Charcoal and compost application induced changes in growth and yield of Wheat (*Triticum aestivum* L.)

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**ABSTRACT**

The utilization of organic fertilizers in farmlands to enhance crop productivity and soil health is increasing globally. Compost and charcoal obtained from the decomposition and slow pyrolysis (respectively) of plants and animals wastes. Here we evaluated the effect of charcoal and compost on the growth and yield of wheat (*Triticum aestivum* L.) at Agriculture Research Farm Peshawar, Pakistan during 2014-2015. Results showed that the application of compost and charcoal as sole or in combination significantly affected the yield and yield attributes of wheat. Data divulged that the maximum numbers of plant tillers (337 m⁻²), number of productive tillers per plant (313 m⁻²), number of grains per spike (56 spike⁻¹) and 1000 seeds weight (50.2 g) were produced by the combined application of compost and charcoal at 5+5 Mg ha⁻¹ while plant height (95.3 cm) was enhanced with the application of charcoal at 10 Mg ha⁻¹. The gain (4106.7 kg ha⁻¹) and biological yield (8473.3 kg ha⁻¹) was significantly increased with the compost application at the rate of 10 Mg ha⁻¹. These results proved that charcoal and compost can be used as organic fertilizers for boosting growth and yield performance of wheat under the agro-climatic conditions of Peshawar, Pakistan.

**Key words:** Compost, Charcoal, Peshawar, Pakistan.

**INTRODUCTION**

Wheat (*Triticum aestivum* L.) is a self-pollinated winter cereal crop of the family Gramineae. It is one of the most important staple diets of one-third of the world population and exported to all low wheat growing countries (A.Y 2005). Pakistan produces about 19.767 million tons from about 8.176 m ha⁻¹ cultivated area with an average yield of 2418 kg ha⁻¹ which placed Pakistan 8th in ranked amongst the world major wheat producing countries. Its contribution in agriculture is 13.7 per cent. The use of fertilizers and high yielding cultivars has increased the agricultural productivity since last three decades. However, wheat production is still low (around 2 t ha⁻¹) due to many constraints including poor soil fertility management.

The wheat production in Khyber Pakhtunkhwa province is gradually decreasing due to low organic matter, less soil biodiversity and nutrient retention. These issues can be solved by adopting advanced agro-technology with suitable agriculture management practices in both rainfed and irrigated areas. The adequate food production (2.6% annually) for ever-growing population (Qazilbash 2002) should be possibly made by using of all available resources. This could be achieved rapidly and efficiently by mean of mineral fertilization but its high energy costs and adverse ecologic factor make it a difficult to access.

To achieve sustainable agricultural production, the use of organic fertilizer sources is beneficial. Compost and charcoal both could be the priceless sources for improving quality and fertility of soil. In Pakistan, due to the high fertilizers prices and soil quality depletion, compost has got considerable attention by improving crop yield and soil fertility. This could be due to costly waste management and public awareness of waste recycling. The composting process is a possible way of managing a large number of organic wastes globally (Lasaridi and Stentiford 1999). Compost and natural manures along with inorganic fertilizers can be efficiently utilized for the betterment of crop yield and soil health (Loecke et al. 2004).

Charcoal and compost can be use as a soil conditioner which can help in improving soil nutrient status, balance soil pH, reduce the risk of soil pollution and thus improves crop yield and productivity. (Rondon et al. 2007) reported that charcoal addition to soil improved the root zone of pea plant which enhanced its weight and accelerate
symbiotic N$_2$ fixation compared to controls. These arguments suggest that charcoal and compost can help in the adsorption of toxic metabolites that often released by plant tissues, especially when the tissue is damaged. Little studies are available on the effect of charcoal and compost application to the soils of Pakistan. This experiment was therefore conducted to evaluate the effect of charcoal and compost on the growth and yield of wheat.

MATERIALS AND METHODS
Experimental site and design: The current study was designed to investigate the effect of charcoal and compost on growth and yield of wheat. The experiment was conducted at Agriculture Research Institute Tarnab Farm Peshawar KPK, during Rabi season of 2014-2015. The variety used was pirbakh 2004. The experiment was laid down as per completely randomized design having five treatments and repeated thrice. Ten representative plants per treatment were used for data recording.

The following are the treatment arrangement.
T1 = Control
T2 = Basal dose of NPK
T3 = 10 Mg ha$^{-1}$ charcoal
T4 = 5 Mg ha$^{-1}$ compost + 5 Mg ha$^{-1}$ charcoal and
T5 = 10 Mg ha$^{-1}$ compost

The field was well prepared by ploughing followed by planking. Charcoal and compost were applied at the time of sowing. Crops were planted at 30 cm row to row distance.

Soil analysis: The physio-chemical characteristics of the experimental soil were tested after collecting the soil samples at a depth of 0-20 cm. Soil pH was checked by pH meter in 1:5 water suspension (Rhoades 1996), soil texture by hydrometer method (Koehler et al. 1984), organic matter by wet digestion (Nelson and Sommers 1996), total nitrogen by Kjeldahl method (Bremner 1996) while soil K was measured by AB-DTPA extract. P

Plant analysis: Plant from treatment plots were randomly selected to determine plant growth and yield related traits. Number of Tillers, productive tillers and nonproductive tillers were collected from 1m row, counted and recorded as tillers m$^{-2}$. Plant height (cm) was measured using meter rod, number of grains spike$^{-1}$ was counted after threshing the spike. Grain yield and biological yield were recorded after threshing.

Statistical analysis: The results were statistically analyzed by computer statistical software MSTATC package (Russel 1989). ANOVA were computed for mean differences and means were compared at <0.05 significance level of probability (Steel and Torrie 1980).

RESULTS AND DISCUSSION
Soil physio-chemical properties: The experimental soil was silt loam, non-saline having a pH value of 8.15, highly calcareous, low in organic matter (OM), N, P deficient and adequate in K (Table 1). The application of charcoal and compost did not affect the soil physio-chemical properties. It could be due to the compost and charcoal were not properly prepared (Table 2).

Number of Tillers per square meter: Numbers of tiller per m$^{-2}$ were significantly different among all the treatments (Table 3). Highest numbers of tillers (337 m$^{-2}$) were recorded in those treatment plots where compost and charcoal were incorporated. Charcoal and compost significantly (p<0.05) affected productive tillers m$^{-2}$ of plants (Table 3). The combined application of compost and charcoal gave the maximum number of productive tillers (313 m$^{-2}$). The non-productive tillers m$^{-2}$ showed opposite trend. This might be due the fact that N is a key nutrient for growth and development and thus improves vegetative growth. Results further suggested that compost additions increased the number of productive tillers of wheat it might be due to the high nitrogen content in compost. These findings were supported by Ling and Silberbush (2002), Bly and Woodard (2003), Siddiqui et al. (2008) and Otteson et al. (2007).

Plant height (cm): The application of charcoal and compost at different levels had a significant (p<0.05) effect on plant height (Table 3). Plant treated with charcoal at 10 Mg ha$^{-1}$ reached maximum plant height (95.3 cm) as compared with other treatments. The reason might be the high cation exchange capacity and nitrogen absorption ability of charcoal and compost which helps in maximizing nutrients availability which increased the plant height and thus improved the yield

Table 1: Soil physio-chemical characteristics before sowing.

| Soil property | Unit | Value |
|---------------|------|-------|
| Soil pH (1:5) |      | 8.15  |
| Soil EC      | dSm$^{-1}$ | 0.230 |
| Lime         | %    | 16.5  |
| OM           | %    | 1.50  |
| Total N      | %    | 0.113 |
| AB-DTPA extract. P | mg kg$^{-1}$ | 5.92 |
| AB-DTPA extract. K | mg kg$^{-1}$ | 233 |
| Sand         | %    | 48.32 |
| Silt         | %    | 16.25 |
| Clay         |      | 35.43 |
| Textural Class |     | Silt loam |

Table 2: Soil physio-chemical properties after harvest.

| Soil property | Unit | Value |
|---------------|------|-------|
| Soil pH (1:5) |      | 8.15  |
| Soil EC      | dSm$^{-1}$ | 0.230 |
| Lime         | %    | 16.5  |
| OM           | %    | 1.50  |
| Total N      | %    | 0.113 |
| AB-DTPA extract. P | mg kg$^{-1}$ | 5.92 |
| AB-DTPA extract. K | mg kg$^{-1}$ | 233 |
| Sand         | %    | 48.32 |
| Silt         | %    | 16.25 |
| Clay         |      | 35.43 |
| Textural Class |     | Silt loam |
of crops. Biochar addition to plants improve all the growth parameters, as the lettuce growth indicators suggested by Carter et al. (2013). Similarly Akhtar et al. (2007) and Schulz et al. (2013) found that charcoal and compost along with chemical fertilizers significantly improved the growth and yield of crop and also enhanced the soil nutrient status.

**Number of grain per spike and 1000 grain weight (g):** The regarding data on number of grains per spike and 1000 grain weight were significantly affected by charcoal and compost applications (Table 4). It was found that grains per spike (56 spike\(^{-1}\)) and 1000 grain weight (50.2 g) were maximum at the combine application of charcoal and compost at 5 Mg ha\(^{-1}\). It could be due to the charcoal and compost role in nutrients cycling and the available nitrogen content in compost progressively improved the grains in plants.

Similar results were also reported by Carter et al. (2013), Akhtar et al. (2007) and Schulz et al. (2013) who found that charcoal and compost along with chemical fertilizers significantly improved the growth and yield of crop and also enhanced the soil nutrient status.

**Biological yield and yield:** Data obtained on biological and grain yield showed that charcoal and compost application

### Table 3: Growth and growth parameters of wheat as affected by charcoal and compost applications.

| Treatments                      | No. of tiller m\(^{-2}\) | No. of prod. tiller m\(^{-2}\) | No. of nan prod. tiller m\(^{-2}\) | Plant height (cm) |
|---------------------------------|--------------------------|-------------------------------|-------------------------------------|-------------------|
| Control                         | 267 c                    | 236 c                         | 39                                  | 79.3 c            |
| Basal dose of NPK               | 302 b                    | 266 b                         | 21                                  | 81.8bc            |
| Compost at 10 Mg ha\(^{-1}\)   | 323ab                    | 304 a                         | 18                                  | 84.4b             |
| Charcoal at 10 Mg ha\(^{-1}\)  | 313 ab                   | 293 a                         | 20                                  | 95.3 a            |
| Compost + Charcoal at 5+5 Mg ha\(^{-1}\) | 337 a | 313 a | 19 | 92.1 a |
| LSD                             | 32.318                   | 26.829                        | NS                                  | 4.54              |
| CV                              | 5.56                     | 5.04                          |                                     | 2.79              |

Mean with different letters are significantly different from each other.

### Table 4: Yield and yield parameters of wheat as affected by charcoal and compost applications.

| Treatments                      | No. of grains spike\(^{-1}\) | 1000 grain weight | Biological yield Kg ha\(^{-1}\) | Grain yield Kg ha\(^{-1}\) |
|---------------------------------|-------------------------------|-------------------|---------------------------------|---------------------------|
| Control                         | 49 c                          | 36.9d             | 5073.4c                         | 1996.7 d                  |
| Basal dose of NPK               | 51b                           | 41.3c             | 6467.3b                         | 2635.2 c                 |
| Compost (10 Mg ha\(^{-1}\))    | 55 a                          | 46.3 b            | 8473.3 a                        | 4106.7 a                 |
| Charcoal at (10 Mg ha\(^{-1}\))| 52 b                          | 45 b              | 7226.6 b                        | 3326 b                   |
| Compost + Charcoal (5+5 Mg ha\(^{-1}\)) | 56 a | 50.2 a | 8376.7 a | 3993.3 a |
| LSD                             | 1.64                          | 3.38              | 8995.54                         | 557.64                    |
| CV                              | 1.65                          | 4.09              | 6.71                            | 9.22                      |

Mean with different letters are significantly different from each other.

![Graph](image.png)

**Fig 1:** Effect of compost and charcoal on biological and grain yield kg ha\(^{-1}\). Treatments T1 control, T2 basal dose of NPK, T3 compost 10 Mg ha\(^{-1}\), T4 charcoal 10 Mg ha\(^{-1}\), T5 compost + charcoal 5 + 5 Mg ha\(^{-1}\). SD bars with similar alphabets showed no significant difference among treatments.
significantly affected yield and yield attribute of wheat crop (Table 4, Fig 1). Results showed that grain and biological yield were notably increased with charcoal and compost application. The highest grain yield (4106.7 kg ha⁻¹) and biological yield (8473.3 kg ha⁻¹) was recorded in those treatment plots where 10 Mg ha⁻¹ compost was applied as compared to other treatments. These results were in line with those of Ling and Silberbush (2002), Woolfolk et al. (2002), Bly and Woodard (2003), Siddiqui et al. (2008) and Otteson et al. (2007) who reported that charcoal and compost were rich sources of all nutrients especially nitrogen which help in improving growth and yield.

**CONCLUSION**

To achieve agricultural sustainability and yield production natural resources could be the best option. Charcoal and compost are natural available resources for enhancing growth and yield parameters of the crop. Here in our results we observed that the incorporation of organic sources like charcoal and compost to crop not only ensures sustainability of soil productivity but also contributes to yield attributes. The suitability of soil for crop production is based on the physio-chemical and biological properties of soil. From the current results it could be conclude that organic fertilizers alone or in combination with chemical fertilizers improved the growth and yield of wheat and can be used as natural resources for the betterment of crop under the agro-climatic condition of Peshwar Valley. Future research is encouraged to outline more of the fact regarding charcoal and compost application for soil health and crop productivity.

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