Biochar for healthy soils

Photo: Elango

Biochar applied to sapota tree

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To enhance the soil carbon content of nutrient poor soils, Tamil Nadu farmers used biochar application on a trial basis. They observed that by applying biochar to soils, the physical structure and chemical properties of the soil improved and the impact remained for three cropping cycles. In this practice, they also found a solution in recycling Prosopis juliflora, which was rapidly invading their fields.

Semi-arid regions are characterized by a climate with insufficient rainfall to sustain agricultural production. Native vegetation is represented by a variety of species, such as grasses and grass-like plants, shrubs and trees. Annual precipitation varies from 200-250 to 500-600 millimetres. Over the last 3 decades, erratic rainfall and relentless invasion of *Prosopis juliflora* (shrub) in the districts of Virudhunagar, Ramanathapuram and Sivagangai has resulted in degradation of cultivable agriculture lands and an increase in fallow land. A drastic reduction in the common traditional grazing grounds has led to a reduction in native livestock population used for agronomic purposes. This has also affected the production and application of farm yard manure (FYM) which was a traditional organic farming practice.

What is biochar?

Biochar is a solid material obtained from the carbonisation of biomass. Biochar may be added to soils with the intention to improve soil functions and to reduce emissions from biomass that would otherwise naturally degrade to greenhouse gases. Biochar also has appreciable carbon sequestration value.

The Organisation of Development Action and Maintenance (ODAM), an NGO working in the area was aware that *Terra Preta*, meaning black earth, in Portugese, and its application to the farming activities could be a better option for enhancing the fertility of nutrient poor soil. Also it was felt that this option could address the issue of rapid invasion of Prosopis juliflora species by converting it into charcoal.

Decades of research in Japan and recent studies in the U.S. have shown that biochar stimulates the activity of a variety of agriculturally important soil microorganisms. The pores in biochar provide a suitable habitat for many microorganisms by protecting them from predation and drying while providing many of their mineral nutrient needs. These studies, experiments and discussions

by the Siemenpuu Foundation representatives prompted ODAM to carry out trials on the application of charcoal as a soil amendment along with different amendments.

Field trials

The field trial was established on the farm site, 8 km northeast of Tiruchuli, near the Biodiesel demonstration unit, established by ODAM. The area is classified as semi-arid with the average annual rainfall between 500 and 600 mm having its seasonal maximum between mid-October and mid-December. The soil might be classified as a weathered oxisol red soil, coarse or medium textured with sandy having poor water and nutrient holding capacity.

Charcoal of *Prosopis juliflora* was purchased from the local charcoal makers for the biochar trials conducted by ODAM. The charcoal pieces were sorted into different grades as per the texture and observing carefully and ensuring that charcoal would be suitable for making char powder. The powdered charcoal was kept in air tight gunny bags insulated with polythene sheets. Otherwise absorption of moisture would affect the quality of the charcoal powder.

Various types of trials were set up. (See Box 1). The pits of 2 x 2 x 1.5 (breadth x width x depth) feet dimension were dug. After digging the pits, top soil was filled up to half the depth of the pit, and then manure was filled in up to 2 to 3 inches. Again top soil was filled for two inches above the manure and manure treated with terra preta soil.

Seed sowing and Plantation

Seeds of bhindi (Lady's-finger), tomato and brinjal were sown in the pits. Four seeds of each species were sown in each pit. During the subsequent rainy days, seeds of tomato and brinjal were washed off from the pit area. The seeds of bhindi germinated and survived. After 15 days, the seedlings of tomato and brinjal borrowed from the neighbouring vegetable farmer were transplanted in the same pits. After transplantation, each pit contained 12 plants altogether (4 each of vegetable species).

Approximately 50 cents was used for all the crops such as red chilli, onion, tomato, lady's finger, brinjal, kidney beans and cluster beans. Apart from these, individual plants of drumstick were also applied with biochar soil amendments.

The fields/plants were watered at frequent and appropriate intervals, manually. Growth of the plants was also observed closely, and the gap filling was carried out during the early stages. Initially, application of raw charcoal powder in the soil caused mortality of seedlings. Later, the charcoal powder was saturated with farmyard manure and de-oiled seed cakes of different non-edible oil seeds by adding water. The mixture was stirred periodically and kept covered with gunny bags for fermentation.

Yield and harvesting

The total yield for bhendi was harvested over a period 3 months but for tomato and brinjal, was completed in less than two months. In charcoal based treatment, the maximum yield was about 4.70 kgs for tomato during peak harvest season, and around 1.4 kgs towards end of the harvest. Bhendi showed maximum yield in the second harvest after with the yield gradually decreased.

Among the non-charcoal soil amendments, the mixture of de-oiled seed cakes of Jatropha and neem yielded maximum harvest of 1.32 kg and 2.5 kg for lady's finger and tomato, respectively. De-oiled seed cake of Jatropha amendment yielded a maximum quantity of brinjal of about 1.15 kg. The average yield of bhendi, tomato and brinjal in the control plots were 338, 100 and 55 gms respectively.

As expected, many of the soil amendments with charcoal powder yielded more vegetables when compared with control plots. This could be attributed to the large surface area available for the storage of nutrients and increased water retention capacity of the soil amendment prepared with charcoal powder.

Box 1: Types of trials and terra preta combinations

1. De-oiled seed cakes of Pongamia, Jatropha, Neem, Silk cotton were made into small pieces and applied to the pits after applying top soil at the bottom of the pit. Again after applying the de-oiled seed cake into the pits, top soil was filled up in the pit.
2. Mixtures of two de-oiled cakes were made in 8 combinations in the ratio of 1:1. E.g. One portion of Jatropha de-oiled seed cake + one portion of Neem de-oiled seed cake. The cakes were made into small pieces and mixed well together. The application process is the same as previous one. In this type of mixture, additionally one more species, *Calophyllum inophyllum* was added.
3. Mixture of four de-oiled cake was made in one combination. All the seeds used in the single combination were used for this amendment.
4. Charcoal of *Prosopis juliflora* of big pieces was also applied as such in one of the pits in the first row.
5. Charcoal granules (small pieces size ranging from 0.5 cm to one cm) collected after sieving the charcoal powder was also applied in one of the pits in the first row.
6. Dry charcoal powder was applied in two pits of the first row.
7. Charcoal saturated with water kept for 15 days before application into the pit.
8. De-oiled seed cakes of neem, silk cotton, Calophyllum and Pongamia were mixed altogether with charcoal powder in the ratio of 1:1:1:1.
9. Jatropha de-oiled seed cake was mixed with 1:2 ratios with charcoal powder and saturated with water. This saturation process was periodically carried out at regular interval of 3 to 4 days for first month and later once in a week in the next month and kept in a closed condition for facilitating to undergo fermentation.
10. Charcoal powder from agriculture wastes such as dried banana leaves, cluster beans, outer shells of Jatropha pods, dust and cones of minor millet, dried palm fruit shells, dried sugarcane straw and sugarcane waste (after extracting the juice) were subjected to make char using a tar drum by pyrolysis method.

Photo: Elango

More pods per plant in biochar applied groundnut plots

The process of saturating the charcoal with de-oiled seed cake of Jatropha using water as medium, exhibited better result than any other soil amendments. In contrast, mixture of de-oiled cake with charcoal powder without undergoing for any saturation processes yielded moderate output. But certain amendments like de-oiled seed cake with charcoal showed poor yield or no yield, particularly for tomato and brinjal. This could be attributed to their accumulation of toxic characters or availability of such de-oiled seed cakes in overdoses.

Further, the saturated biochar soil amendments were applied to various vegetable species such as onion, chilli, kidney beans and moringa, oil seed – ground nut, and fruit species such as Sapota and Amla and jasmine plants. After application of biochar soil amendments, all the species exhibited even growth, increased plant height and formation of more roots than the regular practice of vegetable cultivation with chemical fertilisers and farm yard manures.

When incorporated into soil substrate, biochar and local organic manures altered the soil physical structure (bulk density) and modified the soil chemical properties (pH, CEC and nutrient supply). The impact extended over three cropping cycles.

In the groundnut experimental plot, the structure of the soil was also visibly altered and uprooting plants in the biochar amended soil was much easier than in the case of the non biochar-amended soil. The loss of groundnut pods was greatly reduced due to improved soil condition after the addition of biochar continuously for three times. This could be attributed to the reduced bulk density of the soil and improved soil structure for enhanced water holding capacity. When incorporated into soil substrate, biochar and local organic manures altered the soil physical structure (bulk density) and modified the soil chemical properties (pH, CEC and nutrient supply) and the impact extended over three cropping cycles.

Initially, one of the groundnut farmers nearby to the trial plots was provided the biochar soil amendment to apply in the standing crop of groundnut. He applied the soil amendment during the flowering stage. After the harvest, the farmer himself expressed that the number of pods were more in the biochar applied plants whereas the pods were less in the plants which were not applied with biochar. Another farmer who is involved in jasmine cultivation also encountered similar kind of experience that of groundnut farmer. The jasmine farmer observed that the bigger buds of the jasmine flower in the plants applied with biochar and during the later stages, the size and weight of the matured flowers also increased and fragrance of the flowers was superior to the other flowers. These two factors inspired the farmer to prompt to apply the biochar soil amendment to the remaining crops.

The yield of onion in the plot with the biochar soil amendment was 25% more than the control. The yield of beans showed 30 to 50% increase, and tomato yield increased by 30 to 40% when compared to the yield of control plots. Also, the farmers informed that the size and weight of jasmine flowers increased considerably in the biochar soil amendment applied plots.

Farmers spread biochar application

Based on the results, farmers were invited to observe the yield in the trial plots. Since the water holding capacity of the red loam soil is very poor in the semi-arid region, the farmers were asked themselves to compare the water holding capacity of black and red soil. They were able to understand that if the charcoal is buried in the red soil it would act like black soil in retaining water in the top soil.

After seeing the results, they came forward to adopt the trials on their lands. Fifty farmers from 10 villages were selected based on the following criteria – family farmers, own lands with red loamy soil, have access to irrigation, growing vegetables, interested in organic methods of farming and stay closer to the area where charcoal was available.

Samples of biochar soil amendments were provided to apply in their own lands during cultivation of vegetables and flowers. Among those 50 farmers, 26 farmers were provided with 10 kgs of biochar soil amendment samples to the farmers to apply in 2 sq. meters of trial plots in their land. Among these 26, 3 farmers are involved in jasmine cultivation and the remaining are vegetable cultivators. These farmers also experienced better results after application of biochar soil amendments in their fields.

Future spread

If the progressive or innovative farmers are encouraged to apply the biochar to other crops and share the results with other farmers, this new technique will spread among other farmers. However, cost effective method of preparation of biochar soil amendments will go a long way in adopting the practice, especially by the small farmers. Process of forming organic farmers' associations is in progress. Participatory learning process, like the Farmer Field Schools are being used to promote the biochar application.

Biochar application during land preparation

Photo: Elango

Acknowledgements

We thank Siemenpuu Foundation, Finland for financial support and encouragement for conducting biochar based field trials. Also, special thanks to local farmers for their support and for conducting trials on their field.

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