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POTENTIAL OF BIOCHAR AND COMPOST IN SOIL AMENDMENT FOR ENHANCING CROP YIELD

G. KALYANI[a*], H. JOGA RAO[b], Y. PRASANNA KUMAR[c] and P. KING[d]

[a,b]Department of Chemical Engineering, GMR Institute of Technology, RAJAM – 532127, Dist.: Srikakulam (A.P.) INDIA
[c]SVP College of Engineering, VISAKHAPATNAM (A.P.) INDIA
[d]Department of Chemical Engineering, AU college of Engineering, VISAKHAPATNAM (A.P.) INDIA

ABSTRACT

Biochar is presently being highly researched and promoted for its significant potential to improve soil properties, crop productivity and capability of carbon sequestration in soil. In this study, a novel drum pyrolysis technique was fabricated for the preparation of this bio fertilizer. Here, drum pyrolysis (slow) is used to convert cotton farm waste biomass into char at the temperature about 300-450°C. No air or oxygen is intentionally admitted in this process. Different carboxylic groups were observed by Fourier transform infrared spectroscopy (FTIR) then the different physical and chemical characteristics of soil, compost and biochar were determined by different specific analyses. After the analysis, seeds like beans, fenugreek and mint leaves are ready to sowed in such a way that only soil is present in one pot, soil and biochar mixture is in second pot, soil and compost mixture is in third and at last soil, compost and biochar mixture is present in the fourth pot. The main objective of this project to show effectiveness of the biochar and to compare those results with normal soil and also to prove the yield with biochar and compost mixture is more beneficial.

Key words: Amendment, Crop residue, Biochar, Carbon sequestration, Black soil, Drum pyrolysis.

INTRODUCTION

Soil amendment

A soil amendment is any material added to a soil to improve its physical properties, such as water retention, permeability, water infiltration, drainage, aeration and structure. The goal is to provide better environment for roots purpose of yield. To do its work, an organic amendment must be thoroughly mixed into soil. Factors to consider when choosing an

*Author for correspondence; E-mail: kalyani.gaddam@gmail.com

amendment: How long the amendment will last in the soil, soil texture, soil salinity and plant sensitivities to salts, and salt content and pH of the amendment.

Biochar and compost

Biochar is a name of charcoal when used for particular purposes especially in soil amendment. It is a fine-grained, carbon-rich, porous product remaining after plant biomass has been subjected to thermo-chemical conversion process (pyrolysis) at low temperature (~300-450°C) in an environment with little or no oxygen. Biochar is not a pure carbon, but rather mix of carbon (C), hydrogen (H), oxygen (O), nitrogen (N), sulphur (S) and ash in different proportions. The central quality of biochar and char that makes it attractive as a soil amendment is its highly porous structure, potentially responsible for improved water retention and increased soil surface area. Compost is a key ingredient in organic farming. It is a single most important supplement to the soil, simple way to add nutrient-rich humus, which fuels plant growth and restores vitality to depleted soil. It's also free, easy to make and good for the environment.

EXPERIMENTAL

Materials and methods

Materials

The specific materials used in this experiment were soil, stalks and compost. Surface samples of soil (0-10 cm) were collected in a randomised formation, from a barren area of 20 m^2 with in Ponduru mandal at Srikakulam district in Andhra Pradesh. This soil was dried for 1 week and transported to soil test laboratory in Amadalavalasa at Srikakulam District. At the simplest level, the process of composting simply wetted organic matter known as green waste (leaves, food waste, stalks, dung etc. wastes were used) and waiting for the materials to break down into humus after a period of weeks. The cotton stalks was collected in and around Rajam in Srikakulam district.

Biochar preparation

Pyrolysis is conducted without combustion and the temperature was maintained approximately at 300-400^{o}C. In this present study used the method Drum pyrolysis for the preparation of Biochar using Kilns that are built in place, typically are constructed from soil or other local materials, are located close to biomass resources and are small. In a modified method, char production is done by pyrolysis kiln. A cylindrical metal oil drum (200 L capacity) with both sides intact was procured from local market and was modified for use as charring kiln. A square shaped hole of 16 cm x 16 cm was made on the centre of top side of the drum for loading the crop residues. On the opposite side (bottom) of the oil drum, a total of 36 holes each measuring 4 cm^2 were made in concentric circles with a 5 cm^2 at the center covering 20% of the total surface area of the bottom portion of the oil drum to facilitate uniform circulation of air from below. Another metal sheet measuring 20 cm x 20 cm was made ready to cover the top square hole at the end of burning process to stop the circulation of air. Sufficient amount of clay soil was collected for sealing purpose. The details of the study and major findings are presented below loading the charring kiln: After loading the cotton stalks, Heap method of biochar preparation was happened. Before initiating the burning process, the loaded kiln was placed on three stones (about 15 cm height) to facilitate air flow through the holes at the bottom.

The stalks were ignited through the bottom holes. After the reduction in thickness of smoke, the metal sheet was placed partially on the top hole of the kiln to slow down the flow of air into the drum. This was to reduce the flow of oxygen so that the stalks were not burnt to ashes. Whenever the amount of smoke increased, the cover was opened to allow more air flow. The maize stalks were subjected to three different periods of partial combustion viz. 13, 15 and 16 min. The kiln was allowed to burn until the fire became clear and produced a very thin blue smoke. At this stage, the kiln was ready to be sealed with clay. The metal sheet was placed over the top hole. Later, the kiln was transferred to a leveled surface. Clay was used to seal the bottom edges of the drum and also along the edges of the metal sheet used for covering the top hole. It was ensured that no smoke was escaping from the drum. The drum was left for cooling. After cooling, the sealed clay was removed and the biochar was taken out from the kiln and weighed. Biochar preparation was ready.

The drum is filled with agricultural residues with not too tight packing and the drum is closed from the top with a metal lid having provision for escape of syngas. Heating is provided by wood log externally at the bottom of the drum until the desired temperature (300-400^{o}C) increased.

Fig. 1: Biochar obtained after drum pyrolysis

Chemical characterization

Biochar does not settle from suspension, pH of the biochar samples was determined by about 200 mg of biochar was mixed with 1.25 mL of double distilled water. The pH was recorded with the probe submerged in the paste (Ultra basic pH meter, Denver Instruments). To examine the stability of biochar pH in solution, pH was measured initially, and then after successive 1 hr equilibrium periods. Other samples were treated with either NaOH or HCl to attain a range of pH from 3 to 9, followed by pH determinations over time. Electrical conductivity of the sample determined by using electrical conductivity meter. For measuring this taken the sample as 1:2 ratio sample water suspension by using conductivity bridge. Nitrogen in soil determined by using Kjheldhal Digestion Unit. The available phosphorous present in the soil is determined by (Olsen's method). Potassium is the most critical essential element in influencing plant growth and production throughout the world, and is determined by flame photometer. Concentration of micro nutrients like Zn, Mn by preparing samples with defined solutions and measured the absorbance in AAS (atomic absorption spectroscopy) then measured the concentrations.

Method of application

To establish potential of biochar produced from cotton farm based waste biomass and compost from dung to utilize as a fertilizer in improving soil health for enhancing the crop (Beans, fenugreek and mint leaves) yield. First, we had taken four pots type tins of same volume. In first Pot, we had taken soil only, in second soil and compost, in the third pot soil and biochar had taken and at last soil, biochar and compost had taken in the fourth pot and we planted the crops and maintained requirement like temperature and water. We have done this experiment for beans, fenugreek, and mint plant for 25 days.

Fig. 2: Experimental set up of beans plants growth treatments

Fig. 3: Experimental set up of mint plants growth treatments

Fig. 3: Experimental set up of fenugreek plants growth treatments

RESULTS AND DISCUSSION

Physical and chemical property characterization of soil, biochar and compost

From the results obtained, we observed that we got biochar of good pH, specific gravity and carbon content and surface functional groups for any soil amendment.

Table 1:

Physical properties	Texture	Color	Specific gravity
Soil	Low density	Black	2.54
Biochar	Low density	Black	2
Compost	Low density	Black	2.54

Table 2:

Chemical roperties	Soil	Biochar	Compost
pH	7.15	9.14	10
Electrical conductivity	0.14	0.33	0.2
Carbon	12%	36%	18%
Phosphorous	16	14	20
Potassium	90	21	115
Nitrogen	0.3	0.18	0.63
Zn	1.96 ppm	2.3 ppm	3.42 ppm
Mn	10.52 ppm	8.1 ppm	18.92 ppm

FTIR results for biochar

The FT-IR spectrum presented a broad envelope between 4000 cm^{-1} and 500 cm^{-1} with sharper bands superimposed on it. The presence of the following functions could explain the intensity at different wave numbers. The sharp and intense aromatic ring modes (1700-1500 cm^{-1}) showed the presence of unsaturation such as benzene rings. A search for the out-of-plane C-H bending vibration turns up a band at 798 cm^{-1} accompanied by a ring-bending at 697 cm^{-1}.

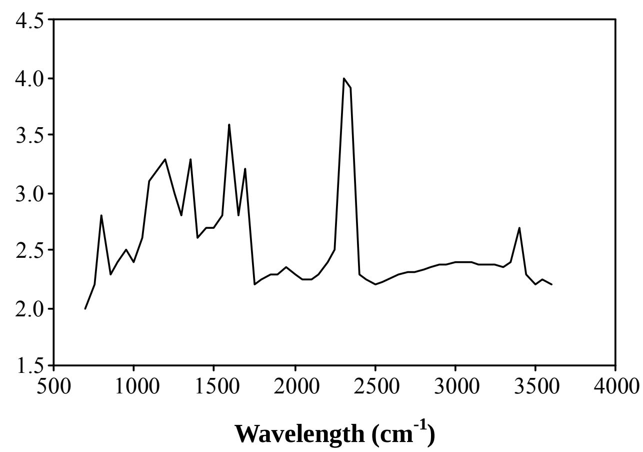

Fig. 4: FTIR graph for Biochar

The presence of C=O stretching vibrations (1800-1600 cm^{-1}) indicated the carboxylic groups and chelated ketones. A search for the C-O stretching vibration (1300-

1000 cm^{-1}) indicated two small bands at 1220 cm^{-1} and 1092 cm^{-1}. These bands could be attributed to saturated and asymmetric branched ethers (1210-1070 cm^{-1}). The vibrations between 1400 and 1250 cm^{-1} could correspond to the O-H in phenols and carboxylic acids (1361 cm^{-1}). Due to these carboxylic groups in the biochar, it can retain the nutrients and toxic metals.

Comparison of growth heights of plants

Effect of biochar and compost on bean plant height

Graph is drawn between height of plants (cm) with different composition as first pot have only soil, second pot have soil and compost, third pot have soil and biochar and fourth pot consist of soil, biochar and compost.

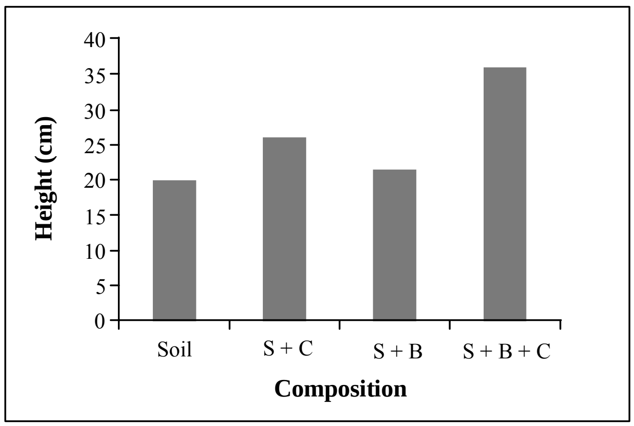

Fig. 5: Effect of biochar and compost on bean plant height

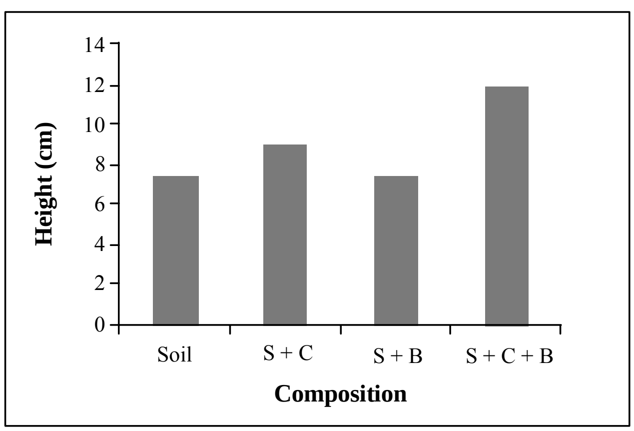

Fig. 6: Effect of biochar and compost on fenugreek plant height

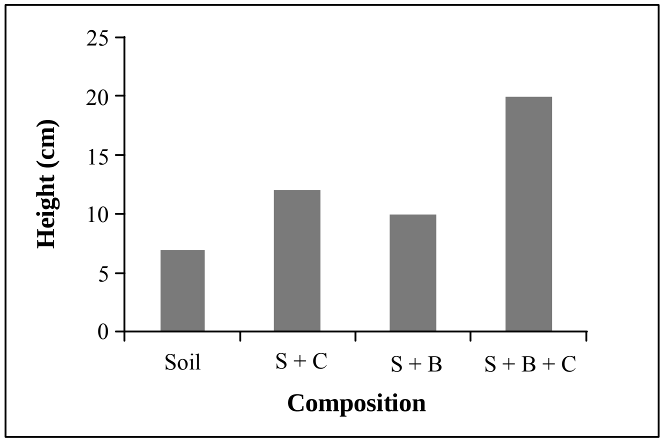

Fig. 7: Effect of biochar and compost on mint plant height

We have measured the heights of plants heights and we have taken average height of each pot and plotted against number pot. Our graph results shows that plants of fourth pot have height but plants of third pot having soil and biochar grown slowly compared to plant of second pot having soil andcompost. Plants of first pot having soil only grown slowly compared all remaining pots. Similarly, we plotted graphs for fenugreek and mint plants.

Comparison of number leaves of plants

We have compared the growth of plants by comparing number of leaves of plants for time interval of five days. For this comparison, we counted the no of leaves of each plant in each pot and we calculated the average number of leaves of each pot for every five days and plotted against number of days.

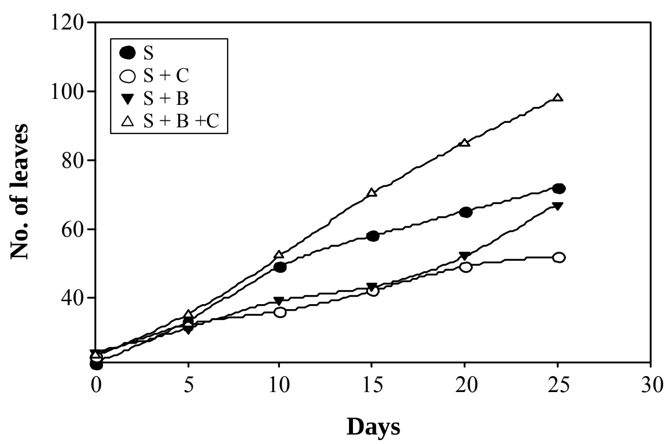

Fig. 8: Effect of biochar and compost on number of leaves of mint plant

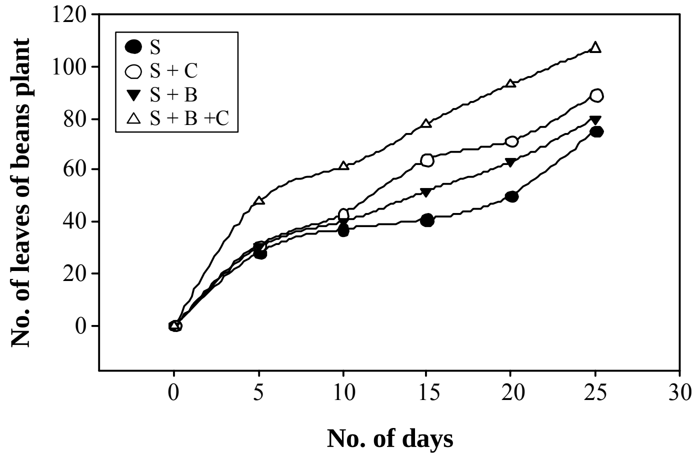

Fig. 9: Effect of biochar and compost on number of leaves of beans plant

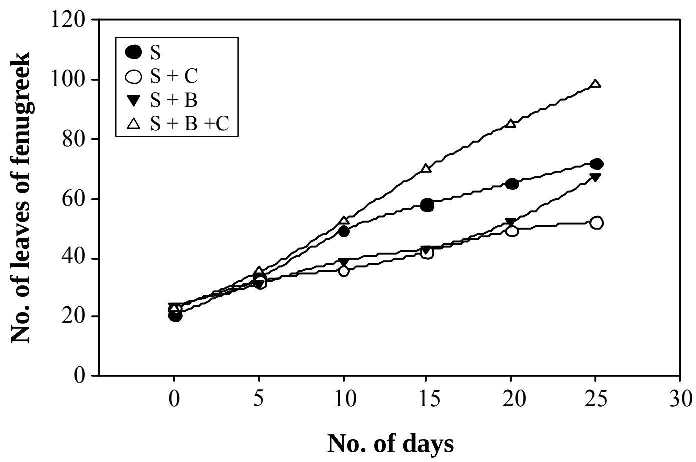

Fig. 10: Effect of biochar and compost on number of leaves of fenugreek plant

Results of this comparison shows that plants of fourth pot having biochar, compost amended soil have more no of leaves but plants of third pot having soil and biochar have less number of leaves compared to plants of pot contain soil and compost. Plants of first pot contain soil only have lowest numbers of leaves. We plotted the results for beans, fenugreek and mint plants.

Comparison of yield of plants

Crop yield = (Amount of harvested product)/(Crop area), crop area is normally expressed in grams per millimeter square.

The estimation of crop yield thus involves both estimation of the crop area and estimation of the quantity of product obtained from that area. So, we measured the diameter of each pot and then calculated the area of each pot. After twenty five days of planting we plucked the plants of each pot and weighed the obtained biomass of each pot and calculated the crop yield of each plot separately. Finally, we plotted the yield against the numbers pots. Results of these plots shows that amending soil with biochar and compost gives more crop yield. Crop yields of all the pots are given in bellow tables. We tabulated the values and plotted the results for beans, fenugreek and mint plants.

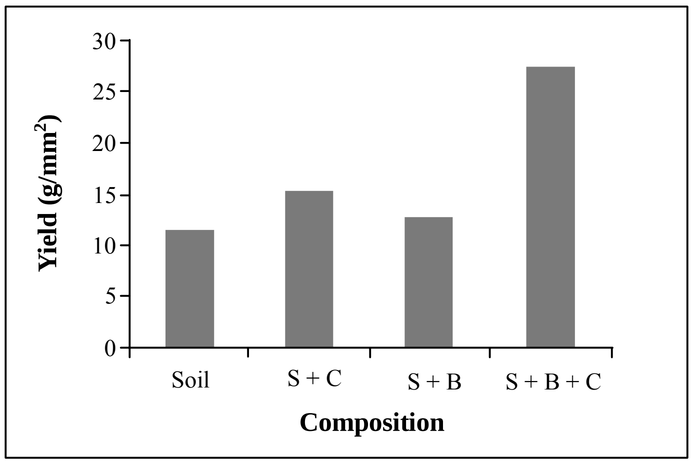

Fig. 11: Effect of biochar and compost on yield of beans plants

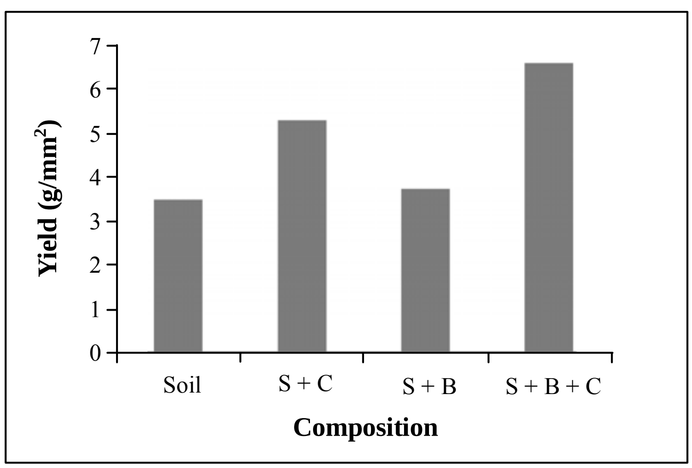

Fig. 12: Effect of biochar and compost on yield of fenugreek plants

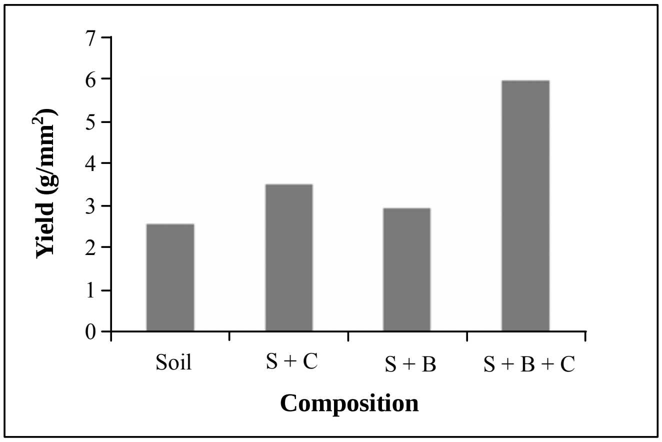

Fig. 13: Effect of biochar and compost on yield of fenugreek plants

CONCLUSION

The results reported herein from our bath experimentation on plant growth by amending soil with biochar derived from cotton stalks by slow drum pyrolysis promoted our biochar as a good soil amendment. Results from our experiment on plant growth by amending and soil with biochar and compost shows good increase in yield of beans, fenugreek and mint plants. And also shows that biomass and height of plants increase by amending soil with biochar and compost. Our results of crop yield shows that amending soil with biochar and compost gives good results but amending soil with biochar only is not good than amending soil with compost alone and soil only.

Our quantitative and qualitative results of yield calculations for study of twenty five days shows that yield of beans is 27.37 g/mm^2, which is 42% greater than yield from soil alone, similarly for fenugreek yield is 6.6 g/mm^2, which is 53% greater than yield from soil alone and for mint yield is 6 g/mm^2, which is 43% greater than yield from soil alone. Height of beans, fenugreek and mint, respectively is 36 cm, 12 cm and 20 cm and these are 55%, 62% and 35%, respectively greater than height of plants planted in soil alone.

All these good results of yield, height and biomass is due to good physical and chemical properties density, surface functional groups, pH, water holding capacity and N, C contents of biochar and compost. FTIR graph results shows that on the surface of biochar different carboxylic groups like C-O and C=O and O-H are there so there is a great tendency to adsorb nutrients and heavy metals. Due to these surface functional groups, it can exchange cations like nutrients. Our results shows that biochar have high water holding capacity so that it can retain water for longer time, which good for plant growth.

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