Impact of Biochar on Wheat Crop Productivity

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Abstract

Biochar has been reported to improve soil structure and yield of the crop; however, less is known about its effects on the physical and, in particular, structural properties of soil. This study examined the potential ability of biochar to improve crop growth through a field trial. This field trial had six different treatments with two genotypes and three replications in combination with biochar. Biochar has significantly affected the plant height spikelet's and yield. However, genotypes and treatments has significantly affected the grain yield. Best performer genotype (Zincol-2016) had given highest grain yield 2943.5 kg/hec while it was followed by genotype (Borloug-2016), 2385.2 kg/hec. Similarly, highest grain yield: 3187 kg/hec was obtained when crop was sown in combination of treatment 4 which was followed by lowest grain yield: 2109 kg/hec recorded at treatment 6.

Keywords: Biochar, genotype, soil structure, wheat.

Introduction

Wheat is one of the most important cereal crops globally and a staple food for many people around the world. It is the member of grass family and is

cultivated for its edible grains. Wheat grains can be milled into flour to make various food products, including bread, pasta and pastries. The cultivation of wheat dates back thousands of years back and has played significant role in the development of human civilization. Wheat is long day crop and is typically grown in temperate regions. It requires well drained soil and adequate water supply during its growth cycle. Moreover, its production involves several stages including planting, germination, tillering, flowering, grain filling and maturity. Farmers often use fertilizers and pesticides to ensure healthy growth and protect the crop from pests and diseases. However, wheat production can be affected by various factors such as weather conditions, pests, diseases and soil quality. Therefore, agricultural practices and technologies continue to evolve to improve yield and quality. Wheat is a staple food crop of Pakistan, dominating all crops in acreage and production. During 2022-2023, area under cultivation was 9,043 thousand hectares, this area contributed to the production of 27.634 million tones (Economic Survey of Pakistan, 2022-2023). More stress in given to increase its average production and for the area of concern, biochar amendment has been done to check its effect. Moreover, biochar can increase the productivity of the wheat crop by improving soil structure and reducing soil compaction thus for better root penetration. Correspondingly, Sail *et al*., 2019 also explained in his article that biochar has a high porosity and can absorb water, which can help in retaining moisture in the soil. However, it also has high cation exchange capacity (CEC), which means it can absorb and retain nutrients like nitrogen, phosphorous and potassium. In addition, depending on the source and material used to produce the biochar, it can influence soil pH. Biochar made from alkaline sources can help buffer acidic soils, while biochar from

acidic sources can help buffer alkaline soils (Sun et al., 2019). Furthermore, some studies suggest that using biochar for crop production can reduce greenhouse gas emissions from the soil, particularly nitrous oxide (a potent greenhouse gas) emissions. Therefore, it is a potentially valuable soil amendment produced from biomass, through pyrolysis. Biochar improves soil aggregation, enhances nutrient and water holding capacity, provides habitat for soil organisms modulates microbial activity and biodiversity and may stabilize soil organic matter. Biochar is thought to mitigate climate change by providing both renewable energy and a soil amendment that may significantly enhance net soil carbon sequestration. It can be utilized as one component in an integrated soil health building program, because it has potential for the further development of sustainable agriculture production systems. Biochar as a soil amendment may have some positive effects on soil moisture retention, even if it is variable from various feedstock sources (Lai *et al*., 2013). Liu, X. *et al.*, 2013, in his research article said that biochar enhances soil fertility primarily by providing cation exchange capacity; reducing leaching loss of nitrate, phosphate and other anion nutrients, improving soil structure and moisture holding capacity and enhances soil biology (Wilson, 2014). Moreover, in recent years biochar has significantly become a scientific interest as a soil amendment. It is reported to reduce the salt stress on crops and increase the production (Akhtar et al. 2015, Saifullah et al. 2018). Wheat is one of the most important crops worldwide. It is one of the backbone base through which value of agricultural economy is estimated.

Material and methods

Description of the study area

A field trial for wheat crop was conducted in National Agricultural Research Center (NARC), Islamabad, Pakistan in 2022-23. It is located at latitude 33.4, longitude 73.8 East and altitude 1632 ft.

Biochar production

A biochar was collected from existing charcoal markets in Islamabad vicinity. The biochar was produced from the conventional method of charcoal making. The produced biochar was in charcoal form that was similar in size with the particles of the soil used in the experiment.

Experimental procedure

A field experiment was conducted in a field area of wheat program, Crop Sciences Institute, National Agriculture Research Center, Islamabad. The trial was arranged in Randomized Complete block Design (RCBD) and replicated three times. Two wheat varieties (Borloug-2016 and Zincol-2016) and six treatments viz T_1= Full fertilizer (1 Bag DAP and 1 Bag Urea), T_2= ½ fertilizer, T_3=1 t/h Biochar, T_4= 2 t/h Biochar T_5= 1/2 fertilizer+ 1t/h Biochar and T_6= ½ fertilizer and 2 t/h Biochar were used. Similarly, 50kg/acre seed rate was used and recommended dose of fertilizer @50 kg/acre was applied at the time of soil preparation before sowing. Moreover, recommended land operations were carried out in order to ensure equal distribution of fertilizer and irrigation. Winterstieger plot planter was used for the planting of the wheat crop and line to line distance

was kept 25 cm apart. The treatments were applied as per the allocation of the treatments for this experiment.

Statistical analysis

Analysis of variance was performed to assess the significant difference among different treatments. Therefore, yield components were analyzed using Statistics software 8.1. Means separation was also done using least significant difference test after the treatments were found significant at $P<0.05$(Steel and Torrie, 1997)

Results and discussion

Effect of biochar application on plant height, spikelet's and yield

The effect of biochar, when combined with fertilizer, on plant height can be positive due to its soil-improving properties. However, the specific results will depend on the unique characteristics of your soil, the crop one is growing, and the way ones apply both biochar and fertilizer. The data of experiment showed that Biochar along with fertilizer addition can have a positive effect on plant height of the wheat crop, as it can help improve soil fertility, water retention and nutrient uptake. However, the specific effect can vary depending on the biochar used and the condition in which it is applied. However, treatments showed significant effect with biochar on plant height. While the maximum plant height 92.0 cm was recorded in treatment 4 whereas in treatment no 1, minimum plant height (83.2 cm) was observed.

Table 1: Effect of plant height (cm) on treatments.

Treatment	Mean
1	83.2 B
2	88.8 A
3	89.9 A
4	92.0 A
5	88.6 A
6	88.6 A
LSD	2.23

The wheat variety used in this experiment may have inherent genetic variability in spikelet production. Some wheat varieties naturally produce more spikelet's than others. Moreover, environmental conditions, such as temperature, humidity, and precipitation, can impact spikelet development. However, treatment number six in combination of biochar applied has given highest number of spikelet's; 22.3 while treatment number four had produced 19.4 number of spikelets.

Table 2: Effect of treatments on number of spikelet's

Treatments	Mean
1	21.0 BC
2	21.7 AB
3	20.1 CD
4	19.4 D
5	21.4 AB
6	22.3 A
LSD	2.23

Likewise, effect of treatments along with biochar on wheat crop has given significant results. While the difference in yield between treatments suggest that there are significant effects of the treatments, including the addition of biochar, on the yield of the wheat crop. However, biochar in combination with treatment number four had given 3187 kg/Hec yield and treatment number six has given 2109.1 kg/Hec yield. The results were also supported with the findings of Zaheer *et al*., 2021

Table 3: Effect of yield (kg/Hec) on treatments

Treatment	Mean
1	2624.4 ABC
2	2452.4 BC
3	2754.4 AB
4	3187.1 A
5	2858.4 AB
6	2109.1 C
LSD	2.23

Similarly, wheat varieties are also impacted due to the addition of biochar along with treatments. The effect of biochar on different wheat varieties can vary depending on the specific characteristics of the varieties and the growing conditions and some wheat varieties may respond more favorably to biochar application than others. Moreover, Wheat varieties have genetic variations that make them suitable for specific conditions or management practices. The response of wheat varieties to biochar can vary, and some varieties may exhibit a more significant yield increase when biochar is applied. Likewise, significant differences were found among varieties in terms of yield produced. Zincol-2016 (variety no. 2) has produced 2943.4 kg/Hec yield, which is the highest in this experiment and it followed by Borloug-2016 (variety no. 1) with 2385 kg/Hec yield.

Table 4: Yield (kg/Hec) data of wheat varieties

Variety	Mean
1	2385.2 A
2	2943.5 B
LSD	2.179

Conclusion

The result of this research suggests that application of biochar is authoritative in order to increase the wheat productivity. The application of biochar to wheat fields has a positive and statistically significant effect on crop productivity. This indicates that biochar can be a valuable soil amendment to enhance wheat yields, potentially offering benefits to farmers and food security. However, in this study, the application of biochar to wheat fields has been shown to have a statistically significant positive impact on crop productivity. The data clearly indicate that biochar can be a valuable and effective soil amendment for enhancing wheat yields. The finding suggests that farmers and agricultural practitioners can consider incorporating biochar into their cultivation practices to achieve increased wheat crop productivity. Therefore, it is important to note that the statistically significant increase in yield observed in this study not only has economic implications for farmers but also holds promise for addressing food security concerns in regions where wheat is a staple crop.

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