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RESPONSE OF WHEAT CROP TO PHOSPHORUS FERTILIZERS AND APPLICATION METHODS GROWN UNDER AGRO-CLIMATIC CONDITIONS OF SOUTHERN PUNJAB

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Fertilizer, particularly phosphatic is a costly input which requires appropriate management to acquire economic and sustainable crop yield. A field experiment was conducted to explore the role of different phosphorus sources and methods of application on growth and yield of wheat crop at Multan, Pakistan during winter 2007-08. The experiment was conducted using randomized complete block design with split plot arrangements with three replications. Wheat variety, Inqlab-91 was used in the experimental trial. The experiment was comprised of two fertilizer sources (DAP & NP) and four application methods: Control (M_0), Broad cast (M_1), Side dressing at planting (M_2), broadcast at planting + at 1st irrigation (M_3) and Broadcast at 1st irrigation (M_4). The application of phosphorus with side dressing at planting increased fertile tillers, spikelets per spike, 1000-grain weight and recorded significantly higher wheat grain yield (5.68 t ha-^{1}) as compared to other methods of application. Among sources, DAP recorded significantly higher wheat grain yield than when NP was used as phosphorus source.

Keywords: Wheat, phosphorus, growth, yield, broad cast, side dressing

INTRODUCTION

Wheat is world's most widely grown cereal crop and staple food of most of the countries. It provides greater nourishment for people globally than any other food grain. In Pakistan it contributes 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).

Despite its higher yield potential, yield per hectare is very low in Pakistan as compared to other wheat producing countries (Sarwar *et al*., 2010). There are many reasons of low yield but the most important is the injudicious use of phosphorus fertilizer. Phosphorus fertilization is very essential for exploitation of good yield of different crops (Rashid *et al*., 1994). Phosphorus plays a vital role in several physiological processes viz photosynthesis, respiration, energy storage and cell division/ enlargement. It is also a structural component of many biochemical processes via nucleic acid (DNA and RNA enzymes and coenzymes) and also stimulates root growth and associated with early maturity of crops. Chemical fertilizer has played a pivotal role in increasing crop production all over the world. The alkaline and calcareous soils of Pakistan are low both in nitrogen and phosphorus. Consequently the use of nitrogen and phosphorus fertilizer increased many fold since their introduction in the late fifties (Ahmad, 2000). Wheat grain yield and yield contributing traits were significantly improved with addition of optimum phosphorus through soil application (Rahim *et al*., 2010; Ahmad *et al*., 2010; Khan *et al*., 2007 and Zia *et al*., 2000). Growth of canola crop was improved with the application of Monoammonium Phosphate (MAP) and Diammonium Phosphate (DAP) as compared with the triple super phosphate (TSP) (Thomas and Rengal, 2002). Similarly the phosphorus application is also a positive contributor in rice crop (Hussain, 2004). Mehdi *et al*. (2007) also reported the higher 1000 grain weight, grain and straw yield with different levels of phosphorus application upto 120 kg ha^{-1}in wheat crop. Phosphorus efficiency increases with integrated use of fertilizer ranging from 4 to 37% over SSP and caused in grain yield comparable to that from OCP, OAP or SSP alone (Alam and Shah, 2002). Khan *et al*. (2010) 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.

Gill *et al*. (2004) conducted varietal trials of wheat crop with phosphorus application and reported the higher grain and biomass yield as well as improved phosphorus harvest index and phosphorus use efficiency in Wh-711 and PBW-343. Fertigation method enhanced grain yield, phosphorus uptake, phosphorus fertilizer efficiency and agronomic efficiency as compared to top dressed method of N and P application (Alam *et al*., 2005). Obaid-ur-Rehman *et al*. (2006) reported the improved grain yield of wheat as well as of rice crop with the combined application of major nutrients like NPK. Improved yield (44%) was recorded with the application of nitrogen and phosphorus fertilizer with side placement as compared to control (Ihsan *et al*., 2007). Furthermore, early sowing of wheat crop (October 25) with phosphorus dose of 120 kg ha^{-1} resulted in maximum yield (Hussain *et al*., 2008). Phosphorus application in wheat cultivars improved grain yield, yield components, water use efficiency and phosphorus uptake in Inqlab-91 (Alam *et al*., 2003, Iqbal, 2003 and Shah *et al*., 2003; Hayyat and Ali, 2010). Side dressing resulted in maximum phosphorus concentration in grain and straw due to enhanced uptake at five irrigation levels in wheat crop (Rahim *et al*., 2007). Application of phosphorus with band placement rather than broadcast method appeared to be better for yield enhancement in wheat crop (Rahim *et al*., 2010).

Fertilizer's demand is increasing day by day to meet the crop requirement which leads toward a curious imbalanced with other nutrients It is understood that balanced fertilization helped towards efficient use of inputs to get an optimum yield. Among other agronomic factors that increased the fertilizer use efficiency, sources and methods of fertilization is also a critically important. Little work is done on interaction of both sources and methods of phosphorus application on growth and yield behavior of wheat crop. Thus the experiment was conducted to evaluate various sources and methods of phosphorus application to enhance the yield of wheat crop.

MATERIALS AND METHODS

Field experiment was conducted to explore the effect of various sources and methods of phosphorus fertilizer on growth and yield of wheat crop at Agronomic Research Farm, University College of Agriculture, Bahauddin Zakariya University Multan. The experiment was conducted by using Randomized Complete Block design with split plot arrangements having plot size of 5m x 1.37m and was replicated thrice. Various sources of phosphorus fertilizer (NP, DAP) were applied with broad cast and side dressing method at the time of first irrigation. Fertilizer application was done at the rate of 120 kg ha^{-1} nitrogen, 90 kg ha^{-1} phosphorus and 60 kg ha^{-1} potash. Soil analysis was performed before crop sowing which indicated that soil was loam with soil pH (8.4), EC (1.30 dSm^{-1}), organic matter (0.39), Available-N (0.16%), Available-P (2.45ppm) and Available-K (75ppm). Wheat cultivar, Inqlab-91 was sown with recommended method, time (25th November), seed rate (50 kg/acre) and row to row distance (25 cm x 25 cm). Two sources of phosphorus fertilizer: Nitrophos (NP) and diammonium phosphate (DAP) was applied with various methods as Control (M_0), Broadcast (M_1), Side dressing at planting (M_2), Broad cast at planting + at 1st irrigation (M_3) and Broadcast at 1st Irrigation (M_4) and supplement irrigation were applied upto crop maturity. Overall five irrigations were applied upto crop maturity. Weeds were controlled chemically by spraying broad and narrow leaved weedicides. StarneM (300 ml/acre) was sprayed after 45 days after sowing to control the boroad leaf weeds while the Atlantis 3.6 WG (160 g/acre) was used for narrow leaf weeds after 56 days of sowing. At harvest data regarding agronomic traits as plant height, number of fertile tillers, number of spikelets per spike, number of grains per spike, 1000–grain weight (g), grain yield (t ha^{-1}) , biological yield (t ha^{-1}) and harvest index (%) were recorded by using standard procedures. Twenty plants were selected from each treatment and there plant height, number of spikelets per spike, number of grains per spike was recorded and average value for each parameter was calculated afterward. Area of square meter was selected randomly from each field and then harvested for calculating number of tillers and fertile tillers from each treatment. This harvested sample was weighed for biological yield and threshed afterward for calculating grain yield per square meter. Harvest index was calculated by dividing the grain yield over biological yield. Calculated data regarding squre meter was then converted into values per hectare. 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).

RESULTS AND DISCUSSION

***Plant height (cm)*:** Data showed that application of phosphorus with different methods, significantly affected the plant height at all growth stages while the different sources did not influence it (Fig. 1). Taller plants were recorded by phosphorus application with side dressing at planting as compared with other methods. Although application of diammonium phosphate (DAP) resulted in enhanced plant height as compared with other source but effect was not statically significant. Taller plants with phosphorus application might be due the balanced application of fertilizers with improved method. Side dressing increased the availability of phosphorus to the plant roots which enhanced the plant growth, while in other methods there may be the more wastage of the fertilizer which decreased its availability to crop plants. Almost similar results regarding plant height were reported by Obaid-ur-Rehman *et al.* (2006) and Gill *et al*. (2004) who observed the improved results with phosphorus application by side dressing as compared to other application methods.

***Total tillers (m^{-2})*:** Tillering is the spirited yield component as more number of tillers ensured the better crop stand which leads toward improved crop yield. Table-2 data showed that the maximum number of total tillers were recorded with the application of DAP source compared with NP. However difference was found to be significant only at the 72 days after sowing (6th Feb) and at final harvest. Data regarding different methods of application showed that side dressing at planting significantly enhanced number of tillers over all other methods. The control plot recorded the lowest number of tillers (Table 1).These results are supported by Alam *et al*. (2003).

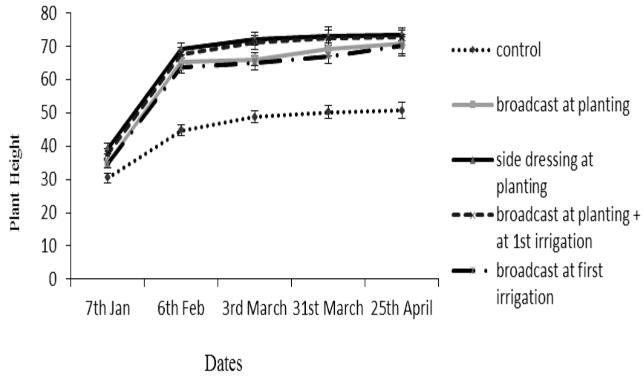

Figure 1. Plant height (cm) as influenced by different methods of phosphorus application

***Number of fertile tillers (m^{-2})*:** Number of fertile tillers in wheat crop is a major yield contributing factor which also differs significantly with the various methods of application. Table-1 data showed that the higher number of fertile tillers were recorded with the application of diammonium phosphate source but not differ significantly. While the number of fertile tillers increased significantly with the phosphorus application by side dressing at planting and resulted in maximum count. Interaction among various sources and methods of application was found to be non-significant. 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).

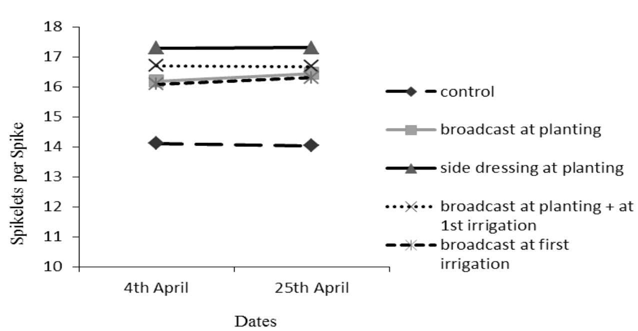

Figure 2. Number of Spikelets per Spike as influenced by different methods of phosphorus application

***Spike length (cm)*:** 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 DAP phosphorus source while it was also at par with second source (NP). 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).

***Spikelets per Spike*:** Data regarding the number of spikelets per spike as influenced by different sources and methods of phosphorus application explained in Fig. 2. It is evident from the figure that DAP application enhances the number of spikelets per spike as compared to nitrophos (NP) while at final harvest difference was found to be non-significant. Side dressing of phosphorus at planting 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.

***1000-grain weight (g)*:** Thousand grain weight is an important agronomic trait which have positive correlation with grain yield. More the 1000-grain weight ultimately enhanced grain yield will be obtained. Data showed that 1000-grain was enhanced with DAP application but the difference was not statistically significant with other source. Minimum thousand grains were recorded in control treatment without phosphorus application. Significant difference among various method showed that the heavier grains were recorded with the application of phosphorus by side dressing at planting. 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).

***Biological yield (t ha^{-1})*:** Biological yield is the total biomass produced by crop from a unit area. Table-1 data showed that significantly improved biomass was produced with the application of DAP phosphorus source. It's also clear from the data that different methods of application also differ significantly for total biomass. Maximum biomass was observed in case of side dressing application as compared with all other methods. Interaction among these two factors was found to be non-significant. Application of phosphorus with improved method and with proper source resulted in improved biomass due to the normal plant growth. Normal plant showed more number of tillers, plant height, grain weight which ultimately enhanced biomass production

(Table-2). Similar results were found my Mehdi *et al*. (2003).

***Grain yield (t ha^{-1})*:** Phosphorous application through DAP significantly increased wheat grain yield as compared to when it was applied through NP. Among application methods, phosphorus applied throgih side dressing recorded significantly higher wheat grian yield than all the other method of application; all the methods, however, were statistically better than control. Interaction among sources and application methods was non-significant. Higher grain yield with side dressing and with the use of DAP might be due to the improved growth and yield parameters. Plants showed normal growth with the application of phosphorus and resulted in improved agronomic traits which lead toward improved grain yield (Table-2). Similar findings were explained in previous research by Ihsan *et al*. (2007), Iqbal *et al*. (2003) and Mehdi *et al*. (2003).

***Harvest index (%)*:** Harvest index is the ratio of the grain yield and biological yield. It showed the efficiency of crop to convert assimilates to grain. Similarly to other parameters harvest index was recorded maximum in case of DAP source while in methods, the side dressing appeared to be the improved method with higher harvest index (Table 2). Similar results were explained by Gill *et al*. (2004) and Shaher *et al*. (2003).

Overall results showed that the application of phosphorus with improved method is very important to get optimum results. Fertilizer is a costly input which requires a big concentration about its application. Side dressing appeared to be the improved method in this research work as in this method, application is done near the seeds to facilitate its uptake by plant. As the phosphorus is immobile in the soil so we should apply this with improved method near the plant roots to reduce its wastage. Farmers can get the economic yield with judicious use of fertilizer to get a higher benefit from these costly inputs.

***Conclusion*:** With the keen observation of our results it is concluded that wheat grain yield can be enhanced with side dressing of Diaamonium Phosphate at 90 kg ha^{-1}. Results also designated that with proper management of costly input (phosphorus), farmers can increase fertilizer use efficiency for sustainable crop production.

Table 1. Number of tillers m^{-2} as influenced by sources and methods of phosphorus application

Treatments	January-07			February-06			March-03			March-31			April-25		
	NP	DAP	Mean	NP	DAP	Mean	NP	DAP	Mean	NP	DAP	Mean	NP	DAP	Mean
P_1	347	349	348c	493	391	442a	410	415	413d	342	343	343d	330	330	330e
P_2	400	414	407b	425	430	428c	451	459	455bc	410	416	413c	404	410	407c
P_3	425	435	430a	434	459	447a	474	497	486a	458	474	466a	448	470	459a
P_4	414	430	422b	427	444	436ab	457	486	472ab	438	450	444b	430	433	432b
P_5	391	405	398bc	418	432	425c	435	442	439c	394	408	401c	393	400	397d
Mean	396	407	401.5	420b	431a	425.5	445	460	452.5	408	418	413	401b	409a	405

Table 2. Effect of phosphorus sources and methods of application on various agronomic traits of wheat crop

Treatments	Fertile Tillers (m^{-2})	Spike length (cm)	1000-garin weight (g)	Grain Yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest Index (%)
Phosphorus Sources						
DAP	379.01	10.04	37.75	4.69a	13.89a	33.44
NP	371.32	9.63	37.06	4.45b	12.73b	33.01
$LSD_{0.05}$	n.s	n.s	n.s	0.13	0.41	n.s
Application Methods						
P_1	300.74e	8.40d	29.75d	3.37e	11.13e	30.35c
P_2	377.28c	10.01b	38.55c	4.38c	13.12c	33.44b
P_3	429.19a	10.76a	41.04a	5.68a	15.52a	36.55a
P_4	401.80b	10.25b	39.74b	5.05b	14.65b	33.92b
P_5	366.82d	9.73c	37.94c	3.86d	12.14d	31.88b
$LSD_{0.05}$	7.545	0.51	0.961	0.271	0.69	2.875

DAP= Diammonium Phosphate, NP= Nitrophos, P_1= Control, P_2= Broadcast at planting, P_3= Side dressing at planting, P_4= Broadcast at planting + at 1st irrigation, P_5= Broadcast at first irrigation.

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