Content list available at http://epubs.icar.org.in, www.kiran.nic.in; ISSN: 0970-6429

Indian Journal of Hill Farming

December 2017, Volume 30, Issue 2, Page 242-250

Population Dynamics of *Hymenia Recurvalis* (FAB.) (Amaranth Leaf Webber) in Garhwal Hills of Uttrakhand

J. S. Aswal[1*] • B. S. Bisht[2]

[1]Uttarakhand State Council for Science and Technology, Dehradun

[2]HNB Garhwal University, Department of Zoology (Entomology), SRT Campus Badshahithoul, Tehri, Uttarakhand

ARTICLE INFO

Article history:
Received 15 September 2016
Revision Received 3 March 2017
Accepted 26 July 2017

Key words:
Grain Amranthus, *Hymenia recurvalis*, population dynamics, Weather parameters

ABSTRACT

In the present study, an attempt has been made to understand the population dynamics of the *Hymenis recurvalis* in different elevations of Garhwal hills. Light traps were installed at three different experimental sites *viz.* Khadi, (950 m asl) at tropical, Gaza (1450 m asl) at sub-tropical and Ranichauri (1750 m asl) in the temperate region. The pest appearance was from 27th standard week (first week of July) (1.42-3.90moth/night) up to 46th standard week (26th November to 2nd December) (1.60-2.0moth/night). first appearance of adult moths (3.90) were recorded at Khadi (tropical), and Gaza (sub-tropical) (1.42) during 27th standard week (first week of July) and thereafter, it appeared at Ranichauri (Temperate) (2.0) during the 28th standard week (second week of July). It is clear that the moths first appeared at lower elevations then spread towards higher elevations. The number of catches with highest peak were observed at 24.66 moths/night at Khadi, 30.0 moths/night at Gaza and 17.14 moths/night at Ranichauri during 39th the week (September last week) respectively, which gradually declined after 40th week and sharply declined from 44th week.

1. Introduction

Amaranth is believed to have originated from Central and South America (Grubben and Slten, 1981) where it has been cultivated for more than 8,000 years (Obrien *et al.*, 1983 and yarger, 2008). It has now become cosmopolitan, (Putnam *et al.,* 1989; Meyers, 1998 and Mposi, 1999) and it is now been grown by the large number of farmers over the past few decades (Meyers, 2002). In Uttarakhand state, the grain species *i.e. Amaranthus hypochondriacus* and *A. caudatus* are mostly grown at foot hills to high hills and often intercropped with maize, finger millet, barnyard millet and sometime as sole crop. No other hilly region in the world has so much of area under this crop. The crop is also sporadically grown in the Northern plains, Central and Southern India. Singh and Thomas (1978) estimated that in the Kullu valley of Himachal Pradesh alone it is grown in 890 hectare while in Gujarat it occupies 120 hectare. In the interior of north-west hills of India under traditional farming method it occupies nearly 60% non-irrigated land of higher hills (Joshi, 1981). The seeds, besides their well-known nutritive characteristics, could be a source of phenolic compounds of high antioxidant properties (Barba de la Rosa *et al*., 2009). The amaranth grain provides ideal amino acids composition for human nutrition. Moreover, the high content of Lysine, Arginine and Histidine makes amaranth seeds a good dietary supplement for treating child malnutrition (Gimplinger *et al*., 2008). The grains of amaranths could be considered either as cereals or legume due to the fact that they contain more than 15% protein in dry basses (Downton, 1973; Gorinstein, 1999 and Garcia *et al*., 2011). However, one of the greatest limiting factors in increasing the productivity of amaranths is the range of insect pests with which they are associated and the level of losses suffered in unimproved and improved agriculture (Banjo, 2007).

*Corresponding author: jagbir77aswal@rediffmail.com

The caterpillar rolls the leaf into distinctive leaf shelter and voraciously feed on the green matter. Severe attack results in complete skeletonisation and drying up of the leaves within a short time (Navarajan, 2007; James *et al.,* 2010; Garcia, 2011; Aderolu, 2013 and Mureithi, 2015) (plate, 1, 2). The biotic potential of a species is the qualitative expression of the capacity of a species to assert itself in an environment. In general the population of a pest is largely governed by complex of interaction of ecological factors both biotic and abiotic. The knowledge of population built up of an insect species or group is quite helpful in determining the index of injury and screening of resistant verities of host plants. Due to variation in the agro-climatic conditions of different altitudes, insects show varying trends in their incidence pattern and extent of damage to the crop. Besides, different weather factors also play a key role in determining the incidence and dominance of a particular pest or pest species (Meena *et al.,* 2013). Available scientific literatures shows that not much information is available especially on population dynamics and influence of various environmental factors. Hence a region oriented study on amaranthus leaf webber population dynamics would provide an idea about pest spreading in different altitudes and peak period of their activity which led to helpful in developing management strategies especially in the state of Uttarakhand where the grain amaranthus grown by farmers as a cash crop.

Plate 1. Damaged Amaranths crop Due to *H. recurvalis*.

2. Materials and Methods

The present investigation was carried out at farmers field by the installation of light traps in three different locations *viz*, Khadi (low hill 950m ASL); Gaza (mid hill 1450m ASL) and Ranichauri (high hill 2200m ASL) in the district Tehri Garhwal. The collections were made from June to November in two consecutive years. The collected adults were preserved after drying in oven at 30 to 35^{0}C. Observations were also made on the various abiotic factors such as temperature (max. mini.), relative humidity and rainfall affecting the population of the pest. Each light trap was locally fabricated made up of metal GI sheet comprising two main sub units *i.e.* trapping unit (funnel shaped) and collection drum. A 20 watt florescent light was used as a source of light and fitted about 30 cm. above the funnel. The trap was installed 2.0 meter above the ground level so as to avoid any short of obstacle in moth's vision and to attract the moths from the longer distance. Each light trap were operated every night from dusk (6.00 pm) to dawn (7.00 am) and collection of trapped moths were made daily. The collected moths were brought to laboratory and counted. The seasonal population fluctuation of *H. recurvalis* was carried out on the basis of catches of adults on light trap in each location.

Larval population was also studied at three experimental sites from the germination to harvesting of crop, similar method was followed as adopted by Bhattacherjee and Menon, 1964; Sinu *et al.* 2013, and Sinu *et al 2013, t*o estimate the larval population of *H. recurvalis* in five different varieties of amaranth *viz.* PRA-1, PRA-2, PRA-3, Anna Purna and Subharna at weekly interval from germination to harvest of the crop. Two methods namely: Ground Cloth Shake Method (GCSM) and Visual Count Method (VCM) were used. Ten plants were selected randomly in each variety and tagged for larval population count. In GCS method, white plastic sheet (30 cm) placed in one side of the plant and briskly shaken the plants so as to dislodge the larvae on to the sheet. The number of larvae available on the sheet were then counted in the sheet and thereafter released on the same plants. While in VC method, the number of larvae was recorded carefully by counting them visually on the tagged plants Kausik and Naresh (1989). The observations were done randomly every week. The meteorological observations *viz.* temperature (minimum and maximum), relative humidity and rainfall were also recorded daily at experimental site during study period. Standard deviation, standard error and relative variance were also studied by following formulae:

(i) Standard deviation (SD) = $\frac{\sqrt{[x \text{ (an observation)} - \mu \text{ (mean)}]^2}}{n \text{ (number of observations)}}$

(ii) Standard Error (SE) = $\frac{\text{Standard deviation}}{\sqrt{n \text{ (number of observations)}}}$

(iii) Relative Variance % (RV) = $\frac{\text{Standard Error}}{\sqrt{x} \text{ (mean no. of larvae/sample}}$

Plate 2: *H. recurvalis* larvae damaging amaranth crop.

3. Results and Discussion

Light trap has often been used in the ecological studies of lepidopteran insect pests in agroecosystems. However, the light trap in Indian agricultural systems is rarely adopted either to monitor the population size or to study the migration of moth pests. In the present study, we have installed light traps in shaded and unshaded tea plantations of North East (NE) India to study (1) the species composition, (2) effect of shade on moth pests, (3) seasonality of major pests and (4) to learn the sex proportion of major pests captured in light traps.

The two-year catches in light traps suggested for monitoring the pest population Sinu *et al.* 2013. The moths of *H. recurvalis* are nocturnal and are positively phototrophic inhabit. The light traps were installed at three experimental sites *viz,* Khadi, (950 m asl) at tropical, Gaza (1450 m asl) at sub-tropical and Ranichauri (1750 m asl) at temperate region. The light trap experiments were performed throughout the year. The pest appearance was observed from 27th standard week (first week of July) upto 47th standard week (26th November to 2nd December). The light traps study was the only plan to record the seasonal activity of the moths and this was carried out by several workers *viz,* Bhattacherjee and Menon (1963, 1964), Pataki *et al.* (1975), Suzuki (1977) and Delobel and Gutierrez (1981). Physical factors like temperature, relative humidity (%) and rainfall (mm) were observed leading to epidemic of this pest and recorded more responsible for the population build up in amaranth crop. Hemlatha and Pai (2009) also reported that, the minimum temperature played significant role in the population build up of a pest. The adult population of moths started their appearance at dusk at around 7pm and hide in their sheltering places such as grasses, cracks of walls and concealed places of houses, sometimes hides under the crop during day time. Initially few months were observed attracted towards light during first hour light trap operation at dusk. This was followed by gradual increase in number of moths attracted towards light. Maximum number of moths attracted in between 8pm and 10pm. Miyahara (1990) reported that adults of this pest take off within half an hour of sunset. The moths showed considerable distribution pattern in different phyto-geographical strata during the study period in district Tehri Garhwal Bisht *et al*. (2005). It was clear from the fig. 1-4, that the first appearance of adult moths (3.90, 1.42/night) were recorded at Khadi (tropical), and Gaza (sub-tropical) during 27th standard week (first week of July) and thereafter, it appeared at Ranichauri (Temperate) (5.99) during 28th standard week (second week of July).

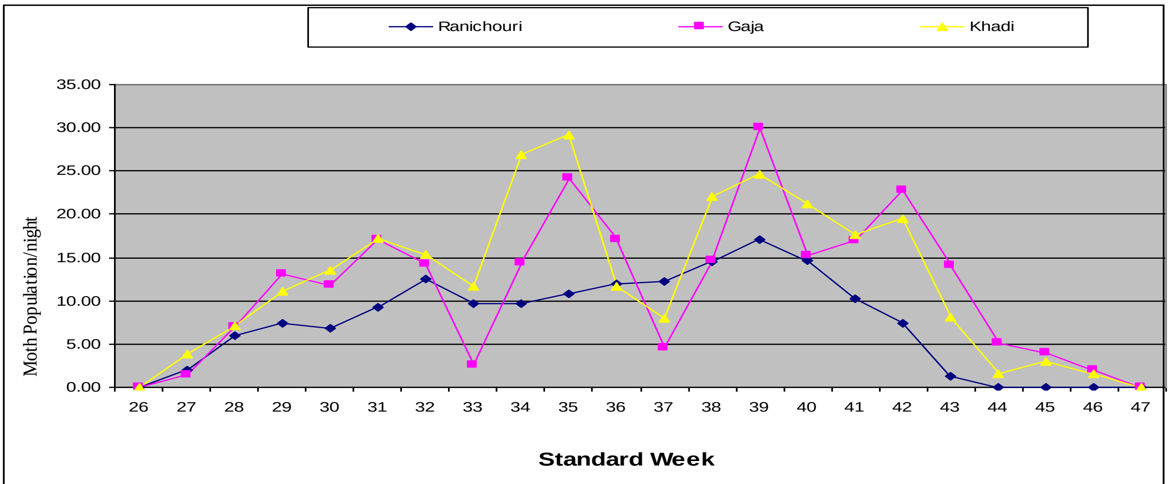

Fig. 1 Population dynamics of *H. recurvalis* moth district Tehri Garhwal

It has been clear from the fact that the moths first appeared at lower elevations then at higher elevations. It was also observed from the field the sowing pattern of amaranth in Uttarakhand state was also same from low hill to higher elevations. The outbreak of pest first in low hill was positively correlated with rising of temperature and availability of host plants. Amongst the different weather factors affecting the population of the pest, the minimum temperature was the most dominant factor. Higher temperature, rainfall, increased relative humidity and availability of host plants favoring pest population Borgohain *et al.* (2015). The number of catches with highest peak were observed 24.66 moths/night at Khadi, 30.0 moths/night at Gaza and 17.14 moths/night at Ranichauri during 39th week (September last week), which gradually declined during 40th week and sharply declined from 44th week in catches of moths /night. The present investigation revealed that, population of the pest (no. of moth trapped/night in light trap and no. of larvae collected from plant) was found lowest during July (3.90 moth and 2.42 larvae), which maintained a gradually increasing trend recording (26.92 moth/night and 32.51/larvae/plant) highest in the month of September. Thereafter, the population declined steadily October onwards and recorded lowest in 46th standard week with lowest catches of moth 1.60/night and 5.70 larvae/plant. During the month of July (27th week) the minimum temperature ranged in between 15.34^{0}C to 18.70^{0}C, Relative humidity was recorded 61.55-86.21% and rainfall ranged 7.67-22.36mm. The average number of moths gradually decreased and disappeared first at higher elevation *i.e.* Ranichauri during 43rd week (1.21) then at middle elevation *i.e.* Gaza and Khadi (2.0, and 1.60 moth/night) in 46th week. *kharif* season crop (especially amaranth) started to ripen earlier (15d) in high hill (Ranichauri 2200m asl) in comparison to low hill (Gaza1450m asl, Khadi 950m asl).

It has also been clear from the fact that with increase in the elevation (from Khadi to Ranichauri) caused decrease in the duration of Kharif crop ripening and vice and versa. Moths were found active between July to November and checked by the onset of hot dry weather, which continues until the end of June. This was supported by Bhattacherjee and Menon (1964), Pande (1973), Miyahara (1990). The maximum catches were found during 34th week, when the minimum, maximum temperature, relative humidity and rainfall were recorded 15.16 to 23.30^0 C, 76.09 %, 1.60 mm at Khadi, 14.52 to 23.96^0 C, and 86.63 %, 1.60 mm at Gaza and 11.78 to 21.91^0 C, 87.21 %, 8.80 mm at Ranichauri. The pest disappear first at Ranichauri (high altitude) during 43th week, when the temperature (mini. Maxi.), relative humidity and rainfall were recorded 6.08 to 18.90^0 C, 69.0% and nil rainfall respectively. The disappearance followed at Gaza, khadi (mid and low hill) during 47th week at temperature (mini, maxi), relative humidity, rainfall recorded 5.07 to 18.20^0 C, 55.5%, nil rainfall, 4.29 to 15.12^0 C, 65.60% and nil rainfall respectively. Sharp decline during the month of December 2004 to June 2005, exhibited no activities caused their outright absence.

This was due to over wintering of moths caused by extreme low temperature and absence of suitable host plant. The moths thus showed considerable distribution pattern not only due to different abiotic factors but also due to different phytogeographical strata Bisht *et al*. (2005). Borgohain, 2015 studied the population dynamics of mulberry leaf webber in context to environmental factors and observed that the minimum temperature increased, the abundance of the pest population went up proportionally. Evening relative humidity was also showed positive significant correlation with the pest population. Chauhan *et al.* (2000) studied the population of *G. pyloalis* in plains and hills of tarai region, India observed that pest population increased in the month of March and peaked during September. Kant and Kumar (2007) observed

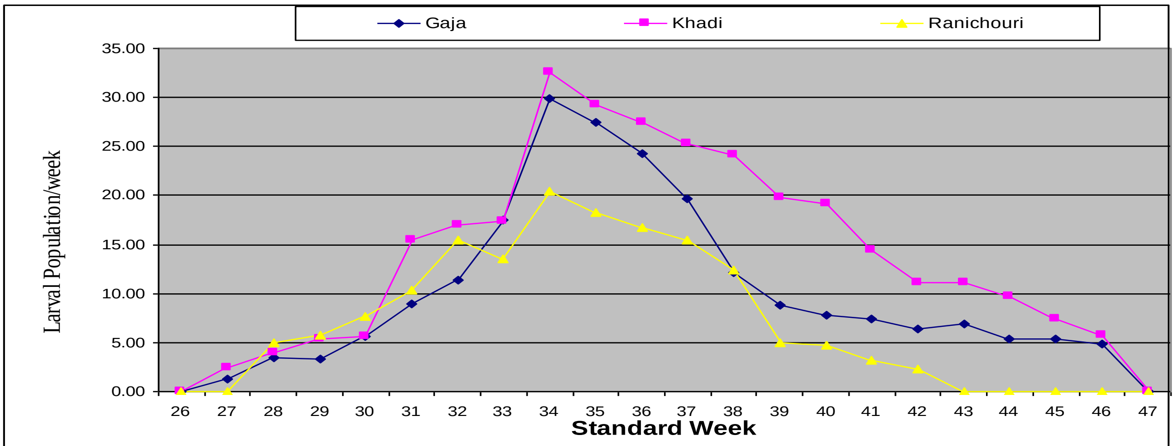

Fig. 2 Population dynamics of *H. recurvalis* larvae at district Tehri Garhwal

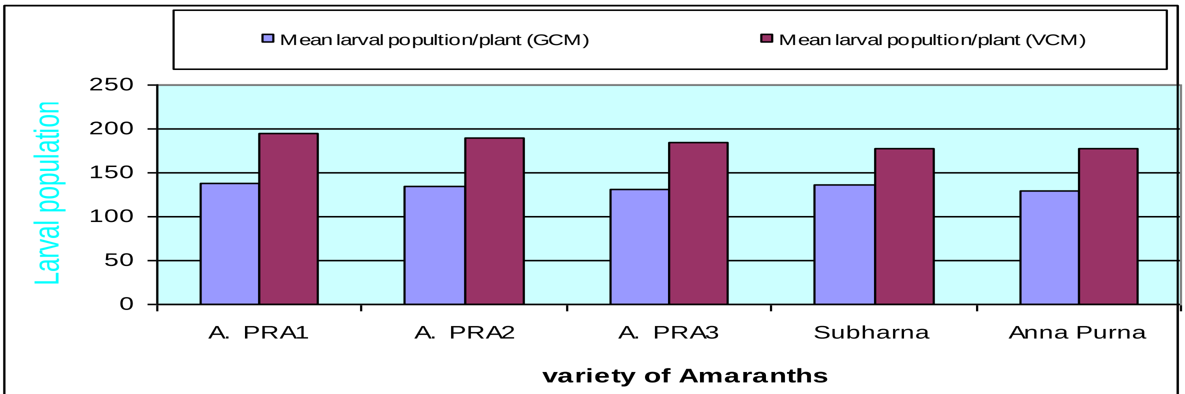

Fig. 3 Larval population of 2004-05 in different variety of amaranths

infestation of another pyralid, *D. pulverulentalis* predominating during the month of August, September and October in Doon valley. Patil (2013) in Kerala observed that gradual decline in insect population from November onwards with the drop of temperature and relative humidity. The decreasing trend in light trap catches (after the peak period *i.e.* last week of September) at all the three experimental sites indicate that most of the moths had emerged out of the soil before the end of September. The moths are highly susceptible to hot and dry weather and appeared mostly around the middle of July all over the Japan which scarcely seen from the spring to early summer. It was also observed that moths appear increasingly from summer to the autumn and annual changes in number were fairly conspicuous. They cannot survive during winter even in the southern most part of Japan because they have no hibernation stage and were less tolerant to cold temperatures (Yamada and Koshihara 1976, Yamada *et al.* 1979. Miyahara (1991, 1993) observed that the adults of *H. recurvalis* were observed emerging until mid October in 1988 and until late October in 1989 after which no more adults emerged. The number of adults suddenly increasing to a total during 8-10 June.

Aderolu *et al.* (2013) observed that the relationship between weekly average abundance of *H. recurvaslis* and weather parameters during rainy and dry season the moth population was not significantly (P>0.05) different and the highest mean population 68.75±0.274 and 68.15±0.651 was recorded at third week after planting in rainy and dry season respectively. Ghirtlahre *et al.* 2015 studied the effect of weather parameters on seasonal incidence of Sapota leaf webber.

4. Co-efficient correlation between abiotic factors and adult population

4.1 Effect of temperature

It has been observed that the peak period of moths at an average minimum temperature ranged between 15.4-17.8^0 C and maximum 20.0-23.0^0 was found most favorable to increase the population. From the co-efficient correlation study point, the minimum and maximum temperature was found positively and significantly correlated with the moth population at all three experimental sites with the 'r' values of 0.411, 0.210, 0.311 for maximum and 0.362, 0.265, 0.133 for minimum temperature.

4.2 Effect of relative humidity

As the results indicated that pest appearance was greater at the relative humidity ranged between 87.0 to 93.0 per cent. The relationship between pest appearance and relative humidity was positively correlated with the 'r' values of 0.237, 0.143 and 0.175 at all three experimental sites.

4.3 Effect of rainfall

No significant positive relationship was observed with the rainfall and adults population**.** The relationship between pest population and rainfall was negatively correlated at all three sites *i.e.* 0.145, -0.178 and -0.167 (Table. 1). Bhattacherjee and Menon (1964) observed large moth numbers from July to October at the temperature and relative humidity ranged 20-30^{0}C and 40-50 per cent respectively. As the severity of winter increases their numbers gradually dwindles and they become very scarce in January and February at the temperature ranged below 10^{0}C and relative humidity ranged below 30 per cent. Yamada *et al.* (1979) observed that the larvae and pupae of this pest died of cold in autumn in temperate region of Tokai and pest was not able to over winter in Japan. Shirai (2006) worked on the adult survivality and flight capacity and observed that the range of 17-23^{0}C was likely optimal for long duration flight.

4.4 Larval population

Larval population of *H. recurvalis* was observed at all three experimental sites from 27th standard week to 46th standard week. The data presented in the fig-1-4 revealed that the first appearance of larvae on amaranthus crop was simultaneously at Khadi and Gaza (low hill, mid hill) during 27th week. At khadi and Gaza, the pest incidence was from 27 DAS (Days After Sowing) and continued upto 134 DAS. But at Ranichauri, the leaf infestation begin from 34 DAS and persist upto 99 DAS. The larvae showed maximum peak during 34th week (77 DAS) at all three experimental sites *i.e.* Khadi, Gaza and Ranichauri. Thereafter, the larvae gradually decreased in number and disappeared during 47th week only at Khadi and Gaza. But at Ranichauri the trend of disappearance occurred during 43rd week only. Jena *et al.* (2001) observed that the leaf webber (*Pachyzancla stutatis*) of grain amaranthus showed its highest population peak at 90 DAS, after which it declined. The larvae showed maximum peak during 34th week at all three experimental sites at temperature ranged (mini. maxi) 14.95-17.81, 22.44-26.86^{0}C, relative humidity ranged 87.50-91.35 per cent and rainfall ranged 0.50-6.22 mm. The larvae gradually decreased in number and simultaneously disappeared during 47th week at Khadi (tropical) and Gaza (sub-tropical) at temperature ranged (mini. maxi) 4.29 ^{0}C-5.27 ^{0}C, relative humidity 55.50-65.60 % and rainfall 0.0-0.5 mm. But at Ranichauri, the same trend of decreasing of larvae occurred except disappearance, which was recorded during 42nd week. Figueroa (2003) observed that population density of *S. recurvalis* larvae were directly related to the population density of weed (host). The Larval population was significantly higher in the days of autumn than in winter. In the town of Juana Diaz revealed that the number of larvae of *S. recurvalis* was higher in the month of October and May. In all other months' population remained more or less constant. In the month of February is the shortest collected number of larvae per stem. In the town of Santa Isabel was observed more in larvae September and October and then declined in November and December, increasing very little in January and February to decline in March, April and May Hajare *et al.* (2012) studied the infestation in chiku moth *Nephoptery xeugraphella* recorded that the larval population was minimum in first and second week of May,

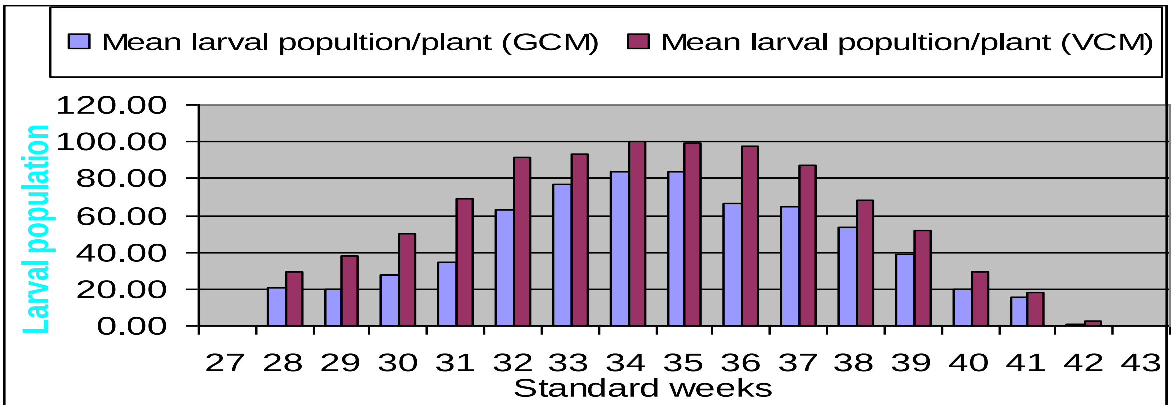

Fig.4 Larval population on different standrad weeks

it increased gradually and reached peak in the second week of September and then dropped down gradually. Larval population had significantly negative correlation with maximum temperature, while the morning relative humidity, evening relative humidity and rainfall were found favorable for pest population in the field. The larvae were collected by two sampling methods *viz.* Ground Cloth Shake Method and Visual Count Method in between 28th to 42nd week. The larval counts were made in five varieties of amaranths namely: PRA-1, PRA-2, PRA-3, Subharna and Anna Purna. The average data were obtained from ten randomly selected amaranths plants. From the fig. 1-4, it was revealed that maximum larval population was noted 923.82 by VCM followed by 668.21 by GCM in all varieties of amaranths. Larval population by VCM was obtained higher *i.e.* 194.61, 189.07, 185.00, 178.30 and 178.84 in PRA-1, PRA-2, PRA-3, Subharna and Anna Purna respectively. These values were observed quite higher than the values *i.e.* 137.54, 134.37, 131.89, 135.89 and 128.52 obtained from the above same varieties of amaranths by GCSM. Kausik and Naresh (1989) reported that GCSM was more efficient and accurate than the VCM for sampling the *Heliothis armigera* in chekpea. In the present study, VCM was more feasible for sampling of *H. recurvalis* larvae on amaranths. The larvae of this pest feed on epidermal layer of leaf by webbing of silvery silken thread secreted by the larvae and sometimes two-three adjacent leaves also found tide up together. Due to this typical feeding habit, was somewhat difficult to dislodge the larvae on the sheet by GCSM. The larval population was recorded highest during 34th standard week in all the varieties of amaranths by both methods.

Table 1. Correlation matrix of weather parameters with *H. recurvalis* moth catches

Meteorological parameters	Ranichauri 2004-05	Gaja 2004-05	Khadi 2004-05
Temp (Max ^{0}C)	0.311	0.210	0.411
Temp (Min ^{0}C)	0.133	0.265	0.362
RH (%)	0.175	0.143	0.237
Rainfall (mm)	-0.167	-0.178	-0.145

5. Co-efficient correlation between abiotic factors and larval population

5.1 Effect of temperature

It has been observed that peak larval population at an average temperature ranged between minimum 14.95-17.81^{0}C and maximum 22.44-26.86^{0}C, the satter was found most favorable to increase the larval population. From the co-efficient correlation studies the temperature was found positively and significantly correlated with the larval population at all three experimental sites with the 'r' values of 0.1490, 0.30051 and 0.2774 for maximum and 0.3122, 0.38037 and 0.40121 for minimum temperature.

5.2 Effect of relative humidity

The larval population was maximum at relative humidity ranged between 87.56 to 91.35 per cent. The relationship between this pest appearance and relative humidity was observed positively correlated with the 'r' values of 0.4723, 0.4725 and 0.4651 at three experimental sites.

5.3 Effect of rainfall

There was no significant positive relationship of rainfall with larval population**.** The relationship between larval population and rainfall was found to be negatively correlated at all three sites *i.e.* -0.692, -0.2087 and -0.4058 (Table. 2). Jena *et al.* (2001) reported that larval population of amaranthus leaf webber was found maximum at 90 DAS. He further pointed out that simple correlation co-efficient studies between meteorological parameters and leaf infestation due to leaf webber on var. SKN-7 indicted that maximum temperature (-0.404), minimum temperature (-0.333), mean temperature (-0.374) and relative humidity (-0.143) were negatively and non-significantly correlated with leaf infestation.

Table 2. Correlation matrix of weather parameters with *H. recurvalis* larvae.

Meteorological parameters	Ranichauri 2004-05	Gaja 2004-05	Khadi 2004-05
Temp (Max ^{0}C)	0.1490	0.30051	0.2774
Temp (Min ^{0}C)	0.3122	0.38037	0.40121
RH (%)	0.4723	0.4725	0.46510
Rainfall (mm)	-0.692	-0.2087	-0.4058

References

Aderolu I. A, Omooloye A. A, Okelana F. A. 2013. Occurrence, Abundance and Control of the Major Insect Pests Associated with Amaranths in Ibadan, Nigeria, *Entomol Ornithol Herpetol* 2013, 2:3.

Banjo A. D. 2007. Bio-ecology and life history of *Gasteroclisus rhomboidalis* Boh. (Coleoptera: Curculionidae) a pest of *Amaranthus cruentus* (L.) *Sauer. J Entomol* 4: 308-316.

Barba de la Rosa A. P, Fomsgaard I. S, Laursen B, Mortensen A. G, Olvera-Martínez L, Silva-Sánchez C, Mendoza-Herrera A, González-Castañeda J, De León-Rodríguez A. 2009. Amaranth (*Amaranthus hypochondriacus*) as an alternative crop for sustainable food production: Phenolic acids and flavonoids with potential impact on its nutraceutical quality. *J Cereal Sci* 49: 117-121.

Bhattacherjee N. S, Ramdas Menon M. G. 1964. Bionomics, Biology and Control of *Hymenia recurvalis* (Fabricius) (Pyralidae: Lepidoptera) *Indian J Entomol*, 26: 176-183.

Bisht B. S, Bisht Suman, Aswal, J. S. 2005. Amaranths (Raamdana) –A cash crop under serious threat in Uttaranchal agro-ecological Conditions, *Himalayan J Environ Zool* 20(2): 207-210.

Borgohain A, Battacharjee j, Singha T. A. 2015. Population dynamics of mulberry leaf roller, *glyphodes pyloalis* walker in jorhat (Assam) in context of environmental factors, *The ecoscan* 9(1&2): 175-178.

Chauhan T. P. S, Lochan R, Siddiqui A. A, Kumar P, Sumbli S. N. 2000. Studies on pest status of mulberry in different zones of Uttar Pradesh. Source of Information: *Annual Report*. pp. 1999-2000.

Delobel A, Gutierrez J. 1981. Fluctuations in the Catches of Lepidoptera in light trap in the course of a year in a biotape in new Caledonia, Cahiers ORSTOM *Series biologie* 44: 23-34.

Downton W. J. S. 1973. *Amaranthus edulis*: a high lysine grain amaranth, *World Crops*, 25: 20- 25.

Figueroa L. P. 2003. Dinamica poblacional de *Spoladea recurvalis* (F.) Lepidoptera: Pyralidae) sus relaciones tritroficas con variaciaciones en la densidad poblacional de la peseta. *Trianthema portulacastrum* part of *M. Sc. thesis, Universidad de Puerto rico recinto universitario de mayaguez.*

García Agustín Aragón, Huato, Miguel Ángel Damián, Manuel Huerta Lara, Francisco J. Sáenz-de-Cabezón, Ignacio Pérez-Moreno, Vicente Marco-Mancebón, Jesús F. López-Olguín. 2011. Insect occurrence and losses due to phytophagous species in the amaranth *Amaranthus hypocondriacus* L. crop in Puebla, Mexico, *African J Agric Res*, 6(27): 5924-5929.

Gimplinger D. M, Schulte aufm Erley G, Dobos G, Kaul H. P. 2008. Optimum crop densities for potential yield and harvestable yield of grain amaranth are conflicting. *European J Agron* 28: 119-125.

Gorinstein S, Jaramillo N. O, Medina O. J, Rogriques W. A, Tosello G. A, Paredes-Lopez O. 1999. Evaluation of some cereals, plants and tubers through protein Composition. *J Protein Chem* 18: 687-693.

Grubben G. J. H, von Sloten D. H. 1981. Genetic resources of amaranth: A global plan of action. Int. Board for Plant Genet. Resources. FAO, Rome, Italy.

Hajare, A. R, Patel J. I, Shitole T. D. 2012. Seasonal incidence of chiku moth (*Nephopteryx eugraphella* R.) in relation to weather parameters. *Int J Plant Prot*. 5(1): 89-92.

Hemlatha Pai, I. K. 2009. Forewarning the infestation of leaf roller (*Diaphania ulverulentalis* Hampson) in mulberry (*Morus* sp.) gardens of Tumkur district (Karnataka). *J Environ Bio-Science* 23: 73-80.

James B, Atcha-Ahowe C, Godonou I, Baimey H, Georgen H, 2010. Integrated Pest Management in Vegetable Production: A guide for extension workers in West Africa. *International Institute of Tropical Agriculture (IITA),Ibadan, Nigeria 120.*

Jena B. C, Mohanty S. K, Mishra P. R, Jena S. N. 2001. Leaf folder infestation in grain amaranths. *Indian J Entomol*. 488-490.

Joshi B. D. 1981. Exploration for amaranth in North-West India. *Plant Genetic Resources News Letter International Board for Plant Genetic Resources*, FAO, Rome, Italy. 48: 41-52.

Kant R, Kumar V. 2007. Impact of climatic condition on the infestation of major pest of mulberry (*Morus* spp.) in Doon valley. *J Entomol Res Soc* 9(2): 17-30.

Kausik S. K, Naresh J. S. 1989. Sampling for estimation of larval population of *Heleothis armigera* Hubner on chekpea. *Indian J Entomol* 51(1): 39-44.

Meena R. S, Ameta O. P, Meena B. L. 2013. Population dynamics of sucking pests and their correlation with weather parameters in chilli, *Capsicum Annum* L. Crop, The *Bioscan*. 8(1): 177-180.

Meyers R. L. 1998. Nitrogen fertilizer effect on Grain Amaranth. *Agron J* 90: 597-602.

Meyers R. L. 2002. Grain Amaranth: A Lost Crop of the Americas. *Thomas Jefferson Agricultural Institute, Columbia, USA.*

Ghirtlahre S. K, Sahu C. M, Nirala Y. P. S. 2015. A effect of weather parameters on seasonal incidence of sapota leaf webber, *Nnephopteryx eugraphella* ragonot (lepidoptera: pyralidae) in Chhattisgarh plain, *The Bioscan*, 10(3): 1153-1156.

Miyahara Y. 1990. The moths of rice leaf roller, *Cnaphalocrocis medinalis* Guenee and Hawaiian beet webworm, *Hymenia recurvalis* Fabricius, found on Seashore vegetation during the summer autumn, *Proceeding – of – the - Association – for – plant – protection – of - kyushu,* 36: 108-112.

Miyahara Y. 1991. Examination of the over wintering of the Hawaiin beet webworm, *Hymenia re curvalis* fabricius, pupae, *Proceeding-of-the-Association–for-plant-protection-of- kyushu,* 37: 156-159.

Miyahara Y. 1993. Immigration of the Hawaiian beet webworm moth, *Hymenia recurves,* during the Bai-u-season. 2. The arrival of the moths in early June. *Proceeding-of-the- Association –for-plant-protection-of kyushu,* 39: 137-141.

Mposi M. S. 1999. Vegetable Amaranth improvement for South Africa. *The Australian New Crops Newsletter*, 11.

Mureithi D. M, Mworia J. K, Meyhoefer R, Murungi L. K, Turoop L, Komivi S. A, Sunday E, Komi K. Fiaboe M. 2015. Survey for Pest and Natural Enemies of Amaranth and African Nightshades in Kenya and Tanzania, Tropentag, September 16-18, 2015, Berlin, Germany "Management of land use systems for enhanced food security: conflicts, controversies and resolutions".

Navarajan A. V. P. 2007. Insect Pests and their Management. *Indian Agricultural Research Institute, New Delhi, India,* 68.

O'brien Kelly G, Price Martin L. 1983. Amaranth Grain and Vegetable Types, *Echo Technical Note.*

Pande Y. D. 1973. Some observations on the bionomics of *Hymenia recurvalis* F (Lepidoptera: pyralidae), feeding on *Trienthema monogyna* and A*maranthus varidis* in India, *Zeitschrift-fur-Angewandle Entomologae*, 72(4): 362-366.

Patil J. J, Bheemanna A. M, Sreenivas A. G, Naganagoud A. 2013. Seasonal incidence of sucking pests on mulberry correlated with weather parameters. *Annals of Plant Protection Sciences* 21: 261-264.

Pataki E, A Sierra-Padiz, padiz-A sierra, 1975. The functioning of a light trap and its use for the study of some Lepidoptera; *Ciencias*-11 10: -29.

Putnam D. H, Oplinger E. S, Doll J. D, Schulte E. M. 1989. Amaranth. Alternate field crops manual. Univ. Wisconsin Coop. Ext., Minnesota Ext. Serv., Univ. Minnesota, St Paul.

Sinu Palatty Allesh, Mandal Picklu, Banerjee Dipak, Mallick Sadhan, Talukdar Tapan, Pathak Sunil Kumar. 2013. Moth pests collected in light traps of tea plantations in North East India: species composition, seasonality and effect of habitat type, *Current Science*, 104, NO. 5: 10

Shirai Yoichi. 2006. Flight activity, reproduction, and adult nutrition of the beet webworm, *Spoladea recurvalis* (Lepidoptera: Pyralidae). *Applied Entomology of Zoology* 41(3): 405-414.

Singh H, Thomas, T. A. 1978. Grain Amaranths, buckwheat and chenopods *Indian Council of Agriculture research* New Delhi, India, 70.

Suzuki H, Hayashi K, Ashatina S. 1977. Note on the transoceanic insects captured on East China Sea Tropical medicine 19(2): 85-93.

Yamada H, koshihara T. 1976. Development of the Hawaiian beet webworm, *Hymenia recurvalis* (Fabricius) (Lepidoptera: Pyralidae), *Japanese-Journal-of-Applied-Entomology–and– zoology*, 20 (4): 213-214.

Yarger Larry 2008. Amaranth *Grain & Vegetable Types* by G. Kelly O'Brien and Price Martin L.