 8 | 61.5 | 7 | 70.0 |
| Amoxycillin | Resistant | | Resistant | |
| Chloramphenicol | Resistant | | Resistant | |
| Ampicillin | Resistant | | Resistant | |
| Gentamicin | 10 | 76.9 | 4 | 40.0 |
| Cloxacillin | Resistant | | Resistant | |
| Cefotaxime | Resistant | | Resistant | |
| Sulphomethaxazole | 4 | 30.8 | Resistant | |

No. of isolates: 13 from Kolasib and 10 from Aizawl

**Table 26 *E. coli* strains subjected to detection of genes through PCR**

| Total no. of samples tested | *EST* | *ELT* | *STX-1* | *STX-2* | *HLY* |
|---|---|---|---|---|---|
| 23 | 1 | - | - | 4 | - |

## SOCIAL SCIENCE

### Role of roots and tuber crops in food security of households in north-eastern hill region of India

The role of roots and tuber crops and their importance and contribution to livelihood and food security of communities dependent on them was studied using Focus Group Discussions, Participatory Research Appraisal and Household Survey. Meghalaya state was purposively selected for the study taking into account the importance of roots and tuber crops in the livelihood of the population. Further, East Khasi Hills and West Garo Hills district were selected as focus districts as these two districts accounts for 49 per cent of the total population of the state and has the major share of area and production of roots and tuber crops in the state. Within the focus districts of East Khasi Hills and West Garo hills, we selected two villages in two different blocks in each district for the assessment studies.

### Agriculture production system in the villages

In both the villages in West Garo Hills district, there are three main agricultural production systems i.e., shifting cultivation (*jhum*), cultivation of commercial crops, particularly plantation crops in homestead land and hills and cultivation of cereals in plain land. In *jhum*, a mix of crops is sown together. Cereal crops are the first to be harvested followed by roots and tuber crops. The harvesting of roots and tuber crops starts at September and will continue till December and sometimes in January. The planning activities for next year's *jhum* crop start early in October. Site selection and jungle cutting takes place during November and December. Once the jungle is burned and land preparation is completed, planting of various crops take place and this is done mainly during March. The planting of cereals as well as roots and tuber crops are done in the beginning of the *jhum* period and the planting is completed by April – May. Cereal crops are planted first during March and other vegetables and roots and tuber crops are planted by the end of May. The harvesting for crops like chilly, brinjal continues throughout the *jhum* period. In case of root and tuber crops harvesting takes place at the end of the *jhum* period, mainly during the months of December, January and February. As different from *jhuming* systems in other parts of north eastern hill region where rice is the main crop in the crop mixture, root and tuber crops dominated the crop mixture in the study area. It indicates that RTCs still played a major role in food security of the households in spite of significant changed in productivity and food habit of the people.

### Biodiversity of root and tuber crops

An important feature observed in the villages is the great diversity of RTCs cultivated and consumed by the households. In Asimgri village, there were 13 varieties of Yam known and cultivated by the villagers. Among them, Tawak and Taruri were the most preferred varieties by the villagers based on various characteristics related to productivity, food security and nutrition. In cassava, there were six varieties commonly cultivated, consumed and marketed by the villagers. The most preferred variety was Meghalaya local followed by Shillongket and Bolchu. Nearly 10 varieties of colocasia were commonly grown by the villagers for daily consumption as well as for marketing. Among the varieties, Tamochanggam is the variety which is highly ranked by the villagers considering various parameters of productivity, market demand, taste, nutrition and resistance to pests and diseases.

### Consumption pattern

The seasonality of consumption of various food items is dependent on the timing of crop harvests from the *jhum* fields. The peak period of consumption of roots and tuber crops is from August-September to November-December which coincides with the harvesting period of roots and tuber crops from the *jhum* fields. Among RTCs, cassava is consumed throughout the year. During the normal period they consume rice and various roots and tuber crops from storage of the previous harvests. However, the preference of the RTCs varies from village to villages depending upon their suitability, local preference, contribution to food security and nutrition and market

demand. In Rombagri village, among all the RTCs colocasia was most preferred by the households followed by cassava, sweet potato, yam and yam bean whereas in Asimgri village Cassava is number one crop followed by yam, colocasia, sweet potato and yam bean.

**Livelihood analysis**

The observation of livelihood analysis of Rombagre village, West Garo hill district, Meghalaya indicates that business/service formed a major share in the total income of rich category households while agriculture and labour contributed highest for medium and poor category households respectively. Income from livestock contributed a significant share in both the rich (23.90%) and medium category (37.25%) households. The poor category households also engaged in *jhum* agriculture and selling of forest produce as sources of livelihood. Expenditure on food constituted a major share in all the three category of households. Poor households made the highest 78.62 per cent share on food only followed by 69.09 per cent and 51.68 per cent in medium and rich category households. The households spent more or less similar pattern of expenditure in other items. The rich and medium households could save ₹ 52/-, ₹ 300/- and ₹ 14800/- out of their income while poor households were on the burden of debt of ₹ 2550/-.

**Problems faced by RTC farmers**

The problems related to roots and tuber crop (RTC) cultivation varies with the crops grown. For tapioca, yam and sweet potato, the major problem is the declining productivity of the present cultivars. In colocasia, the major problems were pests and diseases. In tapioca, the problems were termites, grubs, rats and wild boar attack, irrigation, and availability of quality planning material. Marketing of the produce remains an important constraint for all the RTCs. Absence of adequate knowledge and training in various aspects of RTC cultivation, value addition and marketing is the major reason for low productivity levels of RTCs. Making awareness on the role of RTCs in food and nutritional security, supply of quality planting materials, training and demonstration of package and practices and support of processing and post harvest technologies on selected RTCs would not only increase the productivity but also, would improve the food and nutritional security of the rural households.

**Impact on land-use system**

The arable land area in the watershed area was significantly increased by 22.65 per cent than the non-watershed area. The higher percentage was mostly contributed by more allocation of land under wet land cultivation, orchard or fruits plantations and afforestations. The reasons for increasing the area under fruit crop plantations and afforestation were sincere efforts of the watershed implementing agency and the willingness of the farmers to work more for better income generation and their positive attitudes towards the environment *i.e.* towards sustainability. However, the efforts to minimize the bun areas to permanent cultivation were not marked up to the significant level as indicated by non-significant difference in contour cultivation. It may be due to the lack of awareness, traditional bound system, poor institutional support and lack of suitable technology in the hilly region which is a major concern for policy makers and administrators.

**Impact on income**

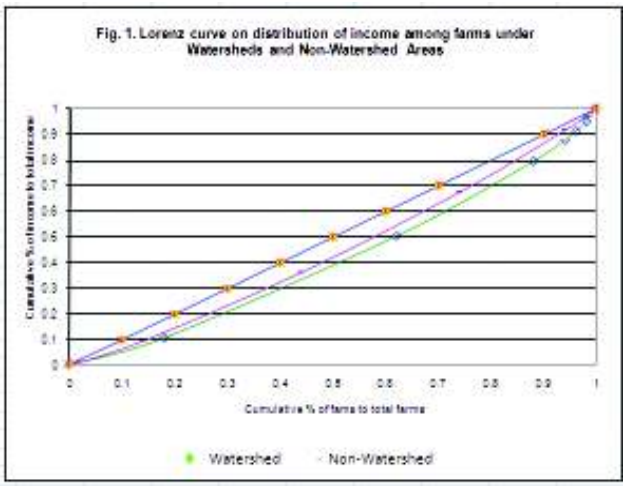
The average farm income was significantly more in the watershed area (₹ 59320.53) than in the non-watershed (₹ 45021.40) *i.e.* 31.76 % higher. Of these, income from fruits contributed the highest with (1109.47% higher) than the non-watershed. This was followed by livestock (86.47% higher) than the non-watershed area. The livestock sector contributed mostly due to the introduction of improved breeds of piggery and poultry units to the unemployed youths. Due to provision of better opportunities in agriculture and allied sector by the watershed project, the dependence of watershed households on casual labour and forest produce declined significantly as indicated by lower income from labour and negligible income from selling of forest produce.

**Employment**

The per acre employment was 132.06 man-days in the watershed area and comparatively more in the non-watershed area (133.62) *i.e.* a percentage difference of (-) 1.17. The reason behind may be due to the increase in crop area which in turn led to the decrease in per acre utilization of labour. On the other hand the per family employment pattern showed that the level of employment was significantly more in the watershed area than in the non-watershed area, *i.e.* a percentage difference of 21.32.

**Pattern of income distribution**

The examination of Lorenz Curve also depicts the existence of income inequalities among the farmers of the watershed and non-watershed area (Fig 1). It indicated that the watershed project increased the income level of the households without attending the equity objective i.e. the gap between rich and poor was increased.




The above facts clearly indicate that the watershed project altered the land use system favourably to horticultural crops mostly fruits. However, area under permanent upland contour cultivation could not be increased resulting into non-reduction in *jhum* cultivation. Since *jhum* cultivation is the way of life of the tribal poor farmers, *jhum* improvement through sustainable farming system is the only solution rather than eradication. The total average annual income of the family was moderately more in the watershed area than in the non-watershed area. However, the most crucial thing was that the increased income was not distributed uniformly to all sections of people in both the area satisfactorily. It necessitates proper attention to the landless, marginal and small farmers while planning for watershed development projects. Self employment schemes such as village level small scale industries, post harvest technologies and value addition and livestock and poultry need to be developed.

## QUALITY SEED PRODUCTION

### MAIZE

The maize seeds of RCM 76 were produced with isolation distance during *rabi* season at ICAR farm (Fig 11). Regular rouging of off-types, diseased and insect pest infested, late flowering plants from the seed plot were done. Agronomic practices like weeding, thinning, fertilization, irrigation, etc. were timely done for successful production of crop. About 400 kg of RCM 76 seeds were produced during 2012.

**Fig. 11. Field veiw of maize seed production**

## FRUITS AND VEGETABLES

Total 14,500 seedlings of fruit and vegetable crops were produced in this centre and distributed to farmers free of cost (Table 27).

**Table 27 Production of seedlings of fruit and vegetable crops**

| Crops | Seedlings produced (nos.) |
|---|---|
| **Fruits** | |
| Mandarin seedling | 2000 |
| Passion fruit | 1500 |
| Banana suckers | 2000 |
| **Vegetables** | |
| Tomato seedlings | 2000 |
| Broccoli seedlings | 2000 |
| Cabbage | 2000 |
| Cauliflower | 2000 |
| Capsicum | 1000 |

## DEMONSTRATION

### WATER HARVESTING STRUCTURE

***In situ* demonstration of water harvesting structure (*Jalkund*)**

Total 60 *jalkund* were made by using silpaulin with the capacity of 30,000 litre (50 nos) and 50,000 litre (10 nos) during March, 2012. *Jalkund* was constructed in four districts of Mizoram viz., Kolasib, Aizwal, Mamit and Saiha covering 20 villages and 60 beneficiaries.

**Performance of *Jalkund***

Ninety nine per cent of the *Jalkunds* could harvest the permitted capacity of rain water during the monsoon period. *Jalkund* water was mostly used during

November and December. From this water harvesting structure, 75 per cent of households utilized for cultivation of crops viz., cole crops, mustard, tomato, chilli, French bean, etc. (Fig 30); 20 per cent of households used for livestock, pig, poultry and fish maintenance and 5 per cent of households utilized for anthurium cultivation. *Jalkunds* are more successful for those households having perennial source of recharge water.

**Fig 30 Utilization of *Jalkund* water in various farming activities**

### Demonstration of pig management

For demonstration pig management, 11 beneficiaries were selected. Low cost pig sty were constructed for each beneficiaries (Fig 31 and 32). All beneficiaries were provided with improved breeds with two piglets of two months old (Hampshire and Yorkshire). Initially, distributed 150 kg of concentrate pig feed to each farmer.

**Fig 31 Hampshire cross breed (10 months old)**

### Performance of pigs at different altitudes of Kolasib district

Performances of two cross breeds of pig viz., Hampshire and Yorkshire along with one local were evaluated in different altitudes of Kolasib district. Cross breed Hampshire performed the best as compared to other breeds in all locations.

**Fig 32 Construction of pig sty under NICRA**

### Demonstration of poultry management

Under demonstration of poultry management, twelve farmers were selected from Kolasib district of Mizoram. Twenty number of Vanaraja chicks (16F:4M) and 210 kg of layer feed (Pre-starter and layer feed) were distributed to each beneficiaries (Fig 33 & 34)

**Fig 33 Beneficiary with eggs and birds of Vanaraja**

**Fig 34 Distribution of eggs and birds of Vanaraja**

### Performance of poultry at different altitudes of Kolasib district

Performance of Vanaraja along with one local was evaluated in different altitudes of Kolasib district. Vanaraja performed better in terms of weight and hatching capacity producing 142 eggs as compared to local one (72 eggs).

### Technologies Intervention at Theiva and Ni-Awthlang, Saiha District, Mizoram

Total of 486 households were benefitted by introduction of maize, pulses, oilseeds, fruits, vegetables and spices covering 86 ha and enhanced their income up to ₹ 23,900 per household. 1200 nos. of poultry, 64 pigs and 9 cattle were distributed to 80, 32, 5 households, respectively and the enhanced income was maximum for livestock (1.2 lakhs) followed by pigs, strawberry, mushroom and poultry.

## TRAININGS

Altogether 11 training programmes (Figs 35e-f) were organized covering 600 farmers and extension functionaries under TSP, NICRA, NAIP and TM.

**Fig 35a Training on 'Soil Water conservation for sustainable hill Agriculture' under NICRA at ICAR, Mizoram centre**

**35 b One day training on 'scientific management of pig and poultry' under TPS**

**35c Two-days farmer field day cum training on 'Climate Resilient Technologies for Mizoram'**

**35d Two-days farmer training on 'scientific rearing of pig and poultry' under NICRA**

**35e Two-days training cum input distribution programme organized under NAIP**

**35f Training and demonstration on 'soil Testing Kits' at KVK, Lengpui, Mamit District under NICRA**

# NAGALAND CENTRE

## WEATHER REPORT

It was observed that during April 2012 to March 2013 mean monthly maximum and minimum air temperatures were found to vary from 23.3$^0$C to 33.4 $^0$C and 7.5$^0$C to 25.1$^0$C, respectively (Table 1). The highest maximum temperature of 36.5 $^0$C was recorded on 25$^{th}$ May while the lowest minimum temperature of 5.1 $^0$C was recorded on 25$^{th}$ January. Average monthly maximum and minimum relative humidity varied from 72% (January) to 84% (September) and 9% (February) to 61% (August). Total rainfall received during the period April'12 to March'13 was 1346.70 mm with the total of 79 rainy days. The monthly rainfall was maximum in the month of July (367 mm) followed by June (240 mm). No rainfall occurred during the month of December and January (0.00mm) (Fig 1). Except during the months from October12 to January13, the sky was clear. The average monthly wind speed varied from 0.20 kmph (January 13) to 3.78 kmph (May 12). Soil temperatures were recorded both in the morning and evening from 5cm, 15cm and 20cm depth. The soil temperature showed an increasing trend along with the depth. Total monthly evaporation was found to vary from 47.0 (December'12) to 143.2 (May'12).

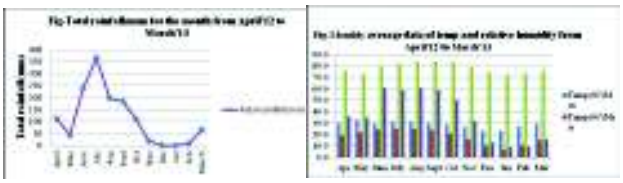


**Fig 1 Weather data April 2012-March 2013**

### Integrated Agro-met Advisory Services (IAAS)

Bi-weekly (Tuesday and Friday) Medium Range Forecast of weather is being provided in Nagaland through e-mail, FAX, Newspapers and radio. Monsoon press release is being prepared once a week on Wednesday. Mobile SMS on daily weather data is being provided to 1541 progressive farmers across the state (Dimapur=1033, Tuensang=78, Kohima=81, Mon=102, Mokokchung=49, Wokha=15, Phek=109, and Zunheboto= 74).

## CROP SCIENCES

### RICE

**Effects of crop establishment methods and fertility levels on growth, yield and quality of rice in rice-lentil cropping system**

The experiment was carried out during the *kharif* season of 2012-13. The soil of the experimental site was slightly clay loam, acidic in reaction (pH=5.0), high in organic carbon (1.24%), low in available nitrogen (215.18 kg/ha), potash (145.21 kg/ha) and moderate in phosphorous (12.44 kg/ha). Three crop establishment methods, *viz.,* system of rice intensification (SRI), integrated crop management (ICM) and conventional rice culture (CRC) were allotted to the main plot. Five treatments of fertility level, i.e. control, 100% RDF,100 % RDF + crop

**Table 1 Average monthly weather data of Nagaland (the mean values are given in parentheses with bold letters)**

| Air temperature ($^0$C) | | Relative humidity (%) | | Pan evaporation (mm) | Total rainfall (mm) | Soil temperature ($^0$C) (5cm) | | Soil temperature ($^0$C) (15cm) | | Soil temperature ($^0$C) (20cm) | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Max | Min | Max | Min | | | Morn | Even | Morn | Even | Morn | Even |
| 23.3 (Jan'13) – 33.4 (May'12) **(28.9)** | 7.5 (Jan'13) - 25.1 (July'12) **(18.3)** | 72 (Jan'13) – 84 (Sept'12) **(78)** | 9 (Feb'13) – 61 (Aug'12) **(37)** | 47.0 (Dec'12) – 143.2 (May'12) **(84)** | 1346.7 | 3.0 (Jan'13) – 17.8 (Aug'12) **(12.2)** | 12.4 (Jan'13) – 24.3 (May'12) **(20.1)** | 14.1 (Jan'13) – 28.3 (Aug'12) **(22.9)** | 22.4 (Jan'13) – 33.8 (May'12) **(29.6)** | 15.1 (Jan'13) – 28.9 (Aug'12) **(23.6)** | 20.2 (Jan'13) – 38.8 (Aug'12) **(29.8)** |

residues, 100 % RDF on and 100 % RDF ON + crop residues were allotted to the sub-plots; where ON represents organic nitrogen (120 kg/ha) through farm yard manure. The results (Table 2) revealed that, SRI recorded significantly the highest yield attributes and yield followed by ICM, and CRC recorded significantly the lowest yield attributes and yield of the crop. In case of fertility levels, the treatment 100 % RDF + crop residues recorded significantly the highest yield attributes and yield of the crop followed by 100 % RDF, 100 % RDF ON + crop residues as compared to control. It was due to better integrated nutrient management that helped the crop for sound growth and development.

**Table 2 Effect of crop establishment methods and fertility levels on yield and yield attributes of rice cropping system**

| Treatments | Panicle length (cm) | Grains/ panicle (No.) | Grain yield (t /ha) | Straw yield (t/ ha) |
|---|---|---|---|---|
| **Crop establishment methods** | | | | |
| SRI | 25.29 | 473.4 | 2.86 | 3.56 |
| ICM | 24.40 | 459.7 | 2.94 | 3.69 |
| CRC | 23.15 | 318.6 | 2.53 | 3.15 |
| **Fertility level** | | | | |
| Control | 23.58 | 386.3 | 2.15 | 2.83 |
| 100 % RDF | 24.91 | 425.1 | 3.05 | 3.56 |
| 100 % RDF + Crop residues | 25.81 | 496.7 | 3.27 | 3.71 |
| 100 % RDF ON | 24.09 | 398.5 | 2.20 | 2.80 |
| 100 % RDF ON + Crop residues | 23.94 | 394.2 | 1.98 | 2.22 |

(RDF= Recommended dose of fertilizer, ON= Organic Nitrogen)

## MAIZE

### Effect of mulching, liming and INM on production potential of *rabi* maize (var.DA-61-A) under rainfed condition

The experiment was carried out the *rabi* season of 2012-13 (Fig 1). The soil of the experimental site was slightly clay loam, acidic in reaction (pH=5.1), high in organic carbon (1.06 %), low in available nitrogen (224.42 kg/ha), potash (136.64 kg/ha) and moderate in phosphorous (11.98 kg/ha). In experiment, mulching was allocated in the main plot (viz., control and mulching), and the sub-plot treatment was allocated with farm manure having four levels (control, 4, 8 and 12 t/ha); and in the sub-sub plot, four levels of liming (control, 0.2, 0.4 and 0.6 t/ha) were allocated. The

**Fig 2 INM trial *rabi* maize var. DA-61-A**

results (Table 3) showed that liming recorded significantly higher yield attributes and yield in the main plot. In the sub-plot treatment, it showed that the increase in the levels of farm yard manure application, increased the yield attributes and finally yield of the crops. In sub-sub plot treatment application, similar trends were observed for farm yard application.

**Table 3 Effect of mulching, liming and INM on production potential of *rabi* rainfed maize (var. DA 61A)**

| Treatments | Cob /plant (No.) | Grains /row (N | Cob length (cm) | Rows /cob (No.) | Grain yield (t/ ha) |
|---|---|---|---|---|---|
| **Mulching** | | | | | |
| Control | 1.02 | 24.83 | 10.06 | 10.86 | 1.56 |
| Mulch | 1.11 | 30.18 | 15.36 | 13.96 | 2.26 |
| **Farm yard manure (t/ha)** | | | | | |
| 4 | 1.04 | 25.34 | 10.86 | 10.68 | 1.96 |
| 8 | 1.17 | 28.89 | 13.82 | 11.82 | 2.02 |
| 12 | 1.20 | 29.00 | 15.81 | 13.96 | 2.18 |
| **Liming (t/ha)** | | | | | |
| Control | 1.06 | 23.84 | 11.63 | 11.22 | 1.56 |
| 0.2 | 1.09 | 25.63 | 13.56 | 11.86 | 2.13 |
| 0.4 | 1.11 | 28.86 | 13.92 | 12.36 | 2.02 |
| 0.6 | 1.18 | 30.26 | 10.56 | 13.18 | 2.26 |

### Performance of maize cultivars during *rabi* season under moisture stress condition

The allocated treatments were fertility level with the recommended dose of fertilizer of N, P, and K (80–60–40 kg/ha) through inorganic fertilizers (urea, DAP and MOP). This treatment was undertaken to evaluate the farmers' practices in relation to the natural resources management condition under climate change scenarios. The other treatments were FYM which was applied as basal application @10 t/ha for improving the physico-chemical and biological properties of the soil. However, lime @ 0.5 t/ha was also applied as

one of the treatment for reclamation of the soil acidity for better soil-reaction and crop health. Mulching was done to minimize the soil moisture loss from the experimental plot and also to improve the water productivity. Six maize varieties (Table 4) such as Nagaland local, Vijay composite, DA 61A, DHM 117, RCM 75 and RCM 76 were grown to evaluate their best suitability under moisture stress condition during the *rabi* season (rainfed condition). Average yield of RCM 76 was maximum due to its genetic potential under the given condition of the environment. On the other hand mulching was found to be superior in yielding more maize than the other treatments, which proved the importance of moisture.

(2.0 – 6.4 cm), no. of pods per inflorescence (1 – 3.6), pod length (7.6 – 17.3 cm), pod width (0.9 – 1.9 cm), no. of locules per pod (4 – 8.5) and yield per plant (4 – 38.3 pods/plant) and the test weight of seeds was ranged from 29.4 g to 56.1 g (Fig 3).

**Fig 3 Germplasm of *rajma* bean**

**Table 4 Yield of the different maize cultivar ast moisture stress condition**

| Cultivars | RDF | FYM | Lime | Mulch | R+L+F+M | Average |
|---|---|---|---|---|---|---|
| Nagaland local | 1.5 | 2.3 | 1.2 | 2.5 | 4.0 | 2.30 |
| Vijay Composite | 1.75 | 2.1 | 2.25 | 3.5 | 2.75 | 2.47 |
| DA 61A | 1.7 | 1.75 | 2.2 | 3.5 | 2.0 | 2.23 |
| DHM 117 | 1.25 | 2.0 | 2.1 | 1.5 | 0.75 | 1.52 |
| RCM 75 | 2.4 | 2.5 | 2.0 | 3.5 | 1.5 | 2.38 |
| RCM 76 | 2.5 | 3.2 | 2.0 | 4.5 | 2.0 | 2.84 |
| Average | 1.85 | 2.31 | 1.96 | 3.17 | 2.17 | |

## PULSES

### RAJMA BEAN

#### Collection, conservation and characterization of *rajma* bean germplasm

Out of 41 germplasm, 32 different germplasm were identified. The morphological characterization was done based on the IPGRI descriptor. Two different types of plant growth were observed. Out of 32 germplasm, 30 were pole types and two were bush type. The data revealed significant variation for the characters *viz*., plant height (36 – 178.3 cm), no. of inflorescence per plant (1.5 – 3.6), inflorescence length

### RICE BEAN

#### Effect of levels of lime application on growth, yield and quality of rice bean

The experiment was carried out during the *kharif* season of 2012-13. The soil of the experimental site was slightly clay loam, acidic in reaction (pH=5.23), high in organic carbon (1.14 %), low in available nitrogen (189.40 kg/ha), potash (153.42 kg/ha) and moderate in phosphorous (16.52 kg/ha). Four levels of lime, *viz.* control (no application), 0.2, 0.4 and 0.6 t/ha- were allotted to the main plot where, four varieties of rice bean such as RBS 16, RBS 53, PRR 2 and RCRB 4 were allotted to the sub-plots. Results (Table 5)

**Table 5 Effect of different levels of lime application on yield attributes and yields of rice bean**

| Lime application (t/ha) | Pod length (cm) | 1000-seed weight (g) | Pods/plant (No.) | Seeds/plant (No.) | Grain yield (t/ha) | Straw yield (t/ha) |
|---|---|---|---|---|---|---|
| Control | 6.32 | 66.10 | 23.56 | 87.00 | 0.36 | 0.56 |
| 0.2 | 6.56 | 66.50 | 30.26 | 70.56 | 0.48 | 0.53 |
| 0. 4 | 6.47 | 68.38 | 35.05 | 100.26 | 0.85 | 0.96 |
| 0. 6 | 6.90 | 69.00 | 32.56 | 105.53 | 0.82 | 0.88 |
| **Varieties** | | | | | | |
| RBS 16 | 6.52 | 67.00 | 54.01 | 81.86 | 0.60 | 0.66 |
| RBS 53 | 6.83 | 68.30 | 57.36 | 80.96 | 0.82 | 0.88 |
| PRR 2 | 6.78 | 67.38 | 49.71 | 101.96 | 0.38 | 0.43 |
| RCRB 4 | 6.32 | 67.38 | 38.55 | 102.27 | 0.76 | 0.82 |

showed that the increase in the level of lime increases the yield of the rice bean varieties. Lime application 0.6 t/ha recorded significantly higher yield attributes and yield of the rice bean followed by 0.4 and 0.2 t/ha. In case of the varieties, RBS 53 recorded significantly higher yield attributes and yield of the crop as compared to the other varieties. The rice bean variety PRR 2 recorded significantly lower yield attributes and yield as compared to the other varieties, which might be due to the lower yield potential of this variety.

## MUNGBEAN

**Effect of date of sowing, seeding rate and integrated nutrient management on production potential of summer mung bean (var. TS 21)**

The experiment was carried out during the *kharif* season of 2012-13. The soil of the experimental site was slightly clay loam, acidic in reaction (pH=5.2), high in organic carbon (1.10 %), low in available nitrogen (207.60 kg/ha), potash (141.50 kg/ha) and moderate in phosphorous (16.63 kg/ha). Two dates of sowing *viz.* 10th and 16th April were allotted to the main plot and four seeding rates of 20, 25, 30 and 35 kg/ha was given in the sub-plot. Another treatment, fertility level was allotted in the sub-sub plot to evaluate their best applicability. The results (Table 6) revealed that 10th April date sowing recorded significantly the highest yield attributes and yield of the crop. In case of seeding rate, it showed that the increase in the level of seeding rate increased the yield; but reverse in case of the yield attributes. However, the maximum yield was recorded with the highest seed rate due to higher plant population. In case of fertility level, 100% IN + 50 % ON recorded the highest yield followed by 100 % RDF.

## DISEASES

## SUN FLOWER

The disease, *Sclerotinia* wilt in sunflower (Fig 4), was observed for the first time in Nagaland, The disease was initiated at 50-60 days after sowing with the development of collar rot, leaf blight (Fig 5) and head rot symptoms. The pathogen was isolated and cultured on PDA media. Symptoms and mycological studies confirm the identity of the pathogen as *S. sclerotiorum*. Pathogenicity test conducted produced the similar symptoms on sunflower seedlings.

**Fig 4 Wilt**

**Fig 5 Leaf blight**

**Fig 6 Head rot**

## HORTICULTURE

## ORCHIDS

**Evaluation of *Dendrobium* orchids**

Seven *Dendrobium* hybrids viz., Snow white, Juwita, Genting Blue, Genting Red, Woonleng, Pink Ruby and Massaco were evaluated for their performance under shade net house (Fig 7). The

**Table 6 Effect of sowing date, seed rate and INM on yield attributes and yields of summer mungbean (var. TS 21)**

| Treatments | Pod plant | Pod weight /plant (g) | Seed weight /plant (g) | Seeds /pod (No.) | 1000-seed weight (g) | Seed yield (t/ha) | Straw yield (t/ha) |
|---|---|---|---|---|---|---|---|
| **Sowing date** | | | | | | | |
| 10th April | 31.56 | 50.00 | 23.18 | 10.86 | 35.37 | 1.18 | 1.554 |
| 16th April | 29.32 | 51.26 | 20.56 | 8.86 | 34.24 | 0.867 | 0.953 |
| **Seed rate (kg/ha)** | | | | | | | |
| 20 | 32.43 | 56.33 | 21.63 | 10.26 | 34.16 | 0.783 | 0.932 |
| 25 | 30.26 | 55.52 | 20.53 | 11.05 | 34.13 | 0.82 | 0.926 |
| 30 | 28.52 | 53.18 | 19.13 | 11.08 | 35.26 | 0.982 | 1.026 |
| 35 | 27.83 | 51.56 | 18.86 | 11.86 | 35.50 | 0.996 | 1.054 |
| **Fertility levels** | | | | | | | |
| Control | 27.26 | 53.16 | 19.83 | 10.96 | 33.06 | 0.763 | 0.963 |
| 100 % IN | 30.23 | 56.53 | 22.13 | 11.18 | 34.28 | 0.986 | 1.026 |
| 100% IN+ 50% ON | 32.17 | 58.56 | 23.86 | 12.02 | 35.10 | 1.000 | 1.061 |

RDF: 20-40-20 NPK kgha$^{-1}$ and IN: Inorganic Nitrogen, ON: organic nitrogen through vermicompost

*Dendrobium* hybrid Snow White recorded the maximum pseudo bulb height (53.7 cm), followed by Genting Red (49.3 cm) and the minimum pseudo bulb height of 32.1 cm was recorded by Massaco, followed by Pink Ruby (39.8 cm). The maximum no. of pseudo bulbs was recorded by Juwita (6.0) which was closely followed by Snow White (5.7) and the minimum no. of pseudobulbs was recorded by Genting Red (3.0) followed by Massaco (3.7). The no. of leaves per pseudo bulb ranged from 4.8 to 6.5 and it did not vary significantly among the *Dendrobium* hybrids. The maximum internode length was registered by Snow White (5.1 cm) and the minimum internode length was registered by Massaco (3.3). Among the *Dendrobium* orchids evaluated for no. of florets per spike, Snow White recorded the maximum of 8.4 florets per spike followed by Juwita which recorded 7.5 florets per spike. The minimum of 4.1 florets per spike was recorded by Massaco followed by Wooleng which recorded 4.2 florets per spike. The maximum spike length of 39.7 cm was found in Pink Ruby which was closely followed by Snow White (38.4 cm). The minimum spike length of 28.5 cm was found in Wooleng followed by Massaco which recorded 30.9 cm. This result may be due to genetic nature of the plant, growing and environmental conditions. The results of this study concluded that the *Dendrobium* variety Snow white and Juwita performed better under Nagaland condition.

Genting Blue | Genting Red | Juwita

Snow White | Pink Ruby | Wooleng

**Fig 7 Performance of *Dendrobium* orchids under shed net**

### Evaluation of orchid species under shade net conditions

Orchid species viz., *Dendrobium, Aranthera, Oncidium, Vanda* and *Mokara* were evaluated for their performance under shade net house (50 %). *Aranthera* recorded the maximum pseudo bulb height of 95.4 cm and *Oncidium* recorded the minimum pseudo bulb height of 29.2 cm. *Dendrobium* recorded 3.9 number of pseudo bulb per plant, whereas *Aranthera, Vanda* and *Mokara* recorded only one pseudo bulb per plant. The maximum internode length was recorded by *Oncidium* (5.4 cm) and minimum internode length was recorded by *Mokara* (2.9). *Mokara* registered maximum of 1.7 spikes per plant and *Aranthera* did not produce a single spike during the study. *Oncidium* recorded the maximum number of florets per spike (13) and maximum spike length was recorded by *Dendrobium* (16.9 cm). *Aranthera* did not produce spike which indicated that it had long juvenile phase. The different species varied for the characters studied and it may be due to genetic nature, and growing conditions.

## ANTHURIUM

### Varietal evaluation

Seven anthurium varieties viz., Violet White, L'Armour, Queen Black, 1st Red, Cynthia, Anastacia and Red were evaluated under Shade net house (Fig 8). The maximum plant height was recorded by L'Armour (36.4 cm) and minimum plant height was recorded by Cynthia (19 cm). The maximum leaf length (25.1 cm) and leaf breadth (14.5 cm) was found in Anastacia and Violet White recorded the minimum leaf length (10 cm) and 1st Red recorded the minimum leaf breadth. Flowering is just initiated. The maximum spade length (10.6 cm) was recorded by L'Armour and minimum spade length was recorded by Queen Black (8.3 cm). The maximum spade breadth of 9.2 cm was recorded by 1st Red and minimum spade breadth of 5.2 cm was recorded by Violet White. The maximum spadix length was recorded by 1st Red (5.4 cm) and minimum spadix length was recorded by Violet White (2.7 cm).

**Fig 8 Anthurium varieties under shed net house**

## GERBERA

### Varietal evaluation

Seven gerbera varieties viz., Eiko, Ice Queen, Jaffna, Liekie, P.Intenzz, Stanza and Venice were evaluated in polyhouse for their performance with drip

and fertigation (Fig 9. The maximum plant height was recorded by Liekie (34.2 cm) and the minimum height was recorded by Ice Queen (26.1 cm). The maximum of 10.5 leaves were found in Liekie and minimum of 8.7 leaves were found in Jaffna. The maximum stalk length was recorded by P. Intenzz (48.9 cm) and minimum stalk length was recorded by Venice (37.2 cm). The maximum neck diameter (0.6 cm), stalk diameter (0.8 cm) and ray floret diameter (11.1) was recorded by Liekie. The maximum trans-floret diameter of 6.3 cm was recorded by Stanza and minimum diameter of 4.8 was recorded by Eiko. The Ice Queen variety did not produce any trans-floret. The maximum disk floret diameter was recorded by P. Intenzz (3.3 cm) and minimum diameter was recorded by Jaffna (2.5). Among the varieties evaluated, the variety Liekie was performed better.

**Fig 9 Gerbera varieties under polyhouse**

## VEGTABLE CROPS

### TOMATO

**Fertigation in sequential cropping system**

The tomato var. Megha tomato 3 (Fg 10) was planted in the polyhouse. The standard package of practices was followed. The water soluble fertilizers were applied through drip irrigation at frequent intervals. The plants were planted at a spacing of 60 x 45 cm (500 plants /140 sq.m area). The plants reached an average height of 1.10 m. The no of branches per plant was 6.5, the average flowers per cluster were 4.2 and the fruit set per cluster was 3.04. Individual fruit was weighing around 47.36 g. A total of 83 kg was obtained from 140 $m^2$. However, the yield was very less due to high incidence of late blight and bacterial wilt disease.

**Fig 10 Megha Tomato 3**

### COLOCASIA

**Collection, conservation and characterization of indigenous colocasia germplasm**

Out of 126 germplasm evaluated, 110 were identified based the morphological characterization (IPGRI descriptor). Among the varieties evaluated, 9 lines were dwarf (< 50 cm height), 68 lines were medium (50 – 100 cm) and 33 lines were tall (>100 cm). The 10 lines recorded no suckers, 99 lines had 1 – 5 suckers and one line recorded more than 6 suckers. Out of 110 lines, only 26 lines are having the character of flowering. Remaining lines are non flowering types. Further, it is observed that flowering is strongly influenced by thermogenic phenomenon. Significant variation was observed for yield. The yield per plant ranged from 51 g to 1318.25 g. The maximum yield of 1318.25 g per plant was registered by line 60 which was closely followed by line 49 (1314.25 g). The minimum plant yield of 51 g was registered by line 92. The starch content is ranged from 10.9 g/100 g fresh weight to 45 g /100 g fresh weight and total sugar content is ranged from 1.6 g/100 g fresh weight to 8.6 g /100 g fresh weight. Out of 110 germplasm lines, six varieties showed good agronomic characters with high yield potential (Fig 11). Most varieties evaluated against *Phytophthora* were susceptible and few lines showed tolerance to disease.

**Fig 11 Indigenous colocasia germplasm**

## SOIL SCIENCE

**Analysis of soil and plant samples from different districts of Nagaland**

Total 579 nos. of soil samples were analyzed in the laboratory covering 7 districts viz., Dimapur, Peren,

Kohima, Wokha, Mon, Tuensang and Phek for N, P, K, Organic Carbon (OC), pH, and EC during 2012-13. The ranges of average N, P, K, OC and pH of all these soil samples were 68.99-338.69 kg/ha, 1.04-213.03 kg/ha, 21.50-507.02 kg/ha, 0.51-2.68%, 3.51-7.90, and 0.04-0.330, respectively. Besides, only 20 nos. of plant samples and 96 nos. of vermicompost samples were also analyzed during 2012-13.

**Model farming system for resilient shifting cultivation in Nagaland (TSP)**

Two *jhum* fields were selected in Medziphema and Jharnapani and three systems were compared *viz.* agri-silvi-livestock, agri-horti-silvi and traditional *jhum*. Contour bunds by using wooden log (locally known as '*Echo'*) were constructed to prevent soil loss. Pits were made to plant fruit crops and some pits were left to use these as a water recharge trench. All infrastructural facilities like pig shed, plot layout, contour bunding, water harvest structure, piglets, manures *etc*. were provided to the beneficiaries. Besides, scientists and technical officers visited to the field regularly and gave technical guidance. Through this approach, these beneficiaries harvested good yield of all crops except Bhalum 4 variety of rice. For instance, in an area of 0.21 ha in each system in Medziphema, the harvest is listed in the table 7.

**Table 7 Harvest (kg) in traditional *jhum,* agri-silvi-livestock and agri-horti-silvi systems in a farmer's field in Medziphema**

| Crop | Harvest (kg) | Crop | Harvest (kg) |
|---|---|---|---|
| Traditional *jhum* (0.21 ha cropped area) | | Agri-horti-silvi (0.21 ha cropped area) | |
| Rice (*Lokhomo*) | 675.0 | Beans | 4.0 |
| Sticky rice | 100.0 | Chilli | 3.5 |
| Maize | 53.0 | Bitter gourd | 12.5 |
| Colocasia | 12.0 | Pumpkin | 104.0 |
| Local pumpkin | 51.0 | Local long bean | 147.0 |
| Agri-silvi-livestock (0.21 ha cropped area) | | Colocasia | 15.0 |
| | | Maize | 65.0 |
| Colocasia | 31.0 | Cucumber | 3.0 |
| Maize | 76.0 | | |
| Rice (Bhalum 4*)* | Not harvested | Rice (*Bhalum-4)* | Not harvested |

In traditional *jhum*, the traditional paddy varieties like *Lokhomo* and *local* gum rice; maize, colocasia and local pumpkin were planted. Improved paddy var. Bhalum 4, maize and colocasia were planted in agri-silvi-livestock model. Pig-shed was constructed along with collecting pit for recharging soil with decomposed pig manure. Fruits plants like *khasi* mandarin, round lemon, mango, mosambi, litchi, colocasia and vegetables like beans, chilli, brinjal, yard long bean, bitter gourd, pumpkin, colocasia and cucumber were integrated with maize and paddy var. Bhalum 4in agri-horti-silvi model. A total of 811 kg, 107 kg and 354 kg of produce were harvested from traditional *jhum*, agri-silvi-livestock and agri-horti-silvi model, respectively. However, the paddy variety var. Bhalum 4in agri-silvi-livestock and agri-horti-silvi model was completely failed due to sudden outbreak of *Gundhi* bug. On the contrary, *Lokhomo* and local gum rice were unaffected. Another reason could be the time of sowing. All rice cultivars were sown delayed by one month, which might have affected the improved variety, but locals were escaped due to its long acclimatization with the place.

Besides this, alder based *jhum* system were developed at Longleng and Wokha. Model systems were developed at ICAR farm at Jharnapani and Wokha and in farmer's field at Medziphema (Fig 12). All together 53 piglets were distributed for inclusion of animals in *jhum* at Dimapur, Phek, Wokha, Longleng and Kohima districts of Nagaland. Pigshed were also constructed at Jharnapani, Medziphema, K-Basa villages. Three days training were organized at Mission centre, Vankhosung, Wokha district for 45 nos. of participants.

**Fig 12 *Jhum* field at Medziphema**

## NAIP

**Livelihood improvement and empowerment of rural poor through sustainable farming systems in north-east India (NAIP)**

Improved and high yielding planting materials of 2 kg of rice *(*Bhalum 4*),* 5 kg pencil/faba bean *(*Annapurna*),* 1.4 kg of radish *(B-4432),* 120 g of cabbage *(*Samrat*),* 60 g of tomato *(*Bioseed 56*),* 100 g of onion *(Nasik red),* 300g of coriander *(Ramses),* 6 quintal of potato *(*K. Jyoti and Megha Jyoti*),* 2 kg of

okra *(Tokita),* 1 kg of bean *(*Yard Long*),* 800 g of bitter gourd *(*Champian*),* 1 kg of ridge gourd (F1 hybrid) and 600 g of cucumber *(*Garima Super*)* were distributed. Besides, they also planted maize, colocasia, tapioca and yam from the seeds saved in last year. To create awareness about the fertilizer application as well as to fertilizer HYVs supplied to them, 150 kg of DAP, 200 kg of MOP and 200 kg of urea were distributed. Guidance was offered to them for application of fertilizer at right dose and at right time. Large cardamom planted with agro-forestry started yielding. Plantation of 0.16 ha large cardamom yielded 60 kg of fresh capsules and after sun-drying yield came to 15.2 kg of dry capsules. Each kg of dry capsules fetched Rs. 500 in the market and thus gross income of Rs. 7600 has been generated.

In addition to this, a total of 5000 nos. of Titachap (*Michelia champaca*) and Hollock (*Terminalia myriocarpa*) seedlings were planted in a cropped area of 12.5 ha among 6 numbers of beneficiaries. Nine numbers of low cost poultry shed were established and distributed 1700 nos. of Vanaraja birds to nine progressive farmers. About 1500 of fish fingerling were reared in pig-fish integration among 2 farmers. Two nos. of honey extractor have been distributed to 6 nos. of beneficiaries who were already given honey box.Two more villages Phuktong and Tuimei were now under the activity of NAIP in Mon district (Fig 13). In Tuimei village, 20 nos. of terraces were constructed with a net area of 321.34 $m^2$ along with a water harvesting structure to ensure irrigation during winter period for growing high value vegetables. Twenty pairs of rabbit along with cage were distributed among 20 beneficiaries in Tuimei.

**Fig 13 Different activities at Mon district under NAIP project**

**Resilient shifting cultivation for sustainable soil-water-nutrient-plant continuum in hilly agriculture system of Nagaland**

The experimental design are composed of 5 treatments such as $T_1$ (Control-forest), $T_2$ (Traditional *jhum*), $T_3$ (Traditional *jhum* with minor interventions), $T_4$ (Improved *jhum* 1), and $T_5$ (Improved *jhum* 2). Field was selected and soil samples for 'before cutting' and 'after burning' have been collected for analysis in all the treatments. Traditional *jhum* system, which is simply a mixed cropping in a slashed and burnt land with traditional varieties of upland rice, maize and colocasia *etc*. were already established. Traditional *jhum* with minor interventions like improved variety of seeds like SARS 1 and SARS 2*;* line sowing etc. were also established. Pig shed construction was completed for 'animal intervention' in *jhum.* Contour bunds had been developed at 10-15 meter interval, on which alternatively colocasia and hedge plant were grown.

**Validation of indigenous techniques knowledge for weed management in sustainable production of *jhum* rice**

The field experiment was initiated in the farmers' *jhum* field of Medziphema village with ten different doses of common salt (20, 40, 60, 80, 100, 120, 140, 160, 180, and 200 kg/ha) at 20 and 40 DAS, weedy check and control (weedy) in randomized complete block design with three replications. Due to scanty of weeds at 20 and 40 DAS, application schedule of common salt was shifted at 45 and 75 DAS, when some weed growth was observed. Even at 45 DAS weed growth was found to be negligible. This might be due to proper burning which resulted in complete destruction of weed seeds. At 75 DAS, no 'grassy' weeds were observed, only broad leave weeds were observed. Plots applied with 18 per cent common salt produce maximum grain yield, followed by 12 and 20 per cent. Straw yield was highest in 8, 18, 20 per cent salt applied plots. Eighteen per cent common salt application leads to maximum harvest index. However, electrical conductivity has increased by 0.07 - 0.056 dS $m^{-1}$ with an average of 0.027 dS $m^{-1}$ after salt application twice during the *jhum* period (Fig 14).

**Development of Non-forest wastelands through Agro-forestry Models in Nagaland State of NEH Region**

A total area of 18.25 ha of degraded land has been rehabilitated. The project sites, confined in six districts

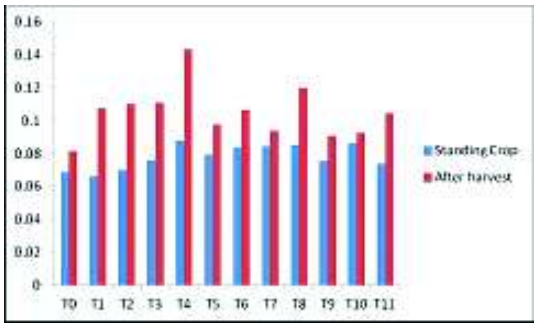



**Fig 14 Changes in EC over salt application**

of the state viz., Dimapur, Mokokchung, Kohima and Peren were first surveyed and appropriate agroforestry models have been established. The main emphasis is given to horticulture in these areas. The establishment of models at Longleng (1 ha) and Wokha (2 ha) are in progress. Three nurseries to raise tree saplings have been established at Jharnapani, Khaibung and Athibung areas. One training on livelihood security through horticulture based farming system and backyard poultry was organized at Songlhuh, Peren district wherein 60 farmers participated.

### Field demonstration on lime and fertilizer application in maize

Three demonstrations on lime application were conducted in collaboration with the Division of NRM (Soil Science section), ICAR Research Complex for NEH Region, Umiam under TSP. The application of lime in furrows (Table 8) enhanced the crop yield as well as soil pH.

**Table 8 Yield of maize variety RCM 75 and soil pH before and after the crop**

| Particulars | Initial soil pH | Final soil pH | Yield (t/ha) |
|---|---|---|---|
| Demonstration (lime application in furrows) | 5.04 | 5.22 | 2.66 |
| Farmers practice | 5.04 | 4.98 | 2.42 |

## TSP

### Seed production program for paddy, maize, soybean and toria

Under the Tribal Sub-plan (TSP), quality seed production program of paddy, maize, soybean and *toria* was initiated by the ICAR research Complex for NEH Region, Nagaland Centre, in the Institute Research Farm during 2012-13. A total of 0.4 t of quality seeds of paddy var. Ranjit (Fig 18), 12 quintal each of vars. RCM 11 and Shahsarang, 0.1 t of maize (var.RCM 76) (Fig 15-17), and 0.05 t of soybean var. JS 335 were produced to partially meet the huge demand of paddy, maize, soybean growing farmers. 0.1 t of quality seeds of *toria* var. TS 36 and 1.50 quintal of TS 38 were also produced at ICAR Research Farm.

**Fig 15 *Kharif* maize seed production**

**Fig 16 Winter maize seed production**

**Fig 17 Drying of maize cobs after harvest**

**Fig 18 Paddy variety Ranjit seed production at Main Scheme farm**

### Glimpses of seed production at ICAR Main Scheme farm

In order to prepare a roadmap for attaining self sufficiency in seed production of major Agricultural crops like paddy, maize, pulses and oilseed in Nagaland, two stakeholder workshops were organized by ICAR Research Complex for NEH Region, Nagaland Centre in collaboration with the Directorate of Agriculture, Govt. of Nagaland at Mokokchung and Kohima on March 14 and 19 respectively. Both the workshop at Mokokchung and Kohima were attended by about 80 officers from Department of Agriculture, Govt. of Nagaland, KVKs, NGOs etc. from all the 11 districts of the State. During the workshop it was decided to take up seed production programme in identified varieties of crops like paddy, maize, rapeseed & mustard and pulses in a participatory mode involving the KVKs, ICAR Complex and the Department of Agriculture, Govt. of Nagaland.

### Fruit based farming system model

Eleven different farming system models (Table 9) have been established at Dimapur, Mokokchung, Wokha and Longleng districts (Fig 19) including one mushroom unit.

**Fig 19 Models developed under TSP-Fruits**

**Table 9 Farming system models and their locations**

| Model | Place |
|---|---|
| Horticulture + Fishery + Poultry | Jharnapani, Dimapur district |
| Agriculture + Horticulture + Fishery + Duckery | Jharnapani, Dimapur district |
| Agriculture + Horticulture + Fishery + Piggery | Jharnapani, Dimapur district |
| Horticulture + Agriculture + Fishery + Poultry | Jharnapani, Dimapur district |
| Horticulture + Poultry + Dairy | Sethikema A, Dimapur district |
| Horticulture + Poultry + Fishery | Videma, Dimapur district |
| Horticulture + Agriculture + Fishery | Bade, Dimapur district |
| Horticulture + Poultry + Piggery + Fishery | Watiyim, Mokokchung district |
| Horticulture + Poultry + Fishery + Dairy | Mokokchung, Mokokchung district |
| Horticulture + Piggery + Fishery | Wokha, Wokha district |
| Horticulture + Poultry | Hukphung, Longleng district |

## TECHNOLOGY TRANSFER

### MUSHROOM

**Scientific oyster mushroom cultivation**

Mushrooms are accepted as an ideal health food and an efficient tool for recycling of organic wastes as well as a source of subsidiary income. The institute has been organizing on and off campus trainings and demonstrations on various aspects of distinguishing edible and poisonous mushrooms, low cost year round organic production technology, management of mushroom units and processing and preservation technologies. Through these trainings, demonstrations and personal contacts/visits, during the period of report, 200 numbers of beneficiaries comprising of practicing farmers, farm women and rural youths of different districts like Mon, Kohima, Peren, Wokha, Longleng, Zhuneboto are benefitted. Supply of high quality spawns of different species of oyster mushroom which can be grown in summer and winter season are made available to the growers throughout the year. On an average during the peak season, 400 packets of 200 g spawn is supplied to beneficiaries from all the districts, NGOs from the state and neighbouring states. Records show that on an average from a mushroom bed prepared out of 2 kg of paddy straw and 200g spawn produce 800 g-1.25 kg of fresh mushroom. ICAR, Nagaland Centre, has revolutionized mushroom production in the state by providing technical guidance to the local budding entrepreneurs and as a result mushroom production is gearing up in the two newly developed low cost mushroom production units for beneficiaries at Medziphema, Kukidolong village under TSP on Horticulture based Farming System and TSP on Mushroom cultivation for subsidiary income and nutritional security in a participatory mode. Each unit has the capacity to hold 150 – 200 beds made by block and polybag method. Evaluation and documentation of these units are in progress.

## ANIMAL SCIENCE

**Mega seed project on pig**

Parent stock of Large Black and Ghungroo breeds of pigs were maintained, besides Hampshire and its cross bred Ghungroo. A total of 546 numbers of piglets were born, of which 347 piglets were distributed to 122 beneficiaries of Dimapur, Kohima, Peren, Wokha, Phek, Longleng and Mokokchung district of Nagaland. The feedback from all the corners of the state is very much encouraging and demand of piglets produced under the project was enormous. Artificial insemination in pig (Fig 20) is initiated to enhance the production of piglets from superior breeding stock. During the reporting year a sum of ₹ 9,16,815 (Rupees Nine lakh sixteen thousand eight hundred and fifteen only) was generated

**Fig 20 Artificial Insemination in pig**

as revenue under the project by selling the piglets and culled animals for meat purpose.

**Establishment of pig breeding unit at farmers' field**

To promote production of piglets, breeding unit at farmers' field has been established (Fig 21) in a participatory mode. A total of nine pig breeding units were established at Dimapur, Kohima, Wokha, Mokokchung and Peren districts of Nagaland. Germplasm were supplied from the stock produced under Mega Seed Project on Pig. Out of nine units, production of piglets began in three units. The pig breeding unit at Mesoma village, Kohima has produced 30 piglets from three female in the span of one year. The unit at Bade village, Dimapur is maintaining 8 adult female and 2 male pig for breeding. All the females got conceived and expected to produce at least 50 piglets which could be used for further extension of the herd strength. In rest of the units, performance evaluation is under progress.

**Fig 21 Pig breeding unit established under TSP program at Bade village, Dimapur**

**Comparative studies on productive and reproductive performances of different breeds of pig in Nagaland**

The feed conversion efficiency in Large Black and Ghungroo pigs were compared in 12 gilts for a month with regular feeding. No significant difference was observed in feed conversion efficiency between Large Black cross and Ghungroo gilts (3-4 months age) and it was varied from 3.88 to 4.13 in Large Black and 3.4 to 4.33 in Ghungroo (Fig 22). Retrospective analysis of farrowing (no: 148 ) record at different parity in Large Black cross (80) and Ghungroo pig (68) was conducted to compare the litter size at first to fifth parity. The litter size was varied from 6.83±0.42 to 8.94±0.81 in Large Black and 7.20 ±0.55 to 10.27±1.31 in Ghungroo. There was no significant difference in litter size between Large Black and Ghungroo at first and second parity, however, it was tended to be significant (P<0.10) at third parity (Fig 22). Further, within breed comparison of litter size revealed significant higher (P<0.05) litter size at 2nd, 3rd and 4th parity compared to the first parity in Large Black cross and at 3rd and 4th parity compared to first parity in Ghungroo pig.

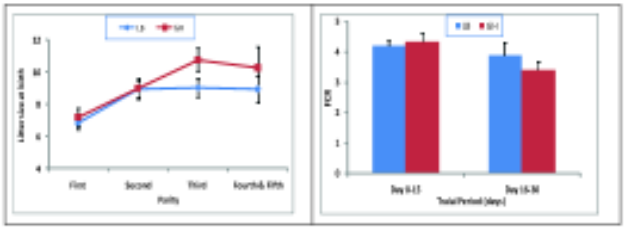


**Fig 22 Productive and reproductive performances of different breeds of pig**

**Parity wise comparison of litter size and feed conversion efficiency in Large Black and Ghungroo pig**

The plasma estradiol, progesterone and testosterone level was estimated in pre-pubertal gilt and boar from second to seven months in representative animals by radio immuno assay kits (Figs 23-25). In large black cross pig, a rising level of progesterone was observed from the 5th month onwards indicating initiation of cyclical activity. However, in Ghungroo gilts the rising of progesterone was observed at the age of 3rd month, much earlier than Large Black cross. Persistence elevation in Progesterone level was observed from 4th

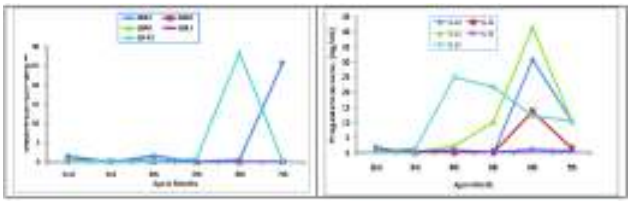


**Fig 23 Plasma Progesterone profile in Large Black and Ghungroo gilts from 2nd to 7th months of age**

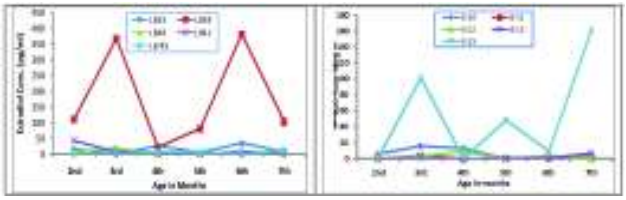


**Fig 24 Plasma Estradiol profile in Large Black and Ghungroo gilts from 2nd to 7th months of age**

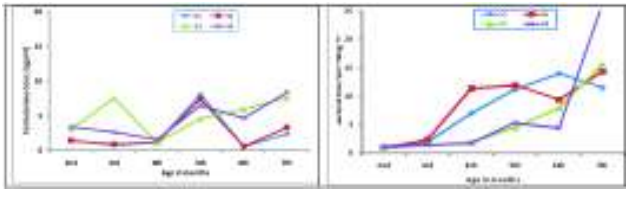


**Fig 25 Plasma Testosterone profile in Large Black and Ghungroo boars from 2nd to 7th months of age**

to 7th month onwards in one Ghungroo gilts that subsequently farrowed at seven months indicating early sexual maturity trait in Ghungroo female. The plasma estradiol concentration was increased at 3rd months onwards in some gilt and a typical estradiol profile was observed in one gilt which came into estrous at 3rd month and subsequently conceived and farrowed at seven months of age. The plasma testosterone profile of boar at 2nd to 7th month of age revealed a rising level from 3rd month onwards in majority of the boars of Ghungroo as compared to at 5th month in Large Black cross. The endocrine profile in male and female elicited early maturity trait in Ghungroo pig as compared to Large Black cross.

**Poultry seed project**

The parent stock of Vanaraja and Gramapriya chicken were maintained in this project. During the reporting year, three new poultry units comprising of hatchery house, brooder -cum- grower house and layer house were acquired under the project. A total of 101,061 numbers of eggs comprised of 82,962 nos. of Vanaraja and 18099 nos. of Gramapriya eggs were produced. Of which, a total 77653 no. of eggs were set and 53776 no. of chicks were produced with 86.34% fertility in Vanaraja 87.46% fertility in Gramapriya. The hatchability on fertile eggs set were 80.52% and 77.78%, respectively in Vanaraja and Gramapriya varieties. The fertility rate was varied from 59.27 to 90.94% in Vanaraja and 80.85 to 93.86% in Gramapriya varieties during last year. Altogether, 45,150 numbers of chicks (Table 10) were distributed to the beneficiaries at subsidized rate in Nagaland, Arunachal, Assam and Meghalaya at day old or after rearing for 3-4 weeks at brooding unit. A total of 21803 no. of chicks were distributed to the farmers directly in different districts of Nagaland and 3300 nos. of chicks were received by farmers in Assam and Manipur. Eight KVKs working in North east has collected 10160 no. of chicks for their on farm trail and demonstration at farmers' filed. Further, 13443 no. of eggs and 3500 kg live birds were sold for table purpose among the staffs and residence in neighboring areas. During the reporting period, a sum of ₹ 18,62,620 (Rupees Eighteen lakh sixty two thousand six hundred and twenty only) was realized as revenue by selling of chicks, eggs and culled birds.

**Table 10 Beneficiaries' details under poultry seed project**

| Particulars of beneficiaries | No. of beneficiaries | Total nos. of chicks collected |
|---|---|---|
| Farmers | 241 | 21833 |
| Distribution through KVKs | 8 | 10,160 |
| Farmers from Assam and Manipur | - | 3300 |
| Distribution under the project TSP /NAIP/NICRA etc. | 180 | 9857 |
| Total no. of chicks distributed | | 45150 |

Under the Tribal Sub - Plan of Poultry Seed Project, four training programs were organized to provide hands-on training on scientific rearing of backyard poultry production. Altogether 204 participants from Dimapur, Kohima, Mon, Peren, Mokokchung, Wokha and Zunheboto districts were participated and learnt the techniques of scientific poultry farming (Figs 26-27). Further, a total of 150 farmers were covered under TSP of Poultry Seed Project and given assistance by proving grown up chicks at subsidized rate and 8757 nos. of Vanaraja and Gramapriya chicks were distributed among the beneficiaries. Out of 11 unit established in previous year, eight farmers has extended the poultry unit and managing a stock of 200 to 200 birds and generating an additional income of ₹ 10,000 to 12,000 per month. The production performances of three different units are presented below (Table 11).

**Fig 26 Vanaraja birds under low input production system**

**Fig 27 Rearing of layer stock at Watiym village, Mokokchung**

**Livelihood improvement and empowerment of rural poor through sustainable farming systems in Mon district of Nagaland (NAIP- III)**

The scientific rearing practice of Vanaraja birds at backyard was demonstrated at farmers' field. Four progressive farmers namely Tayang, Yuao, Tamok, Chingngam established small semi-intensive poultry

**Table 11 Performance and economic evaluation of Vanaraja birds at demonstration units in farmers field under TSP Poultry Seed Project**

| Units | No. of birds procured | Survivability (%) up to 6 months | Production status Body weight gain | Total expenditure ( ₹ ) | Total income( ₹ ) | Net benefit ( ₹ ) |
|---|---|---|---|---|---|---|
| **Unit-1** | 400 | 98 | 8 wks: 1061±36 g<br>16 wks:2544±105 g | 1,18,770 | 158,588 | 39,818 |
| **Unit-2** | 400 | 81 | 12 wks :1700 g<br>24 wks :3008 g | 1,16,000 | 1,79,625 | 63,625 |
| **Unit-3** | 350 | 82.86 | 24 wks: 2.5 to 3.25 kg | 1,00,000 | 1,28,625 | 28,625 |

unit. They established small poultry house with locally available bamboo, thatch grass and wood with floor space of 500 sq ft for rearing 150-200 birds. The birds were maintained under semi –intensive system with minimum supplementation of poultry ration or home-made concentrate mixture comprising of broken rice, maize, and grain residues. The prophylactic measures to the birds against prevalent diseases of Ranikhet, Gumboro and fowl pox were taken care by the ICAR. The average body weight attained about 2.0 – 2.5 kg at five months of age.

### Performances of Vanaraja birds at Lampong Shenghah village of Mon districts

The survival rate of the Vanaraja birds was recorded as 80-85 per cent (Fig 28). All four farmers have used a sizable portion of total birds for home consumption at family function or during festival. The remaining birds were sold at local market (Fig 29) on an average of ₹ 300 – 400 per bird and earned additional income.

**Fig 28&29 Performances of Vanaraja birds at Lampong Shenghah**

The expenditure and income for each unit is presented below (Table 12). The total income included the amount generated out of sale of birds and the estimated value of birds used for home consumption.

All these four progressive farmers learned the scientific knowledge of rearing backyard poultry from ICAR and not only met the requirement of animal protein for their families but also generate additional income. All four farmers have now extended their poultry unit. They are maintaining a stock of 200-400 birds regularly and earning ₹ 10,000 to 11,000 per month. The performance of Vanaraja birds at low input production system created a positive impact on the fellow farmers.

### Establishment of vaccine bank under TSP

The non- availability of vaccine for livestock and poultry in North East region is considered to be major constrain for success in animal husbandry. An initiative was taken under Tribal Sub Plan to set up a vaccine bank for maintaining cold chain and supply of different vaccines for livestock and poultry at free of cost to the beneficiaries directly or through the KVKs and state department. During the reporting year a total of 810 doses of swine fever, 4000 doses of FDRD (F strain), 2600 doses of FDRD (R2B strain), 3600 doses of fowl pox and 200 doses of duck cholera vaccines were distributed in Dimapur, Kohima, Wokha, Peren and Phek districts of Nagaland. Further, two animal

**Table 12 Economic evaluation of backyard poultry demonstration units at Lampong Shenghah village, Mon**

| Farmer name | No. of birds procured | Survival (%) | Total expenditure ( ₹ ) | Total income ( ₹ ) | Net benefit ( ₹ ) | Home consumption (live weight) |
|---|---|---|---|---|---|---|
| Shri Yuao | 400 | 85 | 60,000 | 1,05,000 | 45,000 | 120 kg |
| Shri Chingngam | 175 | 84 | 26,600 | 34,720 | 8,120 | 90 kg |
| Shri Tayang Konyak | 175 | 83 | 24,730 | 39,980 | 15,250 | 25 kg |
| Shri Tamok | 100 | 80 | 15,470 | 25,000 | 9,530 | 30 kg |

health camp cum vaccination program was conducted at Dimapur and Peren districts covering about 121 beneficiaries. Besides distribution of feed supplements and deworming, vaccination was done against rabies in dog, swine fever in pig and FMD in cattle.

## TRAINING AND DEMONSTRATION

**Table 13 List of trainings conducted under different programmes/projects**

| Sl. No | Title of the training | Venue with detail address | Types of beneficiary | Period | Total no. of participants | Name of the project/ programme |
|---|---|---|---|---|---|---|
| 1 | Resilient jhum cultivation through integrated farming system | Mission Centre, Vankhosung, Wokha | Students | 5th-7th February, 2013 | 45 | TSP |
| 2 | Weaving cum Sewing for Women Empowerment at Mon District of Nagaland | Department of Clothing and Textile, College of Home Science, AAU, Jorhat | Farm women | 21st – 30th November, 2012 | 05 | NAIP |
| 3 | One day hands-on training programme on Mushroom Cultivation | Lampong Sheanghah village, Mon, Nagaland | Farmers and local youths | 6th December, 2012 | 29 | NAIP |
| 4 | Honey box making for additional income generation | C.K. Udyog office, Bahana, Jorhat | Farmers | 21st – 23rd November, 2012 | 03 | NAIP |
| 5 | Seminar cum training on tuber crop technologies | Jharnapani | Farmers | 21st September, 2012 | 46 | Technology Mission |
| 6 | Hands on training on scientific mushroom cultivation | Jharnapani | Farmers | 22nd September, 2012 | 39 | Technology Mission |
| 7 | Training on Package of practices of fruit crops | Gariphema | Farmers | 5th January, 2013 | 41 | Technology Mission |
| 8 | Hands on training on scientific mushroom cultivation | KVK, Jharnapani | Farmers | 15th January, 2013 | 33 | Technology Mission |
| 9 | Hands on training on scientific mushroom production and processing | KVK, Jharnapani | Farmers | 16th January, 2013 | 28 | Technology Mission |
| 10 | Training cum demonstration on winter vegetable cultivation | Songlhuh, Peren | Farmers | 08th November, 2012 | 53 | TSP (Fruits) |
| 11 | Diseases of maize | KVK,Dimapur | Farmers and Rural Youth | 10th July 2012 | | DMR, New Delhi |
| 12 | Hands on training on scientific mushroom cultivation | KVK,Dimapur | Farmers and Rural Youth | 22nd September, 2012. | 38 | Horticulture Technology Mission |
| 13 | Integrated management of the major diseases of maize and rice | KVK,Dimapur | Farmers | 20th November 2012 | 35 | NICRA |
| 14 | Hands on training on scientific mushroom production and processing | KVK,Dimapur | Farmers and Rural Youth | 15-16th January 2013 | 32 | Horticulture Technology Mission |
| 15 | Scientific mushroom cultivation technology | Dhansiri subdivision, Shorupathar | Farmers and Rural Youth | 17th January 2013 | 127 | Sunipun Educated Unemployed Farmers Association |
| 16 | Pig and Poultry production in backyard: avenues for entrepreneurship development | ICAR Research Complex, Nagaland Centre | Farmers, rural youth, NGOs | 18-20th September, 2012 | 43 | TSP (Poultry Seed Project) |
| 17 | Promotion of Pig Breeding for Farmers' Empowerment and Entrepreneurship Development | ICAR Research Complex, Nagaland Centre | Farmers and rural youth | 13-14th December, 2012 | 28 | Mega Seed Project on Pig |

*Contd.....*

| | | | | | | |
|---|---|---|---|---|---|---|
| 18 | Backyard poultry and Homestead gardening – Avenues for nutritional security of poor farmers | Songlhuh village, Athibung, Peren District | Farmers | 9th August, 2012 | 75 | TSP (Poultry Seed Project) |
| 19 | Livestock Health Management | Bade village, Dimapur | Farmers | 24th September, 2012 | 60 | TSP (Poultry Seed Project) |
| 20 | Backyard poultry production cum vaccination program | Inbung village, Athibung, Peren | Farmers | 4th December, 2012 | 61 | TSP (Poultry Seed Project) |

**Seed distribution cum training programmes conducted under Tribal Sub Plan**

Seed Distribution Ceremony at Jalukie Town Hall of Peren district was organized in collaboration with the Confederation of Naga Farmers' Union (CONFU), Peren on 28th of April, 2012 (Fig 30). Five quintal RCM 76 variety of maize and 7 quintal *Ranjit* variety of paddy from ICAR were distributed to the farmers. About 650 farmers gathered in the programme from 25 different villages of the district. Mr. T.R. Zeliang, Minister, Veterinary & Animal Husbandry, Govt. of Nagaland was the Chief Guest of the programme and the Deputy Commissioner, Peren district chaired the meeting in presence of the Joint Director, ICAR Research Complex, Nagaland Centre, scientists and officers form Agriculture and Veterinary & Animal Husbandry department, Govt. of India.


**Fig 30 News paper cutting of the programme**

Another seed distribution Ceremony was organized in collaboration with DICE Foundation at Yampha village, Wokha district, Nagaland on 8th of May, 2012. A total of 2.50 quintals of maize var. RCM 75, RCM 76, DA 61 A and Vijay Composite along with lime and chemical fertilizers were distributed to the farmers. Fifty farmers from Ralan area of Wokha district participated in the programme.

**Fig 31 Seed distribution ceremony at Wokha district**

Krishi Vigyan Kendra, Mon District Nagaland organized a training cum seed distribution programme on 22nd of June, 2012 at KVK Mon where a total of 20 farmers attended the programme and 500 kg of hybrid maize variety DMH 849 was provided by ICAR Research Complex for NEH Region, Nagaland Centre, Jharnapani was distributed to the farmers.

A 2 days training programme on 'New Technologies in Maize Production' was organized by KVK Dimapur, ICAR Research Complex for NEH Region, Nagaland Centre at KVK, Dimapur in collaboration with the Directorate of Maize Research , New Delhi on 10th -11th of July, 2012. The Chief Guest of the function Dr. C. Rajkhowa , Director, NRC on Mithun, Jharnapani released a folder on 'Cultivation of Maize (*Zea mays* L)' both in English and Nagamese dialect sponsored by DMR New Delhi**.** A total of 50 maize farmers from Mon, Zunheboto, Phek, Wokha and Dimapur districts of Nagaland attended the training. Two SMS from KVK Zunheboto and NEPED also participated along with other farmers. Maize seeds (Hybrid and composite) and farm implements (weeder and maize sheller) were also distributed to the beneficiaries.

**Fig 32 Training Program organized under TSP of Poultry Seed Project at ICAR-Research Complex, Nagaland Centre, Jharnapani on September 18-20, 2012**

# SIKKIM CENTRE

## WEATHER REPORT

The maximum rainfall of 715.8 mm was received during June, 2012 whereas, minimum rainfall (0.2 mm) was recorded in Nov, 2012 and there was no rainfall during the month of Jan, 2013.The maximum average temperature (28.13$^0$C) was observed in May, 2012 and the minimum (6.44$^0$C) was observed in Jan, 2013 (92.1%). The maximum RH was recorded during June, 2012 and the minimum RH of 44.18% was recorded during May, 2012 (Table 1).

**Fig 1 Rajmash line SKR 57**

**Table 1 Weather parameters of Tadong during 2012-13**

| Months | Temperature (°C) | | Relative humidity (%) | | Bright Sunshine hours | Total rainfall (mm) |
|---|---|---|---|---|---|---|
| | Max | Min | Max | Min | | |
| Apr | 25.04 | 14.12 | 87.13 | 47.17 | 4.31 | 508.0 |
| May | 28.13 | 17.03 | 86.32 | 44.81 | 4.78 | 204.2 |
| Jun | 26.74 | 19.84 | 92.1 | 67.93 | 1.05 | 715.8 |
| Jul | 26.89 | 20.38 | 88.41 | 67.74 | 1.28 | 510.5 |
| Aug | 27.81 | 20.2 | 91.23 | 63.74 | 2.55 | 506.2 |
| Sep | 26.29 | 18.99 | 75.53 | 54.37 | 1.97 | 459.6 |
| Oct | 25.02 | 14.64 | 75.29 | 51.19 | 5.34 | 102.6 |
| Nov | 21.37 | 10.45 | 80.11 | 54.89 | 4.15 | 0.2 |
| Dec | 17.35 | 8.47 | - | - | 1.40 | 1.4 |
| Jan | 16.46 | 6.44 | - | - | 2.86 | 0.0 |
| Feb | 20.81 | 9.51 | - | - | 4.72 | 19.5 |
| Mar | 24.01 | 12.78 | - | - | 4.70 | 92.6 |

(-) RH data were not recorded because of machine failure.

## CROP IMPROVEMENT

### Evaluation of Rajmash germplasm

Thirty five entries were evaluated during *kharif* season, 2012. These entries were already tested during pre-rabi 2011 to observe their performance under both the growing seasons i.e *kharif* and pre-rabi season. Out of 35 entries three entries viz. SKR57, IPR96-4 and Naogaon Rajmash performed well under both the growing seasons. These entries yielded SKR 57 (1.35 t/ha), IPR 96-4 (1.30t/ha) and Naogaon Rajmash (1.30 t/ha). SKR 57 (Fig 1) and Naogaon Rajmash were earliest in maturity (115 days).

### Genetic advancement of elite rapeseed material suitable for cultivation under Sikkim conditions

Yellow Sarson: Eight single plant selections (Table 2) were done in SSY 2 (Sikkim Sarson Yellow 2) population based on yield contributing traits and maturity.

Toria: Selection SKMT 2 selected from the segregating population of SCR 1-2-5 have been put for population stability. This population matures in about 110 days and yields about 1.10 t/ha.

**Fig 2 Evaluation plot of Yellow sarson selections**

**Table 2 Morphological characters of selections from SSY 2 population**

| Selection No. | Plant height (cm) | No. of primary branches | No. of siliqua /plant | No. of seeds /siliqua | Seed yield /plant(g) |
|---|---|---|---|---|---|
| S 19-1 | 115 | 6 | 81 | 36.40 | 10.50 |
| S 20-1 | 124 | 9 | 198 | 24.40 | 16.20 |
| S 10-1 | 118 | 9 | 228 | 24.20 | 16.20 |
| S 1-3 | 148 | 10 | 319 | 14.20 | 19.30 |
| S 1-4 | 115 | 6 | 185 | 16.80 | 8.08 |
| S 1-1 | 132 | 5 | 191 | 16.00 | 14.17 |
| S 1-2 | 112 | 8 | 282 | 23.00 | 21.20 |
| S 15-1 | 90 | 6 | 121 | 39.40 | 17.20 |

**Population improvement in early maturing and high yielding composites of maize (*Zea mays* L.) suitable for Sikkim**

Thirteen single cob selections were done in yellow seeded population coded C-2. Selection based on characters like good cob size, yellow bold round kernel and medium maturity. Five single cob selections were done in white seeded population coded C-11. Selection based on characters like good cob size and medium maturity (Fig 3).

**Fig 3 Single cob selection in yellow and white seeded population**

**Identification of medium height, early to medium duration and high yielding lowland rice genotypes**

Based on the performance of the lowland RCRT trials three lines were identified as better performing under midhills i.e RCPL 1-123, RCPL 1-473 and RCPL 1-469.

**Identification of high yielding buckwheat genotypes**

Thirty six buckwheat genotypes both *Fagopyrum esculentum* and *F. tataricum* type were evaluated per the descriptors for Buckwheat.

**Fig 4 Evaluation plot of RCPL1-123**

**Fig 5 Evaluation plot of RCPL1-473**

The highest yielding entries were IC109728 (3.2 t/ha), PRB1 (3.13 t/ha), IC109549 (2.4 t/ha) and IC202268 (2.12 t/ha).

**Table 3 Morphological characters of paddy lines**

| Entry | Plant height (cm) | Days to 50% flowering | No. of tillers/hill | Panicle length (cm) | No. of grains /panicle | Days to 75% maturity | Yield (t/ha) |
|---|---|---|---|---|---|---|---|
| RCPL 1-473 | 98.80 | 79 | 10.00 | 26.80 | 146.00 | 135 | 4.13 |
| RCPL 1-123 | 102.00 | 78 | 10.40 | 24.20 | 232.40 | 135 | 3.53 |
| RCPL 1-469 | 92.80 | 75 | 10.00 | 20.4 | 257.00 | 130 | 3.04 |

**Fig 6 Evaluation plot of buckwheat germplasm**

### Identification of high yielding soybean genotypes

Based on RCRT soybean trials, entry RCS 1-10 was the highest yielder. It matures in 120 days (3.0 t/ha).

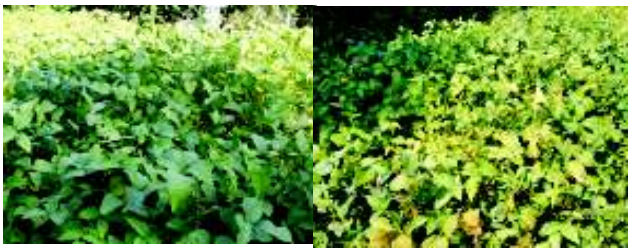


**Fig 7 Soybean line RCS 1-10**

### Upland rice trials

Bhalum 3 and RCPL 412 were identified as better performing genotypes (Table 4) under farmer's field conditions (Fig 8).

**Table 4 Performance of upland paddy varieties in Sikkim**

| District | | Entry | Days to maturity | Estimated yield(t/ha) |
|---|---|---|---|---|
| North | Upper Dzongu and Passingdang | Bhalum 3 | 130 | 2.8 |
| South | Turung (Namthang) | Bhalum 3 and RCPL 412 | Both are of 130 days | 3.0-3.2 (Both varieties) |
| East | Tadong, Gangtok | Bhalum 3 and RCPL 412 | 130 and 135 days respectively | 3.56 and 3.59 respectively |

## INSECT PEST

## BUCK WHEAT

### Identification of pollinators in buck wheat

Buckwheat is the most important life support, multipurpose and nutritious cereal crop of the Sikkim

**Fig 8 Upland paddy evaluation trials**

Himalayas. It is the only crop grown up to 4500 m elevation. Pollinator plays pivotal role in production of buckwheat. Honeybees visit buckwheat flowers for collection of both pollen and nectar. Besides honey bee there are so many insect visitors which visit during flowering time and accomplish pollination. An experiment was conducted to identify the pollinators of buckwheat during 2012-2013. Two sq.m plot of buckwheat crop was taken and the number of pollinators visit to the plot in 10 minutes was recorded in different periods of the day. In Sikkim around 10 insect pollinators were recorded (Table 5). Some of them were nectar feeder and some were pollen robberer (Fig 9). Among the visitors, *Apis cerana indica*, *Eristalis tenax*, *Eristalis* sp, *E. himalayensis* and Syrphid fly visit more. The visit of insect pollinators was influenced positively by the BSSH. The population of pollinators was less in cloudy and rainy days. The maximum population of all pollinators was observed during 10 AM to 11 AM. The population of pollinators was observed more in the buckwheat crop which attained flowering stage in the month of January

***Apis cerana indica*** ***Eristalis tenax*** ***Eristalis himalayensis***

***Eristalis* sp** **Syrphid fly** **Blue housefly**

**Fig 9 Pollinators in buck wheat in Sikkim**

**Table 5 List of insect pollinators observed in buckwheat**

| Name of insect pollinators | Name of Order | Remark |
|---|---|---|
| *Apis cerana indica* | Hymenoptera : Apidae | Nectare and pollen |
| *Eristalis tenax* | Diptera :Syrphidae | Nectare |
| *Eristalis himalayensis* | Diptera :Syrphidae | Nectare |
| *Eristalis* sp | Diptera :Syrphidae | Nectare |
| *Bombus breviceps* | Hymenoptera : Apidae | Nectare and pollen |
| *Danaus chrysippus* | Lepidoptera : Nymphalidae | Nectare |
| Syrphid fly | Diptera :Syrphidae | Nectare |
| Blue housefly (*Lucilia* sp) | Diptera : Calliphoridae | Nectare |
| Cabbage butter fly | Lepidoptera :Pieridae | Nectare |
| Rice skipper | Lepidoptera : Hesperiidae | Nectare |

## MUSTARD

### Study on the effect of abiotic factors on population of mustard aphid and sawfly

The total area of the experimental plot was divided into four plots and from each plot 10 plants were selected randomly to take the observation of population of mustard aphid and saw fly at weekly interval. The meteorological data were also collected periodically. From the study it was observed that the aphids appeared first on 50$^{th}$ standard week and the population was found maximum on 2$^{nd}$ standard week (63.48 aphids/ 10 cm central shoot) (Table 6). The saw fly population appeared on 46$^{th}$ standard week and reached maximum on 47$^{th}$ standard week (1.42 larvae/plant). The correlation study reveals that the population of aphid is significantly influenced negatively by the maximum temperature (r = - 0.64) and minimum temperature (r = - 0.83). The population increased with the decrease of temperatures whereas the population of saw fly influenced positively i.e., the population increased with the increase of maximum temperature (r = + 0.67) and minimum temperature (r = + 0.68). *Coccinella septempunctata*, *Menochilus sexmaculata* and Syrphid fly were found some potential natural enemies for reduction of aphid population.

### Screening of germplasms for resistance/ tolerance against mustard aphid and saw fly

Fourteen different germplasm of rapeseed and mustard viz., Sikkim Sarson Yellow 1, Sikkim Sarson Yellow 2, Sikkim Toria1, Sikkim Toria 2, Sikkim Sarson Brown 2, Yellow Sarson IC 385, Yellow Sarson Yellow 3, Yellow Sarson Jhumka, Yellow Sarson IC 398652, Sikkim Sarson Brown 1, TS 36, TS 38, TS 46, and M 27 were screened against mustard aphid and saw fly during 2012-13. Amongst them Sikkim Toria 2, Sikkim Sarson Yellow 1, Yellow Sarson Yellow 3 and TS 38 were less infested by mustard aphid and saw fly in comparison to others.

### Study the effect of sowing time on population build of mustard aphid and saw fly

To find out the suitable sowing time in case of mustard and rapeseed to avoid the infestation of mustard saw fly and mustard aphid one experiment was conducted by taking six different dates of sowing starting from 25$^{th}$ September. The population of saw fly was recorded at vegetative stage and mustard aphid

**Table 6 Affect of abiotic factors on population of mustard aphid and saw fly**

| Date of observation | Standard week | No. of aphids/ 10 cm central shoot | Date of observation | Standard week | No. of saw fly /plant |
|---|---|---|---|---|---|
| 15.12.2013 | 50 | 12.47 | 17.11.2012 | 46 | 0.68 |
| 22.12.2012 | 51 | 27.15 | 24.11.2012 | 47 | 1.42 |
| 29.12.2012 | 52 | 34.92 | 01.12.2012 | 48 | 1.36 |
| 05.01.2013 | 01 | 46.32 | 08.12.2012 | 49 | 1.18 |
| 12.01.2013 | 02 | 63.48 | 15.12.2012 | 50 | 0.92 |
| 19.01.2013 | 03 | 54.62 | 22.12.2012 | 51 | 0.64 |
| 26.01.2013 | 04 | 50.76 | 29.12.2012 | 52 | 0.82 |
| 02.02.2013 | 05 | 44.14 | 05.01.2013 | 01 | 0.78 |
| 09.02.2013 | 06 | 39.26 | 12.01.2013 | 02 | 0.38 |
| 16.02.2012 | 07 | 23.86 | 19.01.2013 | 03 | 0.30 |
| 23.02.2013 | 08 | 14.20 | 26.01.2013 | 04 | 0.12 |

was recorded at 25% flowering stage of the crop. From the study it was observed that in case of early sowing the infestation of saw fly was more whereas the infestation of mustard aphid was found more in late sown crop. Therefore, the period 8-15th October can be considered as suitable period for sowing of mustard and rapeseed to avoid heavy infestation of aphid and saw fly.

## DISEASE

### Management of white rust in mustard under organic conditions

Among the treatments Trichostar (*Trichoderma viride*) as seed, soil treatment and spray was most effective (38.00 PDI) over the control (64.77 PDI) (Table 7). Following the Trichoderma the spraying of cow urine @ 10 % also significantly reduced the white rust incidence. However the fungicide metalaxyl was most effective with less PDI of 23.66%. The effect of various treatments on stag head incidence was also studied and found to be nonsignificant. The treatment of seed and soil with *T. viride* and also spray application showed fewer incidences of staghead symptoms (6.39%) compared to all other treatments. The staghead incidence was also very less (1.04) in the plants treated with metalaxyl. Among the botanicals none of them found to be effective against white rust.

**Table 7 Effect of different organic treatments on per cent disease incidence of white rust and stag head**

| Treatment | Percent disease incidence | Per centage of stag head |
|---|---|---|
| Cow urine 10% | 49.71(44.82)* | 14.30 |
| Artemisia 10% | 52.89(46.66) | 13.60 |
| Chiloney 10% | 54.49(47.60) | 10.69 |
| Garlic 10% | 56.38(48.69) | 16.50 |
| Turmeric 10% | 55.54(48.18) | 12.76 |
| Ginger 10% | 53.33(46.92) | 12.98 |
| *Trichoderma viride* (seed treatment+ soil application+ spray) | 38.00(38.04) | 6.39 |
| Metalaxyl 0.1% | 23.66(28.68) | 1.04 |
| Control | 64.77(53.77) | 18.19 |
| Cv (%) | 11.78 | 78.77 |
| CD (*P*= 0.05) | 9.14 | Non singnificant |

*Arc sine transformed values

## HORTICULTURE

### Evaluation and screening of chow-chow (*Sechium edule*) germplasm under varied climatic conditions

In total 80 numbers of chow-chow (*Sechium edule*) accessions were collected from Sikkim during 2012. A huge range of fruit phenotypic variations were observed for several parameters under study such as fruit weight, fruit length, fruit width, fruit height, fruit girth, fruit volume, fruit color and surface texture etc. To estimate variations among collected chow-chow fruits germplasm for different chemical and nutritional qualities; several quality parameters were studied for about 40 accessions (Fig 10-11).

**Fig 10 Morphological / phenotypical variations of some chow-chow germplasm**

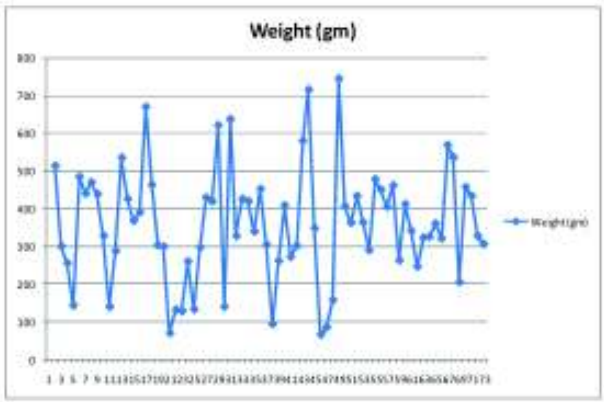



**Fig 11 Variation in weight of different cultivars**

## Horticulture Mission for North Eastern Himalayan States-I

### Production technologies for off season cultivation

### CABBAGE

Cabbage var. Magic Ball transplanted in the month of October, had better head yield compared to November and January transplantation, both in "Open Field" and "Poly House" condition. Whereas, the head yield per hectare in the "Open Field" condition was

nearly double compared to the "Poly House" conditions, which were 74.39 t/ha and 40.57 t/ha, respectively for October transplantation. The yield of the variety Maharani transplanted in the month of May 2012, in the "Poly House" conditions was 18 t/ha, compared to uneconomic yield in "Open Field" condition.

## CAULIFLOWER

Cauliflower variety Shalakha transplanted in the month of November had maximum yield in both the "Poly House" (48.58t/ha) and "Open Field" condition (40.31 t/ha), compared to October (28.53 t/ha in poly house and 38.62t/ha in Open Field), January 2012 (no yield), May (no yield) and August (6.04 t/ha) in poly house and no yield in open field.

## BROCCOLI

Broccoli variety Everest transplanted in the month of November had maximum yield in the "Open Field" condition (17.73 t/ha), compared to "Poly House" condition (202.6 g/plant) and other transplanting time. Whereas, October transplanting produced nearly similar yield in both growth conditions, with partially better performance in the "Open Field" condition (221 g/plant) in poly house and 230.1 g/plant in open field.

## TOMATO

Most of the varieties except a local tomato variety (Cherry Tomato of Sikkim) suffered from severe bacterial wilt infection and growth was adversely affected due to heavy rain fall. Therefore, no economic yield was achieved.

## CARROT

The performance of the variety Nantes was very much promising in Sikkim condition which yielded 73.33 t/ha. Maximum value for parameters such as biomass, single tuber weight, tuber length and tuber girth was observed to be 173.6 g, 115.8 g, 20.34 cm and 35.42 mm respectively in the seed sown in the month of November.

## BEET ROOT

Beet root was grown in RBD with three replications and normal agronomic practices were followed till their harvest. Seeds were shown in 9$^{th}$ of November 2012 and crop was harvested on 12$^{th}$ March 2013. Data on several morphological parameters and yield were collected at harvest. The performance of the beet root under study in the given season was very much promising in Sikkim condition which yielded 30.67 t/ha. Maximum value for parameters such as biomass, single tuber weight, tuber length and tuber girth was observed to be 196.4 g 218.3 g, 69.37 cm and 84.67 mm, respectively.

## OKRA

Local varieties were late in flowering but had longer fruiting period and yielded maximum fruits 25.0 t/ha - 45.0 t/ha, accompanied with better fruit length, fruit width and single fruit weight but had less consumer preference, compared to other six commercial varieties. On the other hand though commercial varieties had lesser yields than the local ones, but proved to be early in maturity and short duration crop in Sikkim condition with good quality fruits, among which maximum yield with quality fruits was produced by the variety Nirmal 303.

## INSECT PESTS

### Assessment of damage of fruit borer and management

An experiment was conducted to determine the extent of damage of fruit borer in tomato during 2012 both in field and protected conditions. In Sikkim, though the infestation of *Spodoptera litura* and *Helicoverpa armigera* were observed but the *S. litura* population was more in comparison to *H. armigera*. The infestation of fruit borer was recorded more in tomato cultivated inside polyhouse (20.50-26.26%) than open field condition (14.54-20.76%)

### Fruit morphology of kiwifruit at harvest (hand pollinated and open pollinated)

Hand pollination produced larger size fruits, compared to open pollination for all three varieties. Hand pollinated Allison, Monty and Bruno had longer fruits (7.99, 7.99 and 7.5 cm respectively), whereas, open pollination resulted in comparatively smaller fruits 5.22, 4.24 and 4.12, respectively. Similarly hand pollination resulted in increased fruit width than such as 3.76, 4.46 and 4.34 compared to open pollination 3.09, 3.07 and 3.26 cm respectively. Hand pollination also showed significantly large fruit weight such as Allison (73.62 g), Monty (107.7 g) and Bruno (92.6 g) compared to open pollinated Allison (43.19 g), Monty (37.5 g) and Bruno (28.64 g).

**Chemical qualities of hand pollinated and open pollinated kiwifruit at harvest**

Kiwifruits of all three varieties produced through hand pollination contained significantly increased quantity of all five chemical quality parameters under study, compared to open pollinated ones. Vitamin C content among all five quality parameters, showed maximum increase due to hand pollination in the variety Allison (Vit-C increased by 98 mg) compared to other varieties. However, Vitamin C content did not significantly changed due to hand pollination in the variety Monty and Bruno compared to open pollination. Total Soluble Solid (TSS) showed a substantial increase due to hand pollination in all the varieties, with maximum TSS increase was observed in the variety Bruno, followed by Monty and Alison. Acidity quantification showed significant decrease in the hand pollinated Bruno followed by Alison, but contrastingly significant increase in acidity was observed in the hand pollinated Monty. Total sugar content decreased in the variety Allison and Monty, whereas a contrasting increase in the variety Bruno was observed. Interestingly hand pollination significantly increased amount of Reducing Sugar Content in all the varieties with maximum increase in the variety Monty, followed by Bruno and Alison.

**Effects of storage temperature on hand pollinated and open pollinated kiwifruit**

All three kiwifruit varieties under study were stored in both the room and refrigerated conditions for up to 4 weeks. Data on several quality parameters were collected at weekly interval. Acidity content was decreased in all the varieties by 3$^{rd}$ week under both the storage conditions. Total Sugar content increased and became nearly double by 4$^{th}$ week of storage under both the room and refrigerated condition, for all the varieties. Maximum increase in total sugar content was observed in the hand pollinated Monty (increased by 10 mg/ 100 g) under room condition and open pollinated Bruno (increased by 10 mg/ 100 g) under refrigerated condition, after four weeks of storage. TSS in room condition continuously increased for the storage period under study, for all the varieties including both hand and open pollinated. Maximum TSS was observed for the hand pollinated Bruno. However maximum increase in TSS (7.60 brix) was recorded in case of open pollinated Monty by 4$^{th}$ week of storage compared to all other varieties. On the other hand in refrigerated storage condition for all the varieties, similar but lesser TSS increase was observed for the storage period under study. Vitamin C content was increased in the variety Allison and Monty by the 4$^{th}$ week of storage in room condition and which was higher than refrigerated condition. Only a little increase of Vit C content was observed in hand pollinated Bruno under both the storage conditions. Contrastingly drastic decreases in Vit C content were evident in open pollinated Bruno verity under both the storage conditions. Reducing sugar content significantly increased by 4$^{th}$ week of storage, in all the varieties and under both the storage conditions. Maximum increase in reducing sugar content was observed in Alison (hand and open pollinated) which was nearly doubled by 4$^{th}$ weeks, under room and refrigerated storage conditions.

**Studies on post harvest storage techniques for var. Bruno**

Kiwifruit variety "Bruno" was stored in both the room and refrigerated conditions for up to 6 weeks, in three different packaging systems. Data on several quality parameters were collected at weekly interval over the storage period. Acidity content increased up to 3$^{rd}$ week of storage in all the packaging system under both the room and refrigerated condition but reduced subsequently till the 6$^{th}$ week. Acidity content was lowest in perforated packaging under room and refrigerated storage conditions. Total sugar content increased in all the packaging systems in both room and refrigerated storage conditions up to 5$^{th}$ week. Maximum increase in total sugar content was observed in poly pack under both the storage condition. TSS in both room and refrigerated conditions increased up to 6$^{th}$ week of storage, with almost similar trends in all the packaging systems. Vitamin C content significantly decreased in all the packaging systems under both the storage conditions up to 6$^{th}$ week of storage, which was reduced nearly by 60 % compared to freshly harvested fruits. Reducing sugar content slightly increased by 6$^{th}$ week of storage, in all the packaging system in nearly equal trend and under both the storage conditions.

**Collection and identification of improved varieties of temperate fruits for their suitability in Sikkim**

Germplasm of various fruit crops viz. apple, almond, plum, walnut, apricot, pecan nut, persimmon and pomegranate were collected and planted in ICAR Sikkim Centre Farm in order to establish the 'Field Gene Bank of Fruit Crops' for their further evaluation for suitability in Sikkim conditions.

### Evaluation of pear germplasm suitable for cultivation under Sikkim conditions

Different pear germplasm from Arunachal Pradesh, CITH, Srinagar, YSPUH&F, Solan and NBPGR RS Bhowali were collected and planted in order to establish Mother Block of pear cultivars. Evaluation studies have been initiated for their suitability in Sikkim conditions. Seeds of various pear germplasm were also collected and seedlings raised for further evaluation and identification of suitable rootstock(s) for Sikkim conditions.

### Field demonstration of ginger production technologywith IPM

The demonstration was undertaken at an elevation of 4739-4950 ft, located at N27018.84' E088036.06' in the Sadam village of South Sikkim under NHB Funding. Total of 5.85 ha area was covered under the project. Progressive farmers/ SHG were selected in consultation with local Panchayat and project team members. Hands on training were provided to the selected farmers/SHG for ginger production technology with IPM in the field conditions. Selected farmers were provided financial assistance for field preparation, cost of planting material, field work, manure and fertilizers and organic input for plant protection as decided by project members and local Panchayat. Total 45 beneficiaries were selected for the field level demonstration and income generation of Rs. 6.0 lakhs was reported from the Panchayat.

### Gnger seed production under TSP

Ginger seed production under TSP was undertaken in the Sadam village of South Sikkim involving only tribal farmers. Total of 3 ha area was covered under the project. Progressive farmers/ SHG were selected in consultation with local Panchayat and project team members. Hands on training were provided to the selected farmers/SHG for ginger seed production in the field conditions. Selected farmers were provided financial assistance for cost of planting material, manure and fertilizers and organic input for plant protection. Total 12 beneficiaries were selected for the demonstration.

## INSECT PESTS

### Network project on management of soft rot of ginger

Survey and surveillance was conducted for the cropping year 2011-12 in different districts of the state. The highest incidence of rhizome rot was observed in East district with 28.22%, whereas lowest incidence of disease was observed in north district (17.55%). The microbial population of the field was studied four months after planting (Fig 12) and at the time of harvest in rhizosphere and nonrhizosphere soil. The population of fungi, bacteria and actinomycetes was higher in *neem* cake+ Hot water treatment+ COC 0.3% followed by Trichoderma+ Hot water+ COC 0.3% treatment in both rhizosphere and nonrhizosphere soil. The total population of microbes in rhizosphere and nonrhizosphere of treatment containing neem cake+HWT+ COC 0.3% was 41793.18 and 71986.77 CFU /ml respectively. Similarly the total population of microbes in rhizosphere and nonrhizosphere soil of treatment containing trichoderma+ hot water treatment (HWT) + COC 0.3% was 29493.13 and 42370.44 CFU /ml respectively. The microbial population at the time of harvest showed somewhat mixed trend. The highest total population was observed in Trichoderma+HWT+ COC 0.3%. The population of fungal was highest in onion+HWT both in rhizosphere and nonrhizosphere 500CFU/g, 340 CFU/g respectively. The population of bacteria was highest in both Trichoderma+HWT+ COC 0.3% and *neem* cake+HWT+ COC 0.3% (19000 CFU/g) in nonrhizosphere whereas the population of actinomycetes was highest in the ginger treated with GF3 (30666.66 CFU/g). In rhizosphere the population of bacteria and actinomycetes was maximum in garlic+HWT and Trichoderma+HWT+ COC 0.3% (30333.33 and 31333.33 CFU g respectively). Among the treatments, *neem* cake + HWT at 47°C for 30 minutes + COC 0.3%, , Trichoderma+ HWT at 47°C for 30 minutes + COC and garlic + HWT at 47°C for 30 minutes showed better germination of more than 90% in comparison to all other treatments. The treatments Trichoderma+HWT+need based application of COC 0.3% showed less incidence of soft rot (15%) followed by *neem* cake+ HWT+need based application of COC 0.3%. The yield of different

**Fig 12 Field trials on ginger soft rot**

treatments is not significant. However the highest yield was recorded in the treatment involoving Trichoderma+HWT+ need based application of COC 0.3% followed by *neem* cake+ HWT+need based application of COC 0.3% and garlic+ HWT @47$^0$C for 30 mins.

## DISEASE

### Molecular characterization and bio-intensive management of *Collectotrichum gloeosporioides* the incitant of leaf blight in large cardamom

Field experiment was conducted to study the effect of different organic treatments against *Collectotrichum gloeosporioides* the causal agent of leaf blight in large cardamom. Among the treatments garlic bulb extract @10% both spray and drench showed less incidence of disease (5.8%) and more number of tillers followed by ginger rhizome extract @ 10% (drench and spray) with disease incidence of 11.11 when compared to control (30.51%)and other treatments (Table. 8).

**Table 8 Effect of differenct organic treatments against leaf blight under field conditions**

| Treatments | Disease incidence |
|---|---|
| T1- Soil application of *Trichoderma viride* with FYM | 28.45 |
| T2-T1+Vermi compost+COC @ 0.2% application | 28.45 |
| T3-T2+*Pseudomonas fluorescens* spray @ 0.2% | 24.86 |
| T4-Alternate application of *T. viride* and *P. fluorescens* spray @ 0.2% | 28.96 |
| T5-Garlic drench and spray @ 0.2% | 5.80 |
| T6-Ginger drench and spray@ 0.2% | 11.11 |
| T7- only COC drench and spray @ 0.2% | 15.22 |
| T8-Panch gavya drench and spray | 20.21 |
| T9- Panch gavya drench + COC spray @ 0.2% | 18.22 |
| T10-Carbendazim @ 0.1% | 4.00 |
| T11-Control | 30.51 |
| T12-Chiloney leaf extract spray and drench @ 0.2% and mulching | 29.20 |
| T13-Turmeric spray and drench @ 0.2% | 26.92 |
| T14- Cow dung extract spray and drench @ 25% | 22.81 |
| T15-Cow urine spray and drech @ 10% | 28.97 |

## NATURAL RESOURCE MANAGEMENT

### Production potential of *toria* var.M 27 as influenced by mulching and vermicompost under mid hill ecosystem of Sikkim

Post rainy season of Sikkim hardy enjoy any rainfall and crop suffer due to water stress in later stages. And also farmers grow the toria crop with minimum or no nutrients inputs and ultimately get low yield. A field experiment was conducted during 2012-13 at research farm .Dolomite @ 1 t/ha was applied to neutralize the soil acidity. The objective of study was to find out the suitable mulching material and dose of organic nutrient sources (vermicompost) for obtaining the optimum yield. The results revealed that, among the mulches, tree leaf (*Chilawney+Utis*) mulch @ 5 t/ha were found suitable mulching material for enhancing the grain yield. With respect to the vermicompost, application of vermicompost @ 1.5 t/ha was recorded the maximum grain yield (0.91 t/ha).

### Productivity of local buckwheat cultivarsas influenced by different levels of vermicompost under mid hills of Sikkim

Buckwheat is the most important life support, multipurpose and nutritious crop of the tribes living in Sikkim. Crop can be successfully grown up to 4500 m elevation. Field experiment was laid out in FRBD, assigning local cultivar *"Mithe and Tithe"* as a factor A and levels of vermicompost (Control, vermicompost @ 1.0 t/ha, vermicompost @ 1.5 t/ha and vermicompost @ 2.5 t/ha) as a factor B. Among the cultivars, *Tithe* recorded higher grain yield as compared to *Mithe*. With regards to the vermicompost, application of vermicompost @ 2.5 t/ha recorded the higher grain yield (1.13t/ha).

## Animal Health

### Prevalence of gastrointestinal helminthes of goat, cattle and yaks of Sikkim

Epidemiological studies on gastrointestinal helminthes of goat, cattle and yaks were carried out in four agroclimatic zones in all the seasons of Sikkim. Animals maintained at organized and unorganized farms of Government/Private/ICAR Institute and also from animals maintained by livestock owners in different villages were studied. The prevalence of GI-helminthes was higher in subtropical and high humid zone (37.31 %) followed by temperate and humid area (34.52 %) as compared to subalpine low humid zone (30.53 %) and alpine dry area ( 17.62 %). Pooled

infested faecal samples of goat, cattle and yaks from various places were cultured for larval composition. Infested cultured larvae were separated using Bayermanns apparatus. The larvae were identified under light microscope and identified as *Haemonchus* spp., *Bunostomum, Nematodirus* and *Oesophagostomum* spp.in all the zones in Sikkim. One kilogram of grass with soil was collected bi-monthly from various pastures located at different district in Sikkim. The pasture larval count was assessed by standared procedure and was expressed as mean larval count per kilogram of grass. Maximum contamination of pasture with third stage larvae was recorded in the month of August to November. *Haemonchus contortus* and *Oesophagostomum* was the predominant species followed by *Bunostomum, Nematodirus* and *Trichostrongylus* sp.

**Prevalence of gastrointestinal helminthes in goats as determined by necropsy examination**

Of the 81 GI-tract of goats examined, helminthic infestation with an overall prevalence of 62.96% were found to harbor. Among the various endoparasites, nematodes (61.72 %) were found higher followed by trematodes (44.44%) and cestodes (33.33 %). Among nematodes, *Haemonchu*s spp. was predominant (61.72%) followed by *Oesophagostomum* (46.91%), *Bunostomum* spp. (29.63%), *Nematodirus* spp. (8.64 %), *Trichuris* spp. (11.11%) and *Trochostrongylus* spp. (7.41%). Average worm burden (242.12 – 273.42) was higher in the month of August –October followed by the month of June-July (142.51-212.46 ). Average worm burden per gastrointestinal tract in goats was also recorded.

**Bioclimatograph of *Haemonchus* and *Trichostrongylus* spp**

To see the effects of temperature, rainfall and relative humidity, bioclimatograph were prepared in which total rainfall (TRF) were plotted against the maximum temperature (Tmax) for *Haemonchus contortus* and average RH was plotted against Tmin (for *Trichostrongylus* spp. and minimum temperature for *Nematodirus filicolis*) for each month and the resultant points were joined by a closed curve. On these graphs, lines indicating the limits of climatic conditions most suitable for development, survival and dissemination of pre-infective stages of GIN were superimposed.

Based on published information the limits of suitable climatic conditions were taken as total monthly RF to the tune of 50 mm or more with average monthly Tmax ranging from 18 to 37 oC for *H. contortus* and same rainfall with temperature ranging from 6 to 20 oC for *Trichostrongylus*. The RH considered for optimum development of parasites was >50%.

**Economic impact of gastrointestinal parasites in livestock of Sikkim**

Economic impact of gastrointestinal parasitism was evaluatedin cowsnaturally infected with GI nematodes and in both treated and untreated cows considering the milk production and epg as an indicator for the intensity of GI nematode infestation. A net profit of Rs. 1404/- (after taking into account the cost of anthelmintics used)over a period of one month was recorded in naturally infected cattle which were treated with anthelmintics. A net loss of Rs. 1859/- in terms of earnings from the milk produced over a period of 1 month was recorded in infected - untreated cows.

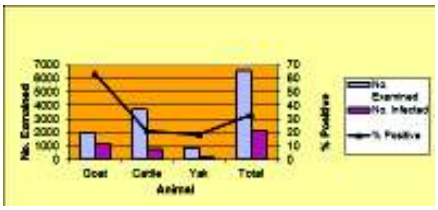



**Fig 1 Overall prevelance of GIP in Goat, Cattle and Yaks**

**Molecular characterization of *Salmonella* isolated from foods of animal origin**

During the year, 325 meat samples of chicken, chevon, pork, and beef were screened from the retail shops for the presence of *Salmonella* spp. The results of examtion are mentioned in table 9.

**Table 9 Isolation of *Salmonella* spp from different sources**

| Source | No. of samples screened | No. of samples positive for *Salmonella* (%) |
|---|---|---|
| Chicken | 110 | 9 (8.18) |
| Chevon | 90 | 4 (4.44) |
| Pork | 75 | 5 (6.66) |
| Beef | 50 | 2 (4.00) |
| Total | 325 | 20(6.15) |

Antibiotic sensitivity testing of isolates showed significant resistance among the isolates. Most effective antibiotics were Colistin, Gentamicin and Ciprofloxacin.Serotyping of the isolates was done. *S. typhimurium* was the most predominant serovar isolated from all types of meat screened.

# TRIPURA CENTRE

## WEATHER REPORT

Monthly mean air temperature recorded 0.6 to 4.4% more than the 20 years normal temperature during April-September and February-March and 0.8 to 5.8% less than the normal temperature during October-January (Table 1). There were 116 rainy days (4.5% more than normal) which contributed 1977.4 mm rainfall, 13% less than yearly normal rainfall and 3% less than previous year. Relative humidity found normal almost throughout the year. Moisture stress found from November to March in respect to total rainfall received and total evaporation in particular month. Moisture found surplus during April-September. Out of 18 raingauge stations including 2 IMD, only 6 stations received normal rain and rest were deficit. District wise, only Unakuti received normal rain. Rainfall is deficit in all seven districts.

**Table 1 Meteorological data of Lembucherra during 2012 - 13**

| Month | Air temperature | | Soil temperature | | | | | | Relative humidity | | Rain fall | Evapo-ration | Wind | | | Sun-shine hour | Cloud coverage | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Morning | | | Evening | | | | | | | Direction | | Speed | | | |
| | Max | Min | 5 cm | 10 cm | 20 cm | 5 cm | 10 cm | 20 cm | Morn | Even | | | Morn | Even | | | Morn | Even |
| Apr' 12 | 32.9 | 22.4 | 25.6 | 27.0 | 28.3 | 38.3 | 35.6 | 31.9 | 77 | 60 | 272.0 | 108.4 | SW | W | 3.2 | 6.8 | PC | MC |
| May' 12 | 33.9 | 24.7 | 27.2 | 28.4 | 29.5 | 41.4 | 39.0 | 35.2 | 81 | 61 | 212.5 | 113.3 | W | N | 2.6 | 6.2 | GC | MC |
| Jun' 12 | 32.5 | 25.2 | 26.8 | 27.9 | 29.2 | 35.4 | 33.7 | 31.3 | 85 | 69 | 418.9 | 93.0 | W | SW | 3.2 | 2.8 | GC | GC |
| Jul' 12 | 32.4 | 25.7 | 26.7 | 27.8 | 28.8 | 35.5 | 33.9 | 32.3 | 91 | 76 | 286.7 | 98.3 | S | E | 3.8 | 4.1 | GC | GC |
| Aug' 12 | 32.4 | 25.6 | 27.0 | 28.2 | 29.1 | 35.6 | 33.6 | 31.8 | 89 | 70 | 447.0 | 107.8 | W | SW | 1.7 | 5.2 | PC | PC |
| Sep' 12 | 32.4 | 25.0 | 27.0 | 28.1 | 29.1 | 34.7 | 32.7 | 31.5 | 86 | 70 | 147.1 | 105.4 | SW | SW | 1.3 | 3.8 | GC | PC |
| Oct' 12 | 31.2 | 22.1 | 25.5 | 26.8 | 29.0 | 34.7 | 32.6 | 31.3 | 75 | 70 | 104.4 | 109.7 | SW | N | 1.0 | 6.1 | MC | MC |
| Nov' 12 | 28.6 | 16.1 | 21.4 | 22.5 | 23.7 | 31.2 | 29.4 | 27.5 | 66 | 68 | 41.0 | 101.0 | SW | N | 1.1 | 6.2 | MC | MC |
| Dec' 12 | 24.1 | 12.3 | 16.5 | 17.8 | 19.7 | 25.8 | 23.8 | 22.1 | 73 | 66 | 0.0 | 88.4 | SW | N | 1.7 | 3.4 | GC | MC |
| Jan' 13 | 24.2 | 8.5 | 15.5 | 18.4 | 19.6 | 25.9 | 23.3 | 21.5 | 67 | 51 | 0.0 | 96.5 | SW | N | 2.0 | 5.4 | PC | MC |
| Feb' 13 | 30.0 | 12.9 | 18.7 | 20.6 | 21.6 | 32.9 | 30.8 | 28.5 | 68 | 53 | 9.2 | 91.8 | SW | N | 5.9 | 7.3 | MC | MC |
| Mar' 13 | 33.9 | 19.1 | 22.6 | 25.4 | 26.6 | 39.3 | 36.0 | 33.1 | 71 | 56 | 38.8 | 108.2 | W | N | 3.9 | 7.1 | MC | MC |

## CROP IMPROVEMENT

### RICE

During the period under report three entries were tested through AICRIP. Two of the entries were in Advance Variety Trial 1, on the basis of their previous year's performance. One entry was nominated to IVT IME. TRC 2008-6 (IET 22580) was promoted to 3rd year of testing on the basis of its yield superiority. Performance of the varieties in AICRIP is presented in table 2.

**AICRP on Rice Improvement**

Eight trials viz., IVT IM, IVT IME, AVT-1IM, AVT-1 IME, AVT-2IM, AVT-2 IME and AVT NIL (DRT) were conducted in *kharif* 2012, in total 218 lines were evaluated under transplanted condition. Under upland direct seeded condition IVT E DS was conducted in *kharif* 2012, under this trial total 40 lines were evaluated.

Under INGER nurseries trials were conducted under various programme such as International Irrigated Observational Nursery 2012 with 80 entries, International Rainfed Lowland Observational Nursery 2012 with 103 entries, Super Green Rice Irrigated Low Land Nursery 2012 with 36 entries, Super Green Rice Rainfed Lowland Nursery 2012 with 36 entries. The top 5 entries were VNIIR 6523, IR 64683-87-2-2-3-3(PSB RC82), IR 09N127, IR 06MI34, IR 04A393; the yield ranged from 5835-6460 kg/ha. VNIIR 6523 recorded the highest yield of 6460 kg/ha and matured in 126 days. IRLON had 103 entries and the top five entries had and yield range of 5028-6123 kg/ha. PSB RC 68 recorded the highest yield of 6123 kg/ha with133 days maturity. 108 Entries were evaluated under GSR-IRLL. The top 5 entries recorded yield in the range of 4500-6000 kg/ha. Highest yield 6000 kg/ha among the entries were exhibited by PSB RC18 (IR51672-62-2-1-1-2-3) with 126 days maturity.

In BMGF – STRASA (Bill & Mellinda Gates Foundation Project "Stress Tolerant Rice for Poor Farmers in Africa and South Asia) trials were conducted at DBN and URSBN with entries AYT 80-

**Table 2 Performance of TRC 2008-6 (IET 22580) Advance Variety Trial 1-Irrigated Medium Early (AVT -IME), *kharif* 2012. The entry was promoted to AVT2 on the yield superiority in zone III**

| Characters | | TRC 2008-6 (22580) | NC (IR 64) | *RC | LC |
|---|---|---|---|---|---|
| Grain yieldkg/ha Regional means | | 5084 | 4971 | 4926 | 5237 |
| Days to 50% flowering Regional means | | 97 | 92 | 97 | 99 |
| Panicles/$m^2$ Regional means | | 296 | 300 | 295 | 285 |
| Plant height (cm) Regional means | | 115 | 94 | 99 | 100 |
| Grain quality characteristics | Hull (%) | 77.9 | 80.2 | 81.6 | |
| | Mill (%) | 68.6 | 69.1 | 66.0 | |
| | Hrr (%) | 63.8 | 63.9 | 51.6 | |
| | KL (mm) | 4.99 | 6.49 | 6.2 | |
| | KB (mm) | 2.13 | 2.08 | 2.1 | |
| | LB (mm) | 2.34 | 3.12 | 2.95 | |
| | Grain type | SB | LS | LB | |
| | Grain chalk | VOC | VOC | VOC | |
| | ASV | 5.0 | 4.0 | 4.0 | |
| | AC (%) | 24.77 | 23.81 | 23.94 | |
| | GC | 25 | 52 | 60 | |

*RC: PPRII3-North Western, Lalat- Eastern, Sasyasree-Western, MTU-1010-Southern

100 rainfed with 32 entries, OYT with 80 entries, Vandana-NILS with 6 entries. Out of 32 entries in AYT 80-100 rainfed tested under this trial only 4 entries could produce more than 2t /ha yiled under field managed drought condition. In OYT observational yiled trial 80 upland entries were tested for their performance under drought stress. Only 8 entries managed to produce more than 2 t/ha. In trialVandana NILs are tested for their performance under drought stress. All the NILs performed better than Vandana. 2 NILs produced 3t /ha yield.

In DBT Twinning Project on Identification of Major QTLs for Grain Yield under drought stress in 'Jhum', 83 Jhum rice germplasm from north-eastern region were screened at Lembucherra, Tripura and under rain-out shelter facility at Hazaribag. Based on two seasons drought screening on the basis of leaf rolling and drying (SES) at both the locations the genotypes were grouped as per their drought tolerance. Only one genotype showed drought scoring of '1', 35 genotypes showed drought scoring of '3', 39 genotypes showed drought scoring of '5', 6 genotypes showed drought scoring of '7' and 2 genotypes scored '9' (Fig. 1). Grain yield was significantly and negatively correlated with drought score, canopy temperature, chaffs/panicle (sterility) and positively correlated with grain number/ panicle and biomass (Table 3). Based on grain yield and other traits, the promising drought tolerant genotypes identified are RCPL 1-128, Bhalum 3, Bhalum 1, Phulbadam and Kataktara.

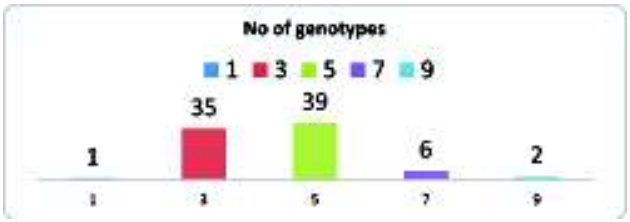



**Fig 1 Distribution of 83 *jhum* rice germplasm lines for drought tolerance (drought scores 1-9)**

For the development of mapping populations, the identified four drought tolerant donors were crossed with high yielding but drought susceptible varieties Naveen and Swarna. About 25 F1s of each cross are being grown in the ensuing *rabi* season for the development of large F2 population.

**Table 3 Correlation among traits**

| TRAITS | PL. HT. (cm) | BIO | DRTSC | CT | GY | PAN. LEN. | GRAIN NO |
|---|---|---|---|---|---|---|---|
| Biomass (g./pl) | 0.2241** | | | | | | |
| Drt. Score (SES) | -0.1733 | -0.1704 | | | | | |
| Canopy temp ($^0$C) | 0.1538 | -0.0526 | 0.1606 | | | | |
| Grain yield (g./plot) | 0.1438 | 0.2076* | -0.4369** | -0.3898** | | | |
| Panicle length (cm) | 0.3491** | 0.2604** | -0.189** | 0.4859** | 0.0757 | | |
| Grain no./pan. | 0.2575** | 0.4359** | -0.4146** | -0.0075 | 0.7583** | 0.2258** | |
| Chaffs no./pan | 0.167 | 0.1256 | 0.2981** | 0.1945* | -0.3065** | 0.3204** | -0.3343** |

*Significant at 5% LS, ** Significant at 1% L.S.

**Table 4 List of crosses**

| Cross designation | Cross designation |
|---|---|
| Bhalum 3 x Naveen | Kataktara x Naveen |
| Bhalum 3 x Swarna | Kataktara x Swarna |
| RCPL1-128 x Naveen | Phulbadam x Naveen |

Molecular diversity of 78 *Jhum* rice germplasm was carried out using 30 SSR markers. All the 30 SSR markers were polymorphic across the genotypes. A total of 88 alleles were detected with an average of 2.9 alleles per locus. A total of six alleles were found to be rare alleles whose frequency was less than 5%. Out of 30 markers studies, only one marker (RM 252) detected five alleles and 4 markers detected four alleles each, 16 markers detected three alleles and 9 markers detected two alleles. Polymorphism information content (PIC) values of the markers ranged from 0.254 (RM 537) to 0.748 (RM 24344) with an average of 0.595.

**Table 5 No. of alleles and polymorphism information content (PIC) of 30 SSR markers across 78 rice genotypes from NE carried out at CRURRS, Hazaribag**

| Marker | No. of alleles | PIC | Marker | No. of alleles | PIC |
|---|---|---|---|---|---|
| RM 20A | 3 | 0.58871 | RM 431 | 3 | 0.63352 |
| RM 3 | 3 | 0.69202 | RM28166 | 3 | 0.61183 |
| RM 252 | 5 | 0.73541 | RM 189 | 2 | 0.60486 |
| RM 60 | 2 | 0.53383 | RM 24390 | 3 | 0.73476 |
| RM 24421 | 3 | 0.60059 | RM 3825 | 3 | 0.59336 |
| RM 72 | 4 | 0.69305 | RM 279 | 4 | 0.70790 |
| RM 324 | 3 | 0.56121 | RM 232 | 3 | 0.61971 |
| RM 566 | 3 | 0.61080 | RM 136 | 4 | 0.55721 |
| RM 537 | 2 | 0.25362 | RM 24334 | 4 | 0.74858 |
| RM 520 | 3 | 0.62229 | RM 5789 | 2 | 0.29003 |
| RM 236 | 3 | 0.60356 | RM 24393 | 3 | 0.54726 |
| RM 518 | 3 | 0.64127 | RM 511 | 3 | 0.73283 |
| RM 555 | 2 | 0.58045 | RM 5443 | 2 | 0.60615 |
| RM 11943 | 2 | 0.56289 | RM 3558 | 2 | 0.63946 |
| RM 28130 | 3 | 0.61661 | RM 211 | 2 | 0.34272 |

## SEED PRODUCTION

**Following TL seed were produced on farmer's field under the direct supervision of the research center, Tripura**

| Variety | Quantity of TL Seed produced |
|---|---|
| TRC 2005-1 | 32000 kg (seed produced under TSP) |
| Swarna sub1 | 450 kg |
| Bhalum1& 3 | 450 kg |

### Front line demonstrations in rice

FLDs were organized in 40 ha area in 3 districts of Tripura covering the areas Hrishyamukh, Belonia, South Tripura; Mirza, Garjanmura and Magpuskarini in Gomati district and Charilam in Shepahijala district. Half of the FLDs covering 20 ha area included variety demonstrations with varieties Gomati (TRC 2005-1) and TRC 2005-3, check plots in these demonstrations were with most popular variety in the state MTU 7029. Average productivity of the FLD plots with Gomati were 5.66 t/ha and 5.17 t/ha with TRC 2005-3. Check plots with variety Swarna (MTU 7029) recorded average productivity of 4.82 t/ha. Gomati recorded 17.4 per cent higher productivity over Swarna whereas, TRC 2005-3 recorded 7.3 per cent yield advantage over the check variety. However, on the basis of per day productivity the FLD varieties performed even better. Per day productivity of Swarna was 33.01 kg; whereas, for Gomati per day productivity was 42.24 kg and for TRC 2005-3 was 42.03 kg, thus recording an per day yield advantage of 27.96% and 27.32%, respectively. Remaining 20 ha demonstrations were on package technology involving ICM, 8 row paddy transplanter and direct seeding 8 row Plastic Drum Seeder. For ICM FLDs SRI was used as check plots. For Machine transplanting and Drum Seeder traditional hand transplanted plots were used as check plots. Machine transplanted Gomati plots recorded yield average of 5.88 t/ha. Plastic Drum Seeder plots recorded yield average 5.52t/ha. ICM plots with Gomati recorded yield average of 5.92 t/ha. SRI plots with the same variety recorded average yield of 5.6 t/ha. ICM package recorded yield advantage of 5.71% over SRI.

### Growth and productivity of low land rice as influenced by substitution of nitrogen fertilizer

### Integrated management of sheath blight disease of rice in Tripura

Integrated application of bioagent, fungicide and hot water treatment were evaluated under field condition on the rice variety, TRC 87-251. It was found that sheath blight intensity in all treated plots was low as compared to control one. However most effective control of the disease was observed with the use of seed treatment with carbendazim followed by application of biopesticide (*Trichoderma viride*) both in seeds and fields and foliar spray of Hexaconazole (0.025%) at 15 days interval since G3 stage (tillering) onwards upto G5 stage (booting).

**Environmental correlations with disease outbreak in rice crop in Tripura**

Three different experiments were set up during three crop seasons, Boro, Aush (*kharif*) and Aman (Late *kharif*) sowing/transplanting rice crops in seven days interval with three replications.

**Boro crop season:** An experiment during Boro crop season was conducted with a hybrid Arize 6444. It was found that a non-parasitic disease (Iron toxicity) prevailed during early growth stages of rice, while parasitic diseases in late age. Leaf blast affected crop during the period when sudden fall in temperature with rain occurred at the middle age of transplanted crop. Bacterial leaf blight and grain discolouration occurred at late age and at later dates.

**Aush *(kharif)* crop season:** An experiment during Aush crop season was conducted with three different varieties *viz*., Mayna (local), NDR97 and TRC 87-251 planting on three different dates keeping gap of 7 days. It was found that the diseases like bacterial leaf blight, sheath blight, sheath rot, narrow leaf spot and Grain discolouration were the major diseases that were affected by prevailing climatic conditions and age of plant. The variety Mayna was affected with high disease incidences of bacterial leaf blight after 58 days of sowing. Sheath rot and grain discolouration at later stage affected so much that it could hardly yield any crop after long day of cropping period (121 days). In NDR97, the diseases were low. However, amongst the diseases affecting the crop, sheath rot and grain discolouration was comparatively more. In TRC 87-251, grain discolouration and sheath rot were very high. In all cases, except Mayna, the diseases affected crops at later stage of growth period.

**Aman (Late *kharif)* crop season:** During Aman season three rice varieties, *viz*., Puja, Pan (commercial hybrid) and Swarna Mahasuri, were cultivated in transplantation method. During the season, only sheath blight disease was found to affect the crops, except, in few cases where traces of other diseases were noticed. The results indicated that Puja which had the shortest crop period was affected maximum by sheath blight disease followed by Swarna Mahsuri and Pan.

## PULSES

### VARIETAL IMPROVEMENT

Single plant selections were made from F6 segregating population from urdbean x mungbean cross (SPS 5 x IPM 99-125). More than 600 segregating lines of mungbean are at different stages of evaluation. Single plant selections were made in segregating population of 9 different crosses in fieldpea. Two entries (TRCM131-1 and TRCM 151-1) were nominated to IVT Summer Mungbean. Both the entries were promoted to AVT 1 and are currently under trial. TRCP 10, a fieldpea entry was promoted to AVT1 on the basis of yield superiority.

### AICRP MULLaRP

Sixteen coordinated trials were conducted during the period under report. Under IVT trial mungbean with 20 entries (summer 2012), 20 (*kharif* 2012); urdbean 17 entries (summer 2012), 18 (*kharif* 2012); fieldpea tall 14 entries (*rabi* 2013), fieldpea dwarf 14 (*rabi* 2013); lentil small seed 20 entries (rabi 2013), lentil large seed 23 (*rabi* 2013) and under AVT 2+1 trial mungbean with 10 entries (summer 2012), 7 (*kharif* 2012); urdbean 17 entries (summer 2012), 10 (*kharif* 2012); fieldpea tall 3 entries (rabi 2013), fieldpea dwarf 6 (*rabi* 2013); lentil small seed 12 entries (*rabi* 2013), lentil large seed 9 (*rabi* 2013) were tested.

### Incidence of Fusarium wilt on field pea

Total of 19 varieties of field pea from IIPR and other varieties from ICAR Research Complex for NEH Region were evaluated against Fusarium wilt. Percent Disease Incidence was calculated and found that PF-11-83 was resistant to the disease followed by TRCP8 and TRCP9 as depicted in fig 2..

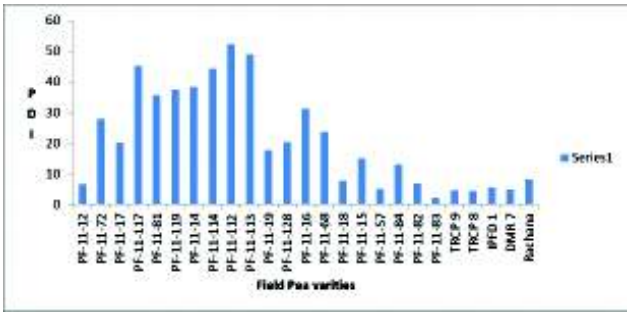



**Fig 2 Incidence of Fusarium wilt on field pea**

## MAIZE

### Effect of different organic sources on maize productivity under native mychorrhizal regime

Maize var. DMH 849 was grown as succeeding crop to bean var Kasikanchan that was identified to be efficient trap crop on field for arbuscular mycorrhizal (AM) build up. The soil accounted a consortium of native AM viz., *Glomus fasculatum, Gigasspora calospora, Acaulospora laevis, Glomus mosseae* with

a spore density to the tune of 600 per 100 gm soil. The slopy land was designed to three countoured gradients viz., top, middle, low. A bottom (virgin) land consisting of native *Acaulospora laevis* and *Glomus* sp. with population count @ 240 per 100 gm soil is also included as check to low gradient. Nitrogen @ 120 kg/hac was applied from various organic source viz., poultry manure, vermicompost, farmyard manure (FYM) in strips in all the gradients with a control. The result (table 3) in general depicts that the yield was higher in the low gradient and poor in the bottom virgin land for control. FYM yielded relatively more cobs than vermicompost which was reverse in regards to weight of cobs. Mycorrhizal consortium synergistically acted with vermicompost and FYM in the top, middle and low gradient and antagonistically with poultry manure. Reverse is the effect of mycorrhizal consortium for the organic manure. Direct correlation was recorded between maize productivity and AM colonization of roots for most treatments. Overall, it is hypothesized that *Acaulospora* performs effectively in poultry manure rather than FYM or vermicompost.

## OILSEED

### Residual effect of tillage and resource conserving methods of weed control on *toria*

*Toria* was grown under zero tillage and double zero tillage condition. There was no significant difference in growth parameters of Toria under zero and double zero tillage. Conventional tillage in rice systemfollowed by zero tillage in toria recorded significantly higher seed yield (1.41 t/ha) as compared to zero tillage (1.23 t/ha) both in toria and rice (double zero tillage). Seed, stover, biomass yield except harvest index were significantly affected by residual effect of resource conserving methods of weed control. Among the methods of weed control, Glyricidia mulch recorded highest seed yield, biomass yield and harvest index. However, stover yield was higher in straw mulch plots compared to other treatments.

## HORTICULTURE

## FRUIT CROPS

### Banana

### Evaluation of banana varieties for resistance against leaf spot disease

Eighteen varieties of banana namely Sabri, Champa, Kach Kola, Gopi, Dwarf Cavendish, Giant Cavendish, Behula, Udhayam, Kannan, Pachanadan, Saba, Bangreri, Ankur, Peyan, Nendran Padathali, Nendran, Ney poovan and Nute pong were evaluated for the host resistance against the leaf spot diseases of banana.The results revealed that the variety Saba showed the lowest level of percent index of leaf spotted (ILS) with the value of 36.8 followed by Kachkola (37.2) while highest disease was observed in Giant Cavendish (87.59) followed by Ankur (87.22).

### Study of the symptomatology of the leaf spot disease

A minute chlorotic fleck appeared first on the abaxial surface of the third or fourth fully opened leaves. These flecks later developed into darkened, narrow streaks (1–2 X 10–20 mm), brown in colour. Similar chlorotic streaks appear on the corresponding side of the upper leaf which later turned to brown and subsequently to black colour. These streaks later enlarged in length with adjacent tissue becoming yellow, and then the lesions enlarged will coalesce. The lesions are found with grey centres with black margins and surrounded by bright yellow halos. Large areas of the leaf may become blackened and water-soaked. All banana leaves can completely dry up and hang by the side of the pseudostem giving a burnt up appearance (100% necrosis).

## VEGETABLE CROPS

### Cabbage

### Effect of *Azotobacter* and phosphate solubilising bacterial biofertilizer on cabbage productivity under native mycorrhizal regime

Cabbage of the variety Himrani was planted in *rabi* 2012 in FSRIII after bean var Disha to investigate the effect of *Azotobacter* and phosphate solubilising bacterial (PSB) biofertilizer (SOVA Enterprise make) under native mycorrhizal regime. The consortium of native AM comprised of *Glomus* sp. and *Acaulosporalaevis* in situ harboured a spore density to the tune of 280 per 100 gm soil. To expedite the AM proliferation, FYM was added @ 9.6 kg per plot of size 2x2 meter. The biofertilizer was added by seedling treatment @ 200 gm and 400 gm for *Azotobacter* and PSB, respectively in adequate water by making slurry and dipping the seedling for 30-45 min. The treated seeds were shade dried and planted immediately. The results in general depicts biofertilizers increased the productivity of cabbage over control. However, PSB alone or in combination with *Azotobacter* biofertilizer attained relatively higher yield among all treatments with maximum curd weight

(1.9 kg) and leaves (13.3). Feeble AM colonization to cabbage roots was accounted. These results conclude that native arbuscular mycorrhiza respond synergistically to PSB in cabbage 'P' nourishment even though it is non-infectious to brassicaceae family.

## Radish

### Effect of alley cropping and integrated nutrient management on marketable yield of radish

Radish grown under Tephrosia alley cropping with 100% N through inorganic fertilizer produced higher yield which was statistically at par with 50% N through inorganic fertilizer and 50% N through leaves under both Tephrosia and Glyricidia alley cropping and also at par with 100% N through Glyricidia leaves (Figure 3). It was found that the radish grown under alley cropping system with 50% N through inorganic fertilizer and 50% N through leaves of respective alley cropping, is a better option for enhancing the productivity and reducing cost of production through minimizing the use of inorganic fertilizer.

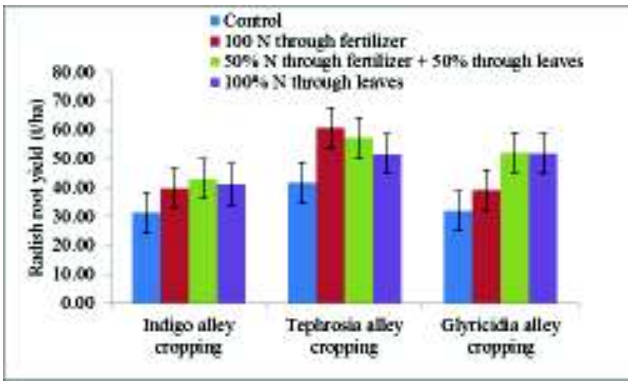



**Fig 3 Interaction effect of alley cropping and nutrient management on marketable root yield of radish**

## Broccoli

### Effect of zero tillage basin planting and N nutrition on late planted broccoli in North East Hilly Region of India

There was a significant effect of methods of planting and nitrogen application on yield component and yield of late planted broccoli. Flat bed planting with conventional tillage recorded highest curd weight (313 g) and compactness coefficient (19.5 g $cm^{-1}$), which was statistically at par with zero tillage basin planting as compared to other methods of planting. Application of N increased the curd weight (30.1 – 68.4%), curd diameter (9.2 – 21.8%), compactness coefficient (21.9 - 41.8%), marketable plant biomass (80.1 – 198.9%), culled plant biomass (14.7 – 46.3%), total plant biomass (46.2 – 112.2%) and marketable yield (81.1 – 201.2%) over control (no nitrogen application) in late planted broccoli.

## Tomato

### Evaluation of tomato entries for Leaf Curl Virus (AICRP Vegetable Crops)

Total 11 entries were evaluated under IET for Tomato Leaf Curl Virus (TLCV) and it was recorded that disease severity index among all the entries ranges from 0 to 28.2%. There was no incidence of TLCV on entries 2012/ToLCVRES2, 2012/ToLCVRES5, 2012/ ToLCVRES7 and H24-C. Whereas, 2012/ ToLCVRES6 recorded the highest (28.2%) incidence, followed by 2012/ToLCVRES9 (15.6%), 2012/ ToLCVRES4 (12.4%), Punjab Chuharra (9.7%), 2012/ ToLCVRES1 (9.3%), 2012/ ToLCV RES8 (6.4%) and 2012/ToLCVRES3 (6.2%) under Tripura agro-climatic conditions which prevailed during the winter season in 2012-2013. Highest total fruit yield was recorded in 2012/ToLCVRES7 (42.5), followed by 2012/ ToLCVRES9 (38.5) and Punjab Chuharra (36.1). The fruit yield ranged from 17.2 to 38.5 t/ha. Under AVT-II, incidence of TLCV was recorded only on Punjab Chuharra (9.3%) and 10/ToLCVRES6 (3.1%), whereas, all other entries were free from TLCV. Total fruit yield was highest in 10/ToLCVRES3 (49.4 t/ha), followed by Punjab Chuharra (36.1t/ha) and 10/ ToLCVRES5 (35.4 t/ha).

### Evaluation of tomato entries for bacterial wilt (AICRP Vegetable Crops)

Entries viz., 2011/TOBW1, 2011/TOBW4 and 2011/TOBW5 were free from bacterial wilt. The fruit yield was highest in 2011/TOBW4 (44.6 t/ha), whereas, overall fruit yield was in the range of 17.5-44.6 t/ha.

## Brinjal

### Evaluation of brinjal for bacterial wilt (AICRP Vegetable Crops)

Brinjal entries under AVT-II (Table 1) show that 10 / BRBWRES-2 and 10 / BRBWRES-3 were totally free from bacterial wilt. However, bacterial wilt incidence (1.5-9.3%) was recorded in other entries viz., 10 / BRBWRES4, 10 / BRBWRES5, 10 / BRBWRES6, SMS6-6 and Arka Nidhi under Tripura. The fruit yield ranged from 31 to 42 t/ha in different

entries. Under IET, entries viz., 2012/ BRBWRES3 and 2012/ BRBWRES7 were free from bacterial wilt, whereas, in other entries the incidence ranged from 1.5-9.6%. The fruit yield ranged from 33 to 40 t/ha.

## BIOFERTILIZER

### Arbuscular mycorrhizal fungi diversity and community differences in crop rhizosphere from three FSR experimental plots

The spore density, species composition, and diversity of arbuscular mycorrhizal fungi (AMF) in three FSR experimental plots viz., Agronomy Plot (AP), FSR-II and FSR-III, were investigated to screen out some efficient strains of AMF from upland ecosystem and sketch out the preponderance of indigenous population in several crop species in situ. AMF spores from rhizosphere of representative plants from three FSR habitats were extracted by wet-sieving and decanting method and identified morphologically. Preliminary result indicates isolation of 58 strains of AM under three species namely *Glomus, Gigaspora and Acaulospora.* Highest spore density was recorded in FSR-III that is organically managed followed by AP and lowest in FSR-II. The spore density and composition varied among crop species and among varieties. In general preponderance of AM in soil around root zone of pH 5 was of the trend as *Acaulospora laevis* > *Gigaspora calospora* > *Glomus* sp. > *Glomus mosseae* > *Glomus fasciculatum*. Root zone soil of bean variety Kasikanchan harboured four species of AM while variety Disha accounted only two species. Elephant foot yam variety Appakodat recorded significant amount of *Glomus mosseae*. In contrary Sreebadama and Sreearothra recorded much amount of *Gigaspora calospora.* Spore density was highest in bean, coconut, maize in the range 610-400 per 100 gm soil. Lowest spore density was observed in Discoris to the tune of 150 per 100 gm soil. Overall, it is hypothesized that the effect of habitats with reduced variation in soil composition on AMF communities were lesser than that of the host preference to AMF.

**Fig 1 Organic cultivation of maize and cabbage under native arbuscular mycorrhizal regime**

## MUSHROOM

### Evaluation of different races of paddy straw mushroom

Different strains, VV02, VV07, VV08 and VV-Tripura of paddy straw mushroom (*Volvariella volvacea*) were cultivated during the favourable seasons. In each case cube bed was prepared with 3kg paddy straw. Mushrooms were harvested at button, egg and elongation stages at a time and weighed in the range 125-235 kg/3kg substrate with the race VV-Tripura scoring the maximum within 13 days.

### Effect of different substrate processing and supplements for the enhancement yield in paddy straw mushroom

Different paddy straw soaking medium *viz*., water, aqueous solution of 2% $CaCO_3$ and aqueous solution of carbendazim (75ppm) + formalin (500ppm) with different supplements i.e.Kuro (100g & 200g/3kg straw) and gram dal powder (100g/3kg straw) were evaluated.. The results indicated that all the treatments were more or less equaly productive, although, paddy straw soaked in 2% $CaCO_3$ solution and supplemented with Kuro (100g/3kg straw) during spawning gave to some extent higher yield in less days of incubation. Further, in paddy straw mushroom cultivation, disinfection of straw with the use of chemical solution did not enhance any production.

### Improvement of oyster mushroom

In order to improve oyster mushroom, a hybridization programme was taken. In doing so, 146 single spore cultures were prepared from seven strains of five oyster mushroom species. Seventy one crossings were made and from which 24 hybridized mushroom cultures were prepared. The yield performances of the hybrids were evaluated. The results indicated that the hybrids *viz*., 6S3X3S12, 6S3X3S12-10, 6S13X4S13, 4S18X5S8 and 1S8X2S30 were higher yielders than the others with an yield range 800-450 g/kg substrate. Certain hybrids did not produce at all.

### Evaluation of different species and strains of oyster mushroom along with local edible mushroom

It was found that *Pleurotus flabellatus* produced highest yield 727g/kg substrate in September and that followed by *Pleurotus* sp. with yield of 695g/ kg substrate and *Lentinus squarrosulus* (K-2) with 426g/ kg substrate, respectively. In July, *P. florida* (strain FLO) gave better yield than the others.


**Fig 1Local mushroom in growing. A. *Lentinus squarrosulus* (K-2); B. *Pleurotus* sp.**

## NATURAL RESOURCE MANAGEMENT

### Cropping System

#### Effect of crop diversification and nutrient management on productivity of rice based cropping system

Among the cropping system, system productivity and total return was higher in rice – toria cropping system as compared to rice – field pea cropping system (Table 7). Low productivity and total return under rice – field pea cropping system was mainly due the highly infestation of field pea crop by fusarium wilt at the time of flowering.

**Table 8 Effect of tillage and resource conserving methods of weed control on total weed density in direct seeded rice**

| Treatment | Total Weed/m² | | | |
|---|---|---|---|---|
| | 30 DAS | 45 DAS | 60 DAS | 75 DAS |
| Tillage | | | | |
| CT | 81.7 | 160.7 | 107.7 | 75.5 |
| ZT | 98.0 | 168.1 | 118.7 | 89.0 |
| SEm± | 0.4 | 0.2 | 1.0 | 1.6 |
| LSD (p=0.05) | 2.6 | 1.1 | 6.1 | 9.6 |
| Weed Management | | | | |
| $W_1$ | 213.7 | 320.3 | 273.8 | 231.5 |
| $W_2$ | 79.0 | 156.5 | 126.2 | 79.5 |
| $W_3$ | 92.0 | 181.8 | 94.0 | 61.0 |
| $W_4$ | 74.5 | 160.0 | 112.7 | 47.5 |
| $W_5$ | 80.0 | 167.5 | 72.5 | 74.0 |
| $W_6$ | 0.0 | 0.0 | 0.0 | 0.0 |
| SEm± | 2.4 | 3.2 | 2.3 | 1.7 |
| LSD (*P*=0.05) | 7.0 | 9.4 | 6.9 | 5.1 |

conventional tillage. Green cob yield of summer maize was not significantly affected by tillage; however land configuration had a significant effect on green cob yield over tillage system. The highest green cob yield was recorded with broad bed and furrow system with conventional tillage (BBFCT), which was at par with Ridge and furrow system with convention system (RFCT) over rest of the treatments as depicted in fig. 1.

**Table 7 Effect of crop diversification on productivity and total return of rice based cropping system**

| Cropping system | Rice yield (kg/ha) | Succeeding crop yield (kg/ha) | System productivity (REY kg/ha) | Total system return (₹ ) |
|---|---|---|---|---|
| Rice-Pea | 3063.8 | 73.7 | 3432.2 | 34322.4 |
| Rice-*Toria* | 3063.8 | 970.0 | 7913.8 | 79137.5 |

#### Effect of conservation tillage, and resource conserving methods of weed control on productivity and quality of upland rice in upland rice-mustard cropping system

Overall total soil organic carbon concentration, carbon stock and soil carbon sequestration from 0-30 cm soil depth was more in zero tillage over conventional tillage. Although, Resource conserving methods of weed control had non-significant effect on soil organic carbon concentration, carbon stock and soil carbon sequestration from 0-30 cm soil depth (Table 8).

#### Effect of tillage modification and land configuration on productivity of maize-pea cropping system

All the yield attributes of summer maize were higher in broad bed and furrow system under

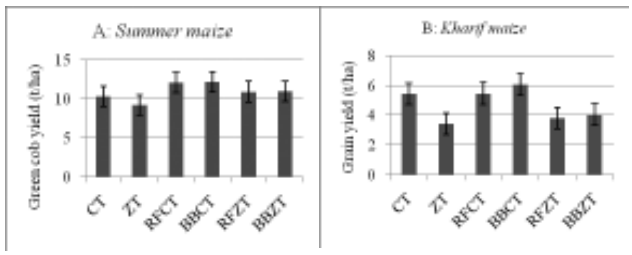



**Fig 1 Effect of tillage and land configuration on green cob yield of summer maize (A) and grain yield of *kharif* maize (B)**

#### Effect of phosphorus nutrition on productivity and economics of groundnut-potato cropping system

The experiment was with five treatments viz. $T_1$-control (No phosphorus); $T_2$-9 kg P/ha; $T_3$- 18 kg P/ha; $T_4$ – 27 kg P/ha and $T_5$ – 36 kg P/ha. Results revealed

that application of 36 kg p/ha recorded maximum pod yield grass return and net returns in groundnut which was statistically at par with 27 kg p/ha. However, Benefit: Cost ratios was higher with the application of 27 kg p/ha. There was a significant residual effect of P applied in groundnut on succeeding potato crop. The residual effect of 36 kg P/ha provided higher tuber yield, grass return, net returns and B: C ratios in succeeding potato. Overall system productivity, gross returns, net returns and B: C ratio of groundnut-potato cropping system was higher with the application of 36 kg P/ha which was statistically at par with 27 kg P/ha.

## FARMING SYSTEM RESEARCH PROJECT

### Farming System Research FSR – I

A number of crop combinations were undertaken in FSR -1 where the cropping intensity was attempted to be made 300 % and the cropping sequence as undertaken with economic return is presented below. The cost benefit ratio of the cropping systems ranged from 1.18-2.47 with mango-banana cropping system recording the highest. From an area of 5690m$^2$ an amount of ₹ 31870/unit area is attained with ₹ 47992/ unit area and ₹ 16112/unit area as gross return and net return respectively. The cost benefit ratio was 1.5.

### Farming System Research FSR-II

The special feature of this model is high value and low volume crops integrated with piggery and fishery which provide high return per unit area round the year. Fruit crops planted in FSR-II are mango, litchi, musambi, banana, papaya, pineapple, lemon, coconut and arecanut in bunds and steep slopes. The commercial variety of Ber- APPLE BER is planted in 2012.The tuber crops grown are elephant foot yam, colocasia, tannia and cassava and *Dioscoria* in terraced plots. A new tuber crop - yambean is introduced for the first and successful .Seasonal vegetables like amaranthas, okra in *kharif* season as inter crop andpotato are cultivated in winter season for increasing the profitability in the same terraced plots. The dry stalk of potato are used as mulching material of next season elephantfoot yam, tannia, colocasia and fruit plants (Fig 2).

It is observed that elephant foot yam, colocasia, dioscoria and tannia (*kharif* ) followed by vegetables like potato (winter crops ) have proved very high return per unit area. Integration of piggery (03 Nos + 18 piglets) with fishery (0.2ha.) also provided high return.

**Fig 2 Tuber crop based farming System**

### Jatropha Progeny Trial

In the progeny trial, 18 seed sources were planted on the in May, 2006 and growth characteristics estimated during 2012-2013. The oil content of the seed of Jatropha planted in the progeny trial was varying from 23.81 to 38.59% thus indicating the highest oil content in the seed source of MNJ-002 (Manipur) and the lowest in the seed from Mandipathar (East Garo Hills). Maximum seed yield (2.62t/ha) was produced by Jatropha genotype from Dimapara (South Garo Hills).

### Evaluation of Low Cost Drip Irrigation System (LCDIS)

An experiment has been conducted at Cocotilla farm, ICAR Research Complex for NEH Region, Tripura Centre, Lembucherra to evaluate the locally available and low cost materials as drip pipes under full LCDIS. Four locally available materials, viz, bamboo, PVC electricity pipes, PVC flexy pipes, aluminium sheet made pipes were taken (Fig 3). PVC electric pipe (spring type) is found to be much suitable as drip pipe under low cost drip irrigation system because it is cheaper in cost, easier in water drop hole making, low labour cost in setting, lesser practical difficulty in use. The PVC flexy pipe is also found suitable because it is having similar advantages.


**Fig 3 A view of the experiment field with LCDIS**

Aluminium sheet made drip pipes were not found suitable due to its high cost of material, drip pipe making, tough in making drip hole etc. Bamboo based drip pipes were not found suitable due to its poor water application efficiency and poor suitability and practical implication. It requires much labour for splitting the bamboo, making drip holes, setting in the field.


**Fig 4 Water Harvesting Antenna and Rain tank unit of Rain Tank Drip Irrigation System (RTDIS)**

### Rain Tank Drip Irrigation System (RTDIS): A new rain water harvesting structure

Two RTDIS unit has been designed and constructed under Network Project on Climate Change (NPCC) under climatic condition of Tripura and considering high value vegetable crops like tomato, okhra, brinjal, cabage, cauliflower, chilly and cucumber etc (Fig 4). As per above design consideration, rectangular shape tank of size 4m x 3.5m x 1.5m (length x width x height) has been constructed which can store 21,000 litres of water at a time and 30,000 litres of water throughout the rainy season. 21,000 and 30,000 litres of water can be used for growing 97 and 139 tomato plants having spacing of 0.6m x 0.45m. Under RTDIS, when stored water is utilized efficiently, it supports more than 300 tomato plants. RTDIS cost higher initially, about 2.0 lakhs, but due to onetime installation that will continue for more than 15 year, the benefit: cost ratio increases year wise.

## ANIMAL SCIENCE

## GOAT

### Multivariate characterization of the phenotypic traits for predicting fetal number in Indian Black Bengal goats

Data on age and body weight at breeding, parity, previous kidding size, days open and some descriptive linear traits from 389 Black Bengal goats in 23 villages at different geographical locations of Tripura state, India, were collected for 3 and ½ years (2007 to 2010). The incidence of 68.39% multiple births with a prolificacy rate of 175.07 % was recorded. Statistical results indicated a significant association ($P$<0.05) between black hair coat color and the incidence of twin birth. Higher age and body weight at breeding could increase ($P$<0.01, $P$<0.05) the chance of triplet birthsas compared to that of the incidence of single birth. The goats with longer ($P$<0.01) ear and neck length were found to give birth of multiple kids. Except clearance at udder, the measurements of all phenotypic descriptors studied were significantly higher ($P$<0.01 or $P$<0.05) in goats bearing multiple fetuses than the goats bearing single fetus.

### Endocrine markers for identifying prolificacy potential and predicting fetal number in goats

Identifying prolificacy potential and determination of fetal number during pregnancy for proper care and management of the pregnant goats bearing multiple fetuses and achieving the benefits out of multiple births are essential for sustainable goat farming. In first experiment (GnRH challenge test), plasma follicle stimulating hormone (FSH) concentrations were significantly higher ($P$<0.01) among the goats belonging to triplet vs. twin vs. single kidding size groups after GnRH administration. Multivariate stepwise discriminant function analysis recognized that one blood sampling at 220 min after GnRH administration can be used to distinguish prolificacy potential in goats. In second experiment, plasma progesterone levels were significantly higher ($P$<0.01)

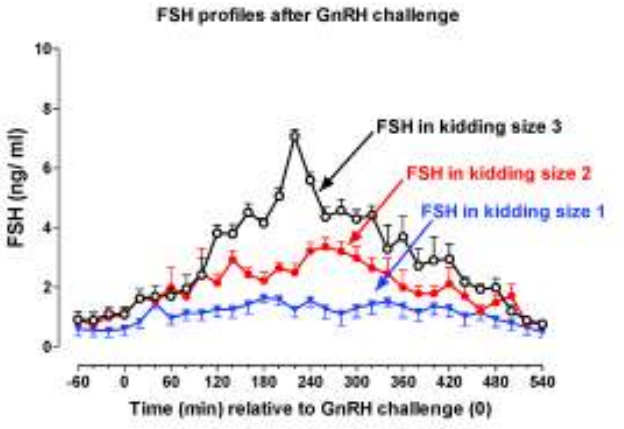



**Fig 1 Plasma FSH profile after GnRH challenge in Black Bengal does with the history of single (n= 6), twin (n= 6) and triplet (n= 6) fetuses**

in goats bearing triplet vs. twin vs. single fetus between day 84 and 21 prior to parturition. A single blood sampling at day 63 prior to parturition was the most probable suitable time for discriminating kidding size by using plasma progesterone as marker.

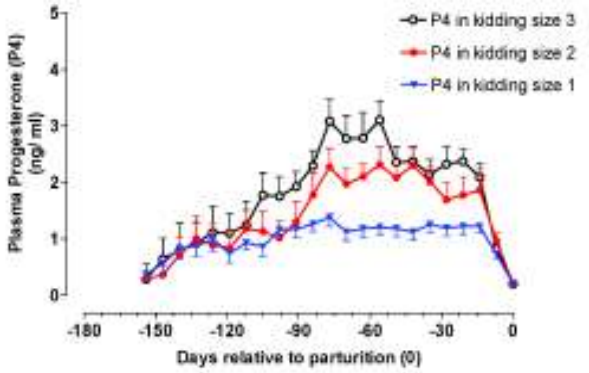



**Fig 2 Plasma progesterone profile during pregnancy in Black Bengal does carrying single (n= 9), twin (n= 9) and triplet (n= 6) fetuses. Day 0 represented the day of parturition**

## PIGS

### Effect of supplemental heat on mortality rate, growth performance and blood biochemical profiles of Ghungroo piglets during cold months in Tripura, a north eastern state

The objective was to explore the effect of supplemental heat on mortality rate, growth performance and blood biochemical profiles of indigenous Ghungroo piglets cold months in Tripura agro- climatic situation. Nineteen piglets were provided with supplemental heat ranging from 17.0$^0$C and 21.1$^0$C for first 30 days period and thereafter between 24.1$^0$C and 29.9$^0$C for next 30 days. Another nineteen control piglets were exposed with natural environmental minimum temperatures ranging between 7.2$^0$C and 15.0$^0$C during first 30 days and then between 18.5$^0$C and 25.5$^0$C for subsequent 30 days. The supplemental heat has brought 10.6% reduction of piglet mortality during the first 2 weeks of life in treatment group when compared with that of the control piglets. Thereafter, no mortality was recorded during the rest period from 15 to 60 days of age. The supplemental heat might have some beneficial effects on treatment group piglets leading to the lower ($P$<0.05) plasma glutamate pyruvate transaminase (GPT) and cortisol levels and higher ($P$<0.05) plasma alkaline phosphatase (AP) concentrations.

**Fig 3 Ghungroo piglets with nursing sow under supplemental heat arrangement system**

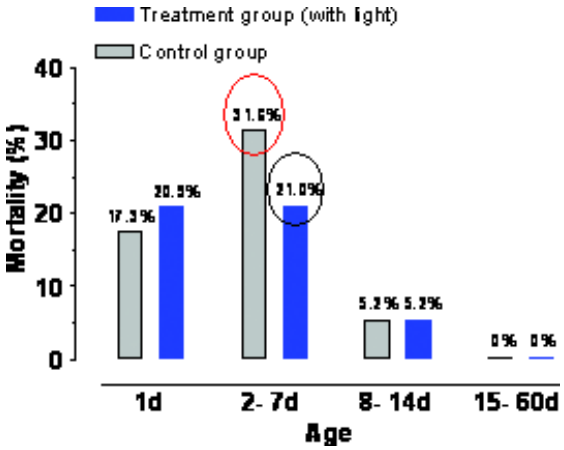



**Fig 4 Piglet mortality (%) of control and supplemental heat treated piglets during the experimental period**

### Comparative accounts for growth performances of piglets of different breeds in sub-tropical climate of Tripura

Litter size and litter weight at birth and weaning are very important economic traits in pig farming. Since body weight at birth as well as subsequent body weights over the pre-weaning period determine the litter size and litter weight at weaning, we aimed to investigate the change in body weight of piglets of different breeds from the day of birth up to 63 day of age, i.e., during 2 months pre-weaning period at pig farm of ICAR Research Complex, Tripura Centre, Lembucherra, West Tripura. The birth weights of Duroc (1.26 ± 0.04 kg) and Hamphire x Khasi crossbred (1.18 ± 0.01 kg) piglets were higher ($P$<0.05) than the birth weight of Ghungroo (0.89 ± 0.03 kg) piglets. The birth weight of Duroc x Mali crossbred (0.69 ± 0.05 kg) piglets was lowest ($P$<0.05) as

compared to the other piglets. The body weights of Duroc (6.78 ± 0.65 kg) and Hamphire x Khasi crossbred (6.96 ± 0.10 kg) piglets became more ($P$<0.05) than the body weights of Ghungroo (6.15 ± 0.16 kg) and Duroc x Mali crossbred (5.87 ± 0.33 kg) piglets at the age of 42 days. Finally, the body weight of Hamphire x Khasi crossbred (10.61 ± 0.25 kg) piglets was highest as compared to the body weights of Duroc (8.74 ± 0.81 kg), Ghungroo (8.73 ± 0.37 kg), and Duroc x Mali crossbred piglets (8.12 ± 0.72 kg) at the age of 63 days. The body weights of Duroc, Ghungroo, and Duroc x Mali crossbred piglets were similar and satisfactory at the weaning age. At farmers' field, Ghungroo, Hampshire cross and Duroc cross piglets were provided to the farmers in three different villages under NICRA project for the investigation of productive and reproductive performances that make them resilient to climate change at farmer's field. At 6 months of age, the average body weights of Ghungroo, Hampshire x Ghungroo, Duroc x Ghungroo and Duroc x Mali pigs were recorded as 25, 33, 35 and 30 kg, respectively.

**Fig 5 A tribal farm womenwith her newly made low-cost pig shelter. She is experiencing the performance of Duroc x Mali cross pig**

### All India Coordinated Research Project on Poultry Breeding

The mean body weights of Coloured broiler dam line at 6 weeks of age were: 1.326 ± 0.010, 1.222 ± 0.009 and 1.268 ± 0.007 kg respectively, in male, female and overall mean at the Institute farm. The mean body weight of Dahlem red in females was: 353.00 ± 2.90 g. at the Institute farm.

### Establishment of biotech hub at Tripura Centre

Under DBT funding a institute level biotech hub has been established at Tripura Centre for conducting research and imparting training to students and faculties interested in biotechnology. Under this all the equipments has been procured and a basic biotechnology and microbiology lab has been established.

### Interacting effects of water temperature on hematological and serum chemistry of *Labeo rohita*

The present study was envisaged to find out the seasonal variation of temperature and other water quality parameters on rohu blood chemistry.

The levels of the different water quality parameters are depicted in table 9 & 10.

**Table 9 Mean Seasonal water quality parameters**

| Parameters | Summer (March-June) | Rainy (July-September) | Winter (October-November) |
|---|---|---|---|
| Temperature $^0$C | 29.27±1.75 | 26.63±2.05 | 22.7±1.9 |
| Dissolved oxygen (DO mg/l) | 5±1.3 | 5±3.5 | 4±1.2 |
| pH | 5.92±1.5 | 5±0.5 | 6±0.8 |
| Total alkalinity (mg/l) | 60±6.5 | 54±7.2 | 72±5 |

**Table 10 Seasonal variation of hematological and serum biochemical parameters of *Labeo rohita***

| Parameters | Summer (March-June) | Rainy (July-September) | Winter (October-November) |
|---|---|---|---|
| TEC (X10$^6$ cells/cu mm) | 3.20±0.03$^a$ | 2.07±0.32$^b$ | 1.50±0.06$^b$ |
| TLC (X10$^3$ cells/cu mm) | 50.71±3.53$^a$ | 42.22±2.93$^a$ | 44.84±0.28$^a$ |
| Serum protein (g/dl) | 3.15±0.02$^a$ | 3.30±0.66$^{ab}$ | 3.47±0.05$^b$ |
| Serum albumin (g/dl) | 0.69±0.03$^a$ | 0.78±0.04$^b$ | 0.74±0.04$^c$ |

The levels of different hematological parameters like total erythrocyte and total leukocyte count were evaluated in this study. It was seen that TEC in summer season was significantly different from the TEC of rainy and winter season. The TLC did not differ significantly in the various seasons, but it was seen that the TLC was maximum in summer months and least in rainy months. Serum protein concentration was significantly different in summer and winter season while serum albumin was significantly different in all the seasons.

**Evaluation of rubber seed meal as a replacement of fish meal in *Cirrhinus mrigala***

An experiment was conducted to evaluate the effect of utilizing rubber seed as a partial replacement of fish meal on mrigala. Feed was given to them @ 3% of body weight twice daily. From table1 it can be seen that rubber seed if incorporated @25% replacement of fish meal shows growth at par with complete fish meal based feed. Hence observation from this present study indicates that rubber seed meal can be used at the rate of 25% of fish meal with good growth and without any adverse effects (Table 11 & 12).

**Table 11 Growth, FCR and survivability of *Cirrhinus mrigala* fed different levels of rubber seed as a replacement of fish meal**

| Parameters | Feed [1] | Feed [2] | Feed [3] | Feed [4] |
|---|---|---|---|---|
| Initial weight (g) | 13.30 ±1.7 | 10.05 ±0.08[a] | 9.57 ±0.51[b] | 0.25 ±1.82 |
| Final weight (g) | 16.02 ±1.88[a] | 15.19 ±1.37[a] | 10.02 ±0.752[b] | 1.01 ±0.79 |
| SGR (%/day) | 1.43 ±0.12 | 1.86 ±0.07[a] | 0.54 ±0.20[b] | 0.88 ±0.21[a] |
| FCR | 2.26 ±0.22 | 1.62 ±0.05 | 3.83 ±0.82 | 2.09 ±0.32 |
| Survivability (%) | 100 | 82.3 | 58.8 | 58.3 |

Means bearing different superscripts are significantly different from each other

**Table 12 Hematological and biochemical parameters of *Cirrhinus mrigala* fed different levels of rubber seed as a replacement of fish meal**

| Parameters | Feed [1] | Feed [2] | Feed [3] | Feed [4] |
|---|---|---|---|---|
| RBC count (million cells/cumm) | 1.72 ±0.30 | 2.75 ±0.43[a] | 2.15 ±0.41 | 1.02 ±0.18[b] |
| WBC count (thousand cells/cumm) | 16.40 ±1.05 | 17.04 ±0.17 | 15.35 ±1.02 | 7.73 ±0.25 |
| Serum protein (g/dl) | 2.75 ±0.52[a] | 2.63 ±0.13[a] | 1.41 ±0.08[b] | 0.80 ±0.26[b] |
| Serum albumin (g/dl) | 0.78 ±0.02[a] | 0.84 ±0.04[a] | 0.59 ±0.07 | 0.33 ±0.17[b] |

Means bearing different superscripts are significantly different from each other

**Composite culture of *Ompokbima culatus* (pabda) with carps**

The productivity and growth performance of pabda catfish was evaluated in composite culture with carps for 6 months at a stocking density of 6,000 fingerlings/ha. The species composition of catla, rohu, mrigal, and pabda was maintained at 40%, 30%, 15% and 15% (mrigal was replaced with catfish at a level of 50%) in the treatment ponds. In the control, only carps were stocked at a species composition of 40%, 30% and 30%, respectively. The pond preparation was done following standard methods. Lime was applied @ 250 kg/ha, raw cowdung @ 5,000 kg/ha, inorganic fertilizers (NPK-4:4:1) @ 75 kg/ha as basal dose and 50 kg/ha on monthly installment. The length and weight increment of fish was recorded on monthly intervals. The water quality, plankton density, soil parameters etc were recorded on weekly intervals and found to be normal without significant variation (p=0.05) throughout the period of experiment and independent of stocking ratio. Final fish harvest was done by repeated drag netting followed by pond dewatering. The number of each fish species was counted and the average survival rate for catla, rohu, mrigal and pabda was found to be 76.04%, 80.56%, 88.89% and 86.11%, respectively in treatment ponds and 78.13%, 84.72% and 86.11% in the control pond. For each species ten fish was randomly sampled and individually weighed for total production. The total fish production was found to be 2075.52 kg/ha in the treatment pond (with catfish) and 2095.65 kg/ha in the control pond (without incorporation of catfish) without significant variation (p=0.05).

**Contribution of pig farming on food security under NAIP**

The aim was to educate and support the farmers for better pig husbandry practices including adaptation of 'piglet production farming system' for ready availability of piglets in the locality. We delivered technical know-how and financial supports for making semi-permanent pig shelter with brick-cement. A total of 3 new pig houses and 20 Ghungroo piglets were provided to ten farmers in two clusters of Maracherra and Balaram during the period under report. The beneficiaries were satisfied with the growth performances of Ghungroo pigs which have been introduced in the field for the first time. The average body weights of female and male Ghungroo pigs at the age of 8 months were 42.2 and 46.0 kg, respectively. Thereafter, eight pigs were reported pregnant. Eight beneficiaries reported to earn more than ₹ 40,000/- in a year from pig rearing. Three farmers have earned more than ₹ 80,000/- by selling pigs in a year. Shri. Nibaran Debnath has come up as the best pig farmer

who earned ₹ 1, 40,000 in a year to date. Considering the expenses for feed @ ₹ 50/- per day for one sow and one boar, the cost of feed was calculated as Rs. 18,250/- during a year period. Thus, there was a net income of ₹. 21,750/- out of gross income ₹ 40,000/- in a year from a pair of pigs. The annual net income (₹ 21,750/-) from piglet production could provide 217 days food security based on the cost of daily food items @ ₹ 100/- for 4- 5 members family.

## A SUCCESS STORY UNDER TSP PROGRAMME

### 'Pig breeding ' – A means to food security

Livestock Production team of ICAR, Tripura Centre conducted a survey in three tribal people dominated villages of Mohanpur block of West Tripura within 5 km radius of ICAR institute and selected few farmers for undertaking the idea of 'piglet production farming system' utilizing both farmer's knowledges and our experiences since 2011. Shri. Karna Debbarma belonging to below poverty line (BPL), was one of the selected poor tribal farmers of Balaramchoudhury para village of West Tripura. Shri. Karna Debbarma received financial and technical assistance from ICAR, Tripura Centre to make an improved brick- cement made pig shelter. He underwent three days hands on training for care and management of pigs. A good quality Duroc male piglet was given to him for breeding with his non-descriptive female pig in due course of time. The Duroc piglet has grown to a size of 90 kg within a period of 8- 9 months. The non-descriptive female pig was mated with this Duroc boar. Shri. Karna Debbarma recorded the birth of seven piglets which was sold after weaning at the age of 2 months @ Rs. 3000/- per piglet. Thus, Shri. Debbarma earned Rs. 21,000/- within one year period. The sow was again pregnant within one month after weaning. This time, the sow delivered 11 piglets of which 2 piglets died (about 18% mortality after birth). Finally, Shri. Debbarma weaned 9 piglets and sold them @ ₹3000/- per piglet and thus earned ₹ 27,000/-. Also, Shri. Karna Debbarma allowed his Duroc boar for breeding of 7 sows owned by the nearby villagers. Subsequently, 5 sows were pregnant and piglets born. Shri. Debbarma received the gift of 5 weaned piglets from another five successful farmers. These 5 piglets were sold and ₹ 15,000/- was added to the earning of Shri. Debbarma. He thus earned a gross of ₹ 63,000/- during one and half year of 'piglet production farming system'. Considering the expenses for feed @ ₹ 50/- per day for one sow and one boar, the cost of feed was calculated as ₹ 27,000/- during a period of one and half year. Thus, Shri. Debbarma achieved a net profit of ₹ 36,000/- out a pair of pigs during 18 months period. The annual net income (₹ 24,000/-) was 2.5 to 3 times more than the previous year gross income (₹ 8000- 9000/-) from pig enterprise. Earlier, the earning from pig enterprise (₹ 8000- 9000/-) was contributing 90 days food security based on the cost of daily food items @ ₹ 100/- for three adult and one school growing child (as reported by the wife of Shri. Debbarma). Now, Debbarma family has secured all most 240 days food security after adopting 'piglet production farming system'. The successful implementation of 'piglet production farming system' could provide 150 days more food security over the traditional production of fattener pigs.The additional income Shri. Debbarma got out of practically no additional investment. No additional risk was involved in terms of care and management of pigs and piglets up to weaning. The new pig shelter benefited the farmer to keep the pigs clean and probably free from diseases. Indeed, it was a small and humble intervention on pig farming system approach intended to make difference in the lives of pig farmers like Shri. Karna Debbarma.

## EXTENSION ACTIVITIES

### NAIP-III

### Farmers' participatory research on different cropping system in Dhalai district of Tripura

The work was initiated to improve the productivity and profitability of rice based cropping system through lentil (WBL77) and toria (TRC-T-1-1-5-1). Total 50 beneficiary's families were selected under sub-project to cover an area about 10 ha land. The introduction of lentil and toria in selected farmer's field increased the cropping intensity up to 200% instead of 100%.

### Entrepreneurship development of mushroom cultivation in Balaram and Maracherra

In all 67 numbers of farmers cultivated mushrooms from 1800 number of spawn bags and they produced 588kg mushrooms from which they earned Rs. 70572/-

### Contribution of goat farming on food security

We have focused majorly on three areas, (i) shelter management, (ii) animal breed improvement and (iii) animal health management under livestock resource improvement activities of NAIP programme at Dhalai.

A total of 131 beneficiaries were given two female goats each. Of them 108 beneficiaries are still having goats on an average of 6 goats to each beneficiary and thus, approximately 650 goats were there in two clusters of Maracherra and Balaram during the period under report. Eight deworming-cum-treatment camps were organized at Balaram and Murracherra villages of Dhalai district during 2012- 13. A total of 680 goats including kids were treated in the camps.

### Contribution of pig farming on food security

The aim was to educate and support the farmers for better pig husbandry practices including adaptation of 'piglet production farming system' for ready availability of piglets in the locality. We delivered technical know-how and financial supports for making semi-permanent pig shelter with brick-cement. A total of 3 new pig houses and 20 Ghungroo piglets were provided to 10 farmers in 2 clusters of Maracherra and Balaram during the period under report. Thereafter, eight pigs were reported pregnant. Eight beneficiaries reported to earn more than ₹ 40,000/- in a year from pig rearing.

## NICRA

### Identification of major QTLs for grain yield under drought stress in rice varieties of North Eastern Region for use in marker assisted breeding to improve yield under drought under climate change

Genotyping of 45 genotypes are completed so far with 200 SSR markers. Data on remaining marker showed monomorphism. As an alternative strategy (as mapping populations attempted by us are only in F2) genotyping and phenotyping work was initiated with a mapping population provided by Dr Arvind Kumar, IRRI, is also being genotyped and phenotyped in Tripura. Parental polymorphism survey and genotyping of RILs are completed with 286 SSR markers. Genotyping of mapping population was carried out on outsourcing basis. Genotyping of the mapping population is under progress; hence analysis could not be carried out yet.

### Demonstration of maize, groundnut and okra cultivation at farmers' fields

Maize (DMH 849), groundnut (TAG24) and okra (Arka Anamika) were sown in the first week of August at Gomcha Kobra, West Tripura on 1.28 ha land of two farmers. Among the three crops, the performance

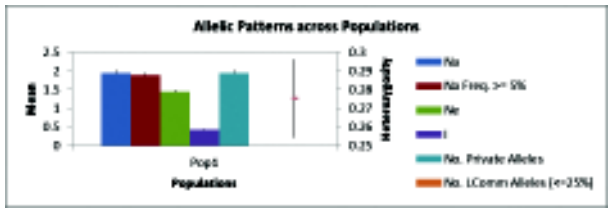



**Fig 1 Allelic patterns across populations**

of groundnut was much better than maize and okra. Maize produced 12 t/ha green cob yield and sell in to local market by farmers.

## TSP

### Paddy seed production

During the period under report seed production activity were taken up with 361 farmers in total. Large quanity of seed were produced under our direct supervision by farmers in Farmer's Clubs in 7 areas in South Tripura, Gomati and Shepahijala district. From the produced seed 32 tonnes of seed were procured and retained for our use of dessimination in triabl areas during 2013 under TSP programme. Large quantity of seed was retained by the members of the Farmers' Clubs for the use of their members. Different KVKs also procuered seed for their use in demonstrations etc from the seed produced under this programme. A large quantity of seed was sold farmers to farmers in the villages as many farmers in the villages procured the seed directly from the seed producer by seeing the very good performance of the seed production and demonstration plots.

### Improvement of livelihood of resource destitute tribal farmer of Tripura through need based integrated organic farming system

### Distribution of improved rice variety Gomati seed to 50 farmers for enhancing the productivity

The seed of rice variety Gomati was distributed to 50 farmers and covering an area about 8.16 ha of Gamsa Kobra, West Tripura. The results revealed that the yield of Gomati paddy on farmer's field was 4.0 t/ha as compared to local variety which gave 3.5 tgrain yield/ha.

### Establishment of vermicompost unit

Establishment of Vermicompost Unit on 15 farmer's field for encouraging the organic farming production and enhancing the livelihood was done.

**FYM distribution**

Thirty tonnes of FYM was provided for 15 farmers for growing rice. The application of FYM increased the yield of rice (15 – 18%) as compared to farmers; those did not apply the FYM

**Organic vegetable cultivation**

Most of the farmers of Gomcha Kobra grow only one crop i.e. rice in season. After harvest of rice field remain fallow till the next season of rice. The organic cultivation of tomato, chilli, and okra was introduced in fallow rice land. Ten tribal farmer beneficiaries were selected covering an area about 2 ha. All the inputs seed, organic manure, fencing net etc. were supplied to farmers for promoting the vegetable cultivation in rice fallow the limited amount of irrigation water.

**Development of small entrepreneur of mushroom cultivation amongst the tribal youths**

**Conduction of training programme and monitoring of cultivation**

Four training programmes one each at Lembucherra, Damdamia, Birchandramanu and Bati Fatikcherra were conducted during the years. In all, 159 trainees participated in the training programme and they were given 1008 packets of spawn.

**Capacity building programme among the tribal farmers under tribal sub plan**

An effort was made to demonstrate on improved pig shelter management as model by establishing brick-cement made pig house (minimum 10 ft long and 5 ft wide) at the farmer's field. To date, a total of 28 pig houses were built in collaboration with Krishi Vigyan Kendras (KVKs) in 4 districts of Tripura covering West Tripura, North Tripura, South Tripura and Dhalai.

Rice bran mixed with locally made *Choak* (rice bear) waste is mainly fed to the pigs. *Choak* is liquor brewed from the rice after fermentation using *Muli* made up of locally available certain plant leaves and roots. In addition to the local feeding practices, concentrate feeds were provided to the farmers for feeding the pigs for augmenting growth.

**Training on rejuvenation techniques of old mango orchards under Tripura condition**

A training for the Agricultural officers and progressive mango growers was organized in ICAR Research Complex for NEH Region, Tripura Centre, Lembucherra, Tripura, and all the technical aspects rejuvenation procedures in the first year were discussed and demonstrated along with the future plan of work in the successive years.

**Integrated farming system of tuber crops studies in tribal areas of tripura**

Tuber crops namely elephant foot yam, tannia, dioscoria and colocasia were cultivated under an integrated farming system. Cultivation of tuber crops during March-November, followed by winter season vegetables is profitable. A training programme was organized at Tripura centre, ICAR Research Complex for NEH Region, Lembucherra, in the month of

**Table 13 Varieties released through State Varietal Release Committee (SVRC)**

| Name of variety | Parentages | IET NO | Yield (kg/ha) | Area of adaptation |
|---|---|---|---|---|
| TRC 2005-1 (rice) | Pyzum X BPT 5204 | 21512 | 5800-6000 | Rainfed shallow lowland and irrigated land in *kharif* season |
| TRC 2005-3 (rice) | Jagannath X Jaya | 21564 | 5400-5800 | rainfed shallow lowland and irrigated land in *kharif* season |
| NAVEEN (rice) | Sattari X Jaya | 14461 | 5400-5600 | suitable for cultivation in both aman and boro season |
| TRCP9 (fieldpea) | DMR 7 X T 163 | - | 1900-2100 | suitable for cropping system involving short duration rice, followed by pre rabi blackgram/ greengram |
| TRCT1-1-5-1(*toria*) | (YSP-842 x YST-8501) X SS-1 | - | 0900-1000 rice | it fits very well in between *kharif* and boro |
| Bholanath (Brinjal) | Local bholanath germplasm | | 44000 | Normal season, Bacterial wilt prone area (entire Tripura) |
| Singnath (Brinjal) | Local singnath germplasm | | 47000 | Normal season, Bacterial wilt prone area (entire Tripura) |

October, 2012. Around 50 farmers including tribal farmers from different parts of Tripura participated in the training. Tuber crop experts from Central Tuber Crop Research Institute, Thiruvananthapuram and its Regional Station, Bhubaneswar, delivered lecture and demonstrated the technologies for scientific cultivation and management practices of tuber crops.


TRC 2005 – 1 (Gomati ) | Swarna (MTU 7029) | TRC T -1-1-5-1 | TRCP - 9

TRC 2005-3 | Naveen | RC Singhnath | TRC Bholanath

**Fig 2 Crop varieties of ICAR Complex, Tripura Centre, released by SVRC in Tripura**

# 3. PUBLICATIONS

## MEGHALAYA (HQ)

### NATURAL RESOURCE MANAGEMENT

#### Research Papers


Choudhury B U, Das A, Kumar M, Ramesh T, Mohapatra K P, Verma B C and Ngachan S V. 2013. Impact of elevated carbon dioxide and temperature on rice productivity in the mid altitude Meghalaya, Northeast India- results from a simulation study.*Journal of Agrometeorology* **15** (Special Issue-I): 1-3.

Choudhury B U, Mohapatra K P, DasA, Das P T, Nongkhlaw L, Abdul Fiyaz R, Ngachan S V, Rajkhowa D J and Munda G C. 2012.Spatial variability in distribution of organic carbon stocks in the soils of North East India. *Current Science***104** (5): 604-614.

Choudhury B U, Singh A K and Pradhan S. 2013. Estimation of crop coefficients of dry-seeded irrigated rice–wheat rotation on raised beds by field water balance method in the Indo-Gangetic plains, India. *Agricultural Water Management* **123**: 20- 31.

ChoudhuryBU, Das A, Ngachan SV, Bordoloi LJ and Chowdhury P. 2012.Trend Analysis of Long Term Weather Variables in Mid Altitude Meghalaya, North-East India.*Journal of Agricultural Physics* **12** (1): 12-22.

Idapuganti R G, Ahlawat I P S and Jat N K. 2011**.**Effect of rockphosphate, pressmud and phosphorussolubilizing bacteria on growth, quality andproductivity of pigeonpea (*Cajanus cajan*)-wheat (*Triticum aestivum*) cropping system**.** *Journal of FarmingSystemsResearch and Development* **17** (1&2): 215-224.

Kumar M, Swarup A, Bhadraray S, Patra AK, Chandrakala JU, Manjaiah KM, Rakshit R, Kumar S and Singh R. 2012. Yield, nutritional quality and phosphorus requirement of wheat (*Triticum aestivum* L.) grown under projected elevation of atmospheric $CO_2$ and temperature in subtropical India. *Agrochimica* **56** (3): 156-174.

Kumar M, Swarup A, Patra AK, Chandrakala JU and Manjaiah K M. 2012.Effect of elevated $CO_2$ and temperature on phosphorus efficiency of wheat grown in an Inceptisol of subtropical India. *Plant Soil and Environment* **58** (5): 230–235.

Kumar M. 2011. Evidences, projections and potential impacts of climate change on food production in Northeast India. *Indian Journal of Hill Farming* **24** (2): 1-10.

Kumar Mand Swarup A. 2012.Impact of elevated atmospheric $CO_2$ and temperature on plant-available phosphorus (A value) in soil – assessment using $^{32}P$ tracer technique.*Journal of the Indian Society of Soil Science* **60**(4): 312-316.

Mahanta K, Jha D K, Rajkhowa DJ and Kumar M.2012. Microbial enrichment of vermicompost prepared from different plant biomasses and their effect on rice (*Oryza sativa* L.) growth and soil fertility. *Biological Agriculture and Horticulture* **28** (4): 241-250.

Patra AK, Kumar M, George Justin K. 2012.Potential impacts of climate change on soil fertility and fertilizer use in India. *Indian Journal of Fertilizers* **8** (11): 42-55.

Rajkhowa DJ and Kumar M. 2013.Biowaste utilisation for improving health and productivity of acid soils in north-east India.*Current Science* **104**(1): 11-12.

RakshitR, Patra AK, Pal D, Kumar Mand Singh R. 2012. Effect of elevated $CO_2$ and temperature on nitrogen dynamics and microbial activity during wheat (*Triticum aestivum* L.) growth on a subtropical Inceptisol in India.*Journal of Agronomy & Crop Science* **198**: 452-465.

Saikia U S, Goswami B, Rajkhowa D J, Venkatesh A, RamachandranK., Rao V U M, Venkateswarlu B and Ngachan S V.2013. Sans comprehensive intervention rainfed agriculture in the North Eastern region of India will suffer from intermittent drought and floods as indicated by standardized precipitation index. *Journal of Agrometeorology* Special Issue.

Tripathi V D, Venkatesh A, Prasad Rand Chaturvedi OP. 2012. Allelopathic effect of *Eucalyptus tereticornis* clones on subabul (*Leucaena leucocephala* L.). *Indian Journal of Agroforestry***14** (1): 89-94.

Verma B C**,** Datta S P, Rattan R K and Singh A K. 2013. Impact of temperature and moisture regimes on carbon and nitrogen mineralization in an alluvial soil amended with organics. *Agrochimica* (Accepted).

Verma B C**,** Datta S P, Rattan R K and Singh A K. 2013.Labile and stabilized fractions of soil organic carbon in some intensively cultivated alluvial soils. *Journal of Environmental Biology* (Accepted.)


#### Books authored/edited


Das A, Ngachan S V, Ramkrushna G I, Choudhury B U, Singh R K, Tripathi A K, Patel D P and Munda G C. 2012. Participatory Rain Water Management for Enhancing Water Productivity and Livelihood in Hill Ecosystem-*action programme for research applications*. ICAR Research Complex for NEH Region, Umiam-793103, Meghalaya, India.

Munda G C, Ngachan S V, DasA, Mohapatra K P, Choudhury B U, Ramkrushna G I,Tripathi A K, Azad Thakur N S, Malngiang S and Chowdhury S. 2012. Book of Extended Summaries. The National Seminar on Livelihood Options for Small and Marginal Farmers in Fragile Ecosystems. NAIP Component-3.pp 216.ICAR Research Complex for NEH Region, Umiam-793103, Meghalaya, India.

Singh A K, Ngachan S V,Munda G C,Mohapatra K P, Choudhury B U, Das A,Rao Ch S, Patel D P, Rajkhowa D J, Ramkrushna G I and Panwar A S. 2012. Carbon Management in Agriculture for Mitigating Greenhouse Effect.pp 377.ICAR Research Complex for NEHRegion, Umiam-793103, Meghalaya, India.


#### Book chapters


Acharya S, Verma B C, Bajpai A K and Srivastava R B. 2013.Applications of Nanotechnology in Plant Nutrition.*(in). Nanotechnology Vol. 1: Fundamentals and Applications*. Navaani N K and Sinha S (Eds.), Govil J N (Exec. Eds.). ISBN: 1-62699-001-8; Publisher: Studium Press LLC, USA.

Choudhury B U, Singh A K, Ngachan S V, Das P T, Nongkhlaw L, Das A, Verma B C, Mohapatra K P, Rajkhowa D J and Munda G C.2013. Soil organic carbon mapping of northeastern region of India: A geographic information system approach, *(in).Carbon Management in Agriculture for Mitigating Greenhouse effect,* pp 83-95. Singh A K, Ngachan, S V, Munda G C, Mohapatra K P, Choudhury B U, Das A, Rao Ch S, Patel D P, Rajkhowa D J, Ramkrushna G I and Panwar A S (Eds.). ICAR Research Complex for NEH Region, Umiam-793103, Meghalaya, India.

Das A, Choudhury B U, Mohapatra K P, Ramkrushna G I, Ngachan S V, Munda G C and Dutta R. 2012. Conservation Agriculture in Rice Based Cropping Systems: Innovations for carbon management and Livelihood. *(in).Carbon Management in Agriculture for Mitigating Greenhouse Effect,* pp.242-263. Singh A K, Ngachan, S V, Munda G C, Mohapatra K P, Choudhury B U, Das A, Rao Ch S, Patel D P, Rajkhowa D J, Ramkrushna G I and Panwar A S (Eds.). ICAR Research Complex for NEH Region, Umiam-793103, Meghalaya, India.

Kumar M. 2012. Climate change and agriculture: impact, mitigation and adaptation. *(in). Carbon Management in Agriculture for Mitigating Greenhouse Effect,* pp 65-189. (Singh A K, Ngachan, S V, Munda G C, Mohapatra K P, Choudhury B U, Das A, Rao Ch S, Patel D P, Rajkhowa D J, Ramkrushna G I and Panwar A S (Eds.) ICAR Research Complex for NEH Region, Umiam-793103, Meghalaya, India.

Mandal S and Verma B C. 2012.Role of Biochar in Carbon Sequestration.*(in). Carbon Management in Agriculture for Mitigating Greenhouse Effect,* pp 348-355. Singh A K, Ngachan, S V, Munda G C, Mohapatra K P, Choudhury B U, Das A, Rao Ch S, Patel D P, Rajkhowa D J, Ramkrushna G I and Panwar A S (Eds.). ICAR Research Complex for NEHRegion, Umiam-793103, Meghalaya, India.

Venkatesh A and Newaj R. 2012.Carbon Sequestration through Agroforestry.*(in).Carbon Management in Agriculture for Mitigating Greenhouse Effect,* pp 152-159. Singh A K, Ngachan S V, Munda G C, Mohapatra K P, Choudhury B U, Das A, Rao Ch S, Patel D P, Rajkhowa D J, Ramkrushna G I and Panwar A S (Eds.) ICAR Research Complex for NEH Region, Umiam-793103, Meghalaya, India.

Venkatesh A, Kumar M, Rajkhowa D J and Mawphlang I S L. 2012.Joint Forest Management (JFM).*(in). Forestry - Principles and Applications,* pp 560-577. Raj A J and LAl S B (Eds.).Scientific Publishers, Jodhpur, Rajasthan, India.

Venkatesh A, Mohapatra K P, Kumar M, Rajkhowa D J and Mawphlang I S L. 2012.Social Forestry.*(in).Forestry - Principles and Applications,* pp 539-559. Raj A J and LAl S B (Eds.).Scientific Publishers, Jodhpur, Rajasthan, India.

Verma B C, Choudhury B U, Hazarika S and Bordoloi L J. 2012.Soil Organic Carbon Fractions and their Management.*(in). Carbon Management in Agriculture for Mitigating Greenhouse Effect,* pp 296-304. Singh A K, Ngachan, S V, Munda G C, Mohapatra K P, Choudhury B U, Das A, Rao Ch S, Patel D P, Rajkhowa D J, Ramkrushna G I and Panwar A S (Eds.). ICAR Research Complex for NEHRegion, Umiam-793103, Meghalaya, India.

**Technical bulletin/Popular articles/Leaflet**

Das A, Patel DP, Ramkrushna GI**,** Munda GC, Ngachan SV, Choudhury BU, Mohapatra KP, RajkhowaDJ, Kumar R and Panwar AS. 2012. Improved Rice Production Technology - for Resource Conservation and Climate Resilience (Farmers' Guide). Extension Bulletin No 78. ICAR Research Complex for NEH Region, Umiam-793103, Meghalaya, India.

Das A, Patel DP, Ramkrushna G I, Munda GC, Ngachan SV, Choudhury BU, Mohapatra KP, Rajkhowa DJ, Kumar R and Panwar AS. 2012. Ka Kot Jingiarap Ia Ki Nongrep Ka Rukom Pynmih Kba Kaba Kham Bha Ban Pynneh Pynsah Ia Ki Lad Jingiarap Bad Ka Jinglah Ban Iaishah Ha Ka Jingkylla Ka Suinbneng Extension Bulletin No. 79. ICAR Research Complex for NEH Region, Umiam-793103, Meghalaya, India.

DasA,Ramkrushna G I, Choudhury BU, Patel D P, Tripathi AK, Singh RK, NgachanSV, Munda GC, Syiem T, Lyngdoh E and Das S. 2012. Karukom Rep Kba SRI Bad ICM Nakabynta Ban Pynkiew Ha Kajingmih Bad Kajingmyntoi (SRI and ICM culture- for higher productivity and income). ICAR Research Complex for NEH Region, Umiam-793103, Meghalaya, India. (in Khasi)

**Papers presented in Conferences / Symposium / Seminars / Workshop**

VenkateshA, Singh P, Tripathi V D and GurunathanN. 2012. Effect of pruning on productivity of *Eruca sativa* in *Anogeissus pendula* based agroforestry system. *Third International Agronomy Congress on Agriculture Diversification, Climate Change Management and Livelihoods.*pp 511-512, 26-30 November.Indian Society of Agronomy, Indian Agricultural Research Institute, New Delhi, India.

Ramkrushna GI. 2012. Multiple use of water for enhancing water productivity and rural livelihood.*National seminar on Livelihood Options for Small and Marginal Farmers in Fragile Ecosystem.*9-10 August, NAIP Component-3.ICAR Research Complex for NEH Region, Umaim-793103, Meghalaya, India.

Ramkrushna GI. 2012. Conservation agriculture in rice based cropping system. *Workshop on Agriculture and Food Security in the Context of Climate Change* 12-14 October. ICAR Research Complex for NEH Region, Manipur Centre at Imphal, Manipur, India.

**Abstracts/Extended summaries**

Choudhury B U, Das A, Hazarika S, Bordoloi L J and Ngachan S V. 2013.Comparative Effectiveness of Direct and Residual Liming on Maize (*Zea mays* L.) Productivity in Strong Acid Soils of North-east India.*(in).International Conference on Bio-resource and Stress Management*. Manuscript No: 323. 6-9 February.Kolkata, West Bengal, India.

Choudhury B U, Das A, Mohapatra K P and Ngachan S V.2012. Climate change and water balance of North-East India: Concern for sustainable agricultural productivity. *(in). International Seminar and Cultural Expo on Natural Resources and Rural Livelihoods among Tribes in Hills Areas.*22-24 March. Department of Geography, North-Eastern Hill University, Shillong Meghalaya, India..

Choudhury B U, Lyngdoh M S and Ngachan SV. 2012. Genotypic response to differential fertilizer management practices in acid soils of rainfed lowlands - an approach to improve rice productivity of resource poor farmers of Meghalaya. *(in).National Seminar on Livelihood Options for Small and Marginal Farmers in Fragile Ecosystems*, pp 97-100. 9-10 August.ICAR Research Complex for NEH Region, Umiam-793103, Meghalaya, India.

Choudhury B U, Lyngdoh M S, Ngachan S V and Bordoloi L J.2012.Crop water productivity of lowland rice genotypes in acid soils of mid altitude Meghalaya. *(in).International Seminar and Cultural Expo on Natural Resources and Rural Livelihoods among Tribes in Hills Areas*. 22-24 March.Department of Geography, North-Eastern Hill University, Shillong, Meghalaya, India.

Choudhury B U, Nongkhlaw L, Das P T, Das A and Ngachan SV. 2012. Linking land use – land cover change to soil health and socio economy in South Garo Hills District of Meghalaya, Northeast India: A remote sensing and GIS approach. *(in).National Symposium on Space Technology for Food & Environmental Security*, pp 212. 5-7 December. New Delhi, India.

Das A, Ngachan SV, Ramkrushna GI,Choudhury BU, Singh RK, Tripathi AK, Patel D P andMunda GC. 2012. Integrated rain water management for enhancing water productivity and livelihood in hill ecosystem. *(in). Abstracts of Conference on Farmers First for Conserving Soil and Water Resources in Southern Region*, pp 71-72. 14-16, March. Indian Association of soil and water conservationists, Bangalore, India.

Das A,Datta M, Singh IM, Ramkrushna GI, Krishnappa R, LayekJ and DasS. 2012. Rice-fish-livestock-vegetable farming systems of north east India: rich heritage for resource conservation and livelihood improvement. *(in). Abstracts of National Seminar on Livelihood Options for Small and Marginal Farmers in Fragile Ecosystem*, pp 180-182. 9-10 August.NAIP Component-3.ICAR Research Complex for NEH Region, Umaim-793103, Meghalaya, India.

DasA, Ramkrushna GI,Mandal S, Layek J, Patel D P, Choudhury BU, Mohapatra KP, Krishnappa R, Munda GC, Rajkhowa DJ and Ngachan SV. 2012. Soil and water conservation in hill slopes through efficient cropping systems, bio-mulching and conservation tillage: a sustainable alternative to shifting cultivation in North East India. *(in). Summaries (Vol 2) of Third International Agronomy Congress on Agricultural Diversification, Climate Change Management and Livelihoods*,pp 654-656. 26-30 November.Indian Society of Agronomy, Indian Agricultural Research Institute, New Delhi, India. .

Hazarika S, Bordoloi L J, Choudhury B U, Kumar M and Panwar A S. 2012.Land Use Impacts on Quality Characteristics of Acid Soil in North Eastern Hill Region of India*In : Proceedings of the 8th International Symposium on Plant-Soil Interaction at Low pH*, pp 42-43.18-22 October. University of Agricultural Sciences Bengaluru, India.

Kumar M, Naropongla, Das A,Buragohain J, Kuotsu K and Ramkrushna GI. 2012. Organic food production through integrated farming system approach for enhancing productivity and livelihood of small and marginal. *(in). Abstracts of National Seminar on Livelihood Options for Small and Marginal Farmers in Fragile Ecosystem*, pp 52-54. 9-10 August.NAIP Component-3.ICAR Research Complex for NEH Region, Umaim-793103, Meghalaya, India.

Kumar M, Patel D P, Das A, Naropongla, Munda G C, Ngachan S V and Ramkrushna G I. 2012. Effect of different organic amendments on productivity and soil health of different field crop based systems in mid altitude of North East India. *(in). Extended Summaries (Vol 2) of Third International Agronomy Congress on Agricultural Diversification, Climate Change Management and Livelihoods*,pp 497-498. 26-30 November.Indian Society of Agronomy, Indian Agricultural Research Institute, New Delhi, India.

Mandal S, Singh RKandRamkrushna GI. 2012. Low-cost poly-house and plastic film lined pond: A noble technique for cultivationof high valued crops and multiple use of rain water. *(in). Abstracts of National Seminar on Livelihood Options for Small and Marginal Farmers in Fragile Ecosystem*, pp 89-90. 9-10 August.NAIP Component-3.ICAR Research Complex for NEH Region, Umaim-793103, Meghalaya, India.

Mandal S, Verma B C, Ramkrushna G I, Singh R K, Rajkhowa D J and Ngachan S V. 2012. Potentiality of weed biomass as a source of biochar for carbon sequestration.*(in). Extended Summaries (Vol 2) of Third International Agronomy Congress on Agricultural Diversification, Climate Change Management and Livelihoods*, pp 499-500.26-30 November.Indian Society of Agronomy, Indian Agricultural Research Institute, New Delhi, India.

Naropongla, Patel DP, Das A, Kumar M, Munda GC, NgachanSV, Ramkrushna GI and Buragohain J. 2012. Effect of land configuration and organic amendments on ginger productivity and soil health in North East India.*(in). Extended summaries (Vol 3) of third international agronomy congress on agricultural diversification, climate change management and livelihoods,* pp 1102-1103.26-30 November.Indian Society of Agronomy, Indian Agricultural Research Institute, New Delhi.

Patel D P, Das A, Munda G C, Ramkrushna G I, Baiswar P, Saikia K, Kumar M and Naropongla. 2012. Response of different organic amendments on productivity and soil health in vegetable-based multiple cropping systems at mid altitude of eastern Himalayas. *(in). Extended Summaries (Vol 2) of Third International Agronomy Congress on Agricultural Diversification, Climate Change Management and Livelihoods*,pp 439-441. 26-30 November.Indian Society of Agronomy, Indian Agricultural Research Institute, New Delhi, India. .

Ramkrushna G I,Das A, Patel D P, Kumar M, Munda G C, Layek J, Krishnappa R and Choudhury S. 2012. Productivity and soil health as influenced by nutrient management and date of transplanting of aromatic rice under mid hill situation of North East India. *(in).Extended Summaries (Vol 2) of Third International Agronomy Congress on Agricultural Diversification, Climate Change Management and Livelihoods*, pp 182-183. 26-30 November.Indian Society of Agronomy, Indian Agricultural Research Institute, New Delhi. .

Ramkrushna GI,Das A,Choudhury BU, Tripathi A K, Singh RK, Patel DP, Munda GC and Ngachan SV. 2012. Multiple use of water for enhancing water productivity and rural livelihood. *(in). Abstracts of National Seminar on Livelihood Options for Small and Marginal Farmers in Fragile Ecosystem*, pp 83-85. 9-10 August.NAIP Component-3.ICAR Research Complex for NEH Region, Umaim-793103, Meghalaya, India.

Verma B C, Kumar M, Choudhury BU, Bordoloi LJ, Ramkrushna G I, Hazarika S, Ramesh T and Mandal S. 2013. Effect of Integrated Nutrient Management (INM) Practices on Maize yield, Organic Carbon and Available Nutrients in Acid Soil of Meghalaya. *(in).The first International Conference on Bio-resource and Stress Management*. 6 -9 February. Kolkata, West Bengal, India.

Verma B C, Kumar M,Choudhury BU, Bordoloi LJ, Ramkrushna GI,Hazarika S, Ramesh T and Mandal S. 2013. Effect of INM practices on maize yield, organic carbon and available N in acid soils of Meghalaya.*(in). Abstarcts of International Conference on BSM*, pp 334.Kolkata, West Bengal, India.

**CROP IMPROVEMENT**

**Research Papers**

Baiswar P, Chandra P, Mohapatra K P, Kipgen T L, Chandra S and Ngachan SV. 2013. First Record of *Rhizoctonia solani* AG 1-IB on *Mucunapruriens* in India. *Plant Disease***97** (2): 284.

Baiswar P, Chandra S, Chandra P, Mohapatra K P, Bemkaireima K, Ngachan S V and Rosa D D.. 2013. First Record of Seedling Blight Caused by *Rhizoctonia solani* AG4 HG-I on *Jatropha curcas* in India. *Environment and Ecology* **31**: 399-400.

Baiswar P, Chandra S, Kumar R and Ngachan S V. 2012. First Report of Leaf Blight of *Basella alba* caused by *Rhizoctonia solani* AG1 -IB in India. *Plant Disease* **96** (6): 911.

Banerjee A, Roy S and Tarafdar J. 2012. The large intergenic region of *Rice tungro bacilliform virus* evolved differentially among geographically distinguished isolates. *Virus Genes* **44** (2): 312-318.

Behere GT, Tay WT, Russell DA, Kranthi KR, Batterham P. 2013. Population genetic structure of the cotton bollworm *Helicoverpaarmigera* (Hubner) (Lepidopetra: Noctuidae) in India as inferred from EPIC-PCR DNA markers. PLoS ONE 8(1): e53448. doi:10.1371/journal.pone.0053448.

Dutta R, Chandra S and Ngachan S V. 2013.Evaluation of tomato genotypes against bacterial wilt (*Ralstonia solanacearum*) under mid-hill conditions.*Indian Phytopathology* **66** (1): 96-97.

Dutta R, Ngashepam Anita, Chandra, S and Ngachan, SV. 2012. Sources of Resistance to Turcicum Leaf Blight (*Exserohilumturcicum*) of Maize for NEH Region. *Indian Phytopathology* **65** (2):200-202.

Firake D M and Khan M A. 2013. Do daily alternating temperatures affect the performance of egg parasitoids, *Trichogramma* spp. *Journal of Insect Science* (US), (in press)

Firake D M, Lytan D and Behere G T. 2012.Bio-diversity and Seasonal Activity of Arthropod Fauna in Brassicaceous Crop Ecosystems of Meghalaya, North East India.*Molecular Entomology*, **3**(4): 18-22, doi: 10.5376/me.2012.03.0004

Firake D M, Lytan D, Behere G T and Azad Thakur NS A. 2012. Host plants alter the reproductive behaviour of *Pierisbrassicae* (Lepidoptera: Pieridae) and its solitary larval endo-parasitoid, *Hyposoterebeninus* (Hymenoptera: Ichneumonidae) in cruciferous ecosystem. *Florida Entomologist* **95** (4):905-913.

Ghate, H V, Riphung S and. Thakur N S A. 2012. First record of the Long-horned Beetle *Sarothroceralowii*White, 1846 (Cerambycidae: Lamiinae: Lamiini) from India. *Journal of Threatened Taxa* **4** (7): 2709-2712

Lytan D and Firake D.M. 2012. Effects of different host plants and rearing atmosphere on life cycle of large white cabbge butterfly, *Pierisbrassicae* (L.). *Archives of Phytopathology and Plant Protection,* http://dx.doi.org/10.1080/03235408.2012.711682

Pale G, Das A and Pattanayak A. 2012. Screening of rice (*Oryzasativa* L.) germplasm of North-eastern India for early vegetative stage heat tolerance. *Indian Journal of Genetics and Plant Breeding* **72**:217-20.

Patra S, Azad Thakur, N S, Saikia K and Firake D M. 2012.Population dynamics of cabbage aphid, *Brevicorynebrassicae*L.on major cole crops in Meghalaya. *Madras Agric. J.* **99**(7-9): 573-575.

Roy A R, Sajeev S, Pattanayak A and Deka B C. 2012. TDZ induced micropropagation in *Cymbidium giganteum* Wall. Ex Lindl.and assessment of genetic variation in the regenerated plants.*Plant Growth Regulation* **68**:435-45.

Roy S, Banerjee A, Tarafdar J and, Senapati B K. 2012.Detection of probable marker free transgene positive rice tungro disease resistant plants from backcross progenies of transgenic Pusa Basmati 1.*Journal of Genetics* **91**: 213-218.

Roy S, Banerjee A, Tarafdar J, Senapati B K and Dasgupta I. 2012. Transfer of transgenes for resistance to rice tungro disease into high-yielding rice cultivars through gene-based marker-assisted selection. *Journal of Agricultural Science* **150**: 610-618.

Roy S, Banerjee A, Tarafdar J, Senapati B K and SarkarG. 2012. Comparative analysis of agro-morphology, grain quality and aroma traits of traditional and Basmati type genotypes of rice, *Oryzasativa*L. *Plant Breeding***131**(4): 486-492.

Saikia K, Azad Thakur NS and Ao, Alemla. 2011.Seasonal incidence of citrus trunk borer (*Anoplophoraversteegi* Ritsema) on *Khasi* mandarin in Meghalaya.*Indian Journal of Hill Farming* **24** (1&2): 14-18

Saikia K, Azad Thakur, NS and Ao, Alemla. 2011.Biology of citrus trunk borer (*Anoplophoraversteegi*Rits.)(Coleoptera: Cerambycidae) under laboratory conditions.*Indian Journal of Hill Farming* **24** (1&2): 19-23.

Saikia, Kanchan, Azad Thakur, N.S., Ao, Alemla and Gautam, Sudhida.2012. Sexual dimorphism in *Pseudonemorphusversteegi* (Ritsema) (Coleoptera: Cerambycidae), citrus trunk borer. *Florida Entomologist***95** (3): 625-629.

**Book authored**

Lytan D and Firake DM.2012. Biology and Parasitism of Cabbage butterfly, *Pierisbrassicae*(L.). LAP LAMBERT Academic Publishing (ISBN-10: 384542771X, ISBN-13**:** 978-3845427713), Saarbrucken, Deutschland/Germany.

**Book Chapters**

Dutta, R., Chandra, S and Devi Jina K. 2013.Management of horticultural diseases with reference to supply chain.*(in).* Supply chain management of horticultural crops in NEH Region.*(in).Supply Chain Management of Horticultural Crops in NEH Region.*Tripathi AK, Roy A, SinghNU, Seeralan S, Ngachan SV, Dutta R, and Debnath A(Eds.).ICAR Research Complex, Umiam-793103, Meghalaya, India.

Das A, Choudhury B U, Mohapatra K P, Ramkrushna GI, Ngachan S V, Munda G C and Dutta R. 2012. Conservation Agriculture in Rice Based Cropping Systems: Innovations for Carbon Management and Livelihood. *(in).Carbon Management in Agriculture for Mitigating Greenhouse Effect,* pp 377.Singh A K, Ngachan, S V, Munda G C, Mohapatra K P, Choudhury B U, Das A, Rao Ch S, Patel D P, Rajkhowa D J, Ramkrushna G I and Panwar A S (Eds.). ICAR Research Complex for NEHRegion, Umiam-793103, Meghalaya, India.

**Papers presented in Conferences / Symposium / Seminars / Workshop**

Banerjee A, Dutta R and Ngachan S V. 2012.Molecular characterization of *Banana bunchy top virus* based on DNA

R segment from Meghalaya: A new member of "Pacific-Indian Oceans" group. *(in).Proceedings of International Symposium on 'Food Security Dilemma: Plant Health and Climate Change Issues*. pp 133-134.7-9 December.BCKV, West Bengal, India.

Roy S, Mishra A K, Banerjee A, Rathi RS, Singh S K and Bhatt B P. 2012. Rice germplasm of Nagaland: a useful resource for rice breeding. *(in).Proceeding of National Seminar on Plant Genetic Research for Eastern and North-eastern India*. 11-12 May. ICAR Research Complex for NEHRegion, Umiam-793103, Meghalaya, India.

**Training manual**

Tripathi AK, Roy A, Singh NU, Seeralan S, Ngachan SV, Dutta R and Debnath A. 2013. Supply Chain Management of Horticultural Crops in NEH Region. ICAR Research Complex for NEHRegion, Umiam-793103, Meghalaya, India.

**Sequences published**

Banerjee A, RoySS, RoyS and NgachanSV. 2012. Molecular detection and characterization of virus complex in solanaceous crops.Accession No. KC119086-KC119093 GenBank (http://ncbi.nlm.nih.gov.in/)

BanerjeeA and NgachanSV. 2012. Molecular characterization of BBTV from NE India.Accession No. KC119098 GenBank (http://ncbi.nlm.nih.gov.in/)

BanerjeeA, Deshmukh N A, Roy S and NgachanSV. 2012. Genomic variation of *Candidatus* Liberibacter asiaticus in NE India. Accession No. JX284239-JX284244 (http://ncbi.nlm.nih.gov.in/)

Banerjee A, DeshmukhNA, Dutta SK and NgachanSV. 2012. Genomic variation of *Candidatus* Liberibacter asiaticus in NE India. Accession No. KC119094-KC119097, KC137978-KC137981 (http://ncbi.nlm.nih.gov.in/)

**HORTICULTURE**

**Research papers**

Nath A, Deka B C, Jha A K, Paul D and Mishra L K. 2013. Effect of slice thickness and blanching on different quality attributes of instant ginger candy. *Journal of Food Science and Technology* **50** (1):197-202.DOI 10.1007/s13197-012-0619-x.

Patel R K, Maiti C S, Deka B C, Deshmukh N A and Roy D. 2011.Variability studies in guava (*Psidium guajava* L.) genotypes for growth, yield and quality attributes at mid-hills of Meghalaya. *Indian Journal of Hill Farming* **24** (1&2): 24-28.

Singh A, Deka B C, Patel R K, Nath A and Mulieh S R. 2012.Effect of pruning time, severity and tree aspects on harvesting period and fruit quality of low chilling peach (*Prunus persica*). *Indian Journal of Agricultural Sciences* **82** (10): 862-868.

Singh A, Syndor A, Deka B C, Singh R K and Patel R K.2012.The effect of microclimate inside low tunnels on off-season production of strawberry (Fragaria xananassa Duch.).*Scientia Horticulturae* **144**: 36-41.

Yadav R K, Yadav D S, Deka B C, Sanwal S K, Jha A K, Verma V K, Patel R K and Nath A. 2012. Megha tomato-3: New tomato variety.*Indian Horticulture* **57** (6): 34-36.

**Book chapters**

Deshmukh N A, Patel R K, Verma V K, Firke D M and Jha A K. 2013.Potential fruit and plantations crops in Meghalaya. *(in). Horticulture for Economic Prosperity and Nutritional Security in 21st Century,* pp 225-242. Hazarika T K and Nautiyal B P (Eds.).Westville Publishing House, New Delhi, India.

Deshmukh N A, Patel R K, Verma V K, Jha A K, Lyngdoh P and Nath A. 2012. Horticulture based farming system for better livelihood in mid hills of Meghalaya. *(in). Book of Extended Summaries of the National Seminar on Livelihood Option for Small and Marginal Farmers in Fragile Ecosystems,* pp 108-111. (Munda G C, Ngachan S V, Das A, Mahapatra K P, Choudhary BU,Ramkrishna G I, Tripathi AK, Azad Thakur NS, Malngiang S and Choudhury S (Eds.). ICAR Research Complex for NEH Region, Umiam-793103, Meghalaya, India.

Patel R K, Deshmukh N A, Nath A, Deka B C and Patel R S. 2013. Sohiong (*Prunus nepalensis*) and Sohshang (*Elaeagnus latifolia* Linn.): Potential fruits of Meghalaya need commercialization. *(in). Developing the Potential of Underutilized Horticultural Crops of Hill Regions,* pp 456-467. Prakash *et al.* (Eds.). Today & Tomorrow's Printers and Publishers, New Delhi, India.

Patel R K, Verma V K, Deshmukh N A, Nath A, Deka B C and Ngachan S V. 2013.Underutilized Horticultural crops of Meghalaya.*(in). Developing the potential of Underutilized Horticultural Crops of Hill Regions,* pp 205-215. Prakash *et al.* (Eds.). Today & Tomorrow's Printers and Publishers, New Delhi, India.

Patel R K, Verma V K, Deshmukh NA, Jha A K, Nath A and Patel R S. 2013. Underutilized fruits of Meghalaya: An option for food and nutritional security. *(in). Horticulture for Economic Prosperity and Nutritional Security in 21st Century,* pp 256-263. Hazarika and Nautiyal (Eds.).Westville Publishing House, New Delhi, India.

Verma V K, Nath A, Jha A K, Deshmukh N A and Patel R K. 2013.Impact of Abiotic Stresses on Horticulture and Strategies for Mitigation in Northeastern India. *(in). Climate-Resilient Horticulture: Adaptation and Mitigation Strategies,* pp 35-44. Singh *et al.* (Eds.) Springer India, New Delhi, India.

**Papers presented in Conferences / Symposium / Seminars / Workshop**

Buragohain Juri, Angami T, Singh V B, Deka B C, Jha A K, Naropongla M and Singh S. 2012. Evaluation of some leafy vegetables from nutritional aspects in Meghalaya, North Eastern India.*(in).Book of Abstracts of National Seminar on Horticulture for Livelihood Security, Economic Prosperity and Sustainable Development.* pp 136.24-26 September.Department of Horticulture, Aromatic & Medicinal Plants, Mizoram University, Aizawl, Mizoram, India.

Deshmukh N A, Patel R K, Verma V K, Jha A K and Nath A. 2012.Potential fruit and plantations crops in Meghalaya. *(in). Souvenir & Abstracts of National Seminar on Horticulture for Livelihood Security, Economic Prosperity and Sustainable Development,* pp 9.24-26 September.Department of Horticulture, Aromatic & Medicinal Plants, Mizoram University, Aizawl, Mizoram, India.

Deshmukh N A, Patel R K, Verma V K, Nath A and Lyngdoh P. 2012.Meadow orcharding in guava under subtropics of Meghalaya. *(in). Souvenir & Abstracts of National Seminar on Horticulture for Livelihood Security, Economic Prosperity and Sustainable Development,* pp 157.24-26

September.Department of Horticulture, Aromatic & Medicinal Plants, Mizoram University, Aizawl, Mizoram, India.

Lalhmingsanga, Jha A K, Nath A, Deka B C and Thakuria D. 2012. Nutrient management influenced the yield and quality of broccoli in acidic soils on hill terrace. *(in). Book of Abstracts of National Seminar on Horticulture for Livelihood Security, Economic Prosperity and Sustainable Development.*pp 76.24-26 September.Department of Horticulture, Aromatic & Medicinal Plants, Mizoram University, Aizawl, Mizoram, India.

Patel R K, Deshmukh N A, Verma V K and Jha A K.2012. Nursery raising of horticultural crops in NE region: An option for livelihood and entrepreneur development. *(in). Proceedings of Regional Seminar cum Workshop on Promotion of Rural Livelihood through Cottage Industries for Upliftment of Rural Economy of NER.*pp.167-176. 26-27July.National Institute of Rural Development, North Eastern Regional Centre, Khanapara, Guwahati, Assam, India.

Patel R K, Nath A, Deshmukh N A and Patel R S. 2012.Fruit growth and ripening physiology of passion fruit species.*(in). Souvenir & Abstracts of 5th Indian Horticulture Congress (Horticulture for food and nutritional security)*, pp 453.6-9 November.PAU, Ludhiana, India.

Patel R K, Roy S S, Deshmukh N A and Lyngdoh A. 2012. DUS characters for the Khasi mandarin (*Citrus reticulata* Blanco). *(in). Souvenir & Abstracts of National Seminar on Horticulture for Livelihood Security, Economic Prosperity and Sustainable Development,* pp 54.24-26 September.Department of Horticulture, Aromatic & Medicinal Plants, Mizoram University, Aizawl, Mizoram, India.

Patel R K, Verma V K, Deshmukh N A, Jha A K, Nath A and Patel R S. 2012. Underutilized fruits of Meghalaya: An option for livelihood and nutritional security. *(in). Souvenir & Abstracts of National Seminar on Horticulture for Livelihood Security, Economic Prosperity and Sustainable Development,* pp 8.24-26 September.Department of Horticulture, Aromatic & Medicinal Plants, Mizoram University, Aizawl, Mizoram, India.

Verma V K, Pandey A, Jha A K, Chaudhury P and Tanya L Swer. 2012. Characterization and genetic studies for yield and related traits in pole type French bean ( *Phaseolus vulgaris* L.) of NE India. *(in). Book of Abstracts of National Seminar on Plant Genetic Research for Eastern and NE India.*pp148-149. 11-12 May. ICAR Research Complex for NEH Region, Umiam-793103, Meghalaya, India.

## AGRICULTURAL ENGINEERING

### Research Papers

Deka B C, Thirugnanavel A, Patel R K, Nath A and DeshmukhN. 2012. Horticultural diversity in North-East India and its improvement for value addition. *Indian Journal of Genetics and Plant Breeding* **72** (2): 157-167.

Mandal S, Kumar A, Singh R K and Ngachan S V. 2012.Evaluation of composition, burn rate and economy of beehive charcoal briquettes.*International Journal of Agricultural Engineering* **5** (2): 158-162.

Mandal S, Roy S and Tanna H. 2012.A Low-Cost Image Analysis Technique for seed size determination.*Current Science* **103** (12): 1401-1403.

Nath A, BarmanK, Chandra S and BaiswarP. 2013. Effect of plant extracts on quality of Khasi mandarin (*Citrus reticulata* Blanco) fruits during ambient storage. *Food and Bioprocess Technology* **6**:470-474.

Nath A, Deka B C, Jha A K, Paul D and Misra L K. 2013. Effect of slice thickness and blanching time on different quality attributes of instant ginger candy. *Journal of Food Science and Technology* **50** (1):197-202.

Singh A, Deka B C, Patel R K, NathA and Mulieh S R. 2012. Effect of pruning time, severity and tree aspects on harvesting period and fruit quality of low chilling peach (*Prunus persica*). *Indian Journal of Agricultural Sciences* **82** (10): 862-866.

Singh R K, Satapathy K K, Kumar A andMandal S. 2012.Impact of land use on quality of surface water in a hilly watershed. *International Journal of Agricultural Engineering* **5** (2), 206-210.

### Book chapters

Kumar A, Mandal S, Singh R K**.** 2012.Energy management and mechanization of *Jhum* cultivation in NE India. *(in). Resilient Shifting Cultivation: Challenges and Opportunities.* Deka B C, Patra MK, Thirugnanavel A, Chatterjee D, Borah T R and Ngachan S V (Eds.). ICAR Research Complex for NEH Region, Umiam-793103, Meghalaya, India.

Singh R K And Mandal S. 2012. Soil and water conservation measures for management of hill agriculture. *(in). Resilient Shifting cultivation: Challenges and Opportunities.* Deka B C, Patra M K, Thirugnanavel A, Chatterjee D, Borah T R and Ngachan S V (Eds.). ICAR Research Complex for NEH Region, Umiam-793103, Meghalaya, India.

### Papers presented in Conferences / Symposium / Seminars / Workshop

Mandal S, Verma B C, Ramkrushna G I, Singh R K, Rajkhowa D J and Nagchan S V. 2012. Potentiality of Weed Biomass as a Source of Biochar for Carbon Sequestration.*(in). Proceedings of Extended Summaries (vol. 2) of 3rd International Agronomy Congress*.26-30 November.IARI, New Delhi, India.

Singh R K, Kumar A, Mandal S and Ngachan S V. 2013.Impact of soil and water conservation practices on productivity and livelihood security in hilly ecosystem of North East hill region.*Conference on Farmers First for Conserving Soil and Water Resources in Southern Region (FFCSWR-2013).*14-16March.University of Agricultural Sciences, GKVK, Bangalore, India.

## ANIMAL PRODUCTION

### Research papers

Barman C, Baruah A, SarmahB K, BaruahK K, SarmahB C, DekaB C, DuttaA, ChakravartyP, KhanM H, KumarS and Bharti P K.2013. Effect of superovulatory treatment on serum estradiol-17â and progesterone concentration and its correlation with embryo recovery in Mithun cows.*Indian Journal of Animal Sciences* **82** (11): 1327-1330.

BarmanC, Baruah A, SarmahB K, BaruahKK, SarmahB C, DekaB C, DuttaA, ChakravartyP, Khan M H and Bharti P K.2013. Superovulatory treatment response and embryo recovery in Mithun cows.*Indian Journal of Animal Sciences* **83** (3): 272-275.

BhuyanM, DekaB C, SarmahB C, ChakravartyP, Goswami J and KhanM H.2013. Duration of oestrus, time of ovulation and

progesterone profile in oestrus synchronized Yak cows. *Indian Journal of Animal Sciences* **83** (3): 254-257.

Chandra R, Chatlod L R, Kumar S, Toppo S, HaqueN and Rahman H. 2012. Nutritional evaluation of NB021 hybrid Napier grass for goats.*Indian Journal of Small Ruminant* **18** (2): 261-263.

Das SK. 2012.Effective population size in carp hatcheries of Asom, India. *Indian Journal of Animal Sciences* **82** (9): 1110–1113.

Doley S, Shakuntala I, Basumatary R, Gupta JJ and Kumar S. 2012. Effect of herbal powders as feed additives on the performance and serum cholesterol level in broiler chicken.*Indian Journal of Animal Production and Management* **28** (1-2):37-39.

Ilakshi, DekaBC, SarmahS K,Goswami J and Dutta D J. 2013.Expression of thyroid hormones and antistress enzymes following supplementation of zinc and copper in weaning piglets .*Indian Veterinary Journal* **90** (3):15-17.

Khan M H, Nath K C, Naskar S, Deka B C, KumarS, SinhaS, Basumatary R and Bharti P K. 2012. Standardization of protocol for cryopreservation of porcine semen with conventional method of freezing.*Indian Veterinary Journal* **89** (11): 27-28.

Kumar S, Jhamb D and Maurya S N.2012).Vitrification of 8-cell stage buffalo embryos.Indian Veterinary Journal.*Indian Veterinary Journal* **89** (9):33-34

Laha R, Das M, Goswami A and Singh P. 2012. A clinical case of *Babesiosis* in a crossbred cow of Meghalaya.*Indian Journal of Animal Research* **43** (3): 302-305.

Laha R, Das M, Goswami A and Singh P. 2012. Loss of milk production due to *Babesia bigemina* infection in a crossbred cow: A case study. *Journal of Protozoology Research* **22**: 6-9.

Majhi S K and Das S K.2013. Feed utilization, gonadal maturation, carcass composition and stress of the catfish, *Heteropneustes fossilis* (Bloch) Fed with Animal Viscera-Based Diets at Varied Temperatures. *(in). Proceedings of the National Academy of Sciences, India Section B Biological Sciences,*.DOI 10.1007/s40011-013-0177-7.

Shankuntal I, Das R, Rajkumari S, Singh P, Dubal Z B and Kumar S. 2012. PCR based detection of Straptococcus agalactiae from milk of bovine subclinical mastitis.*Indian Journal of Animal Sciences* **82** (9): 31-35.

**Book Chapter**

Das SK.2012. Rice –Fish farming- An environment friendly farming system for NEH Region. *(in). Resilient Shifting Cultivation: Challenges and Opportunities.* pp 86-91. Deka B C,Patra M K,Thirugnanavel A,Chatterjee D, Borah T R and Ngachan S V (Eds.) ICAR Research Complex for NEH Region, Nagaland Centre, Jharnapani, Medziphema-797106, Nagaland, India.

Singh P. 2012.Feeds and Feeding Challenges for Rural Poultry Production.*(in).Rural Poultry Production: The Need and Strategy for Sustainable Development*. pp 122-150. Malik S (Eds.). Westville Publishing House, New Delhi, India.

Singh P. 2012.Nutritional requirements of rural poultry germplasm and preparation of low cost ration by using local feed ingredients.*(in).Rural Poultry Production: The Need and Strategy for Sustainable Development*. pp 37-60. Malik S (Eds.). Westville Publishing House, New Delhi, India.

**Popular articles**

Khan M H, BardoloiR K, Bharti P K and Kumar S. 2012.Role of livestock in integrated farming system.*The North-East Veterinarian***12**(2): 4-6.

KhanM H, Kumar S, KadirvelG, BasumataryR, Bharti P K and Dubal Z B.2012.Livelihood improvement of small and marginal farmers through integrated approach of broiler rabbit production in North-east India.*International Journal of Bioresourse and Stress Management* **3**(3): 419-423.

KhanM H, Kumar S, BasumataryR, BhartiP K, Kadirvel G and Barman C. 2012. Livestock Development in Meghalaya: Biodiversity, Threats and Convervation. *International Journal of Bioresourse and Stress Management***3**(1): 122-127.

KhanM H and Kumar S. 2012. Infertility problems in dairy cattle: Causes and Prevention. *Indian Farming* **62**(1): 22-25.

Bharti P K and Khan M H. 2011. Livestock based integrated farming system in NEH Region: Present status and future prospects. *Indian Farming***62**(1): 34-37.

Bharti P K, Khan M H, Basumatary R and Kumar S. 2012. Managemental practices to reduce pre weaning piglet mortality. *The North-East Veterinarian*(Accepted).

Chandra R, Dabas S K, Chatlod L R and Rahman H. 2012.Sikkim main bahut upyogi yak palan.*Kheti***65** (5): 24-27.

**Abstracts**

Baishya S K, Tyngkan L, Kadirvel L, KhanM H and Dabas S K. 2012.Assessment of mitochondrial membrane potential and DNA integrity of cryopreserved bull spermatozoa. *(in). National symposium on Addressing Animal Reproductive Stresses through Biotechnological Tools and XXVIII Annual Convention of The Indian Society for Study of Animal Reproduction,* pp 186. 21-23 November.Department of Animal Reproduction, Gynaecology and ObstetricsCollege of Veterinary Science, Assam Agricultural University, Khanpara, Guwahati, Assam, India.

Deka I, Sarmah B C, Kumar S and Goswami J. 2012. Validation of dietary supplementation of zinc: copper in male weaning pigs with special reference to reproductive performance. *(in). National symposium on Addressing Animal Reproductive Stresses through Biotechnological Tools and XXVIII Annual Convention of The Indian Society for Study of Animal Reproduction,* pp 163. 21-23 November.Department of Animal Reproduction, Gynaecology and ObstetricsCollege of Veterinary Science, Assam Agricultural University, Khanpara, Guwahati, Assam, India.

Khan M H, Kumar S, Kadirvel G, Basumatary R, Murmu K and Ngachan S V. 2013. Analysis of Integrated Pig -Fish Production System under Subtropical Hill Ecosystem for Livelihood Security of Small and Marginal Farmers of North East Hill Region of India.*(in). International Conference on Bioresourse and Stress Management*.6-9 February.Kolkata.

Khan M H, Nath K C, Deka B C, Sarmah B C, Kadirvel G, Bhuyan D and Ngachan S V.2012. Ultra structural Changes in Porcine Spermatozoa during different stages of Processing and after Thawing using Transmission Electron Microscopy (TEM). *(in). National symposium on Addressing Animal Reproductive Stresses through Biotechnological ToolsandXXVIII Annual Convention of The Indian Society for Study of Animal Reproduction,* pp 167.21-23 November.Department of Animal Reproduction, Gynaecology and ObstetricsCollege of Veterinary Science, Assam Agricultural University, Khanpara, Guwahati, Assam, India.

Kumar S, Singh P, Deori L, Doley S, Khan M H, Kadirvel G, Basumatry R, Barman C and Ngachan S V. 2013. SWOT Analysis of Potential for Buffalo Husbandry in North East

Region of India. *(in). National Symposium on Buffalo Development for Food Security,* pp 166.15-16 March.College of Veterinary Science, Assam agricultural University, Khanpara, Guwahati, Assam, India.

Kumar S, Singh P, Deori L, Goswami J, Doley S, Khan M H, Kadirvel G, Basumatary R, Barman C and Ngachan S V.2013. Adaptability studies on Murrah buffaloes under agro-climatic conditions of Meghalaya. *(in). National Symposium on Buffalo Development for Food Securit,* pp 28.15-16 March.College of Veterinary Science, Assam agricultural University, Khanpara, Guwahati, Assam, India.

**Papers presented in Conferences / Symposium / Seminars / Workshop**

Chandra R, Chatlod L R, Toppo S, Haque N, Dabas S K, Kumar S and Rahman H. 2013. Growth pattern of Sikkim Local goats.*(in). National Seminar on New Paradism in Livestock Production: From Traditional to Commercial Farming and Beyond*,pp 51.8-39January.NDRI, Karnal, Haryana, India.

Chandra R, Chatlod L R, Toppo S, Haque N, Dabas S K, Kumar S and Rahman H. 2013. Reproductive performance of Sikkim local goat.*(in). National Seminar on New Paradism in Livestock Production: From Traditional to Commercial Farming and Beyond*, pp 102.28-39January. NDRI, Karnal, Haryana, India.

Kumar S, Chandra R, Pathak P, Nath B G, Rana A, Barman C,Barman G, Khan M H, Kadirvel G and Basumataty R . 2012. Superovulation and Embryo Collection in Sikkemese Yak (*Poephagus granniens* L). *(in). National symposium on Addressing Animal Reproductive Stresses through Biotechnological Tools and XXVIII Annual Convention of The Indian Society for Study of Animal Reproduction,*21-23 November. College of Veterinary Science, Assam Agricultural University, Khanapara, Guwahati, Assam India.

Singh P, Mohpatra K P and Ngachan S V. 2012.Stevia leaf powder as sweetener in the finisher pig diet containing cowpea forage. *(in). Proceedings of 8th Biennial Animal Nutrition Association Conference,* pp 123.28-30 November.RAJUVAS Bikaner, Rajasthan, India.

Singh P, Puro K, Shakuntala I and Ngachan S V. 2012. Performance of Kuroiler chicks on use of Lactobacillus of fecal origin as direct fed microbials. *(in). Proceedings of 8th Biennial Animal Nutrition Association Conference,* pp 249.28-30 November.RAJUVAS Bikaner, Rajasthan, India.

**Training manual**

Khan M H, Basumatary R, Doley S and Kadirvel G. 2012.Sustainable livestock and poultry production under changing climate scenario.ICAR Research Complex for NEH Region, Umiam-793103, Meghalaya, India.

**ANI3MAL HEALTH**

**Research Papers**

Laha R, Das M, Goswami A and Singh P. 2012. A clinical case of Babesiosis in a cross bred cow of Meghalaya. *Indian Journal of Animal Research***46:**302-305.

Laha R, Das M, Goswami A and Singh P. 2012. Losses of milk production due to *Babesia bigemina* infection in a cross bred cow- A case study. *The Journal of Protozoology Research***22**:6-9.

Laha R, Das M and Goswami A. 2013.Gastrointestinal parasitic infections in organized cattle farm of Meghalaya. *Veterinary World***6**: 109-112.

Laha R, Bhattacharjee K, Sarmah PC, Das M, Goswami A, Sarma D and Sen A. 2013. *Babesia* infection in naturally exposed pet dogs from a North-Eastern State (Assam) of India: detection by microscopy and polymerase chain reaction. *Journal of Parasitic Diseases,* DOI 10.1007/s12639-013-0261-1.

Mandal M, Laha R and Sasmal NK. 2013. Experimental studies on survivality and degenerative changes of *Trypanosoma evansi* after death of host. *Journal of Parasitic Diseases,*DOI 10.1007/s12639-013-0245-1.

Laha R, Das M and Goswami A. 2012.Seasonal dynamics of gastrointestinal parasitic infections and prediction of *Haemonchus contortus* infections of goats in a subtropical hilly region of North-Eastern India . *Indian Journal of Animal Research*(Accepted).

Yohannes M, Gill J P S, Ghatak S, Singh D K and Tolosa T. 2012. Comparative evaluation of the Rose Bengal plate test, standard tube agglutination test and complement fixation test for the diagnosis of human brucellosis.*Revue scientifique et technique (International Office of Epizootics)* **31**(3): 979-984.

Gupta B, Ghatak S and Gill J P S. 2013. Incidence and virulence properties of *E. coli* isolated from fresh fish and ready to eat fish products. *Veterinary World,* doi: 10.5455/vetworld.2013.5-9.

Gupta B, Ghatak S and Gill J P S. 2012. Serotypes of *E. coli* from various fish and ready-to-eat (RTE) fish food products. *Indian Journal of Field Veterinarian***8**(1): 59-60.

Puro K, Ahuja A, Doley S, Sanjukta R, Dubal Z B,Ghatak S, Shakuntala I, Laha R and Sen A. 2012. Molecular characterization of *Turkey Pox virus* from recurring infection in Meghalaya.*Veterinary Practitioner***13**(1): 49-51.

Shakuntala I, Kumar A, Das R and Pegu RK. 2012**.**Characterization of *Pasteurella multocida* isolates from pig in Meghalaya. *Indian Veterinary Journal***89**(2): 09-11

Rajkhowa S**,**Shakuntala I,Pegu SR, Das R K and Das A. 2012.Detection of *Pasteurella multocida* isolates from local pigs of India by PCR and their antibiogram.*Tropical Animal Health and Production***44** (7):1497-503.

Puro K, Ahuja A, Doley S, Sunjukta R, Dubal Z B, Ghatak S, Shakuntala I, Laha R and Sen A. 2012**.** Molecular characterisation of *turkeypoxvirus* from recurring infection in Meghalaya**.***VeterinaryPractitioner***13**(1): 49-51.

Puro K, Ahuja A, Chutia H, Doley S, Ghatak S and Sen A.2012. Airsacculitis with Pox infection in Turkey.*Pashudhan* **38**(12): 5.

Shakuntala I, Das R, Sanjukta R K, Singh P, Dubal Z B and Kumar S.2012.PCR-based detection of *Streptococcus agalactiae* from milk of subclinical mastitis in Meghalaya.*Indian Journal of Animal Sciences***82**(9):78-80.

**Technical/popular articles**

Puro K, Ahuja A, Chutia H, Doley S, Ghatak S and Sen A. 2012. Air sacculitis with pox infection in turkey.*Pashudhan***38**(12): 8.

**Bbook chapters**

Ghatak S, Sen A, Shakuntala I, Dubal Z B, Puro K and Sanjukta R K. 2012.Deforestation and risk of zoonoses.*(in). Resilient Shifting Cultivation: Challenges and Opportunities.* Deka B C, Patra M K,Thirugnanavel A, Chatterjee D, Borah T R and Ngachan S V (Eds.). ICAR Research Complex for NEH Region Nagaland Centre, Jharnapani, Medziphema-797106, Nagaland, India.

**Sequence published**

Ghatak S, Singh A, Sen A, Guha C, Ahuja A, Bhattacharjee U, Das S, Pradhan N R, Puro K, Jana C, Dey T K, Prashantkumar K L, Das A, Shakuntala I, Biswas U and Jana P S. *Escherichia coli* strain KOEC3 New Delhi metallo-betalactamase. Accession No. KC769583. GenBank(http://ncbi.nlm.nih.gov.in/).

**Invited article published**

Ghatak S, Sen A, Puro K and Laha R. 2012. Food safety: A public health priority. *(in).10th All India Conference of Association of Public Health Veterinarians and National Symposium on One World-One Health: Emerging Veterinary Public Health Challenges and Strategies*. 14-15 December, 2012. Belgachia, Kolkata, West Bengal, India.

**Papers presented in Conferences / Symposium / Seminars / Workshop**

Dubal Z B, Sen A, Shakuntala I, Mawlong M, Barbuddhe S B, Ahuja A, Uttaran, Ghatak S, Puro K and Sanjukta R K. 2012. Comparison of agarose gel electrophoresis and PAGE for detection of rotavirus.*(in). Abstract of International Symposium on One Health: Way Forward to Challenges in Food Safety and Zoonoses in 21st century.* Abstract No. OHS-115-ABS.13-14 December. Ludhiana, India.

Ghatak S, Sen A, Puro K, Das S, Laha R, Dey T, Bhattacharya U, Ahuja A, Prashant K L, Pyngrope M, Pegu R, Singha A and Ngachan S V. 2012. *(in). Abstract of International Symposium on One Health: Way Forward to Challenges in Food Safety and Zoonoses in 21st century.* Abstract No. OHS-211-ABS.13-14 December. Ludhiana, India.

Laha R, Bhattacharjee K, Sarmah P C, Das M, Goswami A, Sarma D and Sen A. 2012. *Babesia* infection in naturally exposed pet dogs from a North-Eastern State (Assam) of India : detection by microscopy and polymerase chain reaction. *(in). Abstract of XXIII National Congress of Veterinary Parasitology and National Symposium on Parasitology Today: From Environmental and Social Impact to the Application of Geoinformatics and Modern Biotechnology,*pp 81. 12-14 December. Department of Parasitology, College of Veterinary Science, Assam Agricultural University, Khanapara, Guwahati, Assam, India.

Laha R, Goswami A, Das M, Sen A, Puro K and Ghatak S. 2012.Gastrointestinal parasitism in goats from North Eastern region of India-A post mortem study. *(in). Abstract of XXIII National Congress of Veterinary Parasitology and National Symposium on Parasitology Today: From Environmental and Social Impact to the Application of Geoinformatics and Modern Biotechnology,*pp 29. 12-14 December. Department of Parasitology, College of Veterinary Science, Assam Agricultural University, Khanapara, Guwahati, Assam, India.

Puro K, Amarjit K, Prashant, Ghatak S, Laha R and Sen A. 2012.Prevalence of Gid in North East India- a case study.*(in). National Seminar on Future Challenges and Opportunities to Improve Health and Production of Small Ruminants and Annual Conference of the ISSGPU*, pp 157.22-23 December.Mathura, UP, India.

Puro K, Maya, Minakshi, Ghatak S and Sen A. 2012.Colibacillosis in Japanese quail.*(in). Abstract of International Symposium on One Health: Way forward to challenges in food safety and zoonoses in 21st centur,* Abstract No. OHS-145-ABS. 13-14 December. Ludhiana, India.

Puro K, Sen A, Ghatak S, Das S and Ngachan S V. 2012. Microbiocidal effects of Roselle extract. *(in). Abstract of International Symposium on One Health: Way forward to challenges in food safety and zoonoses in 21st centur,* Abstract No. OHS-146-ABS. 13-14 December. Ludhiana, India.

Puro K, Verma D, Laha R, Ghatak S, Sen A and Madrewar L K. 2012.Babesiosis in dog-three case reports.*(in). Abstract of XXIII National Congress of Veterinary Parasitology and National Symposium on Parasitology Today: From Environmental and Ssocial Impact to the Application of Geoinformatics and Modern Biotechnology,* pp 93. 12-14 December. Department of Parasitology, College of Veterinary Science, Assam Agricultural University, Khanapara, Guwahati, Assam, India.

Rao S, Gill J P S, Kumar G R and Ghatak S. 2012.Detection of virulence genes of shiga toxin-producing *Escherichia coli* from pork and ready-to-eat (RTE) pork products by multiplex polymerase chain reaction.*(in). Abstract of International Symposium on One Health: Way forward to challenges in food safety and zoonoses in 21st centur,* Abstract No. OHS-131-ABS. 13-14 December. Ludhiana, India.

Sanjukta R K, Devi M, Ahuja A, Sen A, Shakuntala I, Ghatak S, Dubal Z B, Puro K and Ngachan S V. 2012. Molecular characterization of emerging multi-drug resistant *Escherichia coli* isolates of swine from Northeast India. *(in). Abstract of 15th International Congress on Infectious Diseases.*13-16 June. Bangkok, Thailand.

Sanjukta R K, Mandakini R K, Ahuja A, Puro K, Dubal Z B, Ghatak S, Shakuntala I and Sen A. 2012. Extended-spectrum betal-lactamases and antibiotic resistance integrons recovered from *Escherichia coli* isolates of swine in Northeast India. *(in). Abstract of 22nd International Pig Veterinary Society Congress.*10-13 June. Jeju, Korea.

Sanjukta R, Mandakini R K, Bam J, Puro K, Dubal Z B, Ghatak S, Laha R, Shakuntala I and Sen A. 2012. Traditional remedies against parasitic infestation of animals in some part of North East India. *(in). Abstract of XXIII National Congress of Veterinary Parasitology and National Symposium on Parasitology Today: From Environmental and Ssocial Impact to the Application of Geoinformatics and Modern Biotechnology,*pp 221. 12-14 December. Department of Parasitology, College of Veterinary Science, Assam Agricultural University, Khanapara, Guwahati, Assam, India.

Sarmah P C, Laha R, Bhattacharjee K, Goswami A, Raquib M and Kakoti P. 2012. Rumen Flukes of cattle: prevalence and practice of consumption. *((in). Abstract of XXIII National Congress of Veterinary Parasitology and National Symposium on Parasitology Today: From Environmental and Ssocial Impact to the Application of Geoinformatics and Modern Biotechnology,*pp 57. 12-14 December. Department of Parasitology, College of Veterinary Science, Assam Agricultural University, Khanapara, Guwahati, Assam, India.

Shakuntala I, Ghatak S, Sanjukta R K, Puro K, Das S and Sen A. 2012. Brucellosis in the north eastern hill region of India.*(in). Abstract of 65th Annual Brucellosis Research Conference.*1-2 December. Chicago, USA.

Shakuntala I, Irwin P, Reed S and He Y. 2012.Antibacterial effect of Magnesium oxide nanoparticles on *Salmonella*, *Escherichia coli* and *Campylobacter*.*(in). 2nd International Conference on Nanotek & Expo,* 3-5 December. Center City Philadelphia, USA. Abstracted in *Journal of Nanomedicine and Nanotechnology***3(**9):78.

**SOCIAL SCIENCES**

Lalrinsangpuii, Raju V T, Tripathi A K, Singh R and Singh N U. 2012.Economics of Chow Chow Marketing in Aizawal District of Mizoram.*IndianJournal of Agricultural Marketing* **26** (1): 58-63.

Roy A, Kar A and Kumar S. 2012.Marketing of Raw Jute in Coochbehar District of West Bengal.*Indian Journal of Agricultural Marketin,* **26** (1): 10-20.

Seeralan S, Mishra A, Roy A, Ngachan S V and Tripathi A K. 2012.Likelihood assessment of Women adopting piggery Related Technologies in Meghalaya.*Journal of Community Mobilization and Sustainable Development* **7** (1): 141-144.

**Abstracts / Extended summeries**

Baruah S R, Tripathi A K and Roy A. 2012.Enhancing livelihood of Rural women through value addition in horticultural crops: A case study of Ri Bhoi District, Meghalaya. *(in).Book of Extended Summaries of National Seminar on Livelihood Options for Small and Marginal Farmers in Fragile Ecosystem*, pp 133-135.

Dkhar D S, Tripathi A K and Roy A. 2012.MGNREGA: Impact on income and consumption expenditure of benefiaries in Meghalaya. *(in).Book of Extended Summaries of National Seminar on Livelihood Options for Small and Marginal Farmers in Fragile Ecosystem*, pp 143-146.

Rymbai D, Singh R, Feroze S M, Roy A and Tripathi A K. 2013.A Study of seasonal price structure and market margin of pineapple in Meghalaya" *Indian Journal of Agriculture Marketing* (conference special), pp 84.

Singh S B, Choudhary A, Roy A, Singh N U and Singh S P. 2013. Production and marketing and Vegetables in Manipur: Some Policy Issues"*Indian Journal of Agriculture Marketing* (conference special), pp152.

Tripathi A K, Roy A and Seeralan S. 2012.Zabo and Panikheti-Resource Conserving Farming systems for optimal utilization of water and land resources for Livelihood Improvement in Nagaland.*(in).Book of Extended Summaries of National Seminar on Livelihood Options for Small and Marginal Farmers in Fragile Ecosystem*, pp 168-170.

**ARUNACHAL PRADESH CENTRE**

**Research Paper**

Chandra A, Kumar P, Singh S B, Asharani, Suby S B and Singh S P. 2012. Evaluation of maize germplasm and susceptibility, and DIMBOA role against stem-borer (*Chilopartellus*).*Maize Journal***1** (2):126-130.

Kumar J, Vashisth A, Sehgal V K and Gupta V K. 2013.Assessment of aphid infestation in mustard by Hyperspectral Remote Sensing.*Journal of the Indian Society of Remote Sensing* **41**:83-90.

Ramajayam D, Singh S K, Singh A K, Patel V B and Alizadeh M. 2013. Mycorrhization alleviates salt stress in grape rootstocks during *in vitro* acclimatization. *Indian Journal of Horticulture***70** (1): 26-32.

Singh S P, Bhagawati R and Chandra A. 2012. Economics of substrate in cultivation of oyster mushroom (*Pleurotus djmore* and *P. sajor-caju*) in Arunachal Pradesh. *Annals of Plant Protection Science***20** (2): 403-406.

**Abstracts/Extended Summary**

Choudhary VK, Bhagawati R, Ramajayam D, Chandra A andSingh R.2012. Maize-legumes based crop diversification for sustainability under mid hills of Arunachal Pradesh.*(in).Extended summaries (Vol 2) of 3rd International Agronomy Congress*, pp 569-570. 26-30 November. New Delhi, India.

**Popular article**

Kumar J,Singh R, Choudhary VK, Ramajayam D, Chandra A and Bhagawati R. 2012. Preparation of good vermicompost for small farmer.*Sovenir: 1st Arunachal Krishi Expo and Kisanmela-2012,* pp 37-41.

Ramajayam D, Kumar PS, Choudhary VK, Singh R, Chandra A, Kumar J and Bhagawati R. 2012. Tropical tuber crops: Potential crops to alleviate hunger and malnutrition in Arunachal Pradesh. *Sovenir: 1stArunachal Krishi Expo and Kisanmela-2012,* pp 113-128.

Singh R, Chandra A, Kumar J, Choudhary VK, Ramajayam D and Bhagawati R. 2012. Integrated approach for managing of challenging insect-pests and diseases of solanaceous vegetables. *Sovenir: 1stArunachal Krishi Expo and Kisanmela-2012*, pp 64-72.

Singh R, Bhagawati R, Chandra A, Kumar J, Choudhary VK and Ramajayam D. 2012. Reishi mushroom a medical wonder. *Sovenir: 1stArunachal Krishi Expo and Kisanmela-2012*, pp 101-103.

**Book**

Singh R and Kumar J. 2012.Triterpenoids variability in medicinal mushroom (*Ganoderma* spp.) - A medical wonder.pp 63. LAP Lambert academic publishing, Germany, ISBN: 978 – 3 – 659 – 25983 – 8.

**Pamphlet/ Extension folder/Handout**

Choudhary VK, Bhagawati R, Singh R**,** Chandra A, Ramajayam D and Kanwat M. 2012.Scientific cultivation of Maize in Arunachal Pradesh. pp 1-6. ICAR Research Complex for NEH Region, A.P. Centre, Basar, Arunachal Pradesh, India.

Choudhary V K, Bhagawati R, Singh R, Chandra A, Ramajayam D and Kanwat M. 2012.Cultivation practices of Ranjit variety of Rice in Arunachal Pradesh. pp 1-6. ICAR Research Complex for NEH Region, A.P. Centre, Basar, Arunachal Pradesh, India.

Singh R**,** Bhagawati R, Chandra A, Choudhary VK, Ramajayam D and Kanwat M. 2012.Oyster mushroom production**.**pp 1-6. ICAR Research Complex for NEH Region, A.P. Centre, Basar, Arunachal Pradesh, India.

Kanwat M, Bhagawati R, Choudhary VK, Ramajayam D and Singh R**.** 2012.Importance of Self Help Groups in Rural Development.pp 1-6. ICAR Research Complex for NEH Region, A.P. Centre, Basar, Arunachal Pradesh, India.

Kanwat M, Bhagawati R, Choudhary V K, Ramajayam D, Chandra A and Singh R.2012. Kisan Credit Card: A Ray of Hope for Farmers.pp 1-6. ICAR Research Complex for NRH Region, A.P. Centre, Basar, Arunachal Pradesh, India.

**MANIPUR CENTRE**

**Research Papers**

Ansari M A and Rana K S. 2012. Effect of transpiration suppressants and nutrients on productivity and moisture use efficiency of pearlmillet (*Pennisetum glaucum* L.) - pigeonpea (*Cajanus cajan* L.) intercropping system under rainfed conditions. *Indian Journal of Agricultural Sciences* **82** (8): 676-80.

Ansari M A, Prakash N, Singh I M, Sharma P K and Punitha P. 2013. Efficacy of boron sources on productivity and profitability of groundnut (*Arachis hypogaea* L.) under North East hill regions. *Indian Journal of Agricultural Sciences* (Accepted).

Ansari M A, Rana K S and Rana D S. 2012. Effect of an anti-transpirantas growth suppressant and nutrient management on growth, productivity and quality of pearlmillet (*Pennisetum glaucum*) – pigeonpea (*Cajanus cajan*) intercropping system under rainfed condition. *Indian Journal of Agronomy* **57** (4): 343-8.

Babu Subash, Rana D S, Yadav G S and Ansari M A. 2013.Residual effect of sunflower (*Helianthus annuus*) stover and P management and direct effect of N and P on productivity, nutrient uptake and economics of spring sunflower.*Indian Journal of Agricultural Sciences* **823** (3): 272-8.

Baishya L K, Ansari M A, Singh Roben, Deka B C, Prakash N and Ngachan S V. 2013. Response of groundnut (*Arachis hypogaea* L.) cultivars to integrated nutrient management on productivity, profitability and nutrient uptake in NEH Region.*Indian Journal of Agricultural Sciences* (Accepted).

Baishya L K, Kumar M, Ghosh M and Ghosh D C. 2013.Effect of integrated nutrient management on growth, productivity and economics of rainfed potato in Meghalaya hills. *International Journal of Environmental Biotechnology***6** (1): 1-9.

Batabyal K, Sarkar D and Mandal B. 2013. Critical levels of boron in soils for cauliflower (*Brassica oleracea* var. botrytis). *Journal of Plant Nutrition* (accepted).

Devi Y I, Sharma S D and Roy S S. 2012.Variation in physical characters of fruits in $F_1$ hybrids of peach (*Prunus persica* L.). *Journal of Crop and Weed* **8** (1): 34-9.

Geeta kumari and Ch. Basudha. 2012. *Parambassis waikhomi*, a new glassfish from north-east India (Teleostei: Ambassidae) *Journal of Threatened Taxa***4**(14): 3327-32.

Juliana S, Sing N A and Roy S S. 2012.Field screening of broad bean (*Vicia faba* L.) cultivars of Manipur for their resistance reaction to *Aphis craccivora* (Koch.).*Journal of Crop and Weed* **8** (2): 152-3.

Kumar Pramod, Rana K S, Ansari M A and Hari Om. 2013. Effect of planting system and phosphorous on productivity, moisture use efficiency and economics of sole and intercropped pigeonpea [*Cajanus cajan*] under rainfed conditions of Northern India. *Indian Journal of Agricultural Sciences* (Accepted).

Liu Y, Roy S S, Nebie R H C, Zhang Y and Nair M G. 2012.Functional food quality of *Curcuma caesia*, *Curcuma zedoaria* and *Curcuma aeruginosa* endemic to north-eastern India. *Plant Foods for Human Nutrition* **68**: 72-7.

Punitha P, Singh S B and Netaji Seetharaman R. 2012. Gender Differences on Training needs among Farmers Discussion Groups, *Indian Research Journal of Extension Education* **12** (1):73-7

Roy S S and Hore J K. 2012. Effect of organic manures and microbial inoculants on soil nutrient availability and yield of turmeric intercropped in areca nut gardens. *Journal of Crop and Weed* **8** (1): 90-4.

Surchandra Th, Roy S S, Singh N Rakesh, Sahoo M R and Prakash N. 2012.Partial purification and biochemical characterization of acid phosphatase from germinated mung bean (*Vigna radiata*) seeds.*African Journal of Biotechnology* **11** (103): 16777-82.

Yadav G S, Datta M, Babu Subhash, Debnath C, Bhowmik S N, Ansari M A and Ngachan S V. 2013. Effect of zero tillage basin planting and N nutrition on growth, yield, water productivity and nitrogen use efficiency of late planted broccoli in North East Hilly Region of India. *Indian Journal of Agricultural Sciences* (Accepted).

**Book authored**

Prakash N, Roy S S, Sharma P K and Ngachan S V. 2012.*Developing the Potential of Underutilized Horticultural Crops of Hill Regions.*608 Pages, Prakash N, Roy S S, Sharma P K and Ngachan S V (Eds).Todays and Tomorrows Printers and Publishers, New Delhi. ISBN 81-7019-473-3 (India), ISBN 1-55528-330-6 (USA).

Roy S S, Prakash N, Sharma P K, Singh I M and Ngachan S V. 2013.*Principles and Concepts of Organic Farming,* 150 pages.ICAR Research Complex for NEH Region, Umroi Road, Umiam, Meghalaya, India.

**Book chapters**

Prakash N, Roy S S, Sharma P K, Singh I M and Ngachan S V. 2013. Post harvest Management and Value Addition of Horticultural Crops in North Eastern India with Special Reference to Manipur: Issues and Strategies. (*in*). *Developing the Potential of Underutilized Horticultural Crops of Hill Regions,* pp 503-28.Prakash N, Roy S S, Sharma P K and Ngachan S V (Eds).Todays and Tommorrow's Printers and Publishers, New Delhi, India.

Punitha P, Prakash N and Seeralan S. 2013.Developing the potential of underutilised horticultural crops in the hill area of 'Manipur through farmers' discussion groups-strategy. (*in*). *Developing the Potential of Underutilized Horticultural Crops of Hill Regions,* pp 571-7.Prakash N, Roy S S, Sharma P K and Ngachan S V (Eds).Todays and Tommorrow's Printers and Publishers, New Delhi, India.

Sarkar D and Prakash N. 2013.Soil biodiversity and ecosystem functions. (*in*). *Biodiversity Conservation and Utilization*, pp 127-147. Asha Gupta (Ed). Pointer Publisher, Jaipur, India.

Singh A K, Ngachan S V, Prakash N, Patel R K and Roy S S. 2013. Natural Resource Management of Underutilized Horticultural Crops of Hill Regions. (*in*). *Developing the Potential of Underutilized Horticultural Crops of Hill Regions,* pp 1-17.Prakash N, Roy S S, Sharma P K and Ngachan S V (Eds).Todays and Tommorrow's Printers and Publishers, New Delhi, India.

**Technical Bulletin**

Roy S S, Nath A, Sahoo M R, Sharma P K, Singh I M and Prakash N. 2012. Kiwifruit-The Hairy Berry.Technology Bulletin No. RCM (TB)-04. ICAR Research Complex for NEH Region, Manipur Centre, Lamphelpat, Imphal-795004, Manipur, India.

Roy S S, Sahoo M R, Sharma P K and Prakash N. 2012.Pineapple.Technology Bulletin No. RCM (TB)-05. ICAR Research Complex for NEH Region, Manipur Centre, Lamphelpat, Imphal-795004, Manipur, India.

Roy S S, Sharma P K, Patel R K, Sahoo M R, Kumar D, Punitha P and Prakash N. 2012. Production Manual of Passion Fruit for North Eastern Hill Region.Technology Bulletin No. RCM (TB)-03. ICAR Research Complex for NEH Region, Manipur Centre, Lamphelpat, Imphal-795004, Manipur, India.

**Manual**

Punitha P, Roy S S, Ansari M A, Sharma P K and Prakash N. 2012.*Participatory Rural Appraisal (PRA) - A Guide to*

*Extension Personnel*.Training Manual No.RCM(TM)-01.ICAR Research Complex for NEH Region, Manipur Centre, Lamphelpat, Imphal-795004, Manipur, India.

**Popular articles**

Ansari M A, Choudhary K P, Baishya L K, Sharma P K and Prakash N. 2013. Integrated farming system: an integral approach to improve the livelihood of tribal farmers in North East Hill Regions. *NE Agricultural Fair,* pp 45-49. 19-21 March, 2013. Sangsanggre, Tura, Meghalya, India.

Ch. Basudha and Prakash N. 2012.Aquaculture and food security in the context of climate Change (in). Souvenir *of the Workshop on Agriculture and Food Security in the Context of Climate Change cum Farmers' Fair*, pp 66-67. 12-14 October, 2012. Imphal, Manipur, India.

Kh. Geetakumari and Ch. Basudha. 2012. Breeding biology and behaviour of honey gourami, *trichogaster chuna* (Hamilton) (Teleostei: Osphronemidae). (*in*). *Symposium Proceedings: Biodiversity Status & Conservation Strategies with reference to NE India,* CAS in Life Sciences, Manipur University, Manipur, India.

Prakash N, Roy S S, Sahoo B, Sahoo M R, Sharma P K and Singh I M. 2012. Impact of Climate Change on Agriculture: Needs and Focus. (in). *Souvenir of the Workshop on Agriculture and Food Security in the Context of Climate Change cum Farmers' Fair*, pp 9-26. 12-14 October, 2012. Imphal, Manipur, India.

**Abstracts**

Ansari M A, Prakash N, Singh I M, Sharma P K, Sarkar D, Baishya L K and Punitha P. 2013. Varietal evaluation: An ideal approach to enhance rice (*Oryza sativa* L.) productivity and profitability. (*in*). *Theme-II Sustainable Production through Resource Management and Conservation Agriculture*, pp. 196. 2-5 March.CRRI, Cuttack, Orissa, India.

Ansari M A, Rana K S and Rana D S. 2012.Productivity and water-use-efficiency of pearlmillet (*Pennisetum glaucum* L.)/ pigeonpea (*Cajanus cajan* L.) intercropping system as influenced by transpiration suppressants and nutrient management under rainfed conditions. (*in*). *3rd International Agronomy Congress on Agriculture Diversification, Climate Change Management and Livelihoods"*, pp 419-20.26-30 November. New Delhi, India.

Devi Y Indrani, Singh N Rakesh, Devi A Rajlakshmi, Roy S S, Sahoo M R and Prakash N. 2012.Effect of differential methods of fertilizer application on watermelon grown under low cost polytunnel. (*in*). *Book of Abstract of National Seminar on Horticulture for Livelihood Security, Economic Prosperity and Sustainable Development*, pp 61.24-26 September.Aizawl, Mizoram, India.

Patel R K, Roy S S, Deshmukh N A and Lyngdoh A. 2012. DUS Characters for the Khasi Mandarin (*Citrus reticulata* Blanco). (*in*). *Book of Abstract of National Seminar on Horticulture for Livelihood Security, Economic Prosperity and Sustainable Development*, pp 54.24-26 September.Aizawl, Mizoram, India.

Prakash N, Ansari M A, Kumar Sudhir, Punitha P, Sharma P K, Singh I M, Sarkar D and Baishya L K. 2013. Farmer participation: An integral approach to increase the rice (*Oryza sativa* L.) yield in Manipur. (*in*).*Theme-II Sustainable Production through Resource Management and Conservation Agriculture*, pp 157. 2-5 March.CRRI, Cuttack, Orissa, India.

Prakash N, Sharma P K and Punitha P. 2012. Community based approaches for sustainable agri- rural development. (*in*). *Souveneir and Compendium of* 6th*National Seminar on Emerging Challenges and Paradigm for Sustainable Agri-Rural Development,* pp 71.18-20 December.Nauni, Solan, Himachal Pradesh, India.

Punitha P, Prakash N, Ansari M A and Sharma P K. 2012. Training Integral PRA to Extension Personnel-Need of the Hour: Extension Experience(*in*). *Souveneir and Compendium of* 6th*National Seminar on Emerging Challenges and Paradigm for Sustainable Agri-Rural Development,* pp 193.18-20 December.Nauni, Solan, Himachal Pradesh, India.

Roy S S, Hore J K, Sahoo M R and Prakash N. 2012. Impact of Microbial Inoculants and Inorganic Fertilizers on Productivity, Quality, Leaf Nutrients and Soil Fertility Status in Turmeric Intercropped Arecanut Plantation. (*in*). *Abstract of Papers of Plantation Crops Symposium XX*, pp 83-84. 12-15 December.Coimbatore, Tamil Nadu, India.

Roy S S, Pattanayak A, Sahoo M R, Sharma P K, Prakash N and Ngachan S V. 2012. Study on genetic diversity in king chilli (*Capsicum chinense*) landraces of Manipur using SSR marker. (*in*). *Abstracts of Global Conference on Horticulture for Food, Nutrition and Livelihood Options*, pp 74. 28-31 May. Bhubaneswar, Odhisa, India.

Sahoo M R, Sahoo B B, Cole P C, Mukherjee A, Roy S S, Prakash N and Ngachan S V. 2012. Induction of stress tolerance and characterization of taro [*Colocasia esculenta* L. (Schott)] genotypes against *Phytopthora* leaf blight disease. *Abstracts of Global Conference on Horticulture for Food, Nutrition and Livelihood Options*, pp 79. 28-31 May. Bhubaneswar, Odhisa, India.

Singh J, Kumar S, Abdul F, Pattanayak A and Prakash N. 2012. Cytological studies in interspecific hybrids of *Cajanus* species. (*in*). *Abstracts of National seminar on Plant Genetic Research for Eastern and North-eastern India*, pp 128. 11-12 May. Uniam, Meghalaya, India.

**MIZORAM CENTRE**

**Research Paper**

Dastagiri M B, Ganesh Kumar B, Hanumanthaiah C V, Paramsivam P, Sidhu R S, Sudha M, Mandal S, Singh S B and Chand K. 2013 Marketing efficiency of India's horticultural commodities under different supply chains, *Outlook in Agriculture***41** (4): 271-8.

Nandini K D, Singh L N, Singh M S, Singh S B and Singh K K. 2012. Influence of Sulphur and Boron fertilization on yield, quality, nutrient uptake and economics of Soybean (*Glycine max*) under upland conditions *Journal of Agricultural Science* **4** (4): 1-9.

Seerlan S, Mishra A, Singh S B and Ramasubramaniam. 2012. A study on assessment of livelihood of women adopting piggery related technologies in Meghalaya. *Indian Journal of Extension Education***1** (1): 115-7.

Singh S B and Punitha P. 2012. Entrepreneurship Development through Anthurium Flower-A Case Study of Mizoram, North-East India.*Indian Research Journal of Extension Education* **12** (3): 74-8.

Dutta, SK., VB Patel, C. Viswanathan, S.K. Singh and A.K. Singh. 2012. Arbuscular Mycorrhizal Fungi (AMF) influence on morphological, physiological and biochemical parameters of Kinnow budded on *Jatti Khatti* rootstock upon water deficit stress. In *National Seminar on Horticulture for livelihood*

*security, economic prosperity and sustainable development*, 71pp. Dept. of Horticulture, Aromatic and Medicinal Plants (HAMP), School of Earth Sciences and Natural Resource Management, Mizoram University, Aizawl.

**Abstract**

Dutta S K, Patel V B, Viswanathan C, Singh S K and Singh A K. 2012. Arbuscular Mycorrhizal Fungi (AMF) influence on morphological, physiological and biochemical parameters of Kinnow budded on *Jatti Khatti* rootstock upon water deficit stress. (*in*). *National Seminar on Horticulture for Livelihood Security, Economic Prosperity and Sustainable Development*, pp. 71. 24-26 September. Department of Horticulture, Aromatic and Medicinal Plants (HAMP), School of Earth Sciences and Natural Resource Management, Mizoram University, Aizawl, India.

**Paper presented in Conferences / Symposium / Seminars / Workshop**

Ramakrishna Y, Singh S B, Chinlampianga M, Singh B K, Boopathi T, Rajasekar K, Singh A R, Dutta S K and Pathak K A. 2012. Indigenous Technical Knowledge on Ethno-veterinary Medicine and Soil and Water Conservation in Theiva village, Saiha, Mizoaram" (*in*). *National Seminar on Livelihood Options for Small and Marginal Farmers in Fragile Ecosystem*, pp 177-179. 9-10 August.ICAR Research Complex for NEH Region, Umiam-793103, Meghalaya, India.

Ramakhrishna Y, Singh S B, Boopathi T, Singh B K, Puii L H, and Chimlampianga. 2012. Efficacy of IFS model as alternative to Jhum cultivation at Mizoram. (*in*). *National Seminar on Livelihood Options for Small and Marginal Farmers in Fragile Ecosystem*, pp 55-57. 9-10August. ICAR Research Complex for NEH Region, Umiam-793103, Meghalaya, India.

**Technical Bulletin**

Rajaseker K, Dutta S K, Boopathi T, Ramesh T, Ramakhrisna Y, Singh A R, Puii L H, Singh S B and Ngachan S V. 2013. Soil Management Option for Sustainable Agricultural Production in Mizoram.pp 30.ICAR Research Complex for NEH Region, Mizoram Centre, Kolasib-796081, Mizoram, India.

**NAGALAND CENTRE**

**Research Papers**

Agreesia S, Singh A, Deka B C, Singh R K and Patel R K. 2012. Off-season production of strawberry: Effect of low tunnel and planting time. *Indian Journal of Horticulture* (Accepted).

Borah, Tasvina R, Avasthe, Ravikant and Helim R. 2012. Large cardamom (*Amomum subulatum*)-A Taditional Cash Crop of Sikkim. *Asian Agricultural History Journal***16** (3): 271- 7.

Deka B C, Choudhury and. Bhattacharyya A. 2012. Pre-harvest treatments for shelf life extension of Khasi mandarin under different storage conditions.*Indian Journal of Horticulture***69** (2): 252-7.

Deka B C, Thirugnanavel A, Patel R K, Nath A and Deshmukh, N. 2012. Horticultural Diversity in North East India and its improvement in value addition. *Indian Journal of Genetics***72** (2): 157-67.

Gopi R, Borah, Tasvina R and Kalita H. 2012. A new record of head rots of cabbage in Sikkim Himalayas. *Journal of Mycology and Plant Pathology* **41** (4): 642-3.

Kalita H, Borah, Tasvina R, Gopi R, Helim R and Das B. 2012.A new record of Patchouli wilt from Sikkim, Himalayas. *Journal of Mycology and Plant Pathology* **42** (2): 254-5.

Kumar A, Avasthe R K, Borah, Tasvina R, Lepcha B and Pandey B. 2012. Organic mulches affecting yield, quality and diseases of ginger (*Zingiber officinale*) in mid hills of North Eastern Himalayas. *Indian Journal of Horticulture***69** (3) 439-42.

Kumar A, Mohanty A K, Borah, Tasvina R and Singh A K. 2012. Evaluation of indigenous forest plant leaves for bio-mulching in organic ginger production and income generation under rain-fed conditions of NEH region. *Indian Journal of Traditional Knowledge* **11 (**3): 487-92.

Kumar R, Deka B C, War M, Venugopalan R. 2012. Response of exotic gerbera under low (*Gerbera jamesonii*) cost polyhouse and shade net house in sub-tropical mid hills of Meghalaya.*Indian Journal of Agricultural Sciences***82** (6): 543-7.

Kumar R, Deka BC,Venugopalan R. 2012. Genetic variability and trait association studies in gerbera (*Gerbera jamesonii*) for quantitative traits. *Indian Journal of Agricultural Sciences***82** (7): 615-9.

Loyi T, Kumar H, Nandi S, Mathapati B S, Patra M K, Pattnaik B. 2012. Differential expression of pro-inflammatory cytokines in endometrial tissue of buffaloes with clinical and sub-clinical endometritis. *Research in Veterinary Science* 2012 Oct 4.pii: S0034-5288(12)00258-5. doi: 10.1016/j.rvsc.2012.09.008.

Nath A, Deka B C, Jha A K, Paul D and Mishra L K. 2013. Effect of slice thickness and blanching time on different quality attributes of instant ginger candy. *Journal of Food Science and Technology* **50** (1): 197-202.

Nath A, Deka B C, Singh A, Patel R K, Paul D, Mishra L K, Ojha H. 2012. Extension of shelf life of pear fruits using different packaging materials.*Journal of Food Science and Technology***49** (5): 556-63.

Pathak P K, Mohanty A K, Rahman H and Borah Tasvina R. 2012. Traditional Breeding Management of Yak (*Poephagus grunniens* L.) in North Eastern Hill Region of India. *Asian Agricutural History Journal* **16** (3): 279- 85.

Patra M K, Ravi S K, Islam R, Loyi T and Kumar H. 2012. Bilateral Hydrosalpinx in buffalo: A case report. *Buffalo Bulletin***31** (3): 99-102.

Roy A R, Sajeev S, Pattanayak A, Deka B C. 2012.TDZ induced micropropagation in *Cymbidium giganteum* Wall. Fx Lindl. and assessment of genetic variation in the regenerated plants. *Plant Growth Regulation,* DOI 10.1007/s10725-012-9732-0

Singh A, Agreesia S, Deka B C, Singh R K, Patel R K. 2012. The effect of microclimate inside low tunnels on off-season production of strawberry (Fragaria x Ananassa Duch.).*Scientia Horticulturae***144**: 36-41.

Singh A, Deka B C, Paterl R K, Nath A, Mulieh S R. 2012. Effect of pruning time, severity and tree aspects on harvesting period and fruit quality of low chilling peach (*Prunus persica*). *Indian Journal of Agricultural Sciences* **82** (10): 862-6.

**Papers presented in Conferences / Symposium / Seminars / Workshop**

Borah Tasviva R, Toppo S and Mohanty A K. 2012. Organic mushroom and spawn production-a new vista in rural livelihood of Sikkim. (*in*). *North East Agri Expo*, 15 November. Dimapur, Nagaland, India.

Kuotsu R, Chatterjee D, Krose M, Sahoo B, Kumar R, Patra M K, Thirugnanavel A and Deka B C 2012. Farmers First: Transformation of a *jhumia* to a progressive farmer. (in). *North East Agri Expo*, 15 November. Dimapur, Nagaland, India.

Patra M K, Begum S, Ngullie E, Ngullie L, Das R K and Sangtam H M. 2012. Backyard Poultry Production in Nagaland: Present Scenario and future Scope. (*in*). *XXIX Annual conference and national symposium of Indian Poultry Science Association,* 5-7 December.Project Directorate on Poultry, Hyderabad, India.

Patra M K, Kumar H, Nandi S. Loyi T, Krishnan B B and Islam R. 2012. Up-regulation of certain pro-inflammatory cytokines transcripts as diagnostic indicator of endometritis in buffaloes. (*in*). *National Symposium on Addressing Animal Reproductive Stresses through Biotechnological Tools and XXVIII Annual Convention of ISSAR,* 21-23 November.College of Veterinary Science, Khanapara, AAU, Guwahati, Assam, India.

Patra M K, Ngullie E, Das R K, Begum S and Ngullie L. 2012. Entrepreneurship development through backyard poultry farming: A success story. (*in*). *XXIX Annual Conference and National Symposium of Indian Poultry Science Association*, 5-7 December.Project Directorate on Poultry, Hyderabad, India.

Patra M K, Ngullie L, Ngullie E, Das R K and Begum S. 2012.Comparative evaluation of certain production and reproduction traits of Large Black and Ghungroo pig in Nagaland condition. (*in*). *National Symposium on Addressing Animal Rreproductive Sstresses through Bbiotechnological Tools and XXVIII Annual Convention of ISSAR,* 21-23 November.College of Veterinary Science, Khanapara, AAU, Guwahati, Assam, India.

Patra M K, Sanchu V, Ngullie E, Ngullie L, Begum S and Das R K. 2012. Effect of egg weight on fertility and hatchability in Vanaraja and Gramapriya chicken. (*in*). *XXIX Annual Conference and Nnational Symposium of Indian Poultry Science Association,* 5-7 December.Project Directorate on Poultry, Hyderabad, India.

Patra M K, Thirugnanavel A, Chatterjee D, Krose M, Kumar R, Deka B C and Ngachan S V. 2012. Enhancing nutritional security in rural livelihood through backyard Poultry Production: Way to success. (*in*). *National Seminar on Progressive Agriculture, Farmers-Scientist Interactions in the poster session of Success Stories on Agricultural Technologies and ITKs, North East Region Agri Expo,* 15-17 November. Dimapur, Nagaland, India.

Patra M K, Thirugnanavel A, Ngullie E, Das R K, Begum S, Ngullie L and Deka B C. 2012. Women empowerment through backyard poultry farming: A success story. (*in*). *National seminar on Progressive Agriculture, Farmers-Scientist Interactions in the poster session of Success Stories on Agricultural Technologies and ITKs, North East Region Agri Expo,* 15-17 November. Dimapur, Nagaland, India.

Sangtam H M, Patra M K, Deka B C, Ezung N K and Meyase M. 2012. Women entrepreneurship development through integrated farming system: A success story. (*in*). *National Seminar on Progressive Agriculture, Farmers-Scientist Interactions in the poster session of Success Stories on Agricultural Technologies and ITKs, North East Region Agri Expo,* 15-17 November. Dimapur, Nagaland, India.

Sonuwara B, Patra M K, Ebibeni N, Lily N, Das R K and Sangta H M. 2013. Scenario of indigenous rearing practices of pig in Nagaland. (*in*). *National Seminar on Climate Change and Climate Resilient Agriculture,* 18-19 March. Agromet advisory services, Sonitpur, B N College of agriculture, Bswnath Chariali, Assam, India.

**Book / Book Chapters**

Borah T R, Deka B C, Chatterjee D and Ngachan S V. 2012.*Jhum* park-A new vista in eco-tourism. (*in*). Resilient Shifting Cultivation: Challenges and Opportunities, pp 118-25. Deka B C, Patra M K, Thirugnanavel A, Chatterjee D, Borah T R and Ngachan S V (Eds). ICAR Research Complex for NEH Region, Umiam-793103, Meghalaya, India.

Borah Tasvina R. 2012. Crop diseases in *jhum* and their organic management. (*in*).*Resilient Shifting Cultivation: Challenges and Opportunities*, pp 74 -7. Deka B C, Patra M K, Thirugnanavel A, Chatterjee D, Borah T R and Ngachan S V (Eds). ICAR Research Complex for NEH Region, Umiam-793103, Meghalaya, India.

Chatterjee D, Deka B C, Patra M K, Thirugnanavel A, Borah Tasvina R, Kuotsu, R and Ngachan S V. 2012. Resilient shifting cultivation for sustainable soil-water-nutrient-plant continuum in hilly agriculture system of North Eastern India. (*in*).*Resilient Shifting Cultivation: Challenges and Opportunities*, pp 104-9. Deka B C, Patra M K, Thirugnanavel A, Chatterjee D, Borah T R and Ngachan S V (Eds). ICAR Research Complex for NEH Region, Umiam-793103, Meghalaya.

Chatterjee D. 2012. Impact of *jhum* cultivation on soil and environment: strategic way out. (*in*).*Resilient Shifting Cultivation: Challenges and Opportunities*, pp 27-34. Deka B C, Patra M K, Thirugnanavel A, Chatterjee D, Borah T R and Ngachan S V (Eds). ICAR Research Complex for NEH Region, Umiam-793103, Meghalaya, India.

Chatterjee D. Deka B C, Patra M K, Thirugnanavel A, Sahoo B, Kumar R., Bhatt B P and Krose M. 2012. Livelihood improvement of Konyaks through integrated farming system at Lampong Sheanghah village of Mon District, Nagaland. (*in*).*Book of Extended Summeries of the National Seminar on Livelihood Options in Agriculture for Small and Marginal Farmers' in Fragile Ecosystems,* pp 12-7.9-10 August.ICAR Research Complex for NEH Region, Umiam-793103, Meghalaya, India.

Deka B C, Patra M K, Thirugnanavel A, Chatterjee D. Borah Tasvina R and Ngachan S V (Eds). 2012. *Resilient Shifting Cultivation: Challenges and Opportunities,* Published by: Director, ICAR Research Complex for NEH Region, Umiam-793103, Meghalaya.

Gopi R and Borah Tasvina R. 2012.Disease management in cereals. (*in*). *Biotechnological and Bio rational Approaches for Pest and Disease Management,* pp148-58. H. Kalita, K. Kishore, H. Rahman and L. R. Chatlod. (Eds). Agrobiotech, India.

Kumar R, Deka B C and Patel V V. 2012.Effect of benzyl amino purine (BAP) on growth, flowering and corm multiplication in gladiolus var. Candyman. (*in*). *Proceedings of National Conference on Production of Quality Seeds and Planting Materials: Health Management in Horticultural Crops,* pp 45-9.Society for Promotion of Horticulture, IIHR, Confederation of Horticultural Association of India and NHB.

Patel R K, Deka B C, Nath A, Roy S S, Singh S, Patel R S and Ngachan S V. 2012. Good Agricultural Practices of Khasi mandarin cultivation in Meghalaya. (*in*). *Proceedings of the National Seminar on Citrus Biodiversity for Livelihood and*

*Nutritional Security,* pp 306-9.4-5, October.NRC for Citrus, Nagpur, Maharashtra, India.

Patel R K, Deka B C, Patel R S, Singh S and Lamare R. 2012.Studies on intercropping and mulching in Khasi mandarin. (*in*). *Proceedings of the National Seminar on Citrus Biodiversity for Livelihood and Nutritional Security,* pp 304-6.4-5 October.NRC for Citrus, Nagpur Maharashtra, India.

Patel R K, Singh A, Deka B C, Patel R S and Ngachan S V. 2012. Performance of nucellar, tissue cultured and grafted plants of Khasi mandarin under sub-tropics of Meghalaya. (*in*). *Proceedings of the National Seminar on Citrus Biodiversity for Livelihood and Nutritional Security,* pp 119-21.4-5, October.NRC for Citrus, Nagpur, Maharashtra, India.

Patra M K, Begum S, Ngullie L and Das R K. 2012. Livestock based integrated farming system: An approach for sustainable development in Nagaland. (*in*). *Resilient Shifting cultivation: Challenges and Opportunities,* pp 78-85.Deka B C, Patra M K, Thirugnanavel A, Chatterjee D, Borah T R and Ngachan S V (Eds). ICAR Research Complex for NEH Region, Umiam-793103, Meghalaya, India.

**Training Manual/ Folder/Technical Bulletin**

Borah Tasvina R. 2013. Organic management of crop diseases in *sukhakheti*.(*in*). *Resilient Jhum Cultivation through Integrated Farming System.*Chatterjee D and Ezung N K (Eds).ICAR Research Complex for NEH Region, Nagaland Centre, Jharnapani, Medziphema-797106, Nagaland, India. (*In Press*)

Chatterjee D and Ezung N K. (Eds) 2013.*Resilient jhum cultivation through integrated farming system.*ICAR Research Complex for NEH Region, Nagaland Centre, Jharnapani, Medziphema-797 106, Nagaland, India. (*In Press*)

Chatterjee D, Patra M K, Thirugnanavel A, Deka B C. 2013. *Jhum* improvement: success and shortcoming. (*in*). *Resilient Jhum Cultivation through Integrated Farming System.*Chatterjee D and Ezung N K (Eds). ICAR Research Complex for NEH Region, Nagaland Centre, Jharnapani, Medziphema-797106, Nagaland, India (*In Press*)

Chatterjee D. 2013.Model Farming System for Resilient Shifting Cultivation in Nagaland. (*in*). *Resilient Jhum Cultivation through Integrated Farming System.*Chatterjee D and Ezung N K (Eds).ICAR Research Complex for NEH Region, Nagaland Centre, Jharnapani, Medziphema-797106, Nagaland, India. (*In Press*)

Deka B C, Chatterjee D. Sahoo B, Patra M K, Thirugnanavel A, Kumar R, Krose M, Bhatt B P and Ngachan S V. 2013. Soil-Water-Plant-Animal-Society continuum approach for livelihood improvement of Konyak tribe of Mon in Nagaland.ICAR Research Complex for NEH Region, Nagaland Centre, Jharnapani, Medziphema-797106, Nagaland, India.

Deka B C. 2012. Entrepreneurship development through marketing of commercially important horticultural crops of NE India. (*in*). *Souvenir, The North-East Connect 2011-12*, pp 7-10. 24-25 February. Published by NERAMAC, Guwahati, Assam, India.

Pfukrei K, Borah Tasvina R and Deka B C. 2013.Seed production in Nagaland. Published by Joint Director, ICAR Research Complex for NEH Region, Nagaland Centre, Jharanapani, Medziphema, Nagaland -797106, India.

Yadav R K, Yadav D S, Deka B C, Sanwal S K, Jha A K, Verma V K, Patel R K and Nath A. 2012. Megha Tomato 3: new tomato variety. *Indian Horticulture (November-December),*pp 34-36. ICAR Research Complex for NEH Region, Uniam-793103, Meghalaya, India.

**SIKKIM CENTRE**

**Research papers**

Arora R, Mundra S, Yadav A, Srivastava R B and Stobdan T. 2012. Antimicrobial activity of seed, pomace and leaf extracts of Seabuckthorn (*Hippophae rhamnoides*) against food borne and food spoilage pathogens. *African Journal of Biotechnology***11**(45): 10424-30.

Ashok Kumar, R K Avasthe, G Shukla and Y Pradhan (2012).Ethno botanical edible plant biodiversity of Lepcha tribes.*The Indian Forester***138** (9):798-803.

Avasthe R K, Verma S, Kumar A and Rahman H. 2012.Performance of rice (*Oryza sativa*) varieties at different spacing under system of rice intensification (SRI) in mid hill acid soils of Sikkim Himalayas.*Indian Journal of Agronomy***57** (1): 39-44.

Babu S, Rana D S, Prasad D and Pal S. 2013. Effect of sunflower stover and nutrients management on productivity, nutrient economy and phosphorus use efficiencies of pigeonpea (*Cajanus cajan*)-sunflower (*Helianthus annuus*) cropping system. *Indian Journal of Agricultural Sciences***83** (2): 203-9.

Borah Tasvina R, Helim R, Gogoi R and Kumar A. 2012.Versatile uses of maize in Sikkim. *Asian Agri History***16** (2): 211-5.

Chandra R, Chatlod L R, Kumar S, Toppo S, Haque N and Rahman H. 2012. Nutritional evaluation of NB-21 hybrid Napier grass for goats.*Indian Journal of Small Ruminants***18** (2): 261-3.

Chandra R, Karmakar H D, Chatlod L R and Rahman H. 2012.Studies on production and reproduction traits of Soviet Chinchilla Rabbits in Sikkim.*Indian Journal of Small Ruminants***18** (2): 258-60.

Kalita H, Babu S, Yadav G S, Helim R and Das B. 2013.Citronella-a promising crop for Sikkim Himalayas.*Indian Horticulture* (Accepted).

Kalita H, Borah T R, Gopi R, Helim R and Das B. 2012.A new record of patchouli wilt from Sikkim Himalayas. *Journal of Mycology and Plant Pathology***42** (2): 254-5.

Kalita H, Borah Tashvina R, Helim R and Das B. 2012.A new record of Patchouli wilt from Sikkim Himalays. *Journal of Mycology and Plant Pathology***42** (2): 254-5.

Kalita H, Helim R, Das B, Kapoor C and Rahman H. 2012.Comparison of essential oils composition of *Cymbopogon* species grown in Sikkim.*Medicinal Plants*, **4** (2): 101-103.

Kalita H, Helim R, Das B, Kapoor C and Rahman H. 2012.Comparison of essential oils composition of *Cymbopogon* species grown in Sikkim.*Medicinal Plants***4** (2): 101-3.

Kapoor C and Gopi R. 2012.Performance of some indeterminate breeding lines of field pea under midhills of Sikkim.*Agricultural Science Digest.* (Accepted)

Kapoor C and Lata S. 2013.Screening of some maize inbreds for conversion to quality protein maize lines.*IndianJournal of Agricultural Research.* (Accepted)

Kishore K, Kalita H, Rinchen D and Lepcha B. 2012.Evidence of functional specialization and pollination syndrome in *Amomum subulatum* Roxb.(Zingiberaceae).*Current Science* **103** (2): 193-9.

Kishore K, Kalita H, Rinchen D and Pandey B. 2012.Floral biology of large cardamom (*Amomum subulatum*).*Journal of Agricultural Sciences***82** (7): 578-82.

Kishore K, Monika N, Rinchen D, Pandey B, Singh R, Rahman H, and Kumar A. 2012. Evaluation of exotic mandarin germplasm under Mid-Hills of Sikkim Himalayan region.*Indian Journal of Plant Genetic Resource*s **25** (2): 153-6.

Korekar G, Stobdan T, Dwivedi S K, Yadav A, Srivastava R B. 2012. Pomological and fruit quality characteristics of 'Halman' and 'Raktsey-Karpo' apricot cultivars of trans-Himalayan Ladakh region, India.*Progressive Horticulture***44** (2): 211-4.

Korekar G, Yadav A, Kumar R, Srivastava R B and Stobdan T. 2013. Multivariate analysis of phenological, pomological and fruit quality characters in apricot (*Prunus armeniaca*) grown in trans-Himalayan Ladakh Region, India. *Indian Journal of Agricultural Sciences***83** (2): 150-8.

Kumar A, Avasthe R K, Borah Tasvina R, Lepcha B and Pandey B. 2012. Organic mulches affecting yield, quality and diseases of ginger (*Zingiber officinale*) in mid hills of North Eastern Himalayas. *Indian Journal of Horticulture***69** (3): 439-43.

Kumar A, Avasthe R K, Lepcha B, Mohanty A K and Shukla G. 2012.Impact of front line demonstrations on yield enhancement of ginger (var. Majauley) in tribal reserve biosphere of Sikkim Himalaya.*Journal of Agricultural Sciences***3** (2): 121-3.

Kumar A, Avasthe R K, Pandey B, Lepcha B and Rahman H. 2012.Effect of fruit load on yield and quality of peach (*Prunus persica*) in mid hills of Sikkim Himalaya.*Indian Journal of Agricultural Sciences***82** (3): 268-70.

Kumar A, Babu S and Misra A D D. 2013. Evaluation of genetic variability of pea (*Pisum sativum* ) for plant growth and yield under mid hills of Sikkim Himalayas. *Green Farming***4** (1): 119-20.

Kumar A, Bist L D and Maurya S K. 2012.Estimation of genetic diversity in low-chill *Pyrus* spp. through biochemical characterization.*Indian Journal of Agricultural Research***46** (3): 287-91.

Kumar A, Mohanty A K, Borah T R and Singh A K. 2012. Evaluation of indigenous forest plant leaves for bio-mulching in organic ginger production and income generation under rain-fed conditions of NEH region. *Indian Journal of Traditional Knowledge***11**(3): 487-92.

Kumar A, Subhash Babu and A.D. Deepak Misra (2012).Germplasm evaluation of turmeric (*Curcuma longa*) for growth and yield under mid hills of Sikkim Himalayas.*Green Farming* **3** (5): 617-8.

Lata S, Kapoor C, Kumar A, Sharma J K and Katna G. 2012.Screening of maize inbreds and their crosses against bacterial stalk rot and banded leaf and sheath blight disease. *Crop Improvement.* (Accepted)

Nath B G, Chandra R, Toppo S, Chatlod L Rand Mohanty A K. 2012. Characteristics and constraints of Pig production under rural condition of Sikkim.*Online Journal of Animal and Feed Resaerch***2** (2): 145-8.

Nath B G, Toppo S, Chandra R, Chatlod L Rand Mohanty A K. 2012 Level of adoption and constraints of scientific backyard poultry rearing practices in rural tribal areas of Sikkim, India. Online *Journal of Animal and Feed Resaerch***2**(2): 133-8.

Rahman H, Pal P, Bandyopadhyay S and Chatlod L R. 2012. Epidemiology of gastrointestinal parasitism in goats in Sikkim.*Indian Journal of Animal Sciences***82** (4): 355-8.

Rameash K, Kumar A and Kalita H. 2012.Biorational management of stem borer Chilo partellus in maize.*Indian Journal of Plant Protection***40** (3): 208-13.

Suryavanshi P, Babu S, Baghel J K and Suryavanshi G. 2012. Impact of climate change on agriculture and their mitigation strategies for food security in agriculture: A review. *ISCA Journal of Biological Sciences* **1** (3): 72-7.

Suryavanshi P, Baghel J and Babu S.2012.Aerobic rice-A review.*International Journal of Research in Biosciences* **1** (1): 1-6.

Yadav S K, Babu S, Singh Y, Yadav G S Singh K, Singh R and Singh H. 2013. Production potential and energy budgeting of rice based cropping system as influenced by organic nitrogen sources and biofertilizers. *Indian Journal of Agronomy* (Accepted).

Yadav S K, Singh Y, Yadav M K, Babu S and Singh K. 2013. Effect of organic nitrogen sources on yield, nutrient uptake and soil health under rice (*Oryza sativa*) based cropping sequence. *Indian Journal of Agricultural Sciences***83** (2): 170-5.

Zulfikar A, Yadav A, Stobdan T and Singh S B. 2012.Traditional methods for storage of vegetables in cold arid regions of Ladakh, India.*Indian Journal of Traditional Knowledge***11**(2): 351-3.

**Success stories**

Ashok Kumar. 2012. Nucellar seedling production of mandarin for assured income at Dzongu North Sikkim. *(in).Site Specific Farming System Options for Rural Livelihood-Success Stories from NEH Region,* pp 15-7. Munda G C, Ngachan S V, Das A, Malngiang S and chowdhary S. (Eds). NAIP Bulletin no.2, ICAR Research Complex for NEH Region, Umiam-793103, Meghalaya, India.

Kumar A. 2012. Ginger seed production- a profitable venture at Dzongu, North Sikkim. *(in).Site Specific Farming System Options for Rural Livelihood-Success Stories from NEH Region,* pp 12-4. Munda G C, Ngachan S V, Das A, Malngiang S and chowdhary S. (Eds). NAIP Bulletin no.2, ICAR Research Complex for NEH Region, Umiam-793103, Meghalaya, India.

**Papers presented in Conferences / Symposium / Seminars / Workshop**

Babu S and Suryavanshi P. 2013.Effect of sunflower stover incorporation and nutrient management on energetic of pigeonpea-sunflower cropping system. (*in*).*Proceeding of 100th Indian Science Congress, Section 1: Agriculture and Forestry Sciences,* pp 237-238. 3-7 January.Calcutta University, Kolkata, West Bengal, India.

Babu S, Rana D S and Pachauri D K. 2012. Economic comparison of pigeonpea-sunflower and pigeonpea-wheat cropping systems of north India. (*in*). *Extended Summaries (Vol 2)3rd International Agronomy Congress,* pp 448. 26-30 November 2012. New Delhi, India.

Gopi R, Kalita H and Kumar A. 2013.Management of soft rot disease in organic ginger cultivation in Sikkim. (*in*). *Abstract of the First International Conference on Bio-resource and Stress Management*, 6-9 February.Science city, Kolkata, West Bengal, India.

Kalita H, Kishore K, Lepcha B and Babu S. 2012.Organic manure production through vermicomposting for sustainable hill

agriculture. (*in*). *Book of Extended Summeries of the National Seminar on Livelihood Options for Small and Marginal Farmers in Fragile Ecosystems,* 9-10 August.ICAR Research Complex for NEH Region, Umiam-793103, Meghalaya, India.

Kumar A, Avasthe R K, Lepcha B, Mohanty A K and Shukla G. 2012.Impact of front line demonstrations on yield enhancement of ginger (var. Majauley) in Tribal reserve biosphere of Sikkim Himalaya (*in*).*The National Conference on Demonstrated Options for Improved Livelihood in Disadvantaged Areas of India,* 20- 21 January. IGKV, Raipur, India.

Kumar A, Mohanty A K and Lepcha B. 2012.Constraints analysis in adoption of scientific vegetable cultivation for livelihood improvement in Sikkim Himalayan region. (*in*). *Book of Extended Summaries ofthe National Seminar on Livelihoodoptions for Small and Marginal Farmers in Fragile Ecosystem,* pp 115-9.9-10 August.Munda G C, Ngachan S V, Das A, Mohapatra K P, Chowdhary, B U, Ramakrushna G I, Tripathi A K, Azad Thakur N S, Malngiang S and Chowdhary S (Eds). ICAR Research Complex for NEH Region, Umiam-793103, Meghalaya, India.

Kumar A, Sharma Y P, Avasthe R K and Rameash K. 2012.Cultivation and management status of mandarin decline in Sikkim (*in*).*Souvenir and Abstract of National Ddialogue on Citrus Improvement, Production and Utilization*, pp 341-55.27-29 February.NRC for Citrus, Nagpur, Maharashtra, India.

Mohanty A K, Kumar A, Nath B G, Lepcha B and Pathak P K. 2012.Studies on ethno-veterinary plants used by Lepcha community in Sikkim. (*in*). *Book of Extended Summaries ofthe National Seminar on Livelihoodoptions for Small and Marginal Farmers in Fragile Ecosystem,* pp 173-6.9-10 August.Munda G C., Ngachan S V, Das A, Mohapatra K P, Chowdhary, B U, Ramakrushna G I, Tripathi A K, Azad Thakur N S, Malngiang S and Chowdhary S. (Eds). ICAR Research Complex for NEH Region, Umiam-793103, Meghalaya, India.

Pal P, Chatlod L, Rahman H and Bandyopadhyay S. 2012. A report on the gastrointestinal parasites in Yaks (*Poephagus grunniens*) in the alpine dry area of North Sikkim, India. (*in*). *23rd National Congress of Veterinary Parasitology,* 12-14 December.Div of Vet Parasitology, Vet College, Khanapara, Guwahati, Assam, India.

Panda B, Rahman H, Chatlodand L R, Panda J. 2013.Isolation and Characterization of Phosphate Solubilizing Bacteria from the Soils of Sikkim. (*in*). *International Conference on Biotechnology and Sustainable Management,* 8-9 February, 2013. Science city, Kolkata, West Bengal, India.

Panda P K, Avasthe R K, Kalita Hand Rahman H. 2012. Studies on rice performance in SRI method with that of recommended practices under mid hill terraces of Sikkim. (*in*). *ARRW Golden Jubilee International Symposium on Sustainable Rice Production and Livelihood Security: Challenges and Opportunities*, 2-5 March. CRRI, Cuttack, India.

Prasad D, Rana D S, Babu S, Pal S and Bhan C. 2013. Crop diversification with maize (*Zea mays*) and soybean (*Glycine max*) - based cropping systems under different tillage practices. (*in*). *Abstract and Souvenir of International Conference on Extension Education in the Perspectives of Advances in Natural Resource Management in Agriculture*, 19-21 December.Swami Keswanad Rajasthan Agricultural University, Rajasthan, India.

Singh R, Anand K B and Bisen P K. 2013. Influence of tillage and weed control practices on weed growth and yield of wheat in rice-wheat system. *100th Indian Science Congress*, 3-7 January. Calcutta University, Kolkata, West Bengal, India.

Suryavanshi P and Babu **S.** 2011. Fog water harvesting: A new technology for untapped water: (*in*). *The National Seminar* on *Agro Meteorological Research and Services to Combat Climate Change Challenges,* pp 165-166. 9-10 December.BCKV, Kalyani, West Bengal, India.

**Book**

Varshney J G, Kumar A, Mohanty A K, Yadav A, Babu S, Pathak P K and Lepcha B. 2012. *The Book of Extended Summaries on State Level Stakeholders' Workshop on 'Bridging research to Extension: Strategies and Policies*. pp 177.ICAR Research Complex for NEH Region Sikkim Centre, Tadong, Gangtok, Sikkim, India.

Kalita H, Kishore K, Rahman H and Chatlod L R. 2012. Biotechnological and Biorational Approaches for Pest and Disease Management, pp 1-443. Ansari Road, Darya Ganj, New Delhi, India.(ISBN 978-81-7622-252-5).

**Book chapters**

Avasthe R K, Kumar A and Rahman H. 2013.Potential water management technologies for sustainable agriculture in Sikkim and Darjeeling hills of India. (*in*). *Water Management in the Hill Regions: Evidence from Field Studies,* pp288.Palanisami K, Sharda V N and Singh D V (Eds).Bloomsbury Publishing India. New Delhi, India.

BabuS,Avasthe R K and Varshney J G. 2012. System of rice intensification: An emerging alternative for organic rice production in Sikkim. (*in*). *The Book of Extended Summaries on State Level Stakeholders' Workshop on Bridging Research to Extension: Strategies and Policies,* pp 34-7. 11-12 October. Varshney J G, Kumar A, Mohanty A K, Yadav A, Babu S, Pathak P K and Lepcha B. (Eds). ICAR Research Complex for NEH Region Sikkim Centre, Tadong, Gangtok, Sikkim, India.

Gogoi A, Pathak P K, Mohanty A K, Kumar A and Lepcha B. 2012.Women empowerment through post harvest processing and value addition. (*in*). *The Book of Extended Summaries on State Level Stakeholders' Workshop on Bridging Research to Extension: Strategies and Policies,* pp 169. Varshney J G, Kumar A, Mohanty A K, Yadav A, Babu S, Pathak P K and Lepcha B. (Eds). ICAR Research Complex for NEH Region Sikkim Centre, Tadong, Gangtok, Sikkim, India.

Gopi R and Kapoor C. 2013.Organic disease management in floriculture. (*in*). The *training Manual of Model Training course on IPM in floriculture*, pp 27-33. 26 November to 03 December. NRC on Orchids, Pakuyong, Sikkim, India.

Gopi R, Kumar A and Babu S. 2012.Organic disease management in agricultural and horticultural crops. (*in*). *The Book of Extended Summaries on State Level Stakeholders' Workshop on Bridging Research to Extension: Strategies and Policies,* pp 17. Varshney J G, Kumar A, Mohanty A K, Yadav A, Babu S, Pathak P K and Lepcha B. (Eds). ICAR Research Complex for NEH Region Sikkim Centre, Tadong, Gangtok, Sikkim, India.

Gopi R, Ramesh Babu S, and Kapoor C. 2013. Recent advances in cultural management of crop pests. (*in*). *Current Concepts in Crop Protection,* pp 181-99. Banik S (Ed). Studium Press (India) Pvt. Ltd. (ISBN:978-93-80012-42-1).

Kalita H, Kishore K, Lepcha B and Babu S. 2012.Organic manure production through vermicomposting for sustainable hill agriculture. (*in*). *Book of Extended Summaries of the National Seminar on Livelihood Options for Small and Marginal Farmers in Fragile Ecosystem,* pp 86-8.09-10 August ICAR Research Complex for NEH Region Umiam-793103, Meghalaya, India.

Kapoor C and Babu S. 2012.Seed production of various crops for self sufficiency. (*in*). *The Book of Extended Summaries on State Level Stakeholders' Workshop on Bridging Research to Extension: Strategies and Policies,* pp 23-4. 11-12 October. Varshney J G, Kumar A, Mohanty A K, Yadav A, Babu S, Pathak P K and Lepcha B. (Eds). ICAR Research Complex for NEH Region Sikkim Centre, Tadong, Gangtok, Sikkim, India.

Kumar A, Gopi R, Mohanty A K, Yadav A and Lepcha B. 2012.Organic ginger production technology. (*in*). *The Book of Extended Summaries on State Level Stakeholders' Workshop on Bridging Research to Extension: Strategies and Policies,* pp 92. Varshney J G, Kumar A, Mohanty A K, Yadav A, Babu S, Pathak P K and Lepcha B. (Eds). ICAR Research Complex for NEH Region Sikkim Centre, Tadong, Gangtok, Sikkim, India.

Kumar A, Mohanty A K, Yadav A, Misra A D D, and Chettri T. 2012. Organic Kiwifruit production: A profitable venture in Sikkim. (*in*). *The Book of Extended Summaries on State Level Stakeholders' Workshop on Bridging Research to Extension: Strategies and Policies,* pp 86. Varshney J G, Kumar A, Mohanty A K, Yadav A, Babu S, Pathak P K and Lepcha B. (Eds). ICAR Research Complex for NEH Region Sikkim Centre, Tadong, Gangtok, Sikkim, India.

Kumar A, Yadav A, Mohanty A K, Avinash and Rai W. 2012.Status of cultivation and management of dieback of Sikkim mandarin. (*in*). *The Book of Extended Summaries on State Level Stakeholders' Workshop on Bridging Research to Extension: Strategies and Policies,* pp 70. Varshney J G, Kumar A, Mohanty A K, Yadav A, Babu S, Pathak P K and Lepcha B. (Eds). ICAR Research Complex for NEH Region Sikkim Centre, Tadong, Gangtok, Sikkim, India.

Kumar A, Yadav A, Mohanty A K, Lepcha B., Rai W and Chettri T. 2012. Nursery raising for quality planting material of Sikkim mandarin. (*in*). *The Book of Extended Summaries on State Level Stakeholders' Workshop on Bridging Research to Extension: Strategies and Policies,* pp 98. Varshney J G, Kumar A, Mohanty A K, Yadav A, Babu S, Pathak P K and Lepcha B. (Eds). ICAR Research Complex for NEH Region Sikkim Centre, Tadong, Gangtok, Sikkim, India.

Kumar A. 2012. Ginger seed production- a profitable venture at Dzongu, North Sikkim. (*in*). *Site Specific Farming System Options for Rural Livelihood-Success Stories from NEH Region*, pp 12-4.Munda G C, Ngachan S V, Das A, Malngiang S and Chowdhary S. (Eds).NAIP Bulletin no.2, ICAR Research Complex for NEH Region, Umiam-793103, Meghalaya, India.

Kumar A. 2012. Nucellar seedling production of mandarin for assured income at Dzongu North Sikkim. (*in*). *Site Specific Farming System Options for Rural Livelihood-Success Stories from NEH Region*, pp 15-7.Munda G C, Ngachan S V, Das A, Malngiang S and Chowdhary S. (Eds).NAIP Bulletin no.2, ICAR Research Complex for NEH Region, Umiam-793103, Meghalaya, India.

Lepcha B, Mohanty A K, Kumar A, Pathak P K and Singh S. 2012.Quality nursery raising techniques in vegetable crops. (*in*). *The Book of Extended Summaries on State Level Stakeholders' Workshop on Bridging Research to Extension: Strategies and Policies,* pp 103. Varshney J G, Kumar A, Mohanty A K, Yadav A, Babu S, Pathak P K and Lepcha B. (Eds). ICAR Research Complex for NEH Region Sikkim Centre, Tadong, Gangtok, Sikkim, India.

Mohanty A K, Lepcha B, Pathak P K, Kumar A, Singh S and Khawas T. 2012. KVK, East Sikkim on its way towards empowering farming community. (*in*). *The Book of Extended Summaries on State Level Stakeholders' Workshop on Bridging Research to Extension: Strategies and Policies,* pp 138. Varshney J G, Kumar A, Mohanty A K, Yadav A, Babu S, Pathak P K and Lepcha B. (Eds). ICAR Research Complex for NEH Region Sikkim Centre, Tadong, Gangtok, Sikkim, India.

Rahman H, Karuppaiyan R, Senapati P C, Ngachan S V and Kumar A. 2012. An analysis of past three decade weather phenomenon in the mid-hills of Sikkim and strategies for mitigating possible impact of climate change on agriculture. (*in*). *Climate Change in Sikkim, Patterns, Impacts and Initiatives*, pp 19-48. Arrawatia M L and Tambe S. (Eds).Information and Public Relations Department, Government of Sikkim, Gangtok, Sikkim, India.

Sharma Y P and Kumar A. 2012.Integrated management of citrus diseases. (*in*). *Biotechnological and Biorational Management of Insect Pest and Diseases,* pp 192-200. Kalita H, Kishore K, Rahman H and Chatlod L R. (Eds).Biotech publishers, Daryaganj, New Delhi, India.

Sharma Y P, Borah T R and Kumar A. 2012.Disease management in citrus orchard with Bordeaux mixture. (*in*). *Biotechnological and Biorational Management of Insect Pest and Diseases,* pp 257-61.Kalita H, Kishore K, Rahman H and Chatlod L R. (eds). Biotech publishers, Daryaganj, New Delhi.

Srivastava R B and Yadav A. 2012.Plasticulture for Agriculture and Food Security. (*in*).*Biotechnology in Biopolymers: Development, Applications & Challenging Areas,* pp 395-424. Tiwari A and Srivastava R B. (Eds).Smithers & Rapra Technology Limited, Shrewsbury, UK.(ISBN 978-1-84735-543-0).

Varshney J G and Babu S.2012. Climate change: A challenge to weed management(*in*). *Extended SummariesVol 2*, pp 384-385.26-30 November.3rd International Agronomy Congress. New Delhi, India.

Varshney J G, Babu S and Kumar A. 2012.Agricultural scenario of Sikkim and role of ICAR Research Complex. (*in*). *The Book of Extended Summaries on State Level Stakeholders' Workshop on Bridging Research to Extension: Strategies and Policies,* pp 01. Varshney J G, Kumar A, Mohanty A K, Yadav A, Babu S, Pathak P K and Lepcha B. (Eds). ICAR Research Complex for NEH Region Sikkim Centre, Tadong, Gangtok, Sikkim, India.

Yadav A, Kumar A, Misra A D D, Rai W, Chhetri T and Avinash. 2012. Pear (*Pyrus* spp.): A potential fruit crop for Sikkim. (*in*). *The Book of Extended Summaries on State Level Stakeholders' Workshop on Bridging Research to Extension: Strategies and Policies,* pp 63. Varshney J G, Kumar A, Mohanty A K, Yadav A, Babu S, Pathak P K and Lepcha B. (Eds). ICAR Research Complex for NEH Region Sikkim Centre, Tadong, Gangtok, Sikkim, India.

Yadav G S, Datta M, Babu S, Bhowmik S N, Meena B L, Maitry R S, Das A, Layek J and Ngachan S V. 2012. Effect of mulching

and P nutrition on root nodules and productivity of field pea grown on tilla land under late sown condition. (*in*). *Extended Summaries* (*Vol 2) on 3rd International Agronomy Congress*, pp 663-4.26-30 November. New Delhi, India.

Yadav G S, Datta M, Das A, Babu S, Debnath C, Bhowmik S N, Das S P, Meena B L, Layek J and Ngachan S V. 2012. Intensification of greengram based cropping system through organic toria cultivation. (*in*). *Book of Extended Summaries of the National Seminar on Livelihood Options for Small and Marginal Farmers in Fragile Ecosystem*, pp 91-93. 9-10 August.ICAR Research Complex for NEH Region Umiam-793103, Meghalaya.

**Popular articles**

Babu S and Kalita H. 2012.Attributes of system of rice intensification (SRI) that make differences in productivity of rice.*Sikkim Express* (01/08/2012).

Babu S and Kalita H. 2012. Techniques of raising rice nursery for system of rice intensification (SRI). *Sikkim Express* (23/09/2012).

Babu S and Varshney J. G. 2012.How to transplant rice seedling in system of rice intensification (SRI) *Sikkim Express* (16/08/2012).

Chandra R, Kumar S**,** Chatlod L R, and Rahman H. 2012.Sikkim me Upyogi Yak palan.*Kheti*. May, 2012. 24-28.

Kalita H and Babu S. 2012.Eco-friendly management of rice pests.*Sikkim Express* (05/08/2012).

Prasad D, Ram A, Babu S and Pal S. 2013. Rain water harvesting techniques to improve crop productivity in rainfed areas.*Indian Farming*, **62**(11): 16-8.

Singh H, Babu S, Gupta S K and Chaturvedi A K. 2012.Rabi phaslon me samanvit keet prabandhan.*Prasar Doot* 44-47.

**Technical Bulletins**

Kapoor C, Babu S, Gopi R and Mahajan V. 2012.Single *Cross Hybrid Maize Seed Production Sikkim*, ICAR Research Complex for NEH Region, Sikkim Centre, Gangtok, Sikkim, India.pp 16. (in Nepali)

Kapoor C and Kalita H. 2012.*Seed Production in Sikkim: Present Status and Prospects.*Published Jointly by ICAR Research Complex for NEH Region, Sikkim Centre and FS&ADD and HCCD, Govt. of Sikkim.pp. 19.

**TRIPURA CENTRE**

**Research papers**

Babu S, Rana D S, Yadav G S and Ansari M A. 2013.Residual effect of sunflower (*Helianthus annuus*) stover and P management and direct effect of N and P on productivity, nutrient uptake and economics of spring sunflower.*Indian Journal of Agricultural Sciences***83** (3): 272–278.

Biswas S and Datta M. 2013.Evaluation of biological control agents against sheath blight disease of rice in Tripura.*Indian Phytopathology***66** (1): 77-80.

Datt C, Malik S and Kundu S S. 2013. Effect of substitution of maize with wild sotti (curcuma zedoaria) rhizomes in the diets of crossbred pigs on feed intake, growth and feed conversion ratio. *Indian Veterinary Journal* (Accepted).

Debnath C, Sahoo L, Debnath B, Datta M and Ngachan S V. 2012. Alternative species for aquaculture diversification, A perspective from Tripura. *Fishing Chimes* 32(8): 35-38.

Debnath C, Sahoo L, Yadav G S, Datta M and Ngachan S V. 2013.Integrated fish farming for sustainable livelihood for fish farmers of Tripura.*Indian farming***62**(10):18-21.

Kalita H, Babu S, Kishore K, Singh R and Yadav G S. 2013. Vermicomposting - a viable option for organic nutrients in Sikkim. *Indian Farming.* (Accepted)

Kalita H, Babu S, Yadav G S, Helim R and Das B. 2013.Citronella-a promising crop for Sikkim Himalayas.*Indian Horticulture* (Accepted).

Lalrinsanga P L, Bindu R Pillai, Mahapatra K D, Lopamudra S, Ponzoni R W, Nguyen N H, Mohanty S. 2013. Length–weight relationship and conditionfactor of nine possible crosses of three stocksof giant freshwater prawn, Macrobrachiumrosenbergii from different agro-ecologicalregions of India.*Aquaculture International,* DOI 10.1007/s10499-012-9595-4.

Malik S and Singh N P. 2013. Evaluation of Tripura black local indigenous germplasm of poultry of Tripura at the organized farm conditions. *Indian Journal of Animal Sciences***83** (2): 197-200.

Malik S, Kumar S, Sarkar B, Doley S, Datt C and Datta M. 2013. Evaluation of Tripura Brown native germplasm of poultry at the organized farm and field conditions.*Indian Veterinary Journal* (Accepted).

Nath Bhowmik S, Balasubramanian S and Yadav D N. 2013. Influence of most-probable-number method and container perforation numbers on fungal population density during tempeh production. *The Indian Journal of Agricultural Sciences* (In press).

Yadav G S, Babu S and Datta M. 2012.Role of live mulch in weed management.*Indian Farming* July Issue.Vol. Page No?

Yadav G S, Datta M, Babu S, Debnath C, Bhowmik S N, Ansari M A and Ngachan, S V. 2013. Effect of zero tillage basin planting and N nutrition on growth, yield, water productivity and nitrogen use efficiency of late planted broccoli in North East Hilly Region of India. *Indian Journal of Agricultural Sciences* (Accepted).

Yadav G S, Debnath C, Datta M, Ngachan S V and Babu S. 2013. Comparative evaluation of traditional and improved farming practices in Tripura. *Indian Journal of Agricultural Sciences***83** (3): 310-314.

Yadav S K, Babu S, Singh Y, Yadav G S, Singh K and Singh H. 2013. Production potential and energy budgeting of rice based cropping system as influenced by organic nitrogen sources and biofertilizers. *Indian Journal of Agronomy* (Accepted).

**Book Published**

Biswas S, Datta M and Ngachan S V. 2012.Mushrooms- A Manual for Cultivation pp 206. PHI Learning India Ltd., New Delhi, India.

**Papers presented in Conferences / Symposium / Seminars / Workshop**

Malik S and Datta M. 2012.Success story of a new improved layer germplasm (25 % Tripura black × 75 % Dahlem red) in enhancing livelihood security in Tripura.*(in). National Seminar on livelihood Options for Small and Marginal Farmers in Fragile Ecosystems*. pp 150-152. 9-10 August.ICAR Research Complex for NEH Region, Umroi Road, Umiam-793103, Meghalaya, India.

Malik S, Doley S, Datta M and Ngachan S V. 2013. Native Poultry Germplasm of Tripura: Technological Intervention for Sustainable Production. *(in). Xth National Seminar on Integrated Development Vast Biodiversity of Indigenous Livestock for Long term Rural Livelihood Security.* pp 213-

223. 07-08 February. Department of Genetics and Animal Breeding, College of Veterinary Science and Animal Husbandry, G.B. Pant University of Agriculture and Technology, Pantnagar (U.S. Nagar) Uttarakhand, India.

Nath Bhowmik S, Manikantan M R, Gowsami D, Yadav G S. 2012. Dehulling of Pigeonpea as Influenced by Culture Filtrates of *Aspergillus oryzae* Grown on Different Lignocellulosic Agro-wastes *.(in).Proceedings of International Conference on Sustainable Agriculture for Food and Livelihood Security*, 27-29 November. Punjab Agricultural University, Ludhiana, India.

Yadav G S, Datta M, Babu S, Bhowmik S N, Meena B L, Maitry R S, Das A, Layak J and Ngachan S V. 2012. Effect of mulching and P nutrition on root nodule and productivity of field pea grown on tilla land under late sown condition.*(in). Extended Ssummaries Volume III of 3rd International Agronomy Congress on Agriculture Diversification, Climate Change Management and Livelihood*. pp 663-664. 26-30 November.IARI, New Delhi, India.

Yadav G S, Datta M, Bhowmik S N, Das Chaudhuri D and Chakma L. 2012. Enhancing food security under Climate change context through contingency crop planning in Tripura.*(in). Souvenir of Workshop on Agriculture and Food Security in the Context of Climate Change.* pp 39-48. 12-14 October, ICAR Research Complex for NEH Region, Manipur centre, Imphal, Manipur, India.

Yadav G S, Datta M, Das A, Babu S, Debnath C, Bhowmick S N, Das S P, Meena B L, Layek J and Ngachan S V. 2012. Intensification of green gram based cropping system through organic toria cultivation. *(in). Book of Extended Ssummaries of the National Seminar on Livelihood Ooptions for Small and Marginal Farmers in Fragile Ecosystem*. pp 91-93. 9-10 August.ICAR Research Complex for NEH Region, Umiam-793103, Meghalaya, India.

**Abstracts**

Malik S, Kumar S, Chaudhury A and Datta M. 2012. Evaluation of performance of coloured broiler female line × Tripura black cross in agroclimatic condition of Tripura. *(in). Proceedings of XXIX Annual Conference and National Symposium of Indian Poultry Science Association.*pp 7.05-07 December.Project Directorate on Poultry and Sri Venkateswara Veterinary University, Hyderabad, A. P., India.

Pundir R K, Malik S, Singh P K, Sharma D and Sadana D K. 2013. Indigenous cattle of Tripura – Characterisation and performance evaluation.*(in). Proceedings of Xth National Seminar on Integrated Development Vast Biodiversity of Indigenous Livestock for Long Term Rural Livelihood Security.*pp 109.07-08 February. Department of Genetics and Animal Breeding, College of Veterinary Science and Animal Husbandry, G.B. Pant University of Agriculture and Technology, Pantnagar (U.S. Nagar) Uttarakhand, India.

**Success Stories**

Biswas S, Datta M, Sarkar R and Sarma R. 2012. Mushroom as component of farming system for nutrition and livelihood improvement in Dhalai, Tripura.*(in). Site Specific Farming System Options for Rural Livelihood-Success Stories from NEH Region.*pp 51-53. Munda GC, Ngachan SV, Das A, Maingiang S and Chowdhury(Eds.). NAIP Bulletin No. 2. ICAR Research Complex for NEH Region, Umiam-793103, Meghalaya, India.

**Extension Folders/Technical Bulletins**

Maitry R S, Sahoo L, Debnath C, Datta M and Dascahudhury D. 2013.Farm Pond – A Viable Source for Irrigation-cum-Fish Farming in Tripura.ICAR Research Complex for NEH Region, Tripura Centre.Pub No-50.

Maitry RS, Sahoo L, Hemavati R and Datta M. 2013.Jalkund- a new hope for farmers of Tripura.ICAR Research Complex for NEH Region, Tripura Centre.Pub No-49.

Nath Bhowmik S, Das S P, Datta M and Ngachan S V. 2012. Arbuscular Mycorrhizal Biofertilizer: On-farm Production and Usage Technology. ICAR Research Complex for NEH Region, Tripura Centre.Technical Bulletin No- 48/2012.

Sahoo L, Maitry R S, Debnath C, Datta M and Ngachan S V. 2013.Disease Management in Composite Fish Culture.ICAR Research Complex for NEH Region, Tripura Centre.Pub No-52.

Sahoo L, Maitry R S, Debnath C, Datta M and Ngachan S V. 2013.Feed and Feeding Strategies in Composite Fish Culture.ICAR Research Complex for NEH Region, Tripura Centre.Pub No-51.

# 4. LIST OF CONTRIBUTORS

**Dr S. V. Ngachan, Director**

**NATURAL RESOURCE MANAGEMENT**
Dr. A.S. Panwar, Principal Scientist (Agronomy)
Dr D. J. Rajkhowa, Principal Scientist (Agronomy)
Dr A. Venkatesh, Principal Scientist (Forestry)
Dr. Rajesh Kumar, Senior Scientist (Agronomy)
Dr K. P. Mohapatra, Senior Scientist (Forestry)
Dr S. Hazarika, Senior Scientist (Soil Science)
Dr.Anup Das, Senior Scientist (Agronomy)
Dr B. U. Choudhury, Senior Scientist (Soil Science)
Dr.Ramkrushna, G.I., Scientist (Agronomy)
Mr Puran Chandra, Scientist (Forestry) (On study leave)
Dr Manoj Kumar, Scientist (Soil Science)
Dr B. C. Verma, Scientist (Soil Science)
Dr JayantaLayek, Scientist (Agronomy)
Dr Krishnappa R., Scientist (Plant physiology)

**CROP IMPROVEMENT**
Dr N. S. Azad Thakur, Principal Scientist (Entomology) & Head
Dr Satish Chandra, Principal Scientist (Plant Pathology)
Dr Ram Dutta, Senior Scientist (Plant pathology)
Dr Gajanan T. Behere, Senior Scientist (Entomology)
Dr KanchanSaikia, Scientist(Entomology)
Mr PankajBaiswar, Scientist (Plant pathology)
Mr SandipPatra, Scientist (Entomology)(On study leave)
Dr D. M. Firake, Scientist (Entomology)
Dr (Mrs) RachnaPande, Scientist (Entomology)
Mr Amit Kumar, Scientist (Plant Breeding)
Mr Abdul Fiyaz R, Scientist (Plant Breeding) (Transferred)
Ms Ramya K. T., Scientist (Plant Breeding)(On study leave)
Dr AvinashPandey, Scientist (Plant Breeding)
Dr (Mrs) Amrita Banerjee, Scientist (Plant Pathology)

**HORTICULTURE**
Dr AmitNath, Senior Scientist (Food Science & Technology) &Head (up to 30th Sep. 2012)
Dr Anjani Kumar Jha, Senior Scientist (Horticulture)
Mr R. K. Patel, Scientist (Fruit Science)
Dr V. K. Verma, Scientist (Vegetable Science)
Dr N. A. Deshmukh, Scientist (Fruit Science)

**AGRICULTURAL ENGINEERING**
Dr R. K. Singh, Principal Scientist (SWCE) & Head
Dr AmitNath, Senior Scientist(Food Science & Technology) (from 1st Oct. 2012 to 31st Mar 2013)
Er Arvind Kumar, Scientist (FMP)
Er SandipMandal, Scientist (FMP)

**ANIMAL PRODUCTION**
Dr Suresh Kumar D.S., Principal Scientist & Head (Animal Reproduction)
Dr G. Kadirvel, Senior Scientist (Animal Reproduction)
Dr M. H. Khan, Scientist (Animal Reproduction)
Dr RantuBasumatary, Scientist (Animal Genetics and Breeding)(on study leave)
Dr P. K. Bharti, Scientist (Livestock Production and Management) (on study leave)
Dr S. K. Das, Principal Scientist (Fisheries)
Dr S. K. Majhi, Scientist (Fisheries) (Transferred)
Dr K. Murmu, Scientist (Fisheries)(Transferred)
Dr Sunil Doley, Senior Scientist (Poultry Science)
Dr Pramod Singh, Senior Scientist (Animal Nutrition)

**ANIMAL HEALTH**
Dr ArnabSen, Principal Scientist (Veterinary Microbiology) & Head
Dr R. Laha, Senior Scientist (Veterinary Parasitology)
Dr I. Shakuntala, Senior Scientist (Veterinary Public Health)
Dr S. Ghatak, Senior Scientist (Veterinary Public Health)
Dr Z. B. Dubal, Scientist (Veterinary Public Health)
Dr K. Puro, Scientist (Veterinary Microbiology)
Dr Meena Das, Scientist (Veterinary Parasitology) (On study leave)
Dr R. K. Sanjukta, Scientist (Veterinary Medicine) (On study leave)

**SOCIAL SCIENCES**

Dr A. K. Tripathi, Senior Scientist (Agril. Economics)& Head
Mr N. Uttam Singh, Scientist (Agril. Statistics)
Dr Seeralan S., Scientist (Agril. Extension)
Dr Aniruddha Roy, Scientist (Agril. Economics)

**BIOTECHNOLOGY**

Dr A. Pattanayak, Principal Scientist (Plant Breeding) & Head
Dr Premila Devi Thongbam, Senior Scientist (Plant Biochemistry)
Dr Alpana Das, Senior Scientist (Plant Biotechnology)

**ARUNACHAL PRADESH CENTRE**

Dr R. Bhagawati, Joint Director
Dr D. Ramajayam, Senior Scientist (Horticulture)
Dr DoniJini, Scientist (VEE)
Dr Anup Chandra, Scientist (Entomology)
Mr Raghuveer Singh, Scientist (Plant Pathology)
Mr Jitendra Kumar, Scientist (Soil Physics/SWC)

**MANIPUR CENTRE**

Dr NarendraPrakash, Joint Director
Dr I. Meghachandra Singh, Principal Scientist (Seed Technology)
Dr Pawan Kumar Sharma, Senior Scientist (Plant Pathology)
Dr Dhruvendra Kumar, Senior Scientist (Agricultural Entomology)
Dr Jogendra Singh, Senior Scientist (Plant Breeding)
Dr Ch. Basudha Devi, Senior Scientist (Fisheries)
Dr ManasRanjanSahoo, Senior Scientist (Horticulture)
Dr Lohit Kumar Baishya, Senior Scientist (Agronomy)
Dr SubhraSaikat Roy, Scientist (Horticulture)
Dr DibyenduSarkar, Scientist (Soil Science)
Dr MerajAlam Ansari, Scientist (Agronomy)
Mrs P. Punitha, Scientist (Agricultural Extension)
Dr BlessaSailo, Scientist (Veterinary Public Health)

**MIZORAM CENTRE**

Dr S B Singh, Joint Director
Dr L. H. Puii, Scientist (Vertinary Microbiology)
Mr K. Rajasekar, Scientist (Soil Science)
Dr Sudip Kumar Dutta, Scientist (Horticulture)
DrAkoijamRatankumar Singh, Scientist (Plant Pathology)
Dr Y. Ramakrishna, (T-6) Farm Manager

**NAGALAND CENTRE**

Dr BidyutChandanDeka, Joint Director
Dr Manas Kumar Patra, Kumar, Scientist (Animal Reproduction)
Dr A. Thirugnanavel, Scientist (Horticulture)
Dr DibyenduChatterjee, Scientist (Soil Science)
Dr Tasvina R. Borah, Scientist (Plant Protection)
Dr Ch. Roben Singh, SMS (Agronomy), KVK Dimapur
Dr EbibeniNgullie, SMS (Animal Science), KVK Dimapur& I/c Library

**SIKKIM CENTRE**

Dr H. Kalita, Senior Scientist &Joint Director (I/C)
Dr AshishYadav, Senior Scientist (Horticulture)
Dr Raghavendra Singh, Senior Scientist (Agronomy)
Dr Ashok Kumar, Scientist (Horticulture)
Dr L. R. Chatlod, Scientist (Veterinary Public Health)
Dr R. Gopi, Scientist (Plant Pathology)
Dr ChandanKapoor, Scientist (Plant Breeding)
Dr SubhasBabu, Scientist (Agronomy)
Dr Shaon Kumar Das, Scientist (Soil Science)

**TRIPURA CENTRE**

Dr M. Datta, Joint Director
Dr B. Das, Principal Scientist (Horticulture)
Dr S. Biswas, Senior Scientist (Plant Pathology)
Dr A. Haldar, Senior Scientist (Animal Reproduction)
Dr S. Malik, Senior Scientist (Poultry Science)
Dr S. P. Das, Senior Scientist (Plant Breeding)
Dr S. NathBhowmik, Senior Scientist (Agricultural Microbiology)
Mrs L. Sahoo, Scientist (Fishery Science)
Mr B.L.Meena, Scientist (Plant Breeding)
Mr C. Debnath, Scientist (Fishery Science)
Mrs H. Ranebennur, Scientist (Plant Pathology)
Dr G. S. Yadav, Scientist (Agronomy)
Mr R. S. Maitry, Scientist (Soil and Water Conservation)