Comparative study of the effect of biochar, compost and their combination on plant growth and soil fertility

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Abstract: Soil properties can be significantly influenced by addition of biochar and is a subject matter to enhance plant productivity and soil quality. Biochar is nowadays largely used as a soil amendment and is commercialized worldwide. Biochar is a carbon-rich product defined as "a solid material obtained from the thermo-chemical conversion of biomass in an oxygen limited environment". The use of organic wastes in agriculture plays a great role in recycling essential plant nutrients, sustaining soil security as well as protecting the environment from unwanted hazards. Compost is rich in nutrients, humic matter, and microorganisms; it may be added to agricultural soil as a fertilizer to improve soil fertility and promote the growth of crops and microorganisms. This research work determines the potential role of biochar, compost and their mixture ratios with respect to plant response and soil fertility. For the experiment the soil sample used was collected from the site of textile industry located in Bhiwandi. The growth characteristics of *Trigonella foenum-graecum* were assessed. The main objective of this paper is to show effectiveness of the biochar and compost and to compare those results with plant grown in normal soil.

***Index Terms* - biochar, compost, plant growth**.

I. INTRODUCTION

Soil fertility degradation, caused by erosion and depletion or imbalance of organic matter/nutrients, is affecting world agricultural productivity (Foley et al, 2005). Inorganic fertilizers have played a significant role in increasing crop production since the 'green revolution'; however, they are not a sustainable solution for maintenance of crop yields (Liu et al, 2010; Vanlauwe et al, 2010). Long-term overuse of mineral fertilizers may accelerate soil acidification, affecting both the soil biota and biogeochemical processes, thus posing an environmental risk and decreasing crop production (Aciego and Brookes, 2008). Inorganic fertilizers have played a significant role in increasing crop production since the 'green revolution'; however, they are not a sustainable solution for maintenance of crop yields. Long-term overuse of mineral fertilizers may accelerate soil acidification, affecting both the soil biota and biogeochemical processes, thus posing an environmental risk and decreasing crop production. Intensive agriculture leads to soil nutrient loss which has negative effects on crop productivity resulting in insufficient food production to feed the rising global population. To achieve global sufficiency in response of the rising food, feed and fibre requirements, there is increase in agrochemical inputs including chemical fertilizers in crop production 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.

1.2. 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 root purpose of yield. To do its work, an organic amendment must be thoroughly mixed into soil. Factors to consider when choosing an 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.

1.3. Biochar and Compost

Biochar and Compost, used for the remediation of soil, are seen as attractive waste management options for the increasing volume of organic wastes being produced. The interaction of biochar and composting affect each other's properties. Biochar can be produced from a range of feedstock, including forest and agriculture residues, such as straw, nut shells, rice hulls, wood chips/pellets, tree bark, and switch grass (Sohi et al, 2009, 2010). Biochar could change the physicochemical properties, microorganisms, degradation, humification and gas emission of composting, such as the increase of nutrients, cation exchange capacity (CEC), organic matter and microbial activities. Biochar has been described as a possible tool for soil fertility improvement, potential toxic element adsorption, and climate change mitigation (Ennis et al, 2012; Malghani et al, 2013; and Stewart et al, 2013). Several studies have shown that biochar application to soil can (i) improve soil physical and chemical properties (Mukherji and Lal 2013), (ii) enhance plant nutrient availability and correlated growth and yield (Biederman and Stanley 2013; Jeffery et al, 2011), (iii) increase microbial population and activities (Jaafar et al, 2014; Quilliam et al, 2013; Lehmann et al, 2011) and (iv) reduce greenhouse gas emissions through Carbon sequestration (Crombie et al, 2015). The composting could also change the physico-chemical properties and facial functional groups of biochar, such as the improvement of nutrients, CEC, functional groups and organic matter. These changes would potentially improve the efficiency of the biochar and composting for soil amendment and pollution remediation. This study investigated the effects of biochar and compost applied alone or in combination on some soil to determine its physiochemical properties and growth characteristics of *Trigonella foenum-graecum*. The main objective of this project is to show effectiveness of the biochar and compost and to compare those results with plant grown in normal soil.

II. Materials and Methods

2.1 Soil, Biochar and Compost

The soil was collected from the site of textile industry located in Bhiwandi and was sieved. Biochar used was a commercial charcoal (provided by Greenfield Eco Solution Pvt. Ltd Jodhpur, India) produced by *Prosopis juliflora* was converted in to powdered form and the Compost used prepared at home from vegetable and fruit waste was used.

2.2 Physiochemical properties

The physiochemical properties of soil, biochar, compost such as alkalinity, water holding capacity, moisture content and pH are determined.

2.3 Experimental Set Up

The experiment was carried out in the laboratory. Fresh seeds of *Trigonella foenum-graecum* were placed in the petriplates containing four different substrates (i) unamended soil (US) (ii) unamended soil+biochar (US+B) (iii) unamended soil + compost (US+C) and (iv) unamended soil + biochar + compost (US+B+C). The 3 different concentrations of each substrate were taken in 5%, 10% and 15%.

2.4 Plant Analysis

Plant morphological analyses were performed weekly by measuring the main plant growth parameters: Root Length (RL) and Shoot Length (SL) and the results were then tabulated and compared.

III. OBSERVATION AND RESULT

Table 1: Physiochemical characteristics of Biochar, Compost and Soil.

Physiochemical characteristics of Biochar, Compost and Soil Sample									
Parameters	Samples								
	Soil			Biochar			Compost		
	AVG	STDEV	MEAN ± STD ERRO	AVG	STDEV	MEAN ± STD ERRO	AVG	STDEV	MEAN ± STD ERRO
pH	7.1666	0.28867	7.16 ±0.2	7.1666	0.28867	7.16 ± 0.28	8.O33 3	0.0577	8.3 ±0.05
Moisture content (%)	4.17366	0.66397	4.17 ±0.6	5.03333	0.237557	5.03 ± 0.23	78.600	2.0	78.6 ±2.0
Water holding capacity (%)	41	1.00	41 ±1.0	34.3333	1.52752	34.3 ± 1.52	55.6666	2.081665	55.6 ±2.08
Alkalinity (mg/l)	67.3333	3.0550	67.3 ±5.05	94.3333	6.65832	94.3±6 .6	116.333	5.507570	116.3 ±5.5

Table 2: Effect of different concentrations of Biochar, Compost and their Combinations on soil

Effect of different concentrations of biochar, compost and their combination on plant growth						
Combinations	Concentrations					
	10% Concentration		15% Concentration		20% Concentration	
	Root length(cm)	Shoot length(cm)	Root length(cm)	Shoot length(cm)	Root length(cm)	Shoot length(cm)
US+B (avg)	5.42	3.76	2.16	2.66	3.02	3.03
US+C (avg)	7.04	6.36	5.76	5.16	4.78	6.10

US+B+C (avg)	6.32	5.78	4.43	4.23	4.03	4.02
Control (avg)	2.4	1.80	2.00	1.20	1.80	2.04

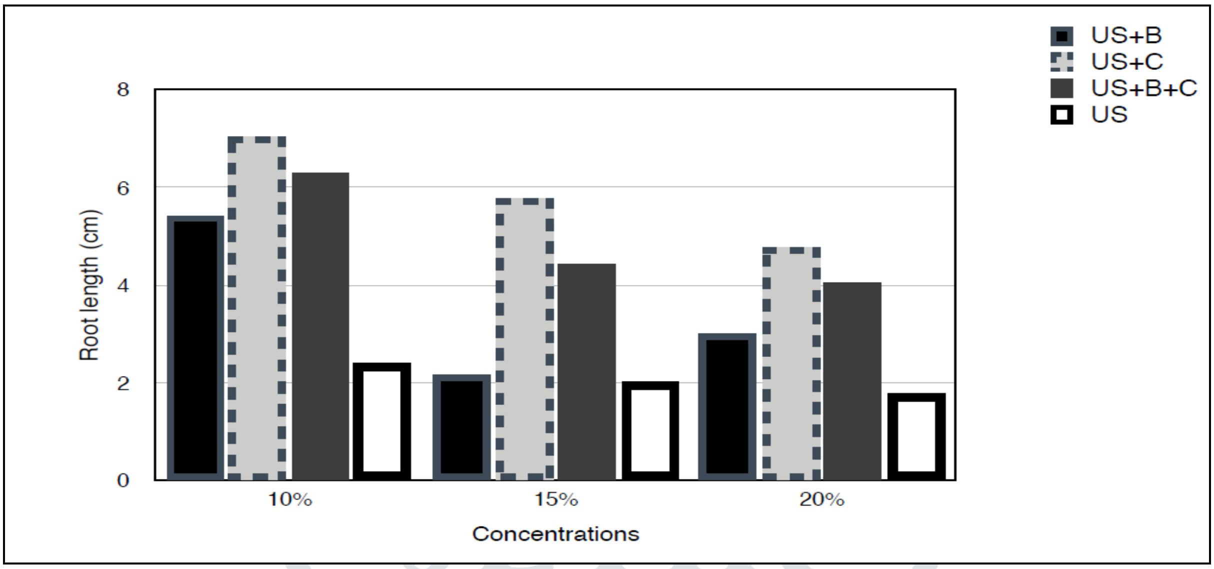

Figure 1: Effect of different concentrations of biochar, compost and their combination on root length.

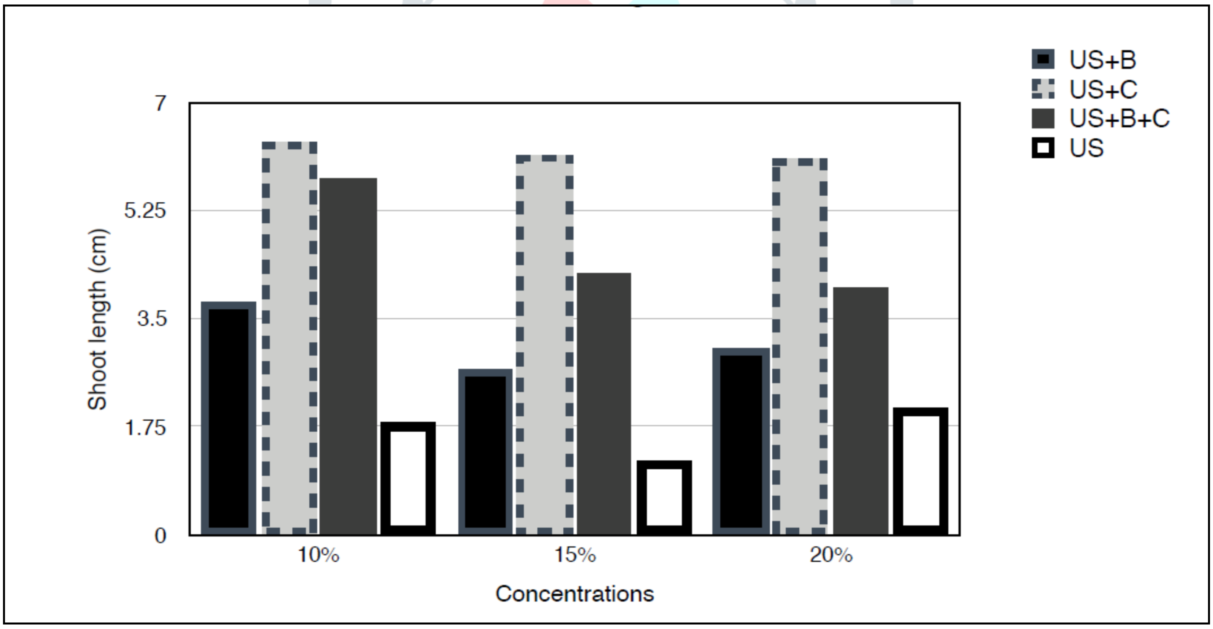

Figure 2: Effect of different concentrations of biochar, compost and their combination on shoot length.

IV. DISCUSSION

4.1 Biochar, Compost and soil characteristics

Biochar, compost and soil characteristics are summarized in Table 1. The growth of soil micro flora is controlled by soil pH. The abundance of soil microbes increases with higher pH up to 8.2. pH value of soil, Biochar and compost was in the alkaline range. The compost showed pH 8.3 which is optimal for propagation of soil microbes. The observation indicates that addition of Biochar and compost to soil may result in the significant increase in soil pH.

Soil moisture influences crop growth not only by affecting nutrient availability, but also nutrient transformation and soil biological behaviour. The maximum moisture content was found to be of compost followed by Biochar and then unamended soil.

Water holding capacity is the total amount of water a soil can hold at field capacity. A healthy soil is able to hold moisture long enough to sustain a plant between rainfalls and throughout dry periods. Compost showed the highest water holding capacity while Biochar and unamended soil showed lower water holding capacity.

Alkalinity- Soil alkalinity is caused due to presence of basic cations. The alkaline level plays a crucial role in growth of plants. The alkalinity of compost was maximum followed by Biochar and unamended soil.

4.2 Plant Growth

The effect of three different concentrations of Biochar, compost and their combinations on root length is represented in Fig. 1. For 10% concentration the maximum growth of root length obtained was in US+C followed by US+B+C and US+B. Similarly, for 15% and 20% concentration the results were as follows: US+C > US+B+C > US+B.

The effect of three different concentrations of biochar, compost and their combination on shoot length is represented in Fig. 2. For 10% concentration US+C shows the maximum growth of shoot length followed by US+B+C and US+B then similar results were obtained for 15 % and 20%.

Among the three different concentrations (10%, 15% and 20%) of Biochar, compost and their combination, 10% gave the best results.

The study showed that both biochar amendment and compost addition to a soil poor in nutrients induced a positive effect on plant growth. US+C showed the best growth results. The US+B+C combination also showed good germination results after the US+C combination. Thus whenever there is less or no availability of compost, Biochar can be used as an alternative amendment to the soil.

V. CONCLUSION

Significant differences in growth parameters were recorded between treatments. The study showed that both biochar amendment and compost addition to a soil poor in nutrients induced a positive effect on plant growth and physiology and on soil chemical and microbiological characteristics. The compost alone showed the best clear and positive effects on plant growth. The combination of biochar and compost amendment to the soil showed great positive effect on plant growth. No synergic or positive effects exerted by biochar was observed here compared to the compost alone treatment. The biochar, compost and soil physiochemical characteristics such as pH, alkalinity, moisture content and water holding capacity were also determined. The pH of all three is alkaline and the maximum water holding capacity and moisture content is of the compost. As three different concentrations of soil amendment were used i.e. 10%, 15% and 20% of biochar, compost and their combination that were mixed thoroughly in the soil and the plant growth response was observed, the maximum and the positive effect was seen in the 10% concentration range. The plant *Trigonella foenum-graecum* showed maximum root length and shoot length in the soil containing 10% compost, followed by biochar and compost combination and then the biochar alone.

VI. REFERENCES

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