Research Article

Role of Carbon Sequestering and Commercial Fertilizers for Minimizing Bio Available K Losses Using Wheat as Test Crop Under Aridisols

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Abstract | Potassium (K) fertilizer is costly in Pakistan and K from soil is depleting with intensive cropping which made it necessary to find out innovative ways to conserve native K in soil. Following study was carried out to possibly find a way to overcome bioavailable potassium losses and to access the efficacy of carbon sequestering fertilizers in this regard using wheat as a test crop under aridisols. Different carbon sequestering fertilizers (CSFs) i.e., press mud, compost and fly ash were applied @ 0% (control), 0.5 and 1% of soil weight along with recommended doses of two K chemical fertilizers (SOP and MOP). After the crop was harvested, soil sampling was carried out followed by analysis in the laboratory. All collected data was statistically analyzed for interpretations. It was depicted from results that use of carbon sequestering fertilizer (press mud @ 1 %) along with commercial K fertilizer (SOP) performed superior by resulting in maximum K content in shoot (2.13 %), K content in root (1.12 %) and K content in soil (330 ppm). Similarly, highest fresh weight (42.43 g) and dry biomass (14.37 g) of wheat were also observed when SOP was used in combination with press mud as CSF. Press mud found to be most effective CSF compared to compost and fly ash.

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Introduction

Potassium (K) is among the 16 elements required for plant growth and metabolism. It is essential for almost all processes compulsory to withstand the satisfactory plant development and its reproduction. Potassium plays a critical part in series of central metabolic and physiological developments in the plant (Cakmak and Kirkby, 2008; Marschner, 1986). In plant body, its buildup rate during initial stages of development leads nitrogen buildup. So, its provision to plants looks to be pivotal for nitrogen exploitation,

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in order expressively affecting plants growth rate and the grade of yield potential comprehension. A high-yielding crop acquires huge amounts of potassium for the fulfillment of its needs throughout the whole vegetative stages. Plants acquire potassium as the K^+ ions. Its accessibility and the plant acquiring rate is affected by various plant and soil factors: (i) size of the soil cation exchange complex, (ii) K concentration in the soil solution, (iii) plant crops internal requirements, (iv) soil properties such as: moisture, soil aeration and oxygen level, temperature, (v) rooting depth (King *et al*., 2003; Jung and Classeen, 1997).

In spite of satisfactory assets of K in Pakistani soils and crops in response 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). In Pakistan, wheat is a crop that requires higher rates of fertilizers. Despite the struggles performed by the government and by national as well as international organizations potassium fertilization remained ignore in term of usage by farmers. Nitrogenous fertilizers are applied usually @ 132 kg hectare^{-1} and phosphorus fertilizers @ 32 kg hectare^{-1} while use of potash is nearly 2 kg hectare^{-1} which showed the ignorance of farming community (Ahmad et al., 2003).

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. Carbon is a part of all living creatures and it is the chief constructing block for life on this planet. Soil carbon exhausts when production of carbon increases than carbon contribution. Sequestration happens 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. In the procedure of photosynthesis, plants integrate carbon and releases back some of it to the air by the process of respiration. The carbon which is not returned back and become the part of plant tissue is the utilized by animals or become part of soil as added by litter or when plants die and decay. The major form in which carbon is deposited in the soil is soil organic matter. Carbon sequestration, known commonly as C-storage, can be acquired by different controlling practices, various management techniques to enhance C-storage of soil by providing a key basin for atmospheric CO_2, Rise in soil organic matter pool can raise extra 30-40 Mt annum^{-1} of C in developing countries (Lal, 2006).

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). The addition of nutrient rich compost increased the total soil organic contents and enhanced maize crop growth (Atuanya *et al*., 2012). Carbon rich compost is agronomically valuable, environmentally safer and relatively cheaper sources of organic amendment that encourages soil microbial activity and enhances crop growth (Raviv, 2005). Nutrient enriched compost enhances crop yield since it is a rich source of crop major and minor nutrients with high OM content (Hussain *et al*., 2001). To enhance crop production on sustainable basis, integrated application of organic and inorganic fertilizers could be more valuable and cost-effective than the application of inorganic fertilizers alone (Akhtar *et al*., 2007).

Carbon rich boiler ash also utilized for stabilizing a soil because this has the capability to provide nutrients to crop plant in minor quantities (Carlson and Adriano, 1993). Therefore, it is utilized as an organic fertilizer source in agriculture. In different crops carbon capturing boiler ash increased the yield up to 20-25% with higher nutritional value and proves valuable nutrients for soil and crops (Yavarzadeh and Shamsadini, 2012). Press mud contains adequate level of organic matter, NPK and essential micro nutrients for crop growth. Efficiency and productiveness of cultivated soils can also be enhanced through this material. Produce of several crops involving millet and maize considerably enhances when sugarcane press mud is incorporated into the soils (Elsyed *et al*., 2008).

By keeping in mind, the above discussion, following trial was carried out to sort out the role of carbon sequestering and commercial fertilizers for minimizing bio available K losses using wheat as test crop under aridisols (having dry climate during most of time of year).

Table 1: *Experimental soil analysis.*

S. 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}	$mmol_eL^{-1}$	3.2
8	Sand	%	45.2
9	Silt	%	26.7

Materials and Methods

The present pot study was conducted during the year 2018 at the departmental wire house to check the impact of integration of carbon sequestering and commercial fertilizers in wheat to minimize bio available K losses". Seeds of wheat (Faisalabad-2008) which were used in this experiment were taken from the Punjab Seeds Corporation, Small Industrial Area, Sargodha. All the carbon sequestering fertilizers (CFSs) i.e., compost, press-mud and boiler ash (collected from Noon Sugar Mill, Bhalwal, Pakistan) were applied. CSFs analysis was given in Table 2. All pots were filled with 10 kg air dried and sieved (2mm) soil was taken from the same soil for pre-experiment analysis. Five seeds were sown in each pot and later on three plants were maintained. 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%.

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

Different agronomic and cultural practices were carried out 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 wire house and remaining parameters were recorded at harvest maturity in wire house and in laboratory.

All of the CSFs were carefully incorporated in pots and soil was kept fallow for 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 (SOP and MOP). 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. Harvesting of wheat was done when the plants were completely mature. The soil and plant samples were collected and used for further analysis.

Data set related to physical and chemical parameters were evaluated statistically using Statistix 8.1 software for calculating analysis of variance (ANOVA). Means were further tested using least significant difference (LSD) at probability level of 5%.

Results and Discussion

Shoot fresh weight (g plant^{-1})

Shoot fresh weight is a parameter which is directly related to the straw yield. Results from the study suggest that there was maximum shoot fresh weight in T15 (K_{SOP} (2.11 g) + Press Mud 1%) with value of 42.43 g plant^{-1} (Figure 1). While T5 (K_{SOP} (2.11 g) + Compost 0.5%) with value 41.17 g plant^{-1} was also statistically equal to the maximum value. When minimum shoot fresh weight was observed it was revealed that T1 (K_0 (No K addition) + Compost 0%) has the lowest shoot fresh weight 27.32 g plant^{-1}. But T19 (K_0 (No K addition) + Boiler Ash 0%), T25 (K_{MOP} (1.75 g) + Boiler Ash 0%) and T10 (K_0 (No K addition) + Press Mud 0%) with values 28.65, 28.55 and 27.59 g plant^{-1}, respectively (Figure 1). Both maximum and minimum values of shoot fresh weight suggested a highly significant ($P \leq 0.001$) resulted by the addition of CSFs and inorganic potassium sources on the shoot fresh weight (g plant^{-1}) in wheat crop. These outcomes were coordination with those of Khan *et al.* (2012) suggesting that there was a marked difference in fresh weight of maize crop.

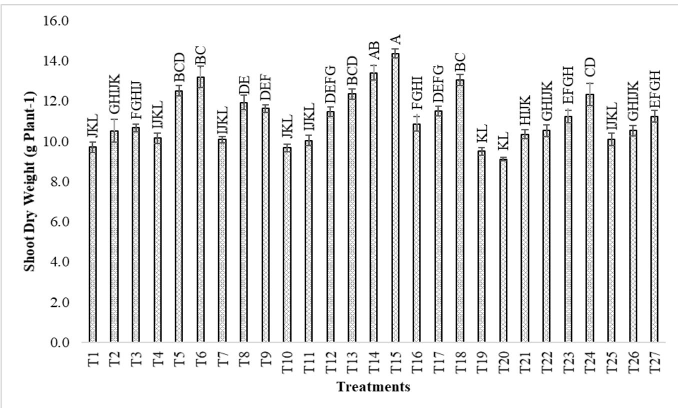

Figure 1: *Impact of CSFs and commercial K fertilizers on shoot fresh weight (g) of wheat.*

Shoot dry weight (g plant^{-1})

Shoot dry weight is directly proportional to the shoot fresh weight. It was observed from the results that highest shoot dry weight was obtained from T15 (K_{SOP} (2.11 g) + Press Mud 1%) valuing 14.37 g plant^{-1} followed by T14 (K_{SOP} (2.11 g) + Press Mud 0.5%) gave value 13.40 g plant^{-1}, which was statistically equal to the maximum value. To the minimum side T20 (K_0 (No K addition) + Boiler Ash 0.5%) gave smallest shoot dry weight 9.11 g plant^{-1}. This minimum value was statistically identical to T4 (K_{SOP} (2.11 g) + Compost 0%), T25 (K_{MOP} (1.75 g) + Boiler Ash 0%), T7 (K_{MOP} (1.75 g) + Compost 0%), T11, T1 (K_0 (No K addition) + Compost 0%), T10 (K_0 (No K addition) + Press Mud 0%) and T19 (K_0 (No K addition) + Boiler Ash 0%) with shoot dry weight of 10.15, 10.10, 10.08, 10.04, 9.71, 9.67 and 9.49 g plant^{-1} (Figure 2). It was concluded from the results that a highly significant ($P \leq 0.05$) outcome of CSFs and artificial potassium addition on the shoot dry weight in wheat crop was there. Bangar *et al.* (2000) also reported an improved maize dry matter yields by the addition of press mud.

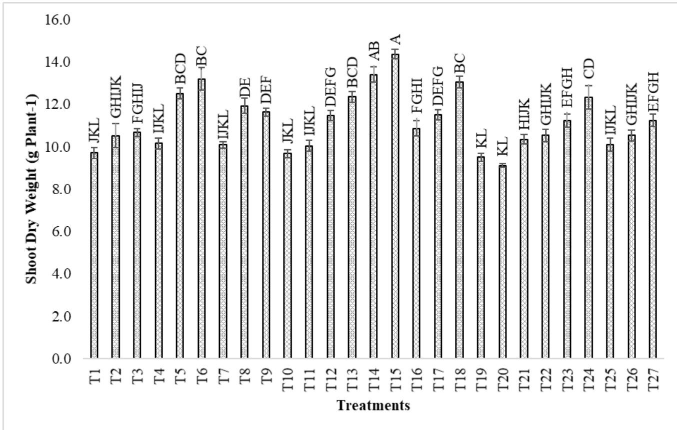

Figure 2: *Impact of CSFs and commercial K fertilizers on shoot dry weight (g) of wheat.*

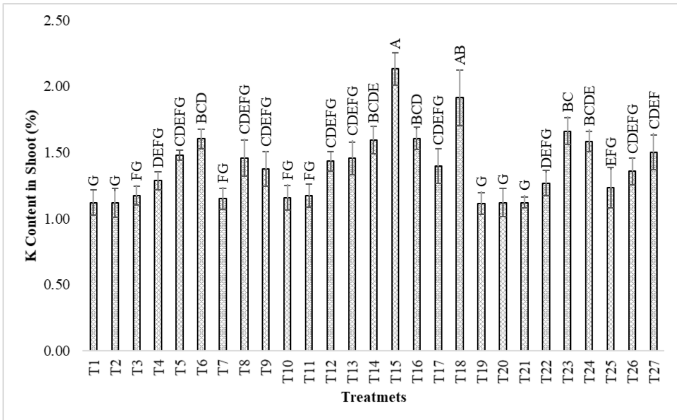

Figure 3: *Impact of CSFs and commercial K fertilizers on K content in shoot (%) of wheat.*

Potassium content in wheat shoot (%)

Highest potassium content in shoot was measured and result showed that in T15 (K_{SOP} (2.11 g) + Press Mud 1%) with value of 2.13%. While T18 (K_{MOP} (1.75 g) + Press Mud 1%) also showed the maximum potassium content in shoot with value 1.91% when observed statistically. Minimum potassium percentage in plant shoot was depicted by T19 (K_0 (No K addition) + Boiler Ash 0%) with the value of 1.11%. Although T19 (K_0 (No K addition) + Boiler Ash 0%) gave minimum value of potassium content in shoot (Figure 3). Both maximum and minimum range of potassium content in shoot (%) suggest that a highly significant ($P \leq 0.05$) consequence of CSFs and artificial potassium sources on potassium content in shoot (%) of wheat crop. Korai *et al.* (2014) also concluded that potassium concentration in shoot was enhanced with the addition of press-mud in maize crop. These results were similarly supported by study carried out by Singh *et al*. (2007) and Kumar *et al*. (2007) suggesting that nutrient uptake was enhanced by rice with the application of press mud.

Potassium content in wheat root (%)

Potassium content in root was maximally observed in T15 (K_{SOP} (2.11 g) + Press Mud 1%) with % of 1.12. On the minimum side T2 (K_0 (No K addition) + Compost 0.5%) gave the minimum potassium content in root (%) with value of 0.69 % (Figure 4). The data revealed that effect of CSFs and artificial potassium fertilization on potassium content in root (%) displayed significant (P ≤ 0.05) result in wheat crop. Juwarkar *et al*. (1993) also concluded the same result that application of press mud to the soil enhanced potassium concentration in root as well as in shoot maize crop. Yang *et al*. (2013) concluded the same result that application of different sugarcane press mud altered the potassium concentration in root positively in sugarcane crop.

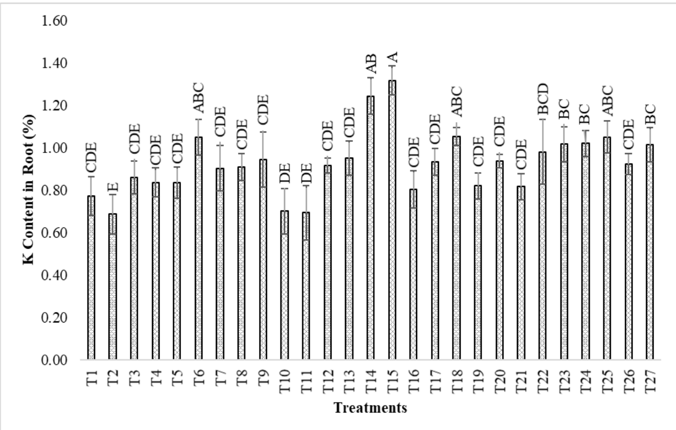

Figure 4: *Impact of CSFs and commercial K fertilizers on K content in root (%) of wheat.*

Potassium content in soil (mg kg⁻¹)

Potassium content in soil was observed maximum in treatment T15 (K_{SOP} (2.11 g) + Press Mud 1%) with the average value from three replicates, 330 mg kg^{-1} soil. While to the minimum side T2 (K_0 (No K addition) + Compost 0.5%) gave the least value of potassium concentration in soil valuing 278 mg kg^{-1} soil (Figure 5). Results about potassium content in soil exposed a highly significant (P ≤ 0.05) result of CSFs aided with artificial potassium sources on the potassium content in soil (mg kg^{-1}) in wheat crop. The outcomes were in line with study of Jamil *et al*. (2008) from which it was concluded that potassium content in soil was enhanced by the addition of press mud. Muhammad and Khattak (2009) too suggested that the press mud application enhanced soil nutrient status.

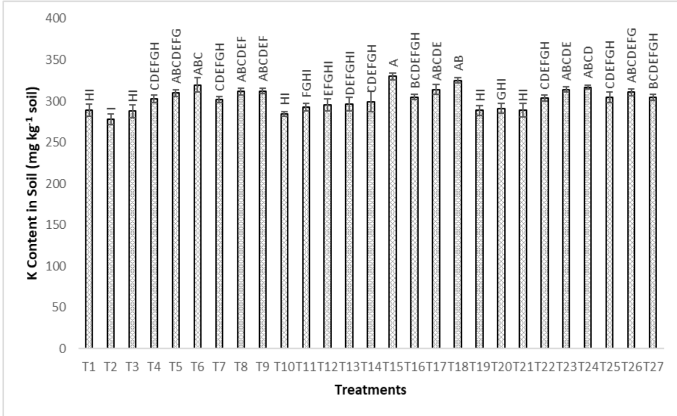

Figure 5: *Impact of CSFs and commercial K fertilizers on K content (%) in soil.*

Conclusions and Recommendations

CFSs performed positive role in terms of minimizing bioavailable K losses when used in combination with commercial sources of K. All CSFs substantially improved the growth and yield of wheat. However, press mud proved best in terms of improving yield contributing parameters, K content of wheat root and shoot as well as growth media.

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Novelty Statement

Use of CSFs along with commercial K fertilizers improved the K content of plants and growth media.

Author's Contribution

Mukkram Ali Tahir: Designed and supervision.
Noor-us-Sabah: Co-Supervision and write up.
Muhammad Waryam Warraich: Conducted the research.
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 reading.

Conflict of interest
The authors have declared no conflict of interest.

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