Biochar Technology from Locally Available Weed Biomass for Acid Soil Management in Sikkim

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Biochar is simply carbon rich charcoal-like substance which is created by heating biomass (organic matter) in limited oxygen condition, through a process known as pyrolysis. It is commonly defined as charred organic matter, deliberately applied to soils to sequester carbon and improve soil physical, chemical and biological properties. Locally available weed biomass which is not economically important and caused crop loss can be used as an important source of biomass for preparation of biochar. Thus, if we prepare biochar from locally available weeds then it is possible to reduce the weed population in the agricultural field which is a serious problem in organic agriculture since use of any chemical herbicide is not permitted.

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ICAR Research Complex for NEH Region, Sikkim Centre, Tadong, Gangtok has utilized six different locally available weed biomass *viz.*, *Ageratum* spp., *Lantana* spp., *Artemisia vulgaris*, *Chromolaena odorata*, *Bidens* spp., *Neyraridia* spp. which were used to prepare biochar. Charring was carried out in a pit ($2\times2\times3$ ft^3) to keep the process simple, quick and low cost having production efficiency 13.2, 23.2, 15.1, 16.4, 14.6 and 19.6%, respectively. The effect of biochar addition of these weeds on the chemical properties of acidic soil such as soil pH was observed to determine the liming potential of biochar. This study was conducted by incubating acidic soil (clay loam) of pH < 5.0 with biochar. The biochar prepared from weeds biomass and dolomite were applied at three rates (0, 2.5, and 5.0 t/ha). Amendment type, application rate, and their interaction had significant effects on soil pH ($p<0.05$). Application of *Lantana* spp. biochar had shown a relatively larger increase in soil pH followed by *Ageratum* spp., *Neyraridia* spp., *Artemisia vulgaris*, *Bidens* spp., *Chromolaena odorata*. These weed spp. can be effectively used as potential source of biochar preparation.

Effect of Biochar on Soil Properties

Biochar guarantees long term benefit for soil fertility and productivity. It can enhance plant growth by improving soil physical characteristics (*i.e.*, bulk density, water holding capacity, infiltration, porosity), soil chemical characteristics (*i.e.*, pH, nutrient retention, nutrient availability), and soil biological properties (*i.e.*, microbial biomass carbon) all contributing to

increased crop productivity. The major quality of biochar that makes it attractive as soil amendment is its highly porous structure which is responsible for improved water retention and increased soil surface area. Biochar application improved the saturated hydraulic conductivity of the top soil. It also increases the water holding capacity in sandy soil. The pores in biochar provide suitable habitat for many microorganisms by protecting them from predation and drying while providing many of their diverse carbon (C), energy and mineral nutrient needs. The intrinsic properties of biochar and its ability to form complex with different soil type can have an impact on soil-plant-microbe interactions.

How can biochar help farmers?

Using locally available materials (*viz.*, weed biomass) for making biochar could provide an unique opportunity to improve soil fertility for longer period of time to the farmers. Biochar should be applied along with other inputs like compost, manure or biopesticides at the same rate every year to realize the actual benefits. Application rates of these organic inputs can be reduced when nutrients are combined with biochar because it also contains some nutrients. During conversion of organic residues into biochar, farmers can also obtain an energy yield by capturing energy given off during biochar production process. In hilly areas like Sikkim soil loss, weathering and degradation occurs at unprecedented rates which causes imbalance in ecosystem properties. Biochar can play a major role in organic agriculture for sustainable soil management by improving existing best management practices, not only by decreasing nutrient loss through leaching by percolating water but also improving soil productivity.

Effect on soil pH

Biochar is alkaline in nature (pH > 7.0). In order to neutralize acidic soils, farmers apply tonnes of lime/dolomite to farm soils at great expense. Biochar have an effect on soil pH. It can react similarly as agricultural lime do (by increasing soil pH). If a soil has low cation exchange capacity, it is not able to retain nutrients and the nutrients are often washed out leaching. Biochar in its pores having large surface area develop some negative charges and thus, provides more negatively charged sites for cations to be retained when added to soil. The negative charge developed on the surface of biochar can easily buffer acidity in the soil (as does organic matter). Due to its highly alkaline nature it has been demonstrated to reduce aluminium toxicity in acid soils.

Application of biochar in soil

Generally farmers apply biochar in their own field only by hand. But due to prolonged contact with airborne biochar particulates, it is not viable on large-scale considering human health. Broadcasting application needs large amount to cover whole field. Suitable method of

application deposits biochar directly into the rhizosphere, and may be viable for perennial cropping systems, and previously established crops. Deep banding of biochar has been successfully implemented in several wheat fields in Western Australia. Mixing of biochar with composts, manures and other organic input may reduce odour, colour and improve nutrient performance over time due to slower leaching rates. Mixtures may be applied for uniform topsoil mixing without incorporation.

Application rates

There is no specific rate of application of biochar in soil. It depends on many factors including type of biomass used, the types and proportions of various nutrients (N, P, K *etc.*), the degree of metal contamination in the biomass, and also climatic and topographic factors of the land. It was found that rates between 5-10 t/ha (0.5-1 kg/m^2) have often been found better. Even low rates of biochar application can significantly increase crop productivity assuming that the biochar is rich in nutrients.

Safety concerns

Application of large amounts of biochar to agricultural soils entails significant practical and technical barriers like safe production and use. The dust of biochar can spontaneously combust and poses a minor risk when handled, stored, or transported in enclosed spaces. Some biochar contain toxic materials that are controlled by “permissible exposure limit” standards in many countries. There is no straightforward permissible exposure limit available for biochar as yet. However, its benefits can be explored on limited basis through pilot trials on farmer’s fields.

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