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EVALUATION OF BIOCHAR AS FERTILIZER FOR THE GROWTH OF SOME SEASONAL VEGETABLES

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ABSTRACT

Biochar was used to replace inorganic fertilizers. Biochar was synthesized by the process of pyrolysis using horse dung (5kg) and dry grass (25kg) to check its effect on the growth of some local vegetables i.e. okra, beans, coriander and mint. These plants were kept in three different environments i.e. outdoor, indoor and greenhouse conditions. In each condition three replications were made for each plant and biochar was applied on them. Control plants (without biochar) were also grown in each condition. Parameters studied were pH, water holding capacity, ammonia, nitrates, chlorophyll content, fertility analysis, temperature and humidity, number of leaves, plant height and length of leaves. It was found that biochar showed positive result in growth of plants. Thus, it can be used as fertilizer.

Keywords: Biochar, Organic fertilizer, Plant growth, Soil analysis.

INTRODUCTION

Plants require fertilizers for their growth which can be organic or inorganic. Inorganic fertilizers are a threat to the environment while organic fertilizers are environmentally friendly (Schnug *et al.,* 1996). Biochar is also an organic fertilizer, it is a form of charcoal which contains high amounts of carbon and is synthesized by the process of pyrolysis (Pessenda *et al.,* 2001) by using raw materials, for example poultry litter (Koutcheiko *et al.,* 2007), biomass (Kwapinski *et al.,* 2010), corn stover (Brewer *et al.,* 2009), switch grass (Brewer *et al.,* 2009), hardwood (Brewer *et al.,* 2009), citrus wood (Graber *et al.,* 2010) and other organic components. It is a more stable form of carbon and is not easy to break into components. Due to this reason, it has the ability to remain in soil for hundreds of years (Schmidt *et al.,* 2002). The positive effects of biochar are due to the chemicals and nutrients present in it and also because of its absorption capacity and the ability to retain nutrients (Hammes and Schmidt, 2009; Lehmann *et al.,* 2011). It also increases the soil organic matter (SOM) value of the soil which is helpful for the plants (Verheijen *et al.,* 2009). Besides this, it also adjusts the pH of the soil to neutral or basic pH which increases the cation exchange capacity level and is beneficial for the growth of the plants (Verheijen *et al.,* 2009). Biochar is also cheaper than other fertilizers. Thus, biochar can be more helpful to plants as compared to inorganic fertilizers. The main objectives for conducting this study are to check whether horse dung and dried grass can be used as raw materials for biochar and to evaluate the

impact of biochar on plant growth in different environmental conditions.

MATERIAL AND METHODS

The study was conducted in BRC (Bioresource Research Centre). On the basis of sowing season, plants of Okra, mint, coriander and beans were selected to assess the affectivity of biochar. Biochar was synthesized by the process of pyrolysis by using dried grass (20kg) and horse dung (5kg) in large sealed container at 300°C for 20-25 minutes. Then percentage yield of biochar was analyzed. Each plant was grown in triplicate and under three different growth condition *viz* indoor, outdoor and green house. Control plants were also grown i.e. without application of biochar. The study was conducted from March, 2013 – April, 2014. The soil with no added fertilizer was mixed with biochar at 3:1 ratio. The sowing land was prepared and each type of seeds were sown. Plants were watered appropriately. Then the soil with and without biochar was analyzed for pH, fertility, water holding capacity. Nitrogen content (ammonia and nitrates) was also analyzed by using electric probe YSI proplus HydroLab. Beside this temperature and humidity was also noted. The plant growth was monitored and evaluated on the basis of following parameters: height of plant, no. of leaves, chlorophyll content and overall growth of plant. Readings for each parameter were taken after every week. Chlorophyll a and b of plant grown in soil with and without biochar was determined by method described by Hiscox and Israelsham (1979). The data obtained was analyzed by using different statistical test using Microsoft Excel. Single factor ANOVA was used to compare the treatments.

RESULTS

The biochar was synthesized by using dried grasses (20kg) and horse dung (5kg) through the process of pyrolysis at 600°C for 20-25 minutes. As result average percentage yield of biochar obtained was 23.1±1.4.

Data for temperature and humidity was noted on weekly basis by using a temperature and humidity analyzing device. As a result of temperature data, it was concluded that temperature is approximately 4 degrees higher in outdoor condition while it was 29 ^{o}C both in greenhouse as well as indoor. However the statistical analysis by ANOVA revealed that there is no significant difference (P-value = 0.092794) between the temperatures of three conditions *viz* indoor, outdoor and greenhouse. Readings for humidity were also taken and it was recorded that humidity was higher (30.2%) in outdoor environment compared to greenhouse (29.5%) and indoor (26.7%). ANOVA shown that there is no significant difference (P-value = 0.868551) between the humidity (%) of three conditions *viz* indoor, outdoor and greenhouse (Table 1).

Table 1: The average temperature (°C) and humidity (%) of outdoor, greenhouse and indoor recorded during the course of experiment.

Condition	Temperature °C	Humidity %
Outdoor	33.4±5.04	30.2±15.3
Greenhouse	29.3±28	29.5±13.2
Indoor	29.8±3.4	26.7±12.9

WHC was also analyzed of soil with and without biochar. Results showed that soil with biochar have more water holding capacity as compared to soil without

biochar. ANOVA showed a significant difference between water holding capacity of soil with biochar and without biochar (P-value = 0.02203) in all growth conditions (Table 2). The nitrogen content of soil is also indicator of its fertility. We estimated the nitrates, nitrites and ammonia in ppm by using YSI probe plus and as a result significant difference (P-value = 2.16×10^{-08}) was observed between the NO_3 of soil with biochar and without biochar which was calculated by ANOVA. Similarly NO_2 in soil with biochar and without biochar exhibited significant difference with P-value = 0.000103 at α of 0.05. No difference in values of NH_3 was observed (Table 3).

Table 2: The percentage water holding capacity of soil with biochar and soil without biochar placed at different growth environments.

Water Holding Capacity (%)		
	WB	**WOB**
Outdoor	51.33±3.21	36.00±6.56
Greenhouse	41.33±1.53	35.33±5.51
Indoor	43.67±5.03	36.00±3.61

WB, with biochar; WOB, without biochar.
Each value is average of at least three replications ± SD

Table 3: The average readings of nitrogen content of soil with biochar, soil without biochar and biochar used in the study.

Treatments	NO_3(ppm)	NO_2(ppm)	NH_3(ppm)
WB	7.00±0.11	0.20±0.00	0.01±0.01
WOB	4.30±0.10	0.47±0.06	0.02±0.02
Biochar	9.70±0.2	0.80±0.1	0.00±0.0
	0	0	1

WB, with biochar; WOB, without biochar.

pH is also important factor for plant growth. We also analyzed the pH of the soil with and without biochar and found that the soil with biochar has pH 6.5 while soil without biochar has pH 6. The fertility was also analyzed and it was found to fall in the low range of the meter.

Plant height is an important factor to analyze growth and health of plants. Plants of okra grown in soil with biochar are higher than plants grown in soil without biochar in outdoor as well as greenhouse condition (Figure 1). The heights of beans were the same in outdoor and greenhouse in soil with and without biochar while mint and coriander also showed higher growth in soil with biochar. There was no growth in indoor condition. On the basis of the height of the plant, we concluded that the outdoor environment is most suitable for plants with biochar added in the soil.

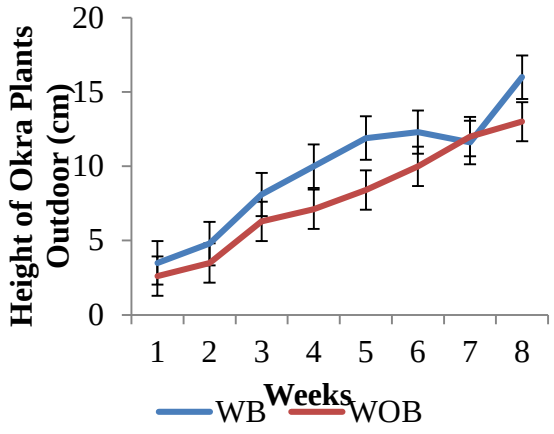


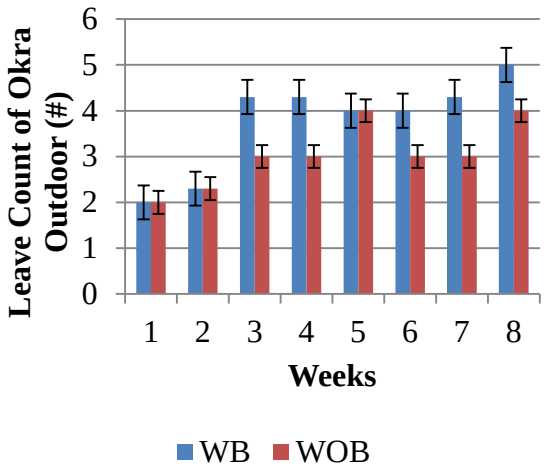
Figure 1: The height of Okra plants recorded: Outdoor plants grown in soil with biochar are higher than plants without biochar. Each value shown in the charts is the mean of three replicates Error bars represent values of critical difference at p<0.05.

Similarly we also counted leaves and noticed their length in all plants for each environmental condition. Okra leaves were more in number and larger in length with biochar as compared to without biochar in outdoor and greenhouse (Figure 2). Whereas beans showed more leave number and leave length with biochar in outdoor but showed equal number of leaves in greenhouse condition. The beans' leaves were larger in plants without biochar. Mint also showed more number of leaves and length with biochar in outdoor condition while no growth was noticed in greenhouse. Coriander showed an equal number of leaves in outdoor and greenhouse conditions but leave length was larger in plants with biochar. No growth was recorded in indoor conditions for all plants. Outdoor conditions was the best environmental condition for all plants. Figure 2 shows graph for okra leave count and leave length in outdoor condition.

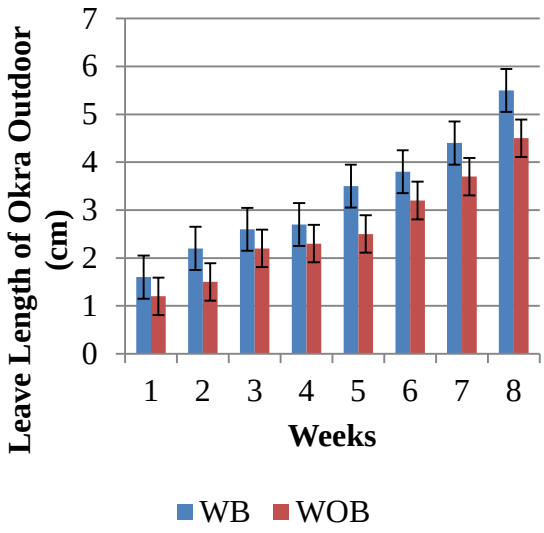
Chlorophyll content was also analyzed for plants with and without biochar. Results showed that total chlorophyll in the plants with biochar (5.38 mg/g) in outdoor conditions is not significantly different from plants without biochar (5.13 mg/g) with P-value of 0.910 at the significance level of 0.05. Similarly the chlorophyll content of plants grown in the greenhouse does not show significance difference due to the presence or absence of biochar. However the chlorophyll content of plants in the greenhouse and plants outdoor is significantly different with P <<< 0.05 (Table 4).

DISCUSSION

All the parameters used showed positive results for plants with biochar applied. Different scientists used different raw materials for biochar synthesis. For example Zwieten *et al.* (2009) synthesized



(a)



(b)

Figure 2: The leave count of okra recorded (a) Outdoor plants grown in soil with biochar have more leave than plants without biochar. (b) Outdoor plants grown in soil with biochar have more leave length than plants without biochar. Each value shown in the charts is the mean of three replicates Error bars represent values of critical difference at p<0.05.

Table 4: Chlorophyll content (mg/g fresh weight of plant) of plants grown in outdoor and greenhouse

Condition	Treatment	Chl. a (mg/g)	Chl. b (mg/g)	Total Chl. (mg/g)
Outdoor	**WB**	2.46±0.9	2.96±1.5	5.38±2.4
	WOB	2.035±0.8	3.097±1.7	5.132±2.5
Greenhouse	**WB**	14.67±3.6	27.67±1.4	42.27±3.9
	WOB	13.917±2.7	22.200±3.2	36.117±5.9

WB, with biochar; WOB, without biochar
Chl., Chlorophyll
Each value is average of at least three replications ± SD

biochar from paper mill waste and noticed that it also increased the water holding capacity and pH of the soil with biochar. The addition of biochar in the soil also enhances the nitrogen content of the soil which proved to be helpful for the growth of plants (Stanford and Smith, 1972). Niklas (1995) worked on plant height. He also concluded that plant height is important for its growth. Chlorophyll content also determines the health and growth of plants (Hiscox and Israelsham, 1979). Thus, biochar can increase the growth and yield of plants and can be used as a fertilizer.

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