Effect of Various Doses and Application Method for Phosphorus Fertilizer on Wheat Under Arid Conditions

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ABSTRACT

An appropriate method and optimal dose of phosphorus (P) fertilizers is important from economic and environmental point of view and for the conservation of the world's phosphoric reserves. A field experiment was conducted during rabi season 2018-19 at Regional Agricultural Research Institute, Bahawalpur to determine the most efficient application method and optimum dose of phosphorus fertilizer on wheat. Three methods of P application i.e. line sowing with P as broad casted (M1), line sowing with P application as bands (M2), Ridging after P and wheat seed as broad casted (M3) were adopted at the time ofsowing. The experiment was laid out following split plot design replicated thrice. Analysis of variance depicted significant differences among various methods of sowing and P application. Maximum grain yield of 4441.9 kg ha^{-1} was recorded for P @120 kg ha^{-1} indicating importance of phosphorus at its highest dose in achieving maximum wheat output. Maximum fertile tillers m^{-2} were obtained in plots treated with P@ 120 kg ha^{-1} indicates Maximum phosphorus dose contributed in achieving highest 1000 grain weight and finally resulted in statistically significant grain yield ha^{-1}. These findings indicate that application of the highest dose of phosphorus contributed maximum to translocate dry matter and physiological attributes towards the yield attributes in wheat variety Mairaj 2008 and therefore maximum phosphorus dose helped in achieving highest number of grains spike^{-1}, 1000 grain weight and ultimately wheat yield. Results indicated that increased the number of fertile tiller, spike length, 1000 grain weight and ultimately wheat yield by using a method ridging after Phosphorus and wheat seed broad caste (M3). More field studies are required to determine interactions between P response and the effects of climate, soil properties, moisture levels and other management practices.

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INTRODUCTION

Inherited potential of a cultivar has been exploited and the harvest index also significantly increased, due to the contribution of the fertilizers to the wheat crop. Among all fertilizers, phosphorus (P) fertilizer is a costly input which requires appropriate management to acquire economic and sustainable crop yield (Ali, 2012) because it is the most important nutrient next to the Nitrogen because it plays a fundamental role in metabolism and energy producing reactions and can withstand the adverse environmental effects, thus causing boost in yield (Azink and Kajfez, 1983). So, Phosphorus is needed by a wheat crop to initiate the development when it is just at seedling stage and continuing all the way to maturity. Phosphorus is not a nutrient to overlook because it is required for quality, formation of seeds, uniform heading and timely maturity and strengthens the plant to help survive at lower temperature.

Appropriate and balanced fertilization on wheat and rice not only causes yield enhancement but also has good impact on phosphorus uptake by these crops phosphorus uptake increased excellently by the use of balanced fertilizers on rice and wheat crop plants respectively, which also causes enhancement of the yield parameter (Rehman et al. 2006).This study is important because methods of application of fertilizer are one of the major causes for low fertilizer P-use efficiency in alkaline calcareous soils (Iqbal. et al 2013).

The supplies of natural resources are limited, which may be maintained or increased only gradually, if found renewable. This is because world population and the wealth of the developing countries is increasing with the increase in demand for foodstuffs. Wheat is the most important worldwide staple foodand widely cultivated cereal graincrop for its seed(Shewry, 2009, James 2014,Belderok, et al 2000). Wheat is the staple food of human beings and Pakistan is the 8th of the important wheat cultivating countries globally. In 2016, world production of wheat was 749 million tonnes,making it the second most-produced cereal after maize(FAO 2016, FAOSTAT 2016). Due to the unique viscoelastic and adhesive properties of gluten proteins,global demand for wheat is increasing, due to which the production of processed foods increased and also the consumption is increasing because of the worldwide industrialization process and the westernization of the diet (Shewry and Hey 2015, Day et al., 2006). Globally, wheat is the leading source of vegetal protein in the human food because wheat is also an important source

of carbohydrates with a protein content of about 13%, which is relatively high compared to other major cereals (CORDIS, 2016).
As compared to other wheat producing countries, yield per hectare is very low in Pakistan despite its higher yield potential (Sarwar et al., 2010). Food production in Pakistan is not increasing with increasing population growth. The yield of the major crops is stagnated. The farmers practice low input agriculture because of high risk due to uncertain prevailing condition (Razzaq et al., 1990).
Wheat provides greater nourishment for people globally than any other food grain like in Pakistan wheat contributes about 12.5 percent to the value added in agriculture, 2.6 percent to GDP and cultivated in an area of 8666 thousand hectare during 2011-12 (Anonymous, 2012). There are many reasons of low yield but the most important one is the injudicious use of phosphorus fertilizer. Phosphorus fertilization is very essential for exploitation of good yield of different crops (Rashid et al., 1994).

Keeping all above in view, the studies were conducted with the objectives to find out the appropriate phosphorus application method and optimal dose of P on wheat variety Mairaj-08 to increase profitability or improved environmental steward ship (Schmidt et al., 2002) and facilitate the farmers to aware them with proper and balanced fertilizer recommendations and is becoming increasingly important, for reasons of crop productivity, food security, and sustainability (Agegnehu et al,, 2015).

MATERIALS AND METHODS

A field trial on a loamy and aerated soil to determine the proper use of phosphorus was conducted at Regional Agricultural Research Institute, Bahawalpur during winter 2018-19 to find out the effect of best phosphorus application method on wheat variety Mairaj-08. P fertilizer was applied as treatments; line sowing with broad caste of Phosphorus fertilizer (M1), line sowing with band application of Phosphorus fertilizer (M2), Ridging after Phosphorus and wheat seed broad caste (M3). The treatments were replicated three times and arranged in a Split plot design. Some selected properties of the soils collected from experimental fields determined by the standard methods are given in Table 1. The methods used for soil analysis have been described by Winkleman et al. (1986). After soil analysis, prepared the land with recommended methods. After that Wheat variety Mairaj 2008 was sown in the field with tractor drill at a seed rate of 120 kg ha^{-1}. Phosphorus was applied as a single full dose at the time of sowing, urea @ 7.8 kg $Plot^{-1}$ at sowing, 7.8 kg $Plot^{-1}$ at 1st irrigation and 7.8 kg $Plot^{-1}$ at 2nd irrigation. Here Fertilizers used as the source of N was Urea, source of P was Di Ammonium Phosphate (DAP) and source of K was Murate of Potash. P fertilizer was applied at 0g P $Plot^{-1}$, 280g 560g, 840g, 1120g respectively in wheat experimental field. DAP in broadcast method was spread over respective plots and incorporated in soil at the time of sowing of wheat. There were six rows in each plot and only the central four rows with a plot size of 1.8 m x 7m were harvested at maturity. Weeding was done manually during the growing season. Weeds were controlled chemically by spraying broad and narrow leaved weedicides. Starne M (300 mlacre^{-1}) was sprayed after 45 days after sowing to control the broad leaf weeds while the Atlantis 3.6 WG (160 gacre^{-1}) was used for narrow leaf weeds after 56 days of sowing. All other agronomic practices were kept normal and uniform. At physiological maturity data regarding agronomic traits as number of fertile tillers, plant height, number of spikelets per spike, number of grains per spike. Plant height were recorded by measuring height of ten randomly selected tiller from ground level to the tip of spike with the help of meter rod and then calculated mean from the average. Number of grain Spike^{-1} and number of spikelets Spike^{-1} was recorded by counting of grain and spiklets of randomly ten Selected spikes. After harvesting, 1000–grain weight (g), grain yield (t ha^{-1}), were recorded by using standard procedures. Twenty plants were selected from each treatment and took plant height, number of spikelets per spike, number of grains per spike was recorded and values were averged to obtain mean for each parameter. A sample of 1000 seeds was taken randomly from the total seed lot of each plot and then weighed using the triple beam balance. Selected three locations of one-meter square in each plot randomly at the stage of physiological maturity, counted the total number of productive tiller and then average was calculated. Grain yield was recorded by harvesting m2 per plot. Grains were threshed and weighed manually. Grain yield was then converted to get the final grain yield in Kg ha^{-1}.Calculated Grain yield data regarding square meter was then converted into the final grain yield in Kg ha^{-1}. Data was analyzed statistically by using MSTAT-C technique and treatment means were compared by using least significant difference (LSD) test at 5% probability level (Steel and Torrie, 1984). Means for the main effects were compared using the MEANS statement with the least significant difference (LSD) test at the 5% probability level.

Table 1: Soils Properties collected from different experimental areas.

Soil Properties	**Value**
pH (1:1)	**8.4**
Organic matter, %	**0.71**
EC, (1:10) dS m^{-1}	**2.8**
P Olsen's, mgkg^{-1}	**6.4**
K mgkg^{-1}	**110**
SP %	**32**
Textural class	**Loam**

RESULTS AND DISCUSSION

Fertile tillers per square meter

The study of Davidson and Chevalier, 1990) illustrated the importance of tillering as a a major yield contributing factor of wheat and other cereals has been recognized (Ishag and Taha, 1974; Masle, 1981).

Data showed significant differences between control and treatment means regarding fertile tillers m^{-2}. Maximumfertile tillers (302.3 m^{-2}) were achieved in treatment where F_5(P@ 120kg ha^{-1}). These results also confirm the efficient and balanced availability of nutrients to crop which lead toward enhanced fertile tillers. Plants may develop better roots with the balanced availability of nutrients and enhanced crop growth (Table 2). These results are directly in line with the findings of Munir et al. (2002) and Hussain et al. (2008) Malik et al. (1995), Pareek et al. (2004) and Memon et al. (2005). It was depicted from the results that P increased fertile tillers m^{-2} by increasing P level. Similarly, minimum fertile tillers m-2 i.e. 285.56 was achieved in F1 where P @0 kg ha^{-1} was applied. Phosphorus (P) deficiency limits the yield of wheat, particularly by reducing the number of ears per unit of area because of a poor tiller emergence. Phosphorus deficiency directly altered the normal pattern of tiller emergence by slowing the emergence of leaves on the main stem (i.e. increasing the phyllochron), and by reducing the maximum rate of tiller emergence for each tiller (Rodr´ıguez 1999).
Data for method of applications of fertilizer showed significant differences regarding fertile tillers m^{-2}. Maximum fertile tillers (304.6 m-2) were achieved in treatment where M3 (ridging after P and wheat seed Broad cast) was applied followed by 295.00 tillersm^{-2} in M2 (Line Sowing with Band Application of P). Phosphorus deficiency reduces tillering capacity and retarded root growth. Statistically, M1 and M2 found similar. Maximum productive and minimum nonproductive tillers m^{-2} were recorded from 100 kg P_2O_5 ha^{-1} when applied through double band placement method, and minimum were recorded from control. Our results are in conformity with Jiand et al., (2006) and Rahim et al., (2010) who reported that number of productive tillers m^{-2} were influenced significantly with phosphorus application methods. like Ali et al., 2004 depicted Phosphorus application through intra row drilling technique gave maximum number of productive tillers m^{-2}.

Plant height

Increase in plant height can improve grain and forage production in wheat. Plant height, number of grains per spike, grain weight per spike, 100-grain weight, biological yield and grain yield contribute equally to average grain yield of wheat crop (Zia 2016). This correlation occurred irrespective of plant spacing. Selection for height was found to be more effective at improving yield than direct selection for yield. The positive correlation between height and yield was observed among a set of varieties and lines (Law,et al., 1978).Table no.2 showed the interaction between methodology and rate of P doses of wheat variety Mairaj-2008 grown by different methods at different fertilizer doses. Statistical analysis of data showed significant differences for rate of fertilizer with maximum height at maximum fertilizer. This phenomenon was confirmed by Aulakh et al. (2003). Observations showed that plant heights were taller in plots treated with P fertilizer than untreated plots Increase in plant height as compared to control treatment might have been due to that phosphorus stimulates root development and growth in the seedling stage and thereby it helps to establish the seedling quickly. Application of phosphorus resulted in normal plant growth, and thus plant height was increased. Highest plant height (101.56 cm) was attained when treated with 125 kg P_2O_5 ha^{-1} and at par with 75 and 100 kg P_2O_5 ha^{-1} such type of result showed by Bashir et al 2015 and the findings are in accordance with the investigations of Memon et al. (2005) and Pareek et al. (2004) who reported that phosphorus application increases plant height in wheat. Hussain et al., (2008) stated that wheat crop with 120 kg P_2O_5 ha^{-1} produced taller plants. From methodology aspects result showed non-significant difference among methods.

Spike length

Spike length or ear size is considered as a yield contributing factor because larger spike have more grains as compared to shorter spike which ultimately leads toward better grain yield. It is evident from the data that the numerically taller spikes were produced by phosphorus. Shorter spikes were found in a treatment where wheat grown without phosphorus application. Significant differences among various methods of application showed the enhanced spike length with side dressing at planting but it was statistically similar with side dressing with 1st irrigation. Improved spike length might be due to crop with efficient nutrient availability as in other methods chances of wastages of nutrients were more (Table 2). Almost similar findings were described by Alam et al. (2003).

Number of spikelets per spike

Data regarding the number of spikelets per spike was found to be significant and revealed that this parameter influenced by different sources and methods of phosphorus application explained in table. 2. It is evident from the figure that highest P rate enhances the number of spikelets per spike. However, application of phosphorus promoted normal plant growth, and as a result number of spikelets per spike increased. The same results were reported by Rehman et al. (1996) and Memon et al. (2005).

M2 and M3 appeared to be improved method with the higher number of spikelets. Interaction among these two factors was found to be non-significant which showed that using any source with the improved methods can increased the spikelets per spike and ultimately the yield of the crop.

Grains per spike

Highest dose of phosphorus application P kg ha-1 produced maximum number of grains per spike (49.55) as against the control with minimum count of 26.77.

The results showed very clear impact of Ridging after Phosphorus and wheat seed broad caste on the number of grains $spike^{-1}$ leading towards increased wheat yield. The results also depicted that P application method and the rate is essential to obtain higher yield of wheat against the

common farmer's practice in the area who do not bother to keep in mind the proper dose and method of fertilizers application. The adequate application of phosphorus supply enables the crop to make rapid growth and to intercept more solar radiation and thus to produce more number of grains per spike. Because of phosphorus deficiency, plant growth and stem remained stunted. However, application of phosphorus promoted normal plant growth, and as a result number of spikelets per spike was increased. When number of spikelets per spike increased, it ultimately increased number of grains per spike. Increase in number of grains per spike can be attributed to greater spike length and more number of spikelets per spike. The results of the present study corroborate the finding of Malik et al. (1995) and Pareek et al. (2004) majeed et al 2014who also reported the decrease in number of grains per spike at lower level of phosphorus application in wheat.
Optimum application of phosphorus increased number of grains spike-1 and thousand grain weight of wheat (Zhang et al., 1999).
The results showed very clear impact of phosphorus fertilizer applied at the time of sowing on the number of grains spike^{-1} leading towards increased wheat yield (Kaleem et al 2009).

1000-Grains weight
Thousand grain weight is an important agronomic trait which have positive correlation with grain yield. It is critical for plant growth, especially in the early jointing stages (GS 31 on Zadoks growth stage scale) and for enhancing grain yield and yield components.
More the 1000-grain weight ultimately enhanced grain yield will be obtained. Data showed that the difference was statistically significant 1000-grain was increasing with increasing P dose Minimum thousand grains (27.24) were recorded in control treatment without phosphorus application. Significant difference among various method showed that the heavier grains were recorded with the application Ridging after Phosphorus and wheat seed broad caste. Interaction among various sources and methods was found to be non-significant for 1000-grain weight (Table-2. Our findings correlate with the previous findings of Memon et al. (2005) and Alam et al. (2003). It is clear from the results that increasing the ratio of NP also increased in 1000 grain weight. These findings are similar to Brennan (1992) and Samad (1984) who reported that maximum N and P fertilizer utilization recorded the highest yield effects due to maximum accumulation of photosynthates. Similarly, Akhtar et al. (2002) showed that combined application of NP and K was required for the maximum economic yield of wheat in rainfed areas of Pakistan.
Similarly, Turk & Tawaha (2001) observed that thousand grain weight of wheat was significantly increased with band placement than broadcast method of phosphorus application.

Grains yield

Nutrient utilization can be measured by of biomass production per unit of nutrient concentration by Siddique and Glass 1989. Plants showed normal growth with the increasing rate of phosphorus and resulted in improved yield components which lead toward enhancement of grain yield (Table-2). Fertilizer treatment, showed significant difference for grain yield of wheat. Highest grain yield of 4441 kg ha^{-1} was obtained in plots treated with P @ 120 kg ha^{-1} as compared to minimum yield of 3342 kg ha^{-1} in treatment where P dose was 0 kg ha^{-1}. These results are in confirmation with the findings of Islam and Baten (1987) and Petal et al. (1991) who recorded maximum yield by the application of appropriate P application. This could be the result of reduced plant senescence rate at the grain filling stage and longer duration of green leaf area duration with the application of

Similar findings were explained in previous research by Ihsan et al. (2007), Iqbal et al. (2003) and Mehdi et al. (2003). Wheat responds well to fertilizer application for increased wheat productivity (David et al., 2003 and Blaga et al., 1989).Application of P fertilizer increased wheat grain yield, up to 30% more than the control(Agegnehuet al 2015).But the effect of different phosphorus rates on grain yield of wheat was significant. Minimum grain yield (3342kg ha^{-1}) was obtained in control (0 kg P_2O_5 ha^{-1}) treatment. The grain yield increased significantly with each increase in phosphorus rates up to the 120 kg P2O5 ha^{-1}. Grain yield at the dose of 120 kg P_2O_5 ha^{-1} are statistically significant. Increase in grain yield with increased phosphorus levels might have been due to balanced fertilizer application, which resulted in higher number of fertile number, grains per $spike^{-1}$ and 1000-grain weight. These results are in line with those reported by Rehman et al. (2004), Pareek et al. (2004), Memon et al. (2005) and Mehdi et al. (2007) Majeed, et al. (2014). Similarly, Alam et al., (2003) found that with the increase of phosphate level from 0, to 150 mg P kg-1 of soil significantly increased the number of tillers $plant^{-1}$ and grain yield over control treatment. Our results are further supported by Hussain et al., (2008) Gokman & Sencar (1999)

Table 3. Analysis of variance (mean square values) for various yield components, various doses and methods of fertilizer application

Sources of variation	DF	Fertile tillers m^{-2}	Plant height	Spike length	Spikelets per spike	Grains per spike	1000 grains weight	Grain yield
Replications	1	278.83	3.65	0.02	0.001	0.02	0.01	14608.00
Doses	4	286.02**	1302.98**	2.43**	63.30**	557.07**	252.45**	1201034.00**
Error	4	73.66	105.21	0.01	0.01	0.11	0.01	13102.00

Methods	2	993.52**	341.21**	1.14**	16.73**	197.55**	73.81**	1229549.00**
Doses*Methods	8	31.43	32.43	7.76**	9.86**	7.31**	5.14**	23444.00**
Error	10	124.08	64.00	0.05	0.02	0.06	0.08	5704.00

Table 2. Impact of phosphorus sources and methods of application on various yield components of wheat crop

Treatments	Fertile tillers m^{-2}	Plant height	Spike length	Spikelets per spike	Grains per spike	1000 grains Weight	Grain yield
T_1	285.56	57.56	7.52	8.37	26.77	17.97	3342
T_2	290.50	78.22	9.13	11.21	35.55	23.21	3606
T_3	293.60	82.52	9.60	13.15	42.55	24.96	3742
T_4	295.50	88.08	11.28	16.15	46.77	26.74	4244
T_5	302.30	94.90	11.76	17.97	49.55	28.93	4441
Significance Level LSD0.05 Phosphorus (kg ha^{-1})	8.12	4.47	.50	1.09	1.24	1.43	160.86
M1	283.93	74.04	9.22	12.00	36.80	22.44	3544
M2	295.00	77.17	9.78	13.50	39.80	24.77	3836
M3	304.00	80.40	10.28	14.50	44.13	25.87	4245
Significance Level LSD0.05 Methods (kg ha^{-1})	11.18	4.43	0.388	1.60	2.73	1.53	116.61

Conclusion

With the keen observation of our results it is concluded that wheat grain yield can be enhanced with M3 of Diaamonium Phosphate at 120 kg ha^{-1}. Results also designated that with proper management of costly input (phosphorus), farmers can increase fertilizer use efficiency for sustainable crop production. On the basis of present finding, it is concluded that phosphorus application in the form of DAP at the rate of 120 kg ha-1 is more conducive for recommendation for the farmers, because it gave maximum benefit to farmers So, from this research, it is suggested that phosphorus source in the form of DAP at the rate of 120 kg ha^{-1} is an optimum dose to get maximum benefit from wheat crop.

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