Research Article

Integration of Carbon Sequestering and Commercial Fertilizers for Growth and Yield of Wheat

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Abstract | Wheat is the major staple cereal of the Pakistani people. For healthy growth of field crops potassium (K) is considered an essential element. Potassium activates many enzymatic reactions in plant body. The deficiency of bio-available potassium is pronounced throughout the world. In Pakistan due to dense plantation and minimum use of artificial potassium fertilization the yield and supply potential is diminishing day by day. The cost of potassium fertilization is very high and awareness for external nutrition of potassium benefits is also on the minimum side. To overcome potassium bio-available losses from Pakistani farming system is very essential to sustain crop growth. Keeping in view of these issues, a pot study was performed at the departmental research area. The aim of the research was to depict the efficacy of the use of carbon sequestering fertilizer (compost, press mud and fly ash) along with conventional potassium fertilizers (MOP & SOP) on wheat growth and potassium availability in soil. Carbon sequestering fertilizers were applied @ 0% (Control), 0.5 & 1% of soil weight along with recommended rated of commercial K fertilizers. After the crop was harvested, soil sampling was carried out followed by analysis in the laboratory. It was observed that use of press mud @ Yield 1 % in integration with SOP as chemical K fertilizer performed as best treatment by improving yield (4.11 t/ha) and yield contributing parameters like maximum plant's height (95.10 cm), length of spike (11.04), number of fertile tillers (5.67), 1000 grains weight (39.26 g) and grain count per spike (51).

Received | June 16, 2021; **Accepted** | December 30, 2021; **Published** | January 11, 2022
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Citation | Warraich, M.W., M.A. Tahir, N.U Sabah, G. Sarwar, M. Aftab, F. Mujeeb, M.Z. Maznoor, A. Riaz and S. Hussain. 2021. Integration of carbon sequestering and commercial fertilizers for growth and yield of wheat. *Pakistan Journal of Agricultural Research,* 34(4): 861-867.
DOI | https://dx.doi.org/10.17582/journal.pjar/2021/34.4.861.867
Keywords | Wheat, Potassium, Carbon sequestering fertilizer, Commercial fertilizer

Introduction

Wheat (*Triticum aestivum* L.) occupies the world's utmost significant grain crop positions being ranked third after maize and rice. It is extensively grown at an area nearly 237 million hectares per year globally, accounting for a total of 420 million tones produce. Worldwide, wheat makes up almost 30% of entire cereal production. Wheat belongs to the family Graminae (Fageria *et al*., 1997). Wheat is the most broadly consumed staple food grain in the world. It is an exceptionally noteworthy globally traded item (Wajid, 2004). Wheat is of supreme importance for Pakistan, with approximately 80% of farmers cultivating it on a gross area of around 9177.6 thousand hectares with a production of 27293.4 thousand tones (Economic Survey of Pakistan, 2020-21).

Potassium is acquired by plants in significant amount. It plays vital acts in movement of nutrients, water, ni-

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trogen utilization, and enhancement of initial growth and in insect and disease confrontation. It has role in transportation of food from the leaves to the other parts of plant body, quality of fruits and seeds, encouraging the roots, strengthening of stem and branches of plants and reduces lodging (Brhane *et al*., 2017). It is selective and basic supplement for plant metabolism improvements. Activation of enzymes, role in preserving tissue turgor and managing the opening and shutting of stomata are physiological characters of K in plant cells. After N and P, K is the most significant supplement component and is procured by harvests in more noteworthy sums as analyzed some other supplements (Brady and Weil, 2005).

In spite of satisfactory assets of K in Pakistani soils and crops replies to K fertilization, exhaustive farming of more productive selections, use of limited levels K fertilizer, the request for K has been heightened and its discharge at slower rate from soil minerals may not encounter necessity of more productive crops (Iftikhar *et al*., 2010; Babar *et al*., 2011; Jamal and Fawad, 2018). Additional aspect, which might root the shortage of K, is drift of large region under grain crops (Nazir, 1994). Soil potassium acquisition by cereal is about 2 to 3 folds higher as compared to legumes (Geovgeorge *et al*., 1989). Potassium nutrients are depleting at the rate on 9mg per kg per year in Pakistani soils which suggest the depletion at the rate of 18 kg hectare^{-1}year^{-1} (Iftikhar *et al*., 2010).

In order to improve the produce and to uphold sustainability of soil productiveness with the help of leftover, reprocessing for nutrient management is among the most important aspects (Chew *et al*., 2019). Carbon is a part of all living creatures and it is the chief constructing block for life on this planet. Soil comprises nearly 75% of total carbon existing on land, more than the quantity stockpiled in living animals and plants. So, soil plays a chief part in maintaining a stable carbon cycle. Over the previous 150 years period, the quantity of carbon present in the air has amplified by 30%. Sequestration takes place when input of carbon enhances as compared to output of carbon. Soil carbon sequestration is the method of relocating CO_2 from the air in to the soil with crop leftover and additional organic solids and in a configuration that is not instantly emitted back to the atmosphere (Lal, 2006; Moore *et al*., 2019; Lal, 2020).

Organic wastes originated from sugar industries such as filter cake press mud, fly ash etc. contains plenty of carbon. All these materials contain high quantity of carbon which if not added to soil may lead to the production of carbon dioxide, which is already considered as a chief source of ozone depletion and other environmental degradation processes, and causes pollution (Khan *et al*., 2012).

Keeping in view the significance of potassium and its continuous losses in soil, present study was conducted using potassium-based fertilizers and carbon sequestration sources to assess the impact of CSFs on the growth of wheat and on the availability of potassium in the growth environment pot conditions.

Materials and Methods

The present pot study was conducted during the year 2018 at departmental research area to check the impact of integration of carbon sequestering and commercial fertilizers in wheat.

Climatic conditions

Climatic conditions have substantial disparity in mean monthly temperature ranging from 20 °C to 41.2 °C with precipitation of 410 mm per year which mainly happens in the months of July & August.

Seeds and Carbon Sequestering Fertilizers (CSF)

Seeds of wheat which were used in this experiment were taken from the Punjab Seeds Corporation, Small Industrial Area, Sargodha. All the carbon sequestering fertilizers (CFSs) were applied, *i.e.* compost, press-mud and boiler ash (collected from Noon Sugar Mill, Bhalwal, Pakistan). Analysis of CSFs was given in Table 2.

Preparation of pots and sowing

All pots were filled with 10 kg soil and same soil sample was taken from the same soil for pre-experiment analysis. Faisalabad 2008 variety was selected for the trial. Sowing of five seeds was done in each pot and later on three plants were maintained.

Treatments

The trial was performed in complete randomized design (CRD) with 3 replicates of each treatment in clay pots which were filled with soil taken from the land near research area. The treatment plan was: T1 = K_0 (No K addition) + Compost 0%, T2 = K_0 (No K addition) + Compost 0.5%, T3 = K_0 + (No K addition) Compost 1%, T4 = K_{SOP} (2.11 g) + Compost 0%, T5 = K_{SOP} (2.11 g) + Compost 0.5%, T6 = K_{SOP} (2.11 g) + Compost 1%, T7 = K_{MOP} (1.75 g) + Compost 0%, T8 = K_{MOP} (1.75 g) + Compost 0.5%, T9 = K_{MOP} (1.75 g) + Compost 1%, T10 = K_0 (No K addition) + Press Mud 0%, T11 = K_0 (No K addition) + Press Mud 0.5%, T12 = K_0 (No K addition) + Press Mud 1%, T13 = K_{SOP} (2.11 g) + Press Mud 0%, T14 = K_{SOP} (2.11 g) + Press Mud 0.5%, T15 = K_{SOP} (2.11 g) + Press Mud 1%, T16 = K_{MOP} (1.75 g) + Press Mud 0%, T17 = K_{MOP} (1.75 g) + Press Mud 0.5%, T18 = K_{MOP} (1.75 g) + Press Mud 1%, T19 = K_0 (No K addition) + Boiler Ash 0%, T20 = K_0 (No K addition) + Boiler Ash 0.5%, T21 = K_0 (No K addition) + Boiler Ash 1%, T22 = K_{SOP} (2.11 g) + Boiler Ash 0%, T23 = K_{SOP} (2.11 g) + Boiler Ash 0.5%, T24 = K_{SOP} (2.11 g) + Boiler Ash 1%, T25 = K_{MOP} (1.75 g) + Boiler Ash 0%, T26 = K_{MOP} (1.75 g) + Boiler Ash 0.5% and T27 = K_{MOP} (1.75 g) + Boiler Ash 1%.

Different agronomic and cultural practices were done as required by wheat crop and pots were irrigated with groundwater when needed. At physiological maturity some parameters, which need to be measured at that time, were recorded in the field and remaining parameters were recorded at harvest maturity in field and in laboratory according to their procedures.

Fertilizer application

All of the CSFs were carefully incorporated in pots and soil was kept fallow for next 20 days to activate the carbon contents of CSFs. Urea and Diammonium Phosphate (DAP) fertilizers were used for N and P source. For potash two fertilizers sources were used. Urea dose was split into three parts one was given at the time of plantation along with P and K, second was given at tillering stage while last application was given at booting stage. However, all the recommended P and desired K fertilizers were given as a basal dose along with 1/3 N.

Irrigation

Underground water was used to keep the optimal moisture level of experimental pots. Pots were irrigated when required.

Harvesting

Harvesting of wheat was done when the plants were completely mature and the grains were ripened in each treatment after 180 days. For data collection all the plants from each replication of each treatment were harvested from each pot. Spike of harvested wheat plants were cut and grains were separated manually and stored in brown paper bags. The plant residue was collected in separate paper bags. They were labeled for further analysis.

Soil and plant analysis

Composite sample (1 kg) of soil, which was used is filing the pots, was taken for various physical and chemical analysis prior to sowing. Analysis values are given in Table 1. Crop was harvested and data of yield and related parameters (plant height, spike length, number of fertile tillers and 1000 grains weight, number of grains per spike and straw yield) was documented by using their customary procedures.

Statistical analysis

Compiled physical and chemical parameters values were evaluated statistically by means of Statistix 8.1 using analysis of variance (ANOVA). Means were further tested using least significant difference (LSD) at probability level of 5%.

Table 1: *Experimental soil analysis.*

Sr. No.	Determinations	Unit	Value
1	pH_s	-----	7.9
2	EC_e	dSm^{-1}	1.27
3	Soil Organic matter	%	0.28
4	Soil Organic Carbon	%	0.16
5	Available potassium	ppm	170
6	Available Phosphorus	ppm	9
7	Ca^{+2}+ Mg^{+2}	$mmolL^{-1}$	3.2
8	Sand	%	45.2
9	Silt	%	26.7

Table 2: *Chemical properties of carbon sequestering fertilizers.*

Determinations	Unit	Fly ash	Pressmud	Compost
pH		7.8	9.2	7.5
Total Nitrogen	%	2.33	0.085	1.2
Total phosphorus	%	1.26	0.048	0.75
Total Potassium	%	0.7	0.33	1.2
Organic matter	%	28	50	42
Total Organic Carbon	%	43.2	0.36	30
C:N Ratio		18.54	4.29	9.2

Results and Discussion

Plant height (cm plant^{-1})

Plant height is an imperative attribute which determines the plant growth and vigor of the crop plant. As more the plant height more is the crop growth rate. Data concerning the plant height of wheat crop by different K sources in addition to CSFs is presented in Figure 1. It is evident from the numbers that T15 (K_{SOP} (2.11 g) + Press Mud 1%) gave maximum value, which was 95.10 cm plant^{-1}. Statistically, T18 (K_{MOP} (1.75 g) + Press Mud 1%) and T12 (K_0 (No K addition) + Press Mud 1%) also gave maximum height of 95.03 cm plant^{-1} and 94.06 cm plant^{-1} respectively. On the other hand, T22 (K_{SOP} (2.11 g) + Boiler Ash 0%) gave the least plant height valuing 89.23 cm plant^{-1}. T19 (K_0 (No K addition) + Boiler Ash 0%) with height 89.81 cm plant^{-1} was also, on the minimum side when observed statistically.

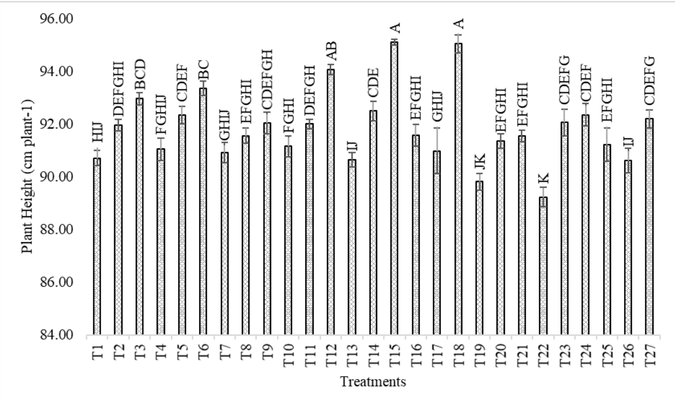

Figure 1: *Impact of CSFs on plant height (cm) of wheat.*

Results suggest that a highly significant effect of CSFs and artificial potassium sources on the height of plant (cm plant^{-1}) in was observed in wheat crop. Findings of Naik and Rao (2004) and Nehra and Hooda (2002) also supported these conclusions. Similarly, Kumar and Chopra (2016) also concluded that the sugarcane press mud significantly influenced the height of plant.

Spike length (cm spike^{-1})

Spike length is a parameter which could increase the crop yield as if the spike is lengthier more grains will be produced leading to the higher yield. Figure 2 revealed that spike length was maximum in T2 (K_0 (No K addition) + Compost 0.5%) 11.14 cm plant^{-1} followed by T6 (K_{SOP} (2.11 g) + Compost 1%) with spike length 11.04 cm spike^{-1} & T15 (K_{SOP} (2.11 g) + Press Mud 1%) with spike length 11.04 cm spike^{-1}. Minimum spike length was observed in T17 (K_{MOP} (1.75 g) + Press Mud 0.5%) with value 10.02 cm spike^{-1}. But when observed statistically all spike length were equal which means there was no significant effect of treatments to the crop suggesting no significant effect of CSFs on the spike length. Both maximum and minimum values suggest that no significant effect of CSFs was there and artificial potassium sources on the length of spike (cm spike^{-1}) in wheat crop. Results of Singh *et al.* (2007) also suggested no significant change in spike length in wheat crop. Same was suggested by Parmer and Sharma (2002) that spike length not varied significantly.

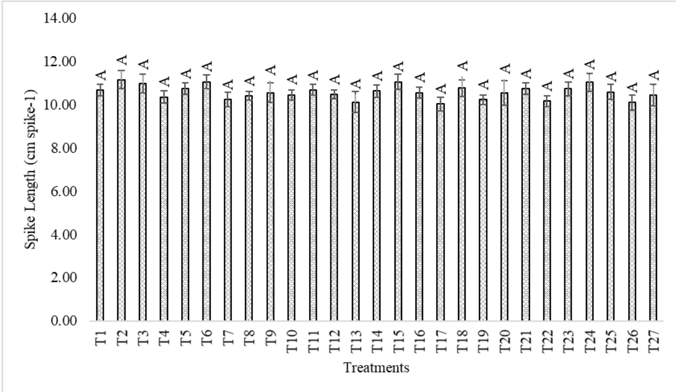

Figure 2: *Impact of CSFs on spike length (cm) of wheat.*

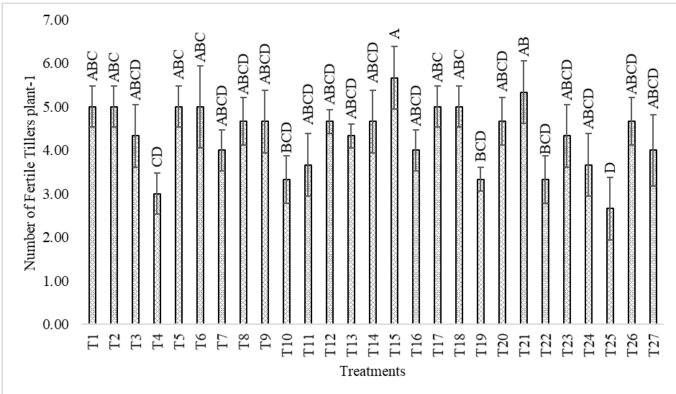

Figure 3: *Impact of CSFs on number of fertile tillers of wheat.*

Number of fertile tillers

Fertile tillers lead to higher grain yield since more spikes will be gained if there is good tillering in wheat crop. Data exposed that extreme number of fertile tillers plant^{-1} were observed in T15 (K_{SOP} (2.11 g) + Press Mud 1%) with replicate average of 5.67 fertile tillers plant^{-1}. Least fertile tillers plant^{-1} were observed in T25 (K_{MOP} (1.75 g) + Boiler Ash 0%) with the value 2.67 fertile tillers plant^{-1} (Figure 3). Both maximum and minimum fertile tillers pot^{-1} data suggesting non-significant ($P > 0.05$) result of CSFs and inorganic potassium application on the number of fertile tillers plant^{-1} in wheat crop.

Akhtar *et al.* (2007) concluded that non-significant outcome of press mud and compost on the number of fertile tillers was. The outcomes were also coordination with Hammad *et al.* (2011).

1000 grains weight (g)

Weight of a grain is directly proportional to the yield. Increase the weight of the grain, more would be the grain yield and vice-versa. Application of CSFs to the wheat showed an increase in grain weight with maximum value of 39.26 g in T15(KSOP (2.11 g) + Press Mud 1%). Whereas least 1000 grains weight was recorded in T4 (KSOP (2.11 g) + Compost 0%) with value 34.29 g (Figure 4). Both maximum and minimum 1000 grains weight exposed that a highly significant ($P \leq 0.001$) result of CSFs and artificial potassium fertilizers on the 1000 grains weight (g) of wheat was there. These outcomes are in line with the study carried out by Oloya and Tagwira (1996) and Al-Mustafa *et al.* (1995) suggesting increased grain weight with different doses of pressmud on wheat crop. These outcomes were also in agreement with Ghulam *et al.* (2012), according to which 1000-grains weight significantly improved with addition of several doses of press-mud and artificial fertilizer in contrast to control.

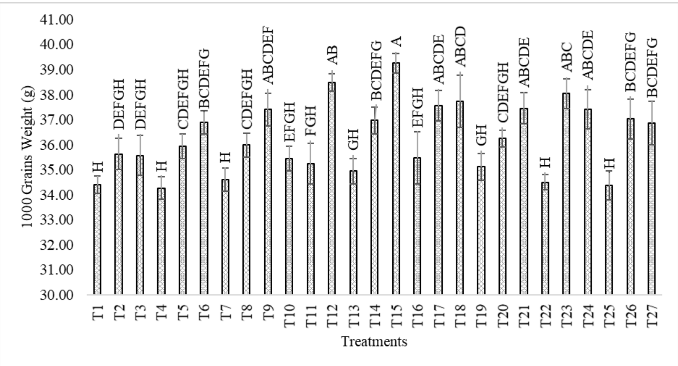

Figure 4: *Impact of CSFs on 1000 grain weight (g) of wheat.*

Number of grains per spike

Added the grains more would be the yield. Maximum grain count was observed in T15 (K_{SOP} (2.11 g) + Press Mud 1%) which were 51. Statistically T12 (K_0 (No K addition) + Press Mud 1%), T18 (K_{MOP} (1.75 g) + Press Mud 1%), T17 (K_{MOP} (1.75 g) + Press Mud 0.5%), T3 (K_0 + (No K addition) Compost 1%), T11, T6 (K_{SOP} (2.11 g) + Compost 1%) (K_{SOP} (2.11 g) + Compost 1%), T14 (K_{SOP} (2.11 g) + Press Mud 0.5%) and T24 (K_{SOP} (2.11 g) + Boiler Ash 1%) also gave maximum number of grains per spike with values 50, 49.67, 49, 48.33, 48, 47.67, 47.33 and 46.67 grains spike^{-1} respectively. Lowest grain count per spike were measured in T1 (K_0 (No K addition) + Compost 0%) which were 39.67 (Figure 5).

Therefore, it could be said that number of grains per spike showed a highly significant ($P \leq 0.001$) response to the addition of CSFs and artificial potassium application in wheat crop. These outcomes are similar to the findings of Jamil *et al.* (2008) who stated more grain count after the application of press mud in lentil crop. Hammad *et al.* (2011) also concluded that press mud application resulted in improved grain count in wheat. These results were also favored those documented by Cherr *et al.* (2006).

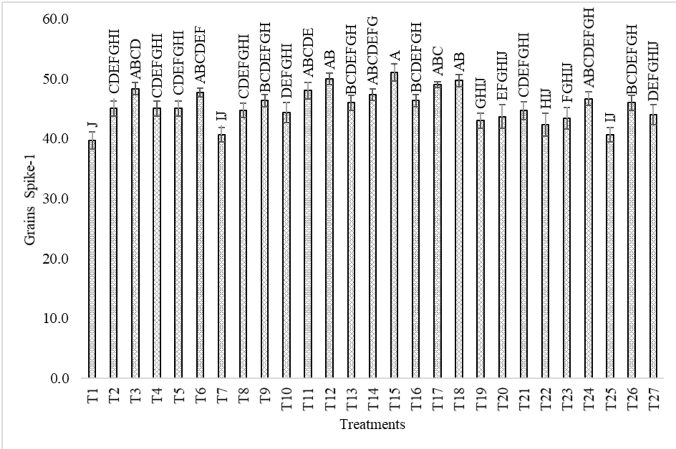

Figure 5: *Impact of CSFs on grain count per spike of wheat.*

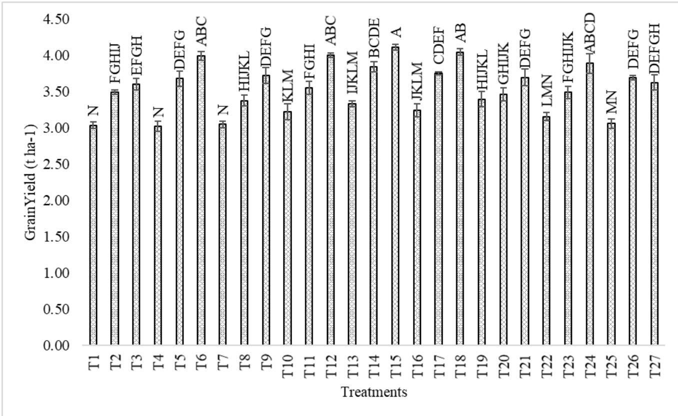

Figure 6: *Impact of CSFs on grain yield (t ha^{-1}) of wheat.*

Grains yield (t ha^{-1})

Grains yield parameter is of much significance as it describes the total yield from the agricultural land. Maximum grain yield was given by T15 (KSOP (2.11 g) + Press Mud 1%) which was 4.11 t ha^{-1}. It was observed that minimum grains yield was recorded from T4 (K_{SOP} (2.11 g) + Compost 0%) with value 3.02 t ha^{-1} (Figure 6). So, it could be said that CSFs and inorganic potassium addition has a highly significant ($P \leq 0.001$) effect on grains yield of wheat crop. The outcomes were similar to that of Jamal and Fawad (2018) and Hammad *et al.* (2011) who reported an improvement in grain yield by the addition of press mud.

Conclusion and Recommendations

All CSFs substantially improved the growth and yield of wheat. However, press mud proved best in terms of improving yield and yield contributing parameters of wheat.

Novelty Statement

CSFs improved the growth and yield of wheat crop under arid conditions.

Author's Contribution

Muhammad Waryam Warraich: Conducted the research.
Mukkram Ali Tahir: Supervised.
Noor-us-Sabah: Co-Supervision.
Ghulam Sarwar and Fakhar Mujeeb: Technically guided at every stage.
Muhammad Aftab and Aneela Riaz: Drafted the write up.
Muhammad Zeeshan Manzoor and Fakhar Mujeeb: Lab. and statistically analyzed the data.
Sarfraz Hussain: Proof read.

Conflict of interest
No conflict of interest is declared by the authors regarding this manuscript.

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