American-Eurasian J. Agric. & Environ. Sci., 16 (3): 455-459, 2016
ISSN 1818-6769

DOI: 10.5829/idosi.aejaes.2016.16.3.12887

Integrated Effect of Phosphorus and Zinc on Wheat Crop

[1]Muhammad Arshad, [2]Muhammad Adnan, [1]Sher Ahmed, [1]Abdul Karim Khan, [1]Irshad Ali, [2]Muhammad Ali, [3]Azaz Ali, [3]Azam Khan, [3]Muhammad Anwar Kamal, [2]Farhana Gul and [1]Muhammad Ayaz Khan

[1]Mountain Agricultural Research Center (MARC), GilgitBultistan, Pakistan
[2]Department of Agriculture, University of Swabi, Pakistan
[3]Department of Soil and Environmental Sciences, the University of Agriculture Peshawar, Pakistan

Abstract: Field experiment on "interactive effect of phosphorus and zinc on wheat crop" was conducted at New Developmental farm, the University of Agriculture Peshawar, Pakistan during 2012-13. Four zinc levels (0, 5, 10 and 15 kg ha^{-1}) were applied to plots with three different levels of phosphorus (45, 90 and 135 kg ha^{-1}).The experiment was conducted in 2 factorial contrast randomized complete block design (RCBD) having three replications. Zn application had significantly increased wheat spike length (10.78cm), 1000 grains weight (49.36g) total dry matter (8200kg ha^{-1}) and grain yield (4426kg ha^{-1}) in the plots which were treated with 10 kg Zn ha^{-1}, while the maximum straw yield (4000 kg ha^{-1}) was recorded at 5 kg Zn ha^{-1}. Applied phosphorus at the rate of 90 kg P_2O_5 ha^{-1}had significantly increased plant height (93.63cm), 1000 grains weight (46.80g), total dry matter (8113kg ha^{-1}), grain yield (4101.1kg ha^{-1}) and straw yield (4012kg ha^{-1}). These results indicated that agronomic characteristics of wheat crop showed more significant response in plots which were treated with 90 kg P ha^{-1} along with 10 kg Zn ha^{-1}.Thus it was suggested that 90 kg P_2O_5 along with 10 kg Zn ha^{-1}would be useful under the similar agro-climatic conditions and soil properties for obtaining more wheat yield.

Key words: Wheat · Phosphorus · Zinc · Interaction · Yield

INTRODUCTION

The quality and production of wheat crop may be influenced by the management of macronutrients (NPK) but is also physiologically dependent to the management of different micronutrients along the major nutrients the recent year [1].

Phosphorus is the essential plant nutrient which plays major role for achieving the maximum agricultural production. Phosphorus observed the second most extensively occurring nutrient deficiency, after nitrogen stress, in cereal chain across the world [2]. Crops phosphorus use efficiency (PUE) ranged from 10-30% [3]. Significantly maximum yield of grain in wheat has been obtained by many researchers with optimum use of P fertilizer [4]. In general, amount of fertilization used depends on type of crop, soil nutritional status, yield goal and other considerations which include the conditions of irrigated or rain fed. Organic and inorganic sources of P are applied to the soil in the form of both fertilizers when available P is less than crop's requirement [5].

Zinc is required for wheat vigorous growth and as Zn is also responsible for activating some enzymatic processes i.e. carbonic anhydrase, dehydrogenase, proteinase and peptidase [6]. A lot of experiment has been proven to highlight the effects of zinc to enhanced wheat and yield quality of wheat [7]. Zinc is an important cofactor in functioning of several enzymatic processes, the synthesis of nucleic acids and auxins metabolisms, protein analysis and crop vigorous growth.

Zinc disposal and uptake by the plant is adversely affected by increasing the phosphorus fertilizer [8]. Both the elements are important for obtaining more yields although they have antagonistic in nature to each other i.e. increasing dose of P adversely effects the Zn nutrient, the translocation and accumulation of Zn from roots toward shoots of the plant is in slow rate and that might be the reason [9]. This antagonism is known to cause yield reduction in many crops. The yield reduction is mainly caused by either P or Zn deficiencies. Deficiencies may be caused in the plants by the excessive application of phosphatic fertilizers to the soil, similarly in the case of Zn excessive application causes P deficiencies.

Corresponding Author: Muhammad Adnan, Department of Agriculture, University of Swabi, Pakistan.

Information regarding Zinc and phosphorus application and it interaction for the wheat crop in not widely available in the agro-climatic condition. Thus, keeping these limitations and features in priority the present study was carried to find out the optimum level of Zn and P for better wheat in agro-climatic conditions of Peshawar.

MATERIALS AND METHODS

A field trial was practiced to find out the interactive effect of P and Zn on wheat crop. The experiment was consisting of 2 factors including 3 levels of phosphorous (45, 90 and 135 kg ha^{-1}), 4 levels of zinc (0, 5, 10 and 15 Kg ha^{-1}) and control, laid in 2 factorial contrasts randomized complete block design with three replications. The wheat variety Siran with a seed rate of 100 kg ha^{-1} was grown in plot of size3×4 m^2 in 30 cm apart rows. The amount of P and Zn as per proposed treatment were applied from diammonium phosphate (DAP) and zinc sulphate, respectively. The deficiency of nitrogen was covered by the application of nitrogen from urea to fulfill the requirement of 120 kg N ha^{-1} and potassium in form of sulphate of potash (SOP) at the rate of 60 Kg ha^{-1}. Nitrogen and potassium applied as a basel dose to each treatment. Nitrogen was applied as two split applications where as all P, K and Zn was applied at sowing time. Data on grains yield, TDM yield, straw yield and 1000-grain weight of wheat were recorded after crop harvest.

Statistical Analysis: The obtained data were analyzed to the procedure as given by Steel and Torrie [10] using MSTAT-C package and Least Significant Difference (LSD) test was used for any significant difference between the treatments.

RESULTS AND DISCUSSION

Spike Length: Spike length of wheat is an important yield contributing parameter. Data regarding spike length of wheat as affected by Zinc, phosphorus application rate and their interaction are reported in Table 1. Statistical analysis of the data revealed that spike length was significantly affected by Zn, P application rate and P x Zn interaction. Higher spike length was found in plots treated 90 kg P ha^{-1} which was at par with P application at the rate of 135 kg ha^{-1}, whereas lower spike length was noted in plants treated with 45 kg P ha^{-1}. Similarly, higher spike length was recorded in plants treated with 10 kg Zn ha^{-1} which was at par with Zn application at the rate of 15 kg ha^{-1} while lower plant P uptake was noted in plots where no Zn was applied. Regarding the P x Zn interaction, higher spike length was found in plots treated with 90 kg P ha^{-1} in combination with 15 kg Zn ha^{-1}.The individual plant performance in zinc applied plots, or more availability of other nutrients due to zinc [11], might have increased the spike length. These results are in agreement with thos reported by Asad and Rafique [12] and Curtin *et al.* [13]. Higher spike length 10.75 cm, whereas lower spike length, these results also are in line with those obtained by Brennan [14] and Samad [15] they concluded that higher P manure consumption noted the maximum spike length because of maximum buildup of photosynthesis.

Table 1: Spike length (cm) as influenced by combine application of phosphorus and zinc

	Phosphorus (kg ha^{-1})			
Zinc (kg ha^{-1})	45	90	135	Mean
0	9.64 ef	10.03def	10.35 def	10.01 b
5	9.33 f	11.58 abc	10.25 def	10.39 ab
10	9.91 def	10.86 bcd	11.91 ab	10.89 a
15	10.17 def	12.10 a	10.64 cde	10.97 a
Mean	9.76 b	11.14 a	10.79 a	
Control	7.93			
Rest		10.57		
LSD Zn= 0.66, P = 0.57 and P*Zn = 1.14				

Table 2: Plant height (cm) as influenced by combine application of phosphorus and zinc

	Phosphorus (kg ha^{-1})			
Zinc (kg ha^{-1})	45	90	135	Mean
0	88.37 gh	91.78 efg	94.02 cde	91.39 b
5	84.65 h	100.45 a	89.41 fg	91.50 b
10	95.70 bcd	92.35 def	91.56 efg	93.20 ab
15	89.96 fg	99.45 ab	96.49 bc	95.30 a
Mean	89.67 c	96.01 a	92.87 b	
Control	85.39			
Rest		92.85		
LSD(0.05) Zn= 2.24, P = 1.94 and P*Zn = 3.88				

Plant Height: Data regarding plant height of wheat as affected by Zn and P application rate and their interaction are presented in Table 2. Statistical analysis of the data indicated that Zn and P significantly affected plant height of wheat while the Zn x P interaction was also significant. Taller plants were produced in plots where P was applied at the rate of 90 kg ha^{-1} followed by P application at the rate 135 kg ah^{-1}, while short stature plants were produced by plots treated with 45 kg P ha^{-1}.

Regarding Zn application rate, higher plant height was recorded in plots where Zn was applied at the rate of 15 kg ha^{-1} followed by Zn application at the rate 10 kg ha^{-1} while lower plant height was recorded in no zinc treated plots. The P x Zn interaction indicated that higher plant height was found in plots where P was applied at the rate of 90 kg ha^{-1} in combination with Zn at the rate of 5 kg ha^{-1}. This may be due to the Zn major role in the shoots and roots elongation due to auxin hormones activation in the wheat crop plant, these results are in accordance with the findings of Khan *et al.* [16]. Plant height was observed maximum 96.01cm in the plot and found minimum 89.67 cm, this minimum height may be due to the insufficient rate of Zn present in the soil the results of our field trail was in line with the findings of Abbas *et al.* [17], who reported that plant height increasing significantly with increased of Zn rate with recommended doses of NPK over control.

1000-grain Weight: Thousand grain weight of wheat is an important yield contributing component. Data concerning thousand grain weight of wheat as affected by P and Zn application rate are presented in Table 3. Analysis of the data revealed that thousand grain weights were significantly affected by Zn and P application rate and their interaction. Heavier grains were produced by plots where P was applied at the rate of 90 kg ha^{-1} followed by P application at the rate of 135 kg ha^{-1} which was at par with P application at the rate of 45 kg ha^{-1}. Moreover, thousand grain weight was higher in plots where Zn was applied at the rate of 10 kg ha^{-1} followed by Zn application at the rate of 5 kg ha^{-1} which was at par with all other Zn application rates. The Zn x P interaction revealed that thousand grain weights was higher in plots treated with 90 kg P ha^{-1} in combination with 10 kg ha^{-1}. The application of zinc might have increased the photosynthetic efficiency due to improved enzymatic activity [18] and thus might have increased thousand grains weight. These results are in conformity with the finding of Abbas *et al.* [19]. Also, Brennan [14] concluded that higher P manure consumption noted the maximum spike length because of maximum buildup of photosynthesis.

Yield: Data concerning total dry matter of wheat as affected by P, Zn and P x Zn interaction are presented in Table 4. The results indicated that P and Zn application rate convincingly affected total dry matter content of wheat. Similarly the P x Zn interaction was also found significant. In case of P, total dry matter production was higher in plots treated with 90 kg P ha^{-1} however; it was at par with P application at the rate of 135 kg ha^{-1}, while lower dry matter production was recorded in 45 kg ha^{-1} P treated plots. Furthermore, total dry matter production was higher in plots treated with Zn at the rate of 10 kg ha^{-1} which was at par with Zn application at the rate of 5 kg ha^{-1}. Total dry matter production was lower in no Zn treated plots. Significant interaction was found for Zn x P and higher total dry matter was produced in plots where 90 kg P ha^{-1} was applied in combination with 10 kg Zn ha^{-1} may be due to the application of more fertilizer to the soil which enhance plant growth, leaf area index and plant height as reported by Jan *et al.* [20]. Higher TDM yield 8113 kg ha^{-1} was recorded where 90 Kg P ha^{-1} was applied these results may be due to the application of more phosphorous to the soil which increased the TDM. Our results are in line with the outcomes of Potarzycki and Grzebisz [21]. These results are further confirmed by Alam *et al.* [22], who also found that the application of Phosphatic fertilizer enhanced the dry matter yield of wheat crop.

Table 3: 1000-grains weight (g) as influenced by interaction of phosphorus and zinc

	Phosphorus (kg ha^{-1})			
Zinc (kg ha^{-1})	45	90	135	Mean
0	40.07 e	44.88 cd	42.97 de	42.64 b
5	44.33 cde	43.67 cde	44.33 cde	44.11 b
10	44.66 cde	53.09 a	50.32 ab	49.36 a
15	42.08 de	48.33 bc	41.66 de	44.02 b
Mean	42.78 b	47.49 a	44.82 b	
Control	34.29			
Rest		45.04		
LSD(0.05) Zn= 2.74, P = 2.37 and P*Zn = 4.75 Biological				

Table 4: Biological yield as influenced by combine application of phosphorus and zinc

	Phosphorus (kg ha^{-1})			
Zinc (kg ha^{-1})	45	90	135	Mean
0	5700g	6400fg	6744efg	6281c
5	6066fg	8766ab	8400bc	7744ab
10	6933def	9666a	8000bcd	8200a
15	6755efg	7619cde	7940bcd	7438b
Mean	6363b	8113a	7771a	
Control	4345			
Rest		7416		
LSD(0.05) Zn= 638.51, P = 552.96 and P*Zn = 1105.9				

Table 5: Grain yield (kg ha^{-1}) as influenced by combine application of phosphorus and zinc

	Phosphorus (kg ha^{-1})			
Zinc (kg ha^{-1})	45	90	135	Mean
0	3090 e	3411de	3807 cd	3436 c
5	3620 cd	3911 cd	3702 cd	3744 b
10	3693 cd	5102 a	4483 b	4426a
15	3670 cd	3980 bc	3485 cde	3711 bc
Mean	3518 b	4101 a	3869.3 a	
Control	1903			
Rest		3830		
LSD(0.05) Zn= 297.83, P = 257.93 and P*Zn = 515.86				

Table 6: Straw yield (kg ha^{-1}) as influenced by combine application of phosphorus and zinc

	Phosphorus (kg ha^{-1})			
Zinc (kg ha^{-1})	45	90	135	Mean
0	2610c	2988c	2937c	2845b
5	2446c	4855a	4698ab	4000a
10	3240c	4564ab	3517.0bc	3773a
15	3085c	3639abc	4522ab	3749a
Mean	2845b	4012a	3918a	
Control	2441			
Rest		3592		
LSD(0.05) Zn= 713.64, P = 618.03 and P*Zn = 1236.1				

Grain Yield: Grain yield of wheat is economically the most important component and is directly affected by nutrients application rate and management practices. Data regarding GY of wheat as affected by P and Zn application rate and P x Zn interaction are presented in Table 5. The results indicated that P and Zn dosage rate synergistically affected grain yield of wheat. Similarly the P x Zn interaction was also found significant. In case of P, grain yield was higher in plots treated with 90 kg P ha^{-1} however; it was at par with P application at the rate of 135 kg ha^{-1}, while lower grain yield was recorded in 45 kg ha^{-1} P treated plots. Furthermore, grain yield was higher in plots treated with Zn at the rate of 10 kg ha^{-1} followed by Zn application at the rate of 5 kg ha^{-1}. Grain yield was lower in no Zn treated plots. Significant interaction was found for P x Zn and higher grain yield was produced in plots where 90 kg P ha^{-1} was applied in combination with 10 kg Zn ha^{-1}. The greater photosynthesis efficiency [23], or more nutrients availability due to increasing decomposition rate of organic matter [11], or improved individual plant performance might the possible reasons for higher grain yield in zinc applied plots compared to other plots. These results are in supports of the finding of Norwood [24] and Jan *et al.* [20]. The maximum grain yield may be due to the application of more phosphorous fertilizer to the soil which meets the required level of P nutrient to the soil. Our results are similar to the findings of Zia *et al.* [25], who determined that grain yield of wheat enhanced with increasing rate of P over control.

Straw Yield: Data regarding straw yield of wheat as affected by P and Zn application rates are shown in Table 6. Statistical analysis of the data indicated that straw yield of wheat showed significant response to P and Zn application rate. Similarly, the P x Zn interaction was also found significant. Higher straw yield was recorded in plots treated with 135 kg P ha^{-1} which was statistically similar with application of P at the rate of 90 kg ha^{-1}. Straw yield was lower in plots treated with 45 kg P ha^{-1}. Furthermore, higher straw yield was investigated in plots where Zn was applied at the rate of 5 kg ha^{-1} which was at par with Zn application at the rate of 10 and 15 kg ha^{-1}. Lower straw yield was recorded in no Zn treated plots. The P x Zn interaction observed that maximum straw yield in plots treated with 90 kg P ha^{-1} in combination with 5 kg Zn ha^{-1}. This higher straw yield could be associated to more zinc content in the soil, which might have increased the wheat straw yield. Our findings are similar by the results of Curtin *et al.*, [13], who reported that increasing zinc application dose increased the straw yield.

CONCLUSION AND RECOMMENDATION

Zinc and phosphorus interaction was found significant for yield components of wheat. Phosphorous applied at the rate of 90 kg ha^{-1} along with10 kg Zn ha^{-1} was found to be the optimum dose for yield and its component of wheat crop under existing soil and climatic conditions. The mentioned levels of P and Zn should be maintained for these soils to encounter the antagonistic effects of one another.

REFERENCES

1. Wiatrak, P.J., D.L. Wright and J.J. Marois, 2006. The impact of tillage and residual nitrogen on wheat. Soil and Tillage Research, 91: 150-156.
2. Marschner, H., 1995. Mineral Nutrition of Higher Plants. 2nd Ed. Academic Press, London UK, pp: 229-312.

3. Bahl, G.S. and N.T. Singh, 1986. Phosphorus diffusion in soils in relation to some edaphic factors and its influence on P uptake by maize and wheat. Journal of Agricultural Sciences Cambridge, 107: 335-341.
4. Grant, C.A. and L.D. Bailey, 1989. Nitrogen, phosphorus and zinc management effects on grain yield and cadmium concentration in two cultivars of durum wheat. Canadian Journal of Plant Science, 1: 63-70.
5. Mosali, J., K. Girma, R.K. Teal, K.W. Freeman, K.L. Martin, J.W. Lawles and W.R. Raun, 2006. Effect of foliar application of phosphorus on winter wheat grain yield, phosphorus uptake and use efficiency. Journal of Plant Nutrition, 29: 2147-2163.
6. Monasterio, O.J.I., R.J. Peña, W.H. Pfeiffer and A.H. Hede, 2002. Phosphorus use efficiency, grain yield and quality of triticale and durum wheat under irrigated conditions. Proceedings of the 5th International Triticale Symposium, Radzików, Poland, pp: 9-14.
7. Sharma, K., B.A. Krants, A.L. Brown and S. Quick, 1986. Interaction of Zn and P in top and root of corn and tomato. Agronomy Journal, 60: 453-456.
8. Salimpour, S., K. Khavazi, H. Nadian, H. Besharati and M. Miransari, 2010 Enhancing phosphorous availability to canola (*Brassica napus* L.) using P solubilizincg and sulfur oxidizincg bacteria. Australian Journal of Crop Science, 4(5): 330-334.
9. Stukenholts, D.D., R.L. Olsen, G. Gogen and R.A. Olsen, 1996. On the mechanism, of phosphorus-zinc interaction in corn nutrition. Soil Science Society of America, 30: 759-763.
10. Steel., R.G. and J.H. Torrie, 1980. Principles and Procedures of Statistics. A Biometrical Approach. McGraw-Hill, New York.
11. Tariq, M., S. Hameed, K.A. Malik and F.Y. Hafeez, 2007. Plant root associated bacteria for zinc mobilization in rice. Pakistan Journal of Botany, 39: 245.
12. Asad, A. and R. Rafique, 2000. Effect of zinc, copper, iron, manganese and boron on the yield and yield components of wheat crop in tehsil Peshawar. Pakistan Journal of Biological Sciences, 3: 1615-1620.
13. Curtin, D., R.J. Martin and C.L. Scott, 2008. Wheat (*Triticum aestivum*) response to micronutrients (Mn, Cu, Zn, B) in Canterbury, New Zealand. New Zealand Journal of Crop and Horticulture Sciences, 36: 169-181.
14. Brennan, R.F., 1992. Effect of super Phosphate and N on yield of wheat. Fert. Res., 31(1): 43-49. Field Crop Abst., 46(3): 1991-1993 Soil and Fertilizers. 56(5): 5188:1993.
15. Samad, A., 1984. Developing a co-efficient of cost benefit ratio for wheat on fertilizer receptive soils. M.Sc Thesis, Department of Agronomy. University of Agriculture, Faisalabad.
16. Khan, R., A.R. Gurmani, M.S. Khan and A.H. Gurmani, 2007. Effect of zinc application on rice yield under wheat rice system. Pakistan Journal of Biological Sciences, 10: 235-239.
17. Abbas, G., M.Q. Khan, M. Jamil, M. Tahir and F. Hussain, 2009. Nutrient uptake, growth and yield of wheat (*Triticum aestivum*) as affected by zinc application rates. International Journal of Agriculture and Biological Sciences, 11: 389-396.
18. Martin-Ortiz, D., L.H. Ndez-Apaolaza and A. Ga-Rate, 2010. Wheat (*Triticum aestivum L.*) Response to a zinc Fertilizer Applied as zinc Lignosulfonate Adhered to a NPK Fertilizer. Journal of Agriculture and Food Chemistry, 58: 7886-7892.
19. Abbas, G., G. Hassan, M.A. Ali, M. Aslam and Z. Abbas, 2010. Response of wheat to different doses of $ZnSO_4$ under the desert environment. Pakistan. Journal of Botany, 42(6): 4079-4085.
20. Jan, A., M. Wasim and Jr. Amanullah, 2013. Interactive effects of zinc and nitrogen application on wheat growth and grain yield. Journal of Plant Nutrition, 36: 1506-1520.
21. Potarzycki, J. and W. Grzebisz, 2009. Effect of zinc foliar application on grain yield of maize and its yielding components. Plant Soil Environment, 55: 519-527.
22. Alam, S.M., S.A. Shah, S. Ali and M.M. Iqbal, 2005. Yield and phosphorus-uptake by crops as influenced by chemical fertilizer and integrated use of industrial by-products Songklanakarin Journal of Science and Technology, 27(1): 9-16.
23. Yilmaz, A., H. Ekiz, B. Torun, I. Gultekin, S. Karanlik, S.A. Bagci and I. Cakmak, 1997. Effect of different zinc application methods on grain yield and zinc concentration in wheat cultivars grown on zinc deficient calcareous soils. Journal of Plant Nutrition, 20: 461-471.
24. Norwood, C.A., 1992. Tillage and cropping system effects on winter wheat and grain sorghum. Journal of Production Agriculture, 5: 120-126.
25. Zia, M.M. Sharif, A.M. Aslam, M.B. Baig and A. Ali, 2000. Fertility issues and fertilizer management in rice wheat system. Quarterly Sciences and Veterinary, 5(4): 59-73.