Effect of different phosphatic fertilizers on growth attributes of wheat (Triticum aestivum L.)

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Abstract: Among all the elements required by a plant, phosphorus (P) is one of the most important nutrients for crop production and emphasis is being given on the sufficient use of P fertilizer for sustainable crop production. A pot experiment was conducted in green house at the Department of Soil Science and SWC, Pir Mehr Ali Shah Arid Agriculture University, Rawalpindi during Rabi season, 2007. Phosphorus was applied at the rate of 40 and 80 kg P ha^{-1} in the form of SSP, TSP, NP and DAP. A basal doze of 100 kg N and 60 kg K ha^{-1} was applied as urea and murate of potash (MOP) respectively. All the growth parameters of wheat were significantly improved by addition of P application. It was concluded from the study that phosphorus application at the rate of 80kg P ha^{-1} as single super phosphate (SSP) showed better results as compared to triple super phosphate (TSP), nitrophos (NP) and diammonium phosphate (DAP) on phosphorus deficient soil of Balkasr area of Tehsil Chakwal.

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1. Introduction

Phosphorus is critical in the metabolism of plants, playing a role in cellular energy transfer, respiration, and photosynthesis. It is also a structural component of the nucleic acids of genes and chromosomes and of many coenzymes, phosphoproteins and phospholipids. Early season limitations in P availability can result in restrictions in crop growth, from which the plant will not recover, even when P supply is increased to adequate levels. An adequate supply of P is essential from the earliest stages of plant growth (Bertrand *et al.*, 2003). A growing plant may experience different stages in mineral nutrition, based on the balance among internal and external nutrient supplies and crop demand for nutrients. Initially, plants will live on their seed reserves, with external supply having little effect on plant growth. A second stage occurs when growth rate is determined by nutrient supply through a dynamic balance between internal plant factors and external (soil) supply (Grant *et al.*, 2001). In a final stage, the relative growth rate may decline for reasons other than inadequate nutrition. At this point, the growth rate of deficient and sufficient plants may converge, since the factor most limiting to growth is not nutrient supply. The length of time required for a P deficiency to show an effect on plant processes depends on the extent of P reserves in the plant. In tissues of higher plants, the majority of the P is present as inorganic P (Holloway *et al.*, 2001).

Among different factors, the role of nutrients is well recognized in crop production. The inadequate supply of the essential plant nutrients in soil is growth limiting factor towards its production. Among all the elements required by a plant, phosphorus (P) is one of the most important nutrients for crop production and emphasis is being given on the sufficient use of P fertilizer for sustainable crop production (Ryan, 2002). It is an expensive nutrient as compared to nitrogen (Nisar, 1996). Therefore it is imperative to manage it properly to achieve its maximum use efficiency. Among other factors, lack of proper balance between nitrogen (N) and phosphorus (P) is considered important as it remained mostly in favor of N and has increased to as high as 4.7:1 against the recommended ratio of 2:1 or lower (Ahmed, 2000).

Soils of Pakistan are alkaline and mostly calcareous in nature and P fixation is a serious problem in these soils (Sharif *et al.,* 2000). According to NFDC (2003), 93 percent of Pakistani soils are P deficient. When P fertilizer is added, the soil can rapidly and firmly adsorb a large amount of P from the soil solution. When P is adsorbed, it becomes unavailable to the plants and with time is difficult to release from the soil (Huang, 1998). At present DAP

(18:46:0) is the principle phosphate fertilizer used in Pakistan, with somewhat less quantities of NP (23:23:0) and much smaller amounts of SSP and TSP. The phosphorus fertilizer use can help to reduce the adverse effect of drought under rainfed conditions. The Potash and Phosphate Institute (PPI, 1999) reported that phosphorus, in balanced soil fertility program, increase water use efficiency and helps crop to achieve optimal performance under limited moisture conditions. As wheat is staple food of Pakistan, the present study was undertaken to compare the effect of different phosphatic fertilizers on wheat crop in Balkasr soil series.

2. Materials and Methods

A pot experiment was conducted to compare the effect of different phosphatic fertilizers on wheat crop in Balkasr soil series of Tehsil Chakwal. The study was conducted in green house at the Department of Soil Science and SWC, Pir Mehr Ali Shah Arid Agriculture University, Rawalpindi during Rabi season, 2007. For this, bulk soil sample from 0-30 cm depth was brought from farmer's field of Balkasr area of Tehsil Chakwal. Soil sample was air dried, ground, passed through a 2 mm sieve and mixed thoroughly. Ten kg of the prepared soil was packed in each earthen pot having height and diameter of 18 and 12, inches respectively. The pots were lined with polythene bags. Eight seeds of wheat (cv. GA 2002) were sown on 20th November, 2007. Phosphorus was applied at the rate of 40 and 80 kg P ha^{-1} in the form of SSP, TSP, NP and DAP. A basal doze of 100 kg N and 60 kg K ha^{-1} was applied as urea and murate of potash (MOP) respectively. Thinning was conducted on 22nd December, 2007 and four plants per pot were grown. Distilled water was used to bring the soil to 50 percent of maximum water holding capacity by weighing the pots as and when required. One plant per pot was harvested at 80 days growth while three plants were harvested at maturity on Saturday, May 5, 2007 at 137 days growth. Experiment was laid out in completely randomized design (CRD) with three replications.

Soil sample collected from the farmer's field of Balkasr soil series was air dried, ground, passed through a 2 mm stainless steel sieve and mixed thoroughly. This soil sample was used for physio-chemical analysis like soil texture, macronutrients (P, K), electrical conductivity (EC_e), soil pH_s, and organic matter (OM) at the beginning of experiment (Table 1). The soil used for the experiment was sandy loam in texture, alkaline in reaction (pH=7.92), poor in organic matter (0.40%), adequate in potassium (92 mg kg^{-1}) and low in available phosphorus (4.6 mg kg^{-1}). Particle Size Analysis was done by Bouyoucus Hydrometer Technique (Bouyoucus, 1962). Soil paste was prepared and saturation extract was obtained. Then the pH was determined with a pH meter (Page *et aI.*, 1982) and Electrical conductivity was measured by using electrical conductivity meter (Page *et al.*, 1982). Organic matter was determined by using Walky and Blake method (Page *et al.*, 1982). Available Phosphorus was measured by spectrophotometer (Olsen, 1982). Extractable potassium was determined by using flame photometer (Knudsen *et al.*, 1982).

2.1 STATISTICAL ANALYSIS

The data collected for various parameters were subjected to Analysis of Variance (ANOVA) and the means obtained were compared by LSD at 5 percent level of significance (Steel and Torrie, 1980).

3. RESULTS

3.1 Effect on Number of Tillers per Plant

The yield of a crop is dependent upon the combined effect of many factors. Among these factors, the number of tillers per plant has a vital position, controlling yield of wheat. The more the number of tillers, the better will be the stand of crop, which ultimately increases the yield (Jamwal and Bhagat, 2004). The data presented in Table 2 show the effect of different phosphorus sources and levels on number of tillers per plant of wheat crop (cv. GA 2002). The results revealed that the maximum numbers of tillers per plant (6.67) were found in the treatment T_6 (80 kg ha^{-1} P as SSP) and minimum numbers of tillers per plant (3.00) in treatment T_1 (control). Different P sources showed significant effect on number of tillers per plant while the number of tillers per plant increased with the increased level of phosphorus application. At both P fertilizer levels applications, Single Super Phosphate (SSP) resulted in maximum number of tillers per plant as compared to Triple Super Phosphate (TSP), Nitrophos (NP) and Diammonium Phosphate (DAP).

3.2 Effect on Plant Height (cm)

Plant height is a genetic character of a variety but its potential can be achieved by adequate crop management. The data on the effect of different P sources and levels on plant height is given in Table 2. The results showed that the maximum plant height (91.67 cm) was recorded in treatment T_6 (80 kg P ha^{-1} as SSP), while it was minimum (75.33 cm) in treatment T_1 (control). Plant height was significantly affected among all the various P sources application. It also increased linearly with the increased level of phosphorus application. Hence, among low level of various phosphorous fertilizer application, Diammonium Phosphate had enhanced more plant height while at high level SSP resulted in maximum plant height as compared to TSP, NP and DAP.

3.4 Effect on Spike Length (cm)

The data in table-2 pertaining to spike length indicated that it was maximum (10.00 cm) in treatment T_6 (80 kg P ha^{-1} as SSP) while recorded minimum (5.00 cm) in farmer practice. Various P sources and levels application to wheat spike length varied significantly. The data concluded from the results that among low P level application, Nitrophos had enhanced more spike length. Among all high P level application, Single Super Phosphate had produced more spike length as compared to TSP, NP and DAP.

3.5 Effect on Number of Grains per Spike

Number of grains per spike is one of the easily determinable characters, which has a positive co-relation with the yield. The effect of different P sources and levels on number of grains per spike along with statistical interpretations is presented in Table 2. The results showed that maximum numbers of grains per spike (39.67) were observed in treatment T_6 (80 kg P ha^{-1} as SSP) and minimum numbers of grains per spike (33.33) were observed in treatment T_1 (control). Different P sources showed significant effect on number of grains per spike. Number of grains per spike increased with the increased level of phosphorus application. At low P level applications, DAP increased more number of grains per spike while at high P level applications, SSP had produced maximum number of grains per spike as compared to TSP, NP and DAP.

3.6 Effect on Grain Yield (g pot^{-1})

The data regarding grain yield (g pot^{-1}) shown in table-2 differed significantly in all treatment. Maximum grain yield (32.20 g pot^{-1}) was observed in T_6 (80 kg P ha^{-1} as SSP) while it was found minimum (12.00 g pot^{-1}) in treatment T_1 (control). Grain yield was significantly affected by different P sources and increased with the increased level of phosphorus application. Among low level of P application, DAP had produced maximum grain yield. Hence among all high P level applications, SSP resulted in maximum grain yield as compared to TSP, NP and DAP.

3.7 Effect on Straw Yield (g pot^{-1})

The data on the effect of different P sources and levels on straw yield (g pot^{-1}) along with statistical interpretations were shown in table-2. The straw yield also showed the similar response like the grain yield. The findings showed that the maximum straw yield (61.24 g pot^{-1}) was observed in the treatment T_6 (80 kg P ha^{-1} as SSP) while it was observed minimum (25.20 g pot^{-1}) in the treatment T_1 (control). Different P sources and levels showed significant effect on straw yield. Hence, among all P applied levels, SSP had produced maximum straw yield as compared to TSP, NP and DAP.

4. Discussion

The result of this research indicated that there existed a significant impact of P containing fertilizers on the various growth attributes of wheat crop. The crop yield is much important for enhancing the farmer and country economy. It is specifically correlated with many growth factors like number of tillers per plant, plant height, spike length, number of grains per spike and straw yield. These had lingering role to enhance or lemmatize the crop productivity. Therefore more number of tillers per plant (6.67) was found in the treatment (table-2) where 80 kg ha^{-1} P as SSP was applied while farmer practice produced very minimum numbers of tillers per plant (3.00). However, our findings showed that the number of tillers per plant increased with the increased level of phosphorus application. Among all P containing fertilizers, SSP application had produced more number of tillers per plant as compared to TSP, NP and DAP. It might be due to maximum availability of phosphorous which established more root establishments. This fact would ultimately maximum availability of mineral nutrients for optimum cell growth, reproduction, photosynthesis and transformation of sugars and starches. The results are in line with the findings of Jamwal and Bhagat (2004) who reported that basal application of the recommended dose of DAP produced significantly higher number of effective tillers m^{-1} row length which ultimately increased the grain and straw yields. Renu *et al.* (2005) also found that the number of tillers per plant was less where no fertilizer was applied as compared to phosphorus fertilizer application in case of wheat crop. Various other scientists (Baon *et al.*, 1992; Bertrand *et al.*, 2003; Glassop *et al.*, 2005) also responded similar to our findings. They also found that phosphorous had a significant impact on various cereal crops growth attributes as these are paradox for the yield enhancing factors. They also suggested for application of phosphatic fertilizers at early growth stages to support the lateral growth stages for enhancing crop productivity as per their potential.

Number of tillers per plant depicted in table-2 also elucidated the similar trend number of tillers per plant. Therefore, our findings do match to Jamwal and Bhagat (2004) who reported that basal application of the recommended dose of DAP produced significantly higher number of effective tillers m^{-1} row length which ultimately increased the grain and straw yields. Renu *et al.* (2005) also found that the number of tillers per plant was less where no fertilizer was applied as compared to phosphorus fertilizer application in case of wheat crop. Various other scientists (Baon *et al.,* 1992; Bertrand *et al.,* 2003; Glassop *et al.,* 2005) also responded similar to our findings. They also found that phosphorous had a significant impact on various cereal crops growth attributes as these are paradox for the yield enhancing factors. They also suggested for application of phosphatic fertilizers at early growth stages to support the lateral growth stages for enhancing crop productivity as per their potential.

In addition to them, plant height also contributed a significant impact on enhancing the straw yield. The table-2 showed that plant height higher plant height (91.67 cm) was also noted in treatment where80 kg P ha^{-1} as SSP, while farmer practice had attained minimum (75.33 cm) plant height. Hence DAP and SSP had enhanced higher plant height as compared to TSP, NP and DAP. Our findings are in line with the accordance of Holloway *et al.,* 2001; Khan 1975; Li *et al.,* 2005) who also reported the similar findings.

Spike length in table-2 was recorded maximum (10.00 cm) in 80 kg P ha^{-1} as SSP application and was noted minimum (5.00 cm) was found in control treatment. Different P sources and levels significantly affected spike length. However, amongst low level, NP resulted in maximum spike length while at high level SSP resulted in maximum spike length as compared to TSP, NP and DAP. Some other scientists (Lombi *et al.,* 2004; McBeath *et al.,* 2005; Mohammad *et al.,* 2004) showed the similar trend for phosphorous application to various crops. They also found that spike length of the cereal crops are the major factor to feed the livestock for the sustainability of the food web. They observed that basal application of the recommended dose of DAP produced significantly taller spike length that ultimately increased the grain and straw yields.

Number of grains per spike shown in table-2 reflected that control practice had produced minimum number of grains per spike while were noted more in treatment T_6 where 80 kg P ha^{-1} as SSP applied. However, DAP and SSP had produced more number of grains per spike as compared to other P containing fertilizers. Poulsen *et al.* (2005) recommended the phosphatic fertilizer application enhanced significantly higher number of grains per spike which ultimately increased the grain and straw yields. Various scientists (Ravnskov *et al.,* 1995; Reuter *et al.,* 1995) also showed the similar results.

In table-2, higher grain yield (32.20 g pot^{-1}) was observed in T_6 (80 kg P ha^{-1} as SSP) while it was found minimum (12.00 g pot^{-1}) in treatment T_1 (control). Grain yield was significantly affected by different P sources and increased with the increased level of phosphorus application. At low level, DAP resulted in maximum grain yield but at high level, SSP resulted in maximum grain yield as compared to TSP, NP and DAP. The results are in line with the findings of Reddy and Sigh, (2003) who observed that among the different phosphatic fertilizers, single super phosphate resulted in the highest grain yield (50.27 q ha^{-1}), followed by nitrophos (43.96 q ha^{-1}) and diammonium phosphate (43.13 q ha^{-1}). Grain yield was higher; where phosphorus fertilizer was applied as compared to that where no P fertilizer was applied in case of wheat crop (Yaseen *et al*., 1998). Highest grain and straw yields were observed where P was applied as nitrophos (Alam *et al., 2002*). Rashid *et al.* (2002) observed that substantial crop yield increases as well as plant P concentration enhancements were observed with applied P. The findings of various scientists (Schweiger and Jakobsen 1999; Smith and Smith 2005; Smith *et al.,* 2003) also responded similar to our results.

The straw yield (table-2) also showed the similar response like the grain yield. SSP had produced more straw yield as compared to TSP, NP and DAP. Straw yield was higher; where phosphorus fertilizer was applied as compared to that where no P fertilizer was applied in case of wheat crop (Yaseen *et al.,* 1998). Highest grain and straw yields were observed where P was applied as NP (Alam *et al.,* 2002). Various other scientists (Rashid *et al*, 2002; Smith *et al.,* 2004; Zhu *et al.,* 2001) observed that substantial crop yield increases as well as plant P concentration enhancements were observed with the application of phosphorus.

Above discussion stated that P containing fertilizer like DAP and SSP fertilizer should be applied at the early growth stages. Hence, these would have significant affect on the lateral growth stages of the wheat crop. Hence, this study would act as a paradox for other scientist to verify this fact at large field scale for it implication.

Table 1: Basic Soil Analyses of the Selected Soil

Parameters	**Units**	**Values**
Sand	%	90.14
Silt	%	7.92
Clay	%	1.94
Textural Class		Sandy Loam
PH_s		7.90
EC_e	$dS\ m^{-1}$	1.48
Organic Matter	%	0.40
Available Phosphorus	$mg\ kg^{-1}$	4.6
Extractable Potassium	$mg\ kg^{-1}$	92

Table 2: Effect of different P sources and levels on yield and yield components of wheat crop

Treatments	Sources and Levels of phosphorus	Number of tillers per plant	Plant height (cm)	Spike length (cm)	Number of grains per spike	Grain yield (g pot^{-1})	Straw yield (g pot^{-1})
T_1	Control	3.00 c	75.33 f	5.00 c	33.33 c	12.00 e	25.20 d
T_2	40 kg P ha^{-1} as SSP	4.00 bc	83.33 bc	7.00 bc	35.67 b	20.50 d	41.21 c
T_3	40 kg P ha^{-1} as TSP	3.67 bc	79.67 e	7.67 ab	35.33 b	20.20 d	40.56 c
T_4	40 kg P ha^{-1} as NP	3.67 c	85.33 b	7.67 ab	36.33 b	20.01 d	40.27 c
T_5	40 kg P ha^{-1} as DAP	4.00 bc	82.33 cd	7.00 bc	36.67 b	21.90 d	39.90 c
T_6	80 kg P ha^{-1} as SSP	6.67 a	91.67 a	10.00 a	39.67 a	32.20 a	61.24 a
T_7	80 kg P ha^{-1} as TSP	5.33 c	80.67 d	9.33 ab	39.33 a	25.50 c	58.03 bc
T_8	80 kg P ha^{-1} as NP	5.67 b	83.00 c	8.67 ab	38.33 a	26.10 c	57.43 bc
T_9	80 kg P ha^{-1} as DAP	6.33 b	80.67 d	9.67 ab	38.67 a	29.30 b	58.84 b

- The means having different letter are significantly different from each other at 5% level of probability.

5. Conclusion

It was concluded from the study that phosphorus application at the rate of 80kg P ha^{-1} as single superphosphate (SSP) showed better results as compared to triple superphosphate (TSP), nitrophos (NP) and diammonium phosphate (DAP) on phosphorus deficient soil of Balkasr area of Tehsil Chakwal. This superiority of SSP over the other three sources could be due to presence of more Ca content and better water solubility of phosphate compound. Single super phosphate can be used on all crops and soils as a basal dressing. Its use for ailing saline/sodic soils is, however, preferred because of the ameliorative effect ascribable to its 46% gypsum content and highly acidic nature (pH 2.0). This product is also manufactured locally and easily available to farmers. However as it contains less percentage of phosphorus therefore its storage and transportation cost is high as compared to other sources.

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