International Journal of Research in Agriculture and Forestry
Volume 2, Issue 6, June 2015, PP 1-9
ISSN 2394-5907 (Print) & ISSN 2394-5915 (Online)

Comparative Performance of Wheat in Response to Different Phosphatic Fertilizers

Mushtaq Ali[1], LiaqatAli[1], Mueen-ud-Din[1], Muhammad Sattar[1], MasoodQadir Waqar[2], Muhammad Anjum Ali[3], Laila Khalid[4]

[1] Adaptive Research Farm, Vehari, Pakistan
[2] Director of Agriculture (Adaptive Research), Punjab, Lahore, Pakistan
[3] Director General of Agriculture (Ext.&AR), Punjab, Lahore, Pakistan
[4] Adaptive Research Station Bahawalnagar, Pakistan

ABSTRACT

The field study was carried out to compare the performance of different phosphatic fertilizers on the growth and yield of wheat at Adaptive Research Farm, Vehari during 2008-09 and 2009-10. The soil of the experimental area was clay loam in texture having EC 2.10-2.85 dS m^{-1}, pH 8.2-8.4, organic matter 0.41-0.66%, P_2O_5 3.80-6.11 ppm, K_2O 98-178 ppm and saturation 36-38% in the two growing seasons. Different phosphatic fertilizers studied were single super phosphate (SSP), triple superphosphate (TSP), diammonium phosphate (DAP), monoammonium phosphate (MAP) and nitrophos (NP). Nitrogen and potash were applied in the form of urea and sulphate of potash (SOP), respectively. The fertilizer nutrients were applied at the rate of 128-114-62 N-P-K kg ha^{-1}. The experiment was laid out according to randomized complete block design with three replications having plot size of 8x12 m. Results revealed that plant height, number of tillers, 1000-grain weight and grain yield of wheat were significantly affected with main effect of year and different phosphatic fertilizers however; different phosphatic fertilizers had approximately equal effects on emergence. It was concluded that application of single superphosphate (SSP) showed better results as compared to nitrophos (NP), diammonium phosphate (DAP), monoammonium phosphate (MAP) and triple superphosphate (TSP) on phosphorus deficient soil. TSP proved to be an inferior source as compared to other sources. The highest benefit cost ratio of 9.06 was also obtained with SSP.

Keywords: Wheat, phosphatic fertilizers, growth, grain yield, cost benefit analysis, Pakistan

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 on an area of 8666 thousand hectare during 2011-12 (Anonymous, 2011-12). Despite its higher yield potential, yield per hectare is very low in Pakistan as compared to other wheat producing countries. There are many reasons of low yield but the most important is the injudicious use of phosphorus fertilizer as it is one of the major plant nutrients that directly or indirectly affect all biological processes and is needed in fairly large quantities by the plants. In spite of its importance; plants strive hard to obtain P form the rhizosphere, primarily due to low availability, because it is one of the least available mineral nutrients in most of the cropping systems all over the world (Shenoy and Kalagudi, 2005). Its deficiency can reduce the crop yields up to 10-15% (Saleem, 1990; Gill *et al*., 2004). Low level of soil P, less availability of P compounds andfixation of applied soluble sources of P are major hindrances in sustainable production of arable crops (Brady and Weil, 2002). Availability and effectiveness of phosphorus to plants depends on many factors like pH, soil physico-chemical properties (Gupta *et al*., 1985), prevailing climate and soil organic matter (Fixen, 1990) and source of P fertilizer (Blake *et al*., 2000).

Application of phospahtic fertilizer as major element in crop production is well established. There are several kinds of phosphatic fertilizers manufactured by industries in different grades of elements

**Address for correspondence*

laila_kld@yahoo.com

essential for plant growth. These inorganic phosphatic fertilizers include SSP, TSP, DAP, MAP and NP. Single super phosphate and NP are manufactured locally. However, DAP is imported from other countries such Jordan, USA, Morocco etc. As 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. 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 Nisar and Rashid (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 it is difficult to release from the soil (Huang, 1998). The application of P fertilizers to soils, with pH levels greater than 7.5 has been problematic mainly due to P fixation. When P is applied to the soil, the plant takes up only small percentage; the remainder is either permanently or temporarily fixed in forms varying in plant availability. The temporarily fixed P, also called residual P, becomes available with time, but at slow rates (Sharif *et al,* 2000). Phosphatic fertilizer can hardly move 3 to 5cm in soil. Resultantly, it is hardly available to the extent of 15-20% to plant. The rest goes to waste from the immediate crop being fixed in soil. Due to alkaline and calcareous nature of Pakistani soils, most of the native and applied phosphorus becomes unavailable at the growing plants. Any measure, which helps reducing the activity of calcium, would ensure the enhanced availability of phosphorus to plants. The plant tissues recover only 11-19% of the applied phosphorus (Sharif, 1985). The average phosphorus fixation of the added phosphorus in clay, clay loam, loam, sandy loam and loamy sand soils is 71, 62, 56, 29 and 29%, respectively after one month of incubation (Chaudhry and Qureshi, 1982).

Phosphorus fertilization is very essential for exploitation of good yield of different crops (Rashid *et al*., 1994). As the soils of Pakistan are low in phosphorus, consequently the use of phosphorus fertilizer increased many fold since their introduction in the late fifties (Ahmad, 2000). At present DAP is the principle phosphate fertilizer used in Pakistan, with somewhat less quantities of NP and much smaller amounts of SSP and TSP. The relative efficiency of phosphorus sources content as a high degree of water soluble phosphorus encourages early season growth in small cereals (Venugopalm and Ponsed, 1989). The phosphorus fertilizer use can help to reduce the adverse effect of drought under rainfed conditions. Khan *et al*. (2010) concluded that phosphorus application at the rate of 80 kg P ha^{-1} as single super phosphate showed better results as compared to triple super phosphate, nitrophos and diammonium phosphate on phosphorus deficient soil of Balkasr area of tehsil Chakwal. Similarly Reddy and Sigh (2003) also observed that among 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}). It is evident from the reports of Alam*et al.* (2002) that wheat plants fertilized with NP and SSP gave higher yield than DAP.Ali *et al*. (2012) evaluated the response of wheat crop to different phosphorus sources under the agro-climatic conditions of southern Punjab. They obtained significantly more number of tillers and higher grain yield of wheat with DAP as compared to NP at the fertilizer dose of 120-90-60 NPK kg ha^{-1}. However, plant height and 1000-grain weight were not affected significantly with different phosphorus sources.Niazi*et al*. (1991) compared different phosphorus sources for wheat crop. They concluded that P sources improved the productive tillers and grain and straw yields. They noticed that productive tillers were maximum with SSP followed by DAP, NP and TSP.The effects of several sources of phosphorus on the emergence of winter wheat (*Triticumaestivum* L.) were compared by Baker *et al.* (1970) under varying soil temperature and moisture regimes. The observed less germination with monoammonium and diammonium phosphate as compared to superphosphate.

Maqbool*et al*. (2012) conducted field experiments on monoammonium phosphate (MAP), diammonium phosphate (DAP) and triple superphosphate (TSP) @100 P_2O_5 kg ha^{-1}as phosphorus fertilizers to optimize as source of phosphatic nutrition for wheat under agro-climatic conditions of Dera Ghazi Khan, Pakistan. They concluded that phosphorus sources have significant effect on plant height. However, the effect of different phosphorus sources on number of tillers, 1000-grains weight and grain yield of wheat were non-significant. Some researchers (Gokmen and Sencar, 1999, Mehdi *et al.* 2003, andMahgoub and Ibrahim, 2012) have reported no differences among sources of P fertilizers (DAP, SSP and NP) on growth and yield of wheat.

Fertilizer's demand is increasing day by day to meet the crop requirementand it is Pakistan's most important and expensive input in agricultural production. Among other agronomic factors that increased the fertilizer use efficiency, sources of fertilizers is also of critical importance. Little work is done on sources of phosphorus fertilizer on growth and yield behaviour of wheat crop in Pakistan. Thus the experiment was conducted to evaluate various sources of phosphorus fertilizer to enhance the yield of wheat crop.

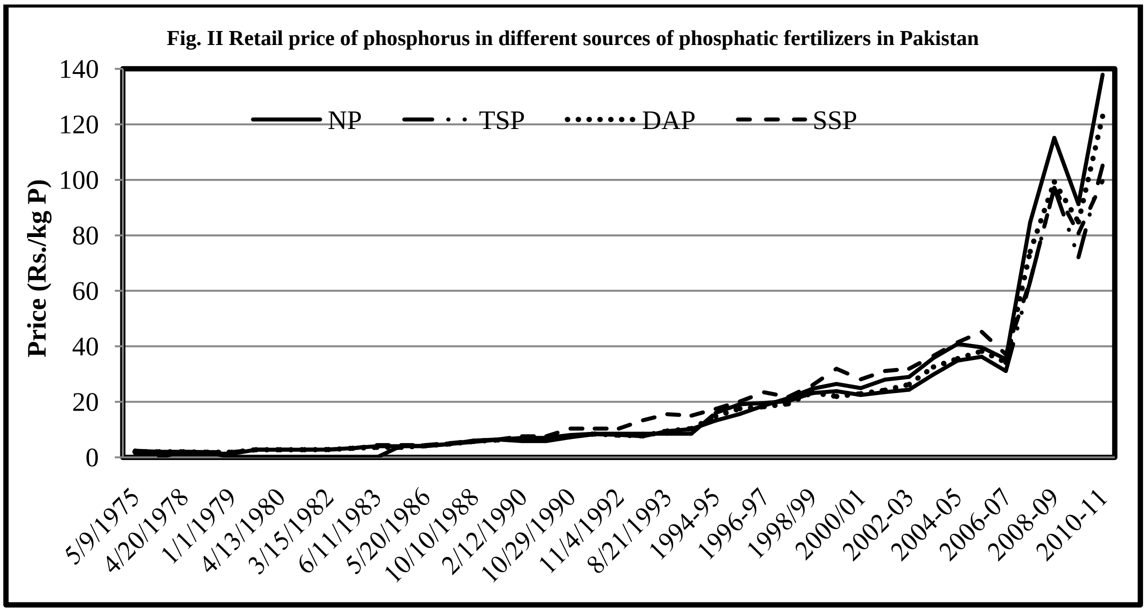

Fig. II Retail price of phosphorus in different sources of phosphatic fertilizers in Pakistan

Source: *NFDC, Islamabad.*

MATERIALS AND METHODS

Site description: The field experiments were conducted during the successive seasons of 2008-09 and 2009-10 at Adaptive Research Farm, Vehari, located at 30^o 02’ 31’’ N latitude 72^o 21’ 10’’ E longitude and an altitude of 135 m above sea level. The climate of the district is mostly dry and hot with annual rainfall of 100-300 mm. The monthly maximum and minimum temperature (°C) and cumulative rainfall (mm) data of the experimental area for the growing period during both the years are presented in Fig. II and Fig. III. The district consists of plain area with fertile land. It is a part of Indus plain. The soil and climatic conditions are favorable for cotton and wheat production. However sugarcane, maize, rice, potato and sunflower are also important crops of the district. The research farm is irrigated by Pakpattan canal from Sutlej River.

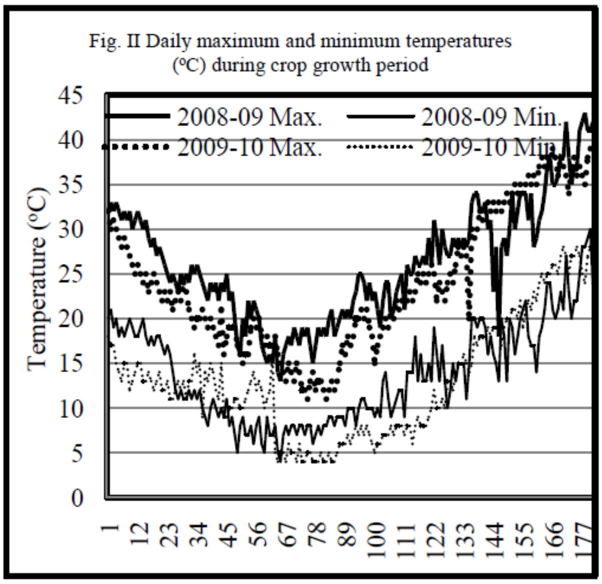

Fig. II Daily maximum and minimum temperatures (°C) during crop growth period

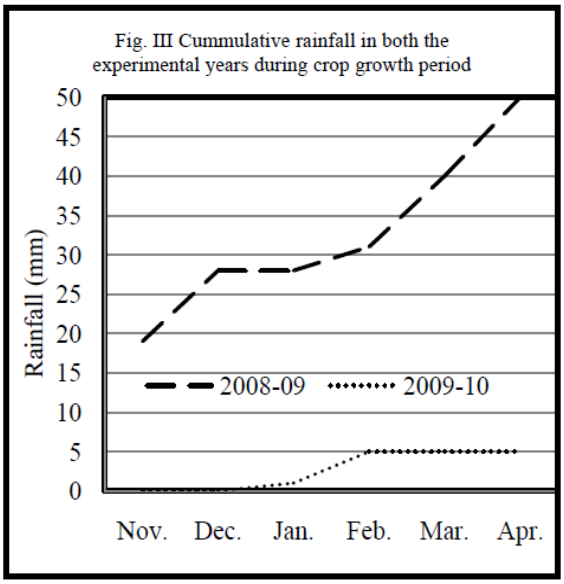

Fig. III Cummulative rainfall in both the experimental years during crop growth period

Experimentation: Prior to initiating the study, soil samples were taken with the help of a soil auger from 0-15 and 15-30 cm depths of the soil at random locations throughout the area used for the field experiment. Composite samples were air dried, ground and passed through a 2 mm sieve and got analyzed for physical and chemical characteristics. The soil of the experimental area was clay loam in texture having EC 2.10-2.85 dS m^{-1}, pH 8.2-8.4, organic matter 0.41-0.66%, P_2O_5 3.80-6.11 ppm, K_2O 98-178 ppm and saturation 36-38% in the two growing seasons.

Before seedbed preparation, pre-soaking irrigation of 10 cm was applied. When soil reached to proper moisture level the experimental area was tilled adequately to prepare a suitable seedbed. The implements used included a tractor mounted cultivator, rotavator, leveller and planker. The plot was properly levelled for even and efficient fertilizer and water distribution. Single super phosphate (SSP), triple superphosphate (TSP), diammonium phosphate (DAP), monoammonium phosphate (MAP) and nitrophos (NP) were used as various sources of phosphorus fertilizer in different experimental treatments. Nitrogen and potash were applied in the form of urea and sulphate of potash (SOP), respectively. The fertilizer nutrients were applied at the rate of 128-114-62 N-P-K kg ha^{-1} as recommended by the Punjab Agriculture Department. Whole of the nitrogen, phosphorus and potash were applied during seed bed preparation and incorporated in the soil. In case of SSP (18% P_2O_5) and TSP (46% P_2O_5) whole N was applied from urea whereas in case of DAP (18% N and 46% P_2O_5), MAP (12% N and 52% P_2O_5) and NP (22% N and 20% P_2O_5) 83.40, 101.70 and 2.60 N kg ha^{-1} was applied from urea, respectively. The same fertilizer lot was used throughout both years of the study.

The experiment was laid out according to randomized complete block design having plot size of 8x12 m and was replicated thrice. Wheat variety Sehar-2006 was sown manually with single row hand drill in 22 cm spaced rows using seed rate of 125 kg ha^{-1} on November 06 and 11in 2008 and 2009 and was harvested on April 25 and 30 in 2009 and 2010, respectively. First irrigation was applied three weeks after sowing the crop, while subsequent irrigations were applied as and when needed. In all five irrigations each of 7.5 cm depth excluding pre-soaking irrigation were applied from sowing to harvesting during both the years. Herbicides Buctril super 60EC (Bromoxinal Octonoate + Heptanoate + MCPA) @ 750 ml ha^{-1} and Topik 15 WP (Clodinafoppropargyl) @ 300 g ha^{-1} were used to control broad and narrow leaved weeds each after 1st and 2nd irrigation, respectively at optimum soil moisture conditions. All other agronomic practices were kept normal and uniform for all the treatments.

For growth and yield parameters standard procedures were applied. Plant population was counted from an area of one meter square by using quadrate on randomly selected three sites. For plant height ten plants were selected randomly from each unit at maturity and plant height was measured from base of the plant to tip of spike with a meter stick and average plant height was computed.Number of fertile tillers was counted at maturity from randomly selected three sites (m^{-2}) and average was obtained. Similarly 1000-grains from individual experimental unit were counted manually. The area randomly selected from three sites (m^{-2}) for number of fertile tillers was harvested, threshed and weighed for calculating grain yield.

Statisticalanalysis: The data were analyzed statistically using computer statistical program MSTAT-C (Freed and Scott, 1986). Analysis of variance was employed to test the overall significance of the data, while the least significance difference (LSD) test at P=0.05 was used to compare the differences among treatment means (Steel and Torrie, 1984).

Economic analysis: Economic analysis was carried out as prescribed by Anonymous (1988). The cost benefit ratio was calculated as per formula given below:

$$\text{Benefit cost ratio} = \frac{\text{Additional income of wheat grains}}{\text{Additional cost of phosphaticfertilizer}}$$

RESULTS

Germination count (m^{-2}): There were no significant differences in different sources of phosphatic fertilizers in terms of the germination count per square meter in either year (Table-1). The mean data of both the years of study showed that the number of germinated plants ranged from 233.67 to 238.33 plants m^{-2} with different phosphatic fertilizers used in the experiment. However, the highest values of 238.33 and 238.17 number of plants m^{-2} were obtained with TSP followed by SSP, respectively as against the minimum number of plants (233.67 plants m^{-2}) in NP treated plots.

Table1. *Effect of different phosphatic fertilizers on germination count (m^{-2}) and plant height (cm) of wheat*

Phosphorus source	Years					
	Germination count (m^{-2})			Plant height (cm)		
	2008-09	2009-10	Mean	2008-09	2009-10	Mean
SSP	245.33	231.00	238.17	114.33	117.00	115.67a
TSP	244.00	232.67	238.33	108.33	110.67	109.50d
DAP	241.00	228.67	234.83	111.00	113.33	112.17bc
MAP	242.67	230.00	236.33	110.33	112.00	111.17cd

NP	239.67	228.00	233.67	113.00	115.33	114.17ab
Mean	242.53a	230.07b	-	111.40b	113.67a	-
	LSD>0.05 Treatments Non significant LSD>0.05 Years p value = 0.000 LSD>0.05 Year x Treatments Non significant			LSD>0.05 Treatment 2.29 LSD>0.05 Years p value = 0.004 LSD>0.05 Yearx Treatments Non significant		

Plant Height (cm): The data regarding comparative performance of wheat in response to different phosphatic fertilizers on plant height are presented in Table-1. Data revealed that main effect ofyear and phosphorus sources significantlyaffected plant height. Maximum plant height (113.67 cm) was recorded in 2009-10 as compared to 2008-09 (111.40 cm). Maximum plant height (115.67 cm) was observed in plots where SSP was applied as a source of phosphatic fertilizer to wheat crop followed by NP, DAP and MAP where average plant height of 114.17, 112.17 and 111.17 cm, respectively were recorded while minimum plant height of 109.50 cm was recorded from the plots where TSP was applied to wheat crop.

Number of Tillers (m^{-2}): The yield of a crop is dependent upon the combined effect of many factors. Among these factors, the number of tillers per unit area has a vital position in 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 showed comparative performance of wheat to different phosphatic fertilizers on number of tillers (m^{-2}). Main effect of years and different phosphatic fertilizers showed significantlyaffected number of tillers (m^{-2}). Whereas year into different phosphatic fertilizer interaction did not affect the number of tillers m^{-2}.The results revealed that maximum number of tillers (321)m^{-2} was recorded with the application of SSP fertilizer followed by NP, DAP and MAP where 315.50, 311.50 and 306 tillers were recorded, respectively. The minimum number of tillers (301) per square meter was recorded from the plots where TSP fertilizer was applied as phosphorus source to wheat crop.Highest number of tillers m^{-2} (316.40) were recorded in 2008-09 followed by number of tillers m^{-2} (305.60) in 2009-10.

Table2. *Effect of different phosphatic fertilizers on number of tillers (m^{-2}) and 1000-grains weight (g) of wheat.*

Phosphorus source	Years					
	Number of tillers (m^{-2})			1000-grains weight (g)		
	2008-09	2009-10	Mean	2008-09	2009-10	Mean
SSP	327	315	321.00a	43.55	41.10	42.46a
TSP	306	296	301.00c	41.25	39.40	40.33e
DAP	317	306	311.50abc	42.40	40.20	41.30c
MAP	311	301	306.00bc	41.80	39.80	40.80d
NP	321	310	315.50ab	43.05	40.70	41.88b
Mean	316.40a	305.60b	-	42.41a	40.24b	-
	LSD>0.05 Treatments 10.94 LSD>0.05 Years p value = 0.004 LSD>0.05 Year x Treatments non significant			LSD>0.05 Treatments 0.36 LSD>0.05 Years p value = 0.000 LSD>0.05 Year x Treatments Non significant		

1000-Grains Weight (g): Thousand grain weight is an important agronomic trait which have positive correlation with grain yield. Grain yield enhances relative to increasing 1000-grain weight. Main effect of year and sources of phosphatic fertilizers showed significant differences ($P<0.05$) in 1000-grain weight. Higher 1000-grains weight was recorded in 2008-09 (42.41 g) over 2009-10 (40.24 g). Moreover highest 1000-grains weight (42.46 g) was observed with SSP followed by NP (41.88 g), DAP (41.30 g) and MAP (40.80 g), respectively as against the minimum 1000-grains weight (40.33 g) recorded from the plots where TSP fertilizer was used as phosphorus source. The interaction of year and different phosphatic fertilizers was found non significant.

Grain Yield (kg ha^{-1}): The data presented in Table-3 showed that the grain yield of wheat in the first season (2008-09) was significantly higher (4474 kg ha^{-1}) than that in the second season (2009-10) of the study (4277 kg ha^{-1}).The higher grain yield of wheat during the first year might be attributed to favourable temperature and rainfall regimes than the second year of the study (Fig. II and Fig. III) leading to greater leaf area and average crop growth rate during first year. The effects of different phosphatic fertilizers on grain yield of wheat were highly significant in either year of the study. The mean grain yield data of both the years of experiment showed that maximum grain yield of 4481 kg ha^{-1} were obtained in the plots where SSP fertilizer was applied to wheat crop followed by NP, DAP and MAP with grain yield of 4437, 4343 and 4323 kg ha^{-1}, respectively. The minimum grain yield of 4294 kg $ha^{-1}$was obtained from the plots whereTSP was used as source of phosphatic fertilizer. The interaction of year and different phosphatic fertilizers had significant effect ($P<0.05$) on grain yield.

Table3. *Effect of different phosphatic fertilizers on grain yield (kg ha^{-1}) of wheat*

Phosphorus source	Years			% inc./dec.
	Grain yield (kg ha^{-1})			
	2008-09	2009-10	Mean	
SSP	4598a	4364e	4481a	+3.18
TSP	4382d	4206i	4294e	-1.13
DAP	4425c	4261g	4343c	-
MAP	4412c	4234h	4323d	-0.46
NP	4552b	4321f	4437b	+2.16
Mean	4474a	4277b	-	-
	LSD>0.05 Treatments 11.72 LSD>0.05 Years p value = 0.000 LSD>0.05 Year x Treatments 16.57			

Economic Analysis

The economic analysis on the basis of two years average grain yield of wheat revealed that maximum net income of Rs. 96291 per hectare were obtained from the plots where SSP was applied as a source of phosphatic fertilizer whereas MAP proved to be uneconomical as compared to all the other sources of phosphatic fertilizer used in the experiment.The highest

Table4. *Economic analysis of different phosphatic fertilizers*

Phosphatic fertilizer	Yield (kg ha^{-1})	Addl. Yield (kg ha^{-1})	Gross Income (Rs. ha^{-1})	Addl. Income (Rs. ha^{-1})	Total Exp. (Rs. ha^{-1})	Addl. Exp. (Rs. ha^{-1})	Net Income (Rs. ha^{-1})	B.C.R.
TSP	4294	-	101983	-	9643	-	92340	-
MAP	4323	29	102671	688	13250	3607	89421	1:0.19
DAP	4343	49	103146	1163	10496	853	92650	1:1.36
NP	4437	143	105379	3396	11762	2119	93617	1:1.60
SSP	4481	187	106424	4441	10133	490	96291	1:9.06
Average prevailing market prices of different phosphatic fertilizers during 2008-09 and 2009-10								
i. SSP	@ Rs. 88.89 kg^{-1} P_2O_5			ii. MAP	@ Rs. 116.23 kg^{-1} P_2O_5			
iii. TSP	@ Rs. 84.59 kg^{-1} P_2O_5			iv. NP	@ Rs. 103.18 kg^{-1} P_2O_5			
v. DAP	@ Rs. 92.07 kg^{-1} P_2O_5			Price of wheat grain @ Rs. 23.75 kg^{-1}				

benefit cost ratio of 9.06 was also obtained with SSP followed by NP and DAP with cost benefit ratio of 1.60 and 1.36, respectively. The data further revealed that the lowest cost benefit ratio of 0.19 was obtained with the application of MAP.

DISCUSSION

The results of two year study regarding comparative performance of wheat in response to different phosphatic fertilizers revealed that plant height, number of tillers, 1000-grain weight and grain yield of wheat were significantly affected with different phosphatic fertilizers however; different sources of phosphorus had approximately equal effects on emergence. It was concluded that application of single superphosphate (SSP) showed better results as compared to nitrophos (NP), diammonium phosphate (DAP), monoammonium phosphate (MAP) and triple superphosphate (TSP) on phosphorus deficient soil. TSP proved to be an inferior source as compared to other sources. The effects of different sources of phosphatic fertilizers on the emergence of wheat were compared and it was observed that different phosphatic fertilizers did not affected germination count (m^{-2}) significantly during both the experimental years (Table-1). The non-significant effect of different phosphatic fertilizers on germination count might be attributed to the similar behaviour of phosphatic sources on seed germination. However, nitrophos decreased emergence to a much greater extent than any other source.This reduced emergence, however, had no effect on grain yield of wheat. The results corroborate with the findings of Baker *et al.* (1970) who observed less germination with monoammonium and diammonium phosphate as compared to superphosphate.Plant height contributes a significant impact on the straw yield of wheat. The data presented in Table-1 regarding comparative performance of wheat in response to different phosphatic fertilizers on plant height showed that single super phosphate (SSP) produced taller plants (115.67 cm) as compared to nitrophos (NP), diammonium phosphate (DAP) and monoammonium phosphate (MAP) while triple superphosphate (TSP) had attained minimum plant height (109.50 cm). Some other scientists (Khan *et al.*, 2010 and

Maqbool*et al*., 2012) also reported significant effect of phosphorus sources on plant height. However, these results are contrary to the findings of Ali *et al*. (2012) who found non significant differences in plant height among different phosphorus sources.

Among all phosphatic fertilizers, single super phosphate (SSP) produced more number of tillers per meter square as compared to nitrophos (NP), diammonium phosphate (DAP), monoammonium phosphate (MAP) and triple superphosphate (TSP) might be due to maximum availability of phosphorous from SSP which established more root establishments. This would ultimately result in 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 Niazi*et al*. (1991) who compared different phosphorus sources for wheat crop. They noticed that productive tillers were maximum with SSP followed by DAP, NP and TSP. The results are also in line with the findings of Khan *et al.* (2010) who concluded that SSP application had produced more number of tillers per plant as compared to TSP, NP and DAP. Similarly Ali *et al*. (2012) obtained significantly more number of tillers of wheat with DAP as compared to NP at the fertilizer dose of 120-90-60 NPK kg ha^{-1}. It is also evident from the data that different sources of phosphatic fertilizers had significant effect on 1000-grains weight. The main reason for increase in grain yield with different phosphatic fertilizers might be the higher 1000-grain weight which might be due to higher rate of photosynthesis and better crop health which ultimatelyincreased the final grain yield.Higher 1000-grain weight of wheat was also recorded with DAP than TSP by Gokmen and Sencar (1999). However, the results of the present study are contrary to the findings of Ali *et al*. (2012) and Maqbool*et al*. (2012) who observed non significant difference in 1000-grains weight of wheat with different sources of phosphorus fertilizer.

Grainyield of wheat is an important parameter used for the evaluation ofeffectiveness of any treatment because grain productionis the ultimate objective of production of cereals used forfeeding of human beings in the world (Anonymous, 1988).The effects of different phosphatic fertilizers on grain yield of wheat were highly significant during both the years of study. The data showed that maximum grain yield of 4481 kg ha^{-1} were obtained in the plots where SSP fertilizer was applied to wheat crop followed by NP, DAP and MAP with grain yield of 4437, 4343 and 4323 kg ha^{-1}, respectively. Minimum grain yield of 4294 kg ha^{-1} were obtained from the plots where TSP was used as source of phosphatic fertilizer. This might be possibly due to decreased pH surrounding the SSP that reduced the fixation of P with agreater movement and availability of P from the SSP. Higher grain yield in case of SSP over other sources of phosphatic fertilizer might be due to additional amount of sulphur in SSP which increased the availability of phosphorus to the plants. Previous work on different sources of P fertilizer showed inconsistent results. Most of the studies (Niazi*et al*., 1991, Alam*et al.*, 2002, and Ali *et al*., 2012) have reported results similar to the present study, where different P fertilizers showed significant results in wheat crop. The results of our study are strongly supported by Khan *et al*. (2010) who concluded that phosphorus application of single super phosphate showed better results as compared to triple super phosphate, nitrophos and diammonium phosphate on phosphorus deficient soil of Balkasr area of tehsil Chakwal. Similarly Reddy and Sigh (2003) also observed that among different phosphatic fertilizers, single super phosphate resulted in the highest grain yield of wheat followed by nitrophos and diammonium phosphate. However, Gokmen and Sencar (1999), Mahgoub and Ibrahim (2012) and Maqbool*et al*. (2012)found that different sources of P fertilizer do not differ significantly.

CONCLUSIONS

From the results of the study it was concluded that application of single superphosphate (SSP) as a source of phosphatic fertilizer to wheat crop showed better results as compared to nitrophos (NP), diammonium phosphate (DAP), monoammonium phosphate (MAP) and triple superphosphate (TSP) on phosphorus deficient soil. The superiority of SSP over all the other sources might be due to presence of more sulphurcontent and better water solubility of phosphate compound. 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.The highest benefit cost ratio of 9.06 was also obtained with SSP as compared to other sources of phosphatic fertilizers.

REFERENCES

[1] Ahmad, N., 2000. Integrated Plant Nutrition management in Pakistan: Status and Opportunities. pp. 18-39. In: Proc. Symp. On Integrated plant nutrient management, NFDC, Islamabad.

[2] Alam, S.M., A. Latif and Z. Iqbal, 2002. Wheat yield and phosphorus use efficiency as influenced by method of phosphorus and Zinc application. Pak. J. Ind. Res., 45: 117-119.

[3] Ali, H., N. Sarwar, S. Ahmad, A.W. Tariq and A.N. Shahzad, 2012. Response of wheat crop to phosphorus fertilizers and application methods grown under agro-climatic conditions of southern Punjab. Pak. J. Agri. Sci., 49(4): 485-489.

[4] Anonymous, 1988. From Agronomic Data to Farmers Recommendations. An Economic Training Manual, CIMMYT, Mexico.

[5] Anonymous, 2011-12. Pakistan Economic Survey, Economic Adviser's Wing, Finance Division, Government of Pakistan, Islamabad.

[6] Baker, J.M., B.B. Tucker and L.G. Morrill, 1970. Effects of sources of phosphorus under varying soil temperature and moisture regimes on the emergence of winter wheat. Soil Sci. Soc. Am. J., 34(4): 694-697.

[7] Blake, L., S. Mercik, M. Koerschens, S. Moskal, P.R. Poulton, K.W.T. Goulding, A. Weigel and D.S. Powlson, 2000. Phosphorus content in soil, uptake by plants and balance in three European long term field experiments. Nut. Cycling Agro-Ecosys.56: 263–275.

[8] Brady, N.C. and R.R. Weil, 2002. The Nature and Properties of Soils, 10$^{th.}$ ed., pp: 351–380. Prentice-Hall Inc., New Jersey.

[9] Chaudhry, T.M. and S.M. Qureshi, 1982. Agricultural Chemistry Section. Review of Work 1926-80. ARI.,Tandojam, Government of Sindh.

[10] Fixen, P.E., 1990. Agronomic evaluations of MAP and DAP. Proc. Illinois Fertilizer Conf., January 23–24, Illinois.

[11] Freed, R.D. and D.E. Scott, 1986. MSTATC. Crop and Soil Science Department, Michigan State University, Michigan, USA.

[12] Gill, M.A., F. Ahmad, T. Aziz, Rahmatullah and M.A. Tahir, 2004. Growth and phosphorus uptake by *brassica* cultivars growth with adequate and deficient phosphorus level. Pak. J. Agri. Sci., 42: 3–4.

[13] Gokmen, S. and O. Sencar, 1999. Effects of phosphorus fertilizer and application methods on the yield of wheat grown under dryland conditions. Tr. J. Agric. For., 23: 393–399.

[14] Gupta, A.P., S.S. Khanna and N.K. Tomar, 1985. Effect of sodicity on the utilization of phosphatic fertilizers by wheat. Soil Sci.,139: 47–52.

[15] Huang, Q. N., 1998. Properties of phosphorus adsorption and desorption in red soil under a stand of Chinese fir in Fijian Nanjing. Journal of Forestry Universal, 22(2): 39-44.

[16] Jamwal, J.S., and K.L. Bhagat, 2004. Response of wheat (*Triticumaestivum*L.) to top dressing of diammonium phosphate in rainfed areas of Shivalik foothills. Ind. J. Agro., 49(4): 251-253.

[17] Khan, M.B., M.I. Lone, R. Ullah, S. Kaleem and M. Ahmad, 2010. Effect of different phosphatic fertilizers on growth attributes of wheat (*Triticumaestivum*L.). J. Amer. Sci. 6:(12):60-62.

[18] Mahgoub, S.A.G., and Y.M. Ibrahim, 2012. Performance of wheat yield under different fertilizer types, application and doses at Northern Sudan State. Agric. Biol. J. N. Am., 3(3): 125-130.

[19] Maqbool, M.M., M. Ahmad, A. Ali, R. Mehmood, M. Ahmad and M. Sarwar, 2012.Optimizing the method and source of phosphatic nutrition for wheat (*Triticumastivum*L.) under agro-climate of Dera Ghazi Khan, Pakistan. Pak. J. Nutr., 11 (9): 787-792.

[20] Mehdi, S.M., N. Sajjad, M. Sarfraz, B.Y.K.G. Hassan and M. Sadiq, 2003.Response of wheat to different phosphatic fertilizers in varying textured salt affected soils. Pak. J. Appl. Sci.,3(7): 474-480.

[21] Niazi, M.H.K., J. Iqbal, S.M. Mehdi and K. Hussain. 1991. Comparison of different phosphorus sources for rice and wheat production in sodic soil. Pak. J. Agri. Sci., 28(3): 305-310.

[22] Nisar, A., 1996. Annual Fertilizer Review.NFDC Publication No. 11/96. Islamabad, 31.

[23] Nisar A. and M. Rashid, 2003. Fertilizers and their use in Pakistan. An extension guide. National Fertilizer Development Centre, Islamabad, Pakistan.

[24] Rashid, A., 1994. Phosphorus use efficiency in soil of Pakistan. pp: 115-127. In: Proc. $4^{th.}$ National Cong. Soil Sci. Islamabad, Pakistan.

[25] Reddy, M.P. and S.S. Singh, 2003. Effect of different sources of phosphatic fertilizers on growth and yield of wheat (*Triticumaestivum L*.). *Crop Research*, 26(3): 386-389.

[26] Saleem, M.T., 1990. An overview of phosphatic fertilizers in Pakistan. In: Symposium on Role of Phosphorus in Crop Production, pp: 9–38. July, 15-17, Islamabad, Pakistan.

[27] Sharif, M., 1985. Improvement of phosphatic fertilizer efficiency. In: Proc. Symposium on fertilizer uses efficiency. FFC. Lahore, pp: 106-110.

[28] Sharif, M., M.S. Sarir, and F. Rabi, 2000. Biological and chemical transformation of phosphorus in some important soil series of NWFP. Sarhad J. Agri. 16 (6): 587-592.

[29] Shenoy, V.V. and G.M. Kalagudi, 2005. Enhancing plant phosphorus use efficiency for sustainable cropping. Biotech. Adv., 23: 501–513.

[30] Steel, R.G.D. and J.H. Torrie, 1980. Principles and Procedures of Statistics, 2^{nd}ed. McGraw Hill Book Company Inc., New York, 507.

[31] Venugopalm, M.V. and R. Ponsed, 1989. Relative efficiency of ammonium polyposphate and orthophosphate for wheat and their residual effects on succeeding cowpea fodder. Fert. Res., 20: 109-114.