Original Article **Asian J Agri Biol, 2014, 2(1):14-19.**

EFFECT OF PHOSPHORUS FERTILIZER SOURCES AND RATES ON GROWTH AND YIELD OF WHEAT (*Triticum aestivum* L.)

Muhammad Atif Majeed[1], Rashid Ahmad[2], Muhammad Tahir[1], Asif Tanveer[1] and Muhammad Ahmad*[3]

[1]*Department of Agronomy, University of Agriculture, Faisalabad, Pakistan*
[2]*Department of Crop Physiology, University of Agriculture, Faisalabad, Pakistan*.
[3]*Agriculture Adaptive Research Complex, Dera Ghazi Khan, Pakistan*

ABSTRACT

A field experiment was carried out to study the effect of two phosphorus fertilizer sources (diamonium phosphate and nitrophos) and four phosphorus rates (0, 60, 90 and 120 kg ha^{-1}) on growth and yield of wheat cultivar Bhakar-2002 at the Agronomic Research Area, University of Agriculture, Faisalabad, during Rabi 2006-2007. Significant differences in plant height (cm), number of fertile tillers per unit area, number of spikelets per spike, number of grains per spike, 1000- grain weight (g), straw yield (t ha^{-1}), grain yield (t ha^{-1}) and fertilizer use efficiency (kg kg^{-1}) were observed by the application of different rates of phosphorus fertilizers. However, only straw yield (t ha^{-1}) and fertilizer use efficiency (kg kg^{-1}) were significantly affected by different sources of phosphorus fertilizers. It is concluded that phosphorus application in the form of DAP at the rate of 90 kg ha^{-1} is more conducive for recommendation for the farmers, because it gave maximum benefit cost ratio (5.27) and value cost ratio (5.29). So, from this research, it is suggested that phosphorus source in the form of DAP at the rate of 90 kg ha^{-1} should be applied to get maximum benefit from wheat crop. It is, therefore, suggested that phosphorus source in the form of DAP at the rate of 90 kg ha^{-1} should be applied to get maximum benefit from wheat crop.

Keywords: Wheat, Phosphorus sources, rate of application, yield

INTRODUCTION

Wheat *(Triticum aestivum* L.) is the most important food grain crop grown in the world and is a staple food of about one third of the world's population. Pakistan is predominantly an agricultural country. In spite of favourable conditions of soils, irrigation water and climate, agriculture in the country suffers from under-production in term of yield per hectare. It contributes 14.4 % to the value added in agriculture and 3.0 % to gross domestic product. Wheat was sown over an area of 8.693 million hectares with total production of 24.231 million tons with an average yield of 2787 kg ha^{-1} during 2012-13 (Anonymous, 2013). Nitrogen and phosphorus are the main important plant food nutrients and most of our soils are deficient in these nutrients (Tahir, 1980). Role of phosphatic fertilizer is of much importance to rise per hectare yield of wheat. Dann (1969) reported that increasing phosphorus fertilizer application to wheat caused an increased in grain yield, number of tillers per plant, plant height and number of grains per spike. It is also involved in many metabolic activities and if the soil is deficient in phosphorus, the response of crop to nitrogen is reduced (Senigigaliesi *et al.*, 1983). It has been found that time of application plays an important role in increasing phosphorus efficiency and crop yield (Min Keni and Mackenzie, 1988). Recovery of applied phosphorus is low in alkaline calcareous soils due to reversion to unavailable forms (Chaudhry, 1982). It has been reported that banding phosphate with wheat seed gives early availability of P, and in many cases total dry matter and grain production increased, even in soils with medium-to-high levels of available phosphorus (Alessi and Power, 1980). Soils of Pakistan are mostly alkaline and calcareous in nature and phosphorous fixation is a serious problem in these soils (Sharif *et al.*, 2000). Phosphorus stimulates root development and growth in the seedling stage and thereby it helps to establish the seedling quickly. It increases the number of tillers in cereal crop and also increases the ratio of grain to straw. It strengthens the straw of cereal crops and thus helping to prevent lodging (Das, 2004). Phosphorus plays a vital role in photosynthesis, respiration, energy storage, transfer, cell

**Corresponding author:* e-mail: mahmada2003@yahoo.co.uk

division, cell elongation and several other processes in the living plants (Singh, 2003). Direct effects of phosphorus on plant leaf area expansion and tillering have also been proposed in wheat (Rodry-guez *et al.*, 1999). Keeping in view the above discussion a field study was conducted to study the best source and optimum level of phosphorus for increasing yield of wheat crop sown under the agro-ecological conditions of Faisalabad.

MATERIALS AND METHODS

The field experiment was conducted at Agronomic Research Area, University of Agriculture, Faisalabad, during winter 2006-07. Soil samples were taken before sowing of crop to a depth of 15cm and 30cm for physio-chemical analysis. The experiment was laid out in randomized complete block design with factorial arrangement having a net plot size 1.5 m x 5 m with four replications. Wheat cultivar Bhakar-2002 was sown on 17th November 2006 using seed rate of 100 kg ha^{-1} in 25 cm apart single rows. Nitrogen and potash @ 160 and 62 kg ha^{-1} were used as Urea and Sulphate of Potash respectively, while diammonium phosphate (DAP) or nitrophas (NP) as per treatment were used as sources of phosphorus. Whole of P, K and half N was side dressed at the time of sowing and remaining N was top dressed with first irrigation. The experiment comprised two phosphorus sources S_1 = DAP and S_2 = NP and four phosphorus rates P_0 = 0, P_1 = 60, P_2 = 90 and P_3 = 120 kg ha^{-1}. Ten plants were selected at random for recording plant height at harvest (cm), number of spikelets per spike and number of grains per spike. An area of one m^{-1} was selected at random from three different plots in each plot for recording number of fertile tillers (m^{-2}). Three samples of 1000 seeds each were selected from seed lot of each plot to record 1000-grains weight. Grains and straw yield was recorded on per plot basis and was converted to kg ha^{-1}. Fertilizer use efficiency (kg kg^{-1}) was calculated as a ratio of additional grain yield to amount of fertilizer applied as calculated by Barber (1976). Economic analysis was done to determine the economy of the experimental trial as described by CIMMYT (1988). First of all total income/gross income was calculated by adding prices of grain and straw yield. Then total expenditure was calculated by adding cost of production and prices of fertilizer applied. Net income was calculated by subtracting total expenditure from gross income and benefit cost ratio was calculated as ratio of gross income with total expenditure. Value cost ratio was measured as ratio between value of additional grain yield (Rs.) and the value of amount of fertilizer (Rs.) applied (Jain *et al., 2005*). Data collected was analyzed statistically using Fisher's analysis of variance technique. Difference among the treatment means were compared using least significant difference at 5 % probability level (Steel *et al*., 1997).

RESULTS AND DISCUSSIONS

Plant Height (cm)

Effect of different phosphorus sources on plant height of wheat was non significant. Similar trend was found by Alam *et al.* (1999). But the effect of different phosphorus rates on plant height of wheat was significant. This phenomenon was confirmed by Aulakh *et al.* (2003). Minimum plant height (94.47 cm) was obtained in control (0 kg P ha^{-1}) treatment. Application of phosphorus significantly increased the plant height over control. The differences among different phosphorus levels however were statistically non-significant. Interaction between fertilizer sources and rates was non significant. 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. But the increase in plant height was similar in all the plots except control, which might be due to equal application of nitrogen in all other plots. 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.

Number of Fertile Tillers per m^2

The response of different phosphorus sources on number of fertile tillers of wheat was non significant. But the effect of different phosphorus rates on number of fertile tillers of wheat was significant. Minimum number of fertile tillers (276.5) was obtained in control (0 kg P_2O_5 ha^{-1}) treatment. The number of fertile tillers increased significantly with each increase in phosphorus rates up to the 90 kg P_2O_5 ha^{-1}. Further increase in phosphorus rate resulted in no change in number of fertile tillers per unit area. Higher dose of phosphorus might have caused phytotoxicity to plant due to which number of fertile tillers per unit area might have not increased. Interaction between fertilizer sources and rates was non significant. Increase in number of fertile tillers with phosphorus might have been due to balanced fertilizer application, which might have resulted in better plant growth and more number of total tillers per unit area. Phosphorus deficiency reduces tillering capacity and retarded root growth. These results are in line with the findings of Malik *et al.* (1995), Pareek *et al*. (2004) and Memon *et al.* (2005) *who* reported that number of fertile tillers increased with increased in phosphorus levels.

Number of spikelets per spike

Effect of different phosphorus sources on number of spikelets per spike of wheat was non significant. But the effect of different phosphorus rates on number of spikelets per spike of wheat was significant. Minimum number of spikelets per spike (14.20) was obtained in control (0 kg P_2O_5 ha^{-1}) treatment. Application of phosphorus significantly increased the number of spikelets per spike over control. The differences among different phosphorus levels however were statistically non-significant. Interaction between fertilizer sources and rates was non significant. Increase in number of spikelets per spike as compared to control treatment might have been due to balanced fertilizer application. 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 increased. The same results were reported by Rehman *et al.* (1996) and Memon *et al*. (2005).

Number of grains per spike

The data given in table 1 had a significant effect on number of grains per spike. Effect of different phosphorus sources on number of grains per spike of wheat was non-significant. The effect of different phosphorus rates on number of grains per spike of wheat was significant. Minimum number of grains per spike (39.39) was obtained in control (0 kg P_2O_5 ha^{-1}) treatment. Application of phosphorus significantly increased the number of grains per spike over control. The differences among different phosphorus levels however were statistically non-significant Interaction between fertilizer sources and rates was non significant. 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) who also reported the decrease in number of grains per spike at lower level of phosphorus application in wheat.

1000-Grain weight (g)

Effect of different phosphorus sources on 1000-grain weight of wheat was non significant. But the effect of different phosphorus rates on 1000-grain weight of wheat was significant. Minimum 1000-grain weight (34.02 g) was obtained in control (0 kg P_2O_5 ha^{-1}) treatment. The 1000-grain weight at the dose of 60, 90 and 120 kg P_2O_5 ha^{-1} are statistically at par with each other. Interaction between fertilizer sources and rates was non significant. The 1000-grain weight increased with increased in phosphorus up to 90 kg P_2O_5 ha^{-1}. When phosphorus deficiency is in severe condition, plant may not flower at all; large proportion of grains remains empty. When phosphorus deficiency is very severer, grain formation may not occur, low 1000-grain weight and poor grain quality, no response to mineral nitrogen fertilizer application. These results are agreed with those of Memon *et al.* (2005) and Mehdi *et al.* (2007).

Straw yield (t ha^{-1})

It is clear from the table 2 that the effect of different phosphorus sources on straw yield of wheat was significant. Phosphorus application in the form of DAP produced more straw yield (12.43 t ha^{-1}) than that of the phosphorous fertilizer in the form of NP (11.94 t ha^{-1}). The possible reason might be that wheat production can be greatly affected by reduced phosphorus availability. At low pH (below 5.5), iron and aluminum react with phosphorus to form highly insoluble compounds that severely reduce the amount of plant available phosphorus (Phillips *et al.,* 2000). But the effect of different phosphorus rates on straw yield of wheat was significant. Minimum straw yield (10.13 t ha^{-1}) was obtained in control (0 kg P_2O_5 ha^{-1}) treatment. Application of phosphorus significantly increased the straw yield over control. The differences among different phosphorus levels however were statistically non-significant. Interaction between fertilizer sources and rates was non significant. The increase in straw yield was similar in all the plots except control, which might be due to equal application of nitrogen in all other plots because nitrogen effect on vegetative growth in wheat. Phosphorus also strengthens the straw. Similar results were reported by Rehman *et al*. (2004), Pareek *et al*. (2004) and Mehdi *et al.* (2007) who reported that phosphorus affects on straw yield.

Grain yield (t ha^{-1})

The table (1) illustrates that the effect of different phosphorus sources on grain yield of wheat was non significant. But the effect of different phosphorus rates on grain yield of wheat was significant. Minimum grain yield (2.903 t 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 90 kg P_2O_5 ha^{-1}. Further increase in phosphorus rate resulted in no change in grain yield. Higher dose of phosphorus might have caused phytotoxicity to plant due to which grain yield might have not been increased. Grain yield at the dose of 90 and 120 kg P_2O_5 ha^{-1} are statistically at par with each other. Interaction between fertilizer sources and rates was non 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).

Fertilizer use efficiency (kg kg^{-1})

It is evident from the table (2) that fertilizer use efficiency (FUE) markedly affected by different phosphorus sources. Similar trend was noticed by Phillips *et al.,* (2000). Phosphorus application in the form of NP has higher fertilizer use efficiency (35.80 kg kg^{-1}) than that of the phosphorus application in the form of DAP (32.47 kg kg^{-1}). Similarly, the effect of different phosphorus rates on fertilizer use efficiency of wheat was also significant. The minimum fertilizer use efficiency (0.00 %) was obtained in control (0 kg P_2O_5 ha^{-1}) treatment. Fertilizer use efficiency decreased significantly with each increase in phosphorus rates. The maximum fertilizer efficiency (69.75 kg kg^{-1}) was obtained, when 90 Kg P_2O_5 ha^{-1} was applied. Interaction between fertilizer sources and rates was also significant. The maximum fertilizer use efficiency (57.15 kg kg^{-1}) was obtained when NP source of phosphorus fertilizer was at 90 kg P_2O_5 ha^{-1}, followed by DAP source of phosphorus (51.67 kg kg^{-1}) applied at the same rate. The control plot (0 kg P_2O_5 ha^{-1}) in both sources of phosphorus resulted in the minimum fertilizer use efficiency. Increase in grain yield per unit increase in fertilizer at higher phosphorus levels was less as compared to lower levels. So, fertilizer use efficiency decreased with increasing phosphorus rates. Soni *et al.* (2000) and Kumar *et al.* (2001) also reported wheat crop response to added phosphorus fertilization.

Economic analysis

The data pertaining to economic analysis is given in table 3. It is clear from the data that maximum net income (87584.6 Rs.) was obtained from when phosphorus was used in the form of NP source at the rate of 90 kg ha^{-1} followed by the treatment when phosphorous was used in the form of DAP at the rate of 90 kg ha^{-1}. Minimum net income (39049 Rs.) was recorded in control (0 kg ha^{-1}) treatment. As the phosphorus application in the form of NP at the rate of 90 kg ha^{-1} produce maximum grain yield, therefore, net income obtained from this treatment was also maximum. The data regarding the benefit cost ratio (BCR) revealed that maximum BCR (5.27) was obtained; when phosphorus was used in the form of DAP source at the rate of 90 kg ha^{-1} followed by the treatment when phosphorous was used in the form of NP at the rate of 90 kg ha^{-1}. Minimum BCR was (4.71) recorded in the control treatment where no fertilizer was applied. Maximum value cost ratio (VCR) was obtained from the treatment when phosphorus was applied in the form of DAP at the rate of 90 kg ha^{-1} (5.29) followed by the treatment where phosphorus was applied in the form of NP at the rate of 90 kg ha^{-1}. Minimum VCR was recorded in control treatment where no fertilizer was applied.

Table-1: Effect of phosphorus fertilizer sources and rates on yield parameters of wheat (*Triticum aestivum* L.)

Phosphorus rates (kg ha^{-1})	No. of fertile tillers (m^{-2})			No. of grains per spike			1000-grain wt. (g)			Grain yield (t ha^{-1})		
	Phosphorus Sources			Phosphorus Sources			Phosphorus Sources			Phosphorus Sources		
	DAP	NP	Mean	DAP	NP	Mean	DAP	NP	Mean	DAP	NP	Mean
0	276.5	276.5	276.5C	33.39	39.39	39.39B	34.02	34.02	34.02B	2.903	2.903	2.903C
60	401.0	401.0	401.0B	43.33	44.67	44.00A	35.42	37.20	36.31AB	6.003	6.332	6.168B
90	445.5	475.0	460.3A	43.90	42.35	43.13A	37.70	38.05	37.88A	7.003	7.327	7.165A
120	453.5	416.0	434.8AB	46.47	44.72	45.60A	36.40	37.00	36.70A	6.823	7.332	7.077A
Mean	394.1	392.1		43.27	42.78		35.89	36.57		5.682	5.947	
LSD	49.06			2.983			2.548			0.5891		

Where DAP= Diammonoium Phosphate, NP= Nitrophos

Table-2: Effect of phosphorus fertilizer sources and rates on yield parameters of wheat (*Triticum aestivum* L.)

Phosphorus rates (kg ha^{-1})	Plant height (cm)			No. of spikelets per spike			Straw yield (t ha^{-1})			Fertilizer use efficiency (kg kg^{-1})		
	Phosphorus Sources			Phosphorus Sources			Phosphorus Sources			Phosphorus Sources		
	DAP	NP	Mean	DAP	NP	Mean	DAP	NP	Mean	DAP	NP	Mean
0	94.44	94.44	94.44B	14.20	14.20	14.20B	7.5	7.5	7.5B	0.00 g	0.00 g	0.00 D
60	98.76	99.86	99.31A	15.38	14.93	15.15A	12.92	12.42	12.67A	51.67 b	57.15 a	54.41 A
90	98.45	98.01	98.23A	15.13	14.90	15.01A	13.25	13.09	13.17A	45.55 d	49.15 c	47.35 B
120	98.10	99.00	98.55A	15.52	15.27	15.40A	13.43	12.10	12.76A	32.66 f	36.90 e	34.78 C
Mean	97.44	97.83		15.06	14.82		11.77A	11.27B		32.47 B	35.80 A	
LSD	1.844			0.6107			Rates=0.4976, Sources=0.3518			Rates=1.084, Sources=0.703, Interaction=1.532		

Table-3: Effect of phosphorus fertilizer sources and rates on economic analysis of wheat

Treat. (kg ha^{-1})	Grain yield (kg ha^{-1})	Straw Yield (kg ha^{-1})	Grains Price (Rs.)	Straw Price (Rs.)	Gross Income (Rs.)	Total Expenditure (Rs.)	Net Income (Rs.)	B.C.R	V.C.R
Control	2900	7500	30798	18750	49548	10499	39049	4.71	0
DAP-60	6000	13250	63720	33125	96845	19059	77786	5.08	4.8
DAP-90	7000	12920	74340	32300	106640	20232.6	86407.4	5.27	5.29
DAP-120	6820	13420	72428.4	33550	105978.4	21331.5	84646.9	4.96	4.68
NP-60	6330	13090	67224.6	32725	99954.6	19806	80148.6	5.04	4.12
NP-90	7330	12420	77844.6	31050	108894.6	21310	87584.6	5.11	4.96
NP-120	7330	12090	77844.6	30225	108069.6	22804.5	85265.1	4.73	4.28

CONCLUSION

On the basis of present finding, it is concluded that phosphorus application in the form of DAP at the rate of 90 kg ha^{-1} is more conducive for recommendation for the farmers, because it gave maximum benefit cost ratio (5.27) and value cost ratio (5.29). So, from this research, it is suggested that phosphorus source in the form of DAP at the rate of 90 kg ha^{-1} should be applied to get maximum benefit from wheat crop.

REFERENCES

Alam SM, Iqbal Z, and Latif A. 1999. Fertigation technology for improved phosphorus use efficiency in wheat. Pak. J. of Scientific and Ind. Res. 42: 380-383.

Alessi J, and Power JF. 1980. Effects of Banded and Residual Fertilizer Phosphorus on Dry Spring Wheat Yield in the Northern Plain (USA). Soil Sci. Soc. Am. J., 44: 792-796.

Anonymous 2013. Agriculture Statistics of Pakistan 2012-13, (Economic Wing), MINFAL. Govt. of Pakistan, Islamabad, pp. 20-21.

Aulakh MS,Pasricha NS and Bahl GS. 2003. Phosphorus fertilizer response in an irrigated soybean-wheat production system on a subtropical, semiarid soil. Field Crops Res. 80: 99-109.

Barbar SA. 1976. Efficient fertilizer use In: Patterson, F.L.Ed. pp. 13-29. Agronomic research for food, Amer. Soc. Agronomy, Special Pub. 26, Madison. USA.

Chaudhry TM. 1982. Use of phosphorus in alkaline calcareous soil. In Soil Fertility and Fertilizer Use. National Fertilizer Development Center. Tr. Bulletin I. pp. 26-29.

CIMMYT. 1998. From agricultural data to farm records-an economic Dann, P.R. 1969. Response by wheat to phosphorus and nitrogen with particular reference to laying off. Aust. Jour. Expt. Agric. Anim. Husb. 9: 625-634.

Dann PR. 1969. Response by wheat to phosphorus and nitrogen with particular reference to laying off. Aust. Jour. Expt. Agric. Anim. Husb. 9: 625-634.

Das PC. 2004. Manures and fertilizers. Kalyani Publishers, New Dehli. Manual Economics prog. CIMMYT, Maxico D.E. pp. 7-8.

Jain NK, and Dahama AK. 2005. Residual effect of phosphorus and zinc on yield, nutrient content and uptake and economics of pearl millet-wheat cropping system. Ind. J. of Agri. Sci., 75: 281-284.

Kumar A, Singh B, and J. Singh J. 2001. Response of macaroni wheat to nitrogen, phosphorus and sodic water on loamy sand soils of south-west Haryana. Ind. J. Agron., 46: 118–121.

Malik MA, Shah SH, and Ali A. 1995. Response of two wheat cultivars to different levels of phosphorus. Pakistan. J. Agri. Sci., 27: 183-185.

Mehdi SM, Abid M, Sarfraz M, Hafeez M and Hafeez F. 2007. Wheat response to applied phosphorus in light textured soil. J. of Bio. Sci., 7: 1535-1538.

Memon, K. S. and H. K. Puno. 2005. Effect of different nitrogen and phosphorus levels on the yield and yield components of wheat variety Pavan. Agriculture Research Station Dadu, Sindh, Pakistan. Indus. J. Plant Sci., 4(3): 273-277.

Min Keni, P.M.S., and A.F. Mackenzie. 1988. Ortho and polyphosphate P fertilizer as effected by added organic materials and calcium carbonate Can. J. Soil Sci. 68: 243-250.

Pareek. 2004. Effect of phosphorus, sulphur and zinc on growth, yield and nutrient uptake of wheat (*Triticum aestivum*). Indian. J. Agronomy., 49(3): 160-162.

Phillips, S.B., W.R. Raun, G.V. Johnson and W.E. Thomason. 2000. Effect of dual applied phosphorus and gypsum on wheat forage and grain yield. J. of Plant Nut. 23 (2): 251-261.

Rahman *et al*. 1996. Effect of phosphorus applied as superphosphate on rate of development and spikelet number per ear of different cultivars of wheat. Australian. J. of Agr. Res., 28(2): 183– 86.

Rodry-guez, D., H.F. Andrade and J. Goudriaan. 1999. Effects of phosphorus nutrition on tiller emergence in wheat. Plant and Soil. 209: 283-295.

Senigigaliesi, C.A.R. Garcia., S. Miria, M.L.R. Galetto, E. 1983 Fertilizer application to wheat in the north province of Buenos Aires and South of Sana Fe. Agropecuaria Pergamino; 191; 28 Argentina. (Field Crop Absts., 37(7): 5117-1984).

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

Singh, S.S. 2003. Soil fertility and nutrient management. Kalyani Publishers, New Dehli. pp. 37-38.

Soni, M. L., A. Swarup and M. Singh. 2000. Effect of manganese and phosphorus application on yield and nutrition of wheat in reclaimed sodic soil. Curr. Agric., 24 : 105–109.

Steel, R.G.D, J.H. Torrie and D.A. Dickny. 1997. Principles and Procedures of Statistics, a biological approach. 3rd Edition. McGraw Hill Book Co., Inc., NY, USA. pp. 352-358.

Tahir, M. 1980. Wheat Production Mannual. Pakistan Agricultural Research Council, Islamabad, pp. 72-80.