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Response of late sown wheat to phosphorus and zinc nutrition in eastern Uttar Pradesh

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ABSTRACT

Field experiment was conducted at Agronomy Research Farm of Narendra Deva University of Agriculture & Technology,Kumarganj,Faizabad(U.P.) during rabi season of 2012-13 to study the effect of phosphorus (60,80,100 and 120 kg ha^{-1}) and zinc (0,5 and 10 kg ha^{-1}) on growth , yield attributes, yields and economics of late sown wheat. Results revealed that application of 60 to120 kg P_2O_5 ha^{-1}improved the growth, yield attributes, yields and nutrient uptake. The per cent increase in grain yield due to 120 kg P_2O_5 ha^{-1} was to the tune of 1.9,6.0 and 17.3 over 100, 80 and 60 kg P_2O_5 ha^{-1},respectively. Wheat fertilized with 120 kg P_2O_5 ha^{-1} had the maximum gross return (Rs. 65439 ha^{-1}) and net return (Rs.37375 ha^{-1}). Benefit :cost ratio was highest (1.36) with 80 or 100 kg P_2O_5 ha^{-1}, Significant response of zinc was recorded up to 5 kg Zn ha^{-1} on growth, yield attributes, yield and nutrient uptake as compared to without zinc. The maximum values of growth, yield attributes, yields and nutrient uptake were recorded with 10 kg zinc ha^{-1}. The percent increase in grain yield due to 10 kg Zn ha^{-1} was recorded to be 2.7 and 12.9 over 5 kg Zn ha^{-1} and without zinc, respectively. The gross return was increased with corresponding increase in zinc application from 0 to 10 kg Zn ha^{-1}, but net return (Rs.36500 $ha^{-1}$and benefit : cost ratio (1.36) was highest with 5 kg Zn ha^{-1}. The harvest index and test weight were not affected significantly due to phosphorus and zinc application but highest values of both parameters were registered with 100 kg P_2O_5 ha^{-1} and 10 kg Zn ha^{-1}.

Keywords: Phophorus, zinc, nutrition, yield, Uttar Pradesh

INTRODUCTION

Wheat (*Triticum aestivum* L. Emend Flori and Paol) is grown predominately in rice- wheat cropping system which is the backbone of Indian food security. Wheat is an important food crop for billions people of the world and among cereals, it occupies maximum area. Wheat exhausted the soil nutrient, limiting the crop production and creating micronutrient deficiencies in addition to major nutrient in soil. During the recent years, zinc deficiency is common throughout the arid and semi arid regions of over country. Correction of zinc deficiency through addition of zinc is a commons practice. However, its excess application is harmful to crop and environment. Zinc application improved the grain yield due to its role in various enzymatic reaction, growth processes, hormone production and protein synthesis and also translocation of photosynthates to reproductive parts (Singh *et al.* 2011 and Chaudhary *et al.* 2014). Phosphorus use efficiency ranged from 10 to 30 per cent. Significantly maximum yield of wheat has been obtained with the use of optimum P fertilization. Phosphorus is an important nutrient needed for normal growth and development of the plants. It plays an important role in energy transformation and metabolic processes in plants. It is known to be associated with nucleus formation, cell division and nitrogen fixation and transfer of heredity. The continuous use of phosphatic fertilizers may disturb the nutritional balance, particularly of micronutrients which may become a limiting factor in crop production. Information regarding systematic studies on levels of P and Zn and their interaction for wheat crop in alluvial soil of eastern Uttar Pradesh is lacking. Hence, an attempt was made to study the response of late sown wheat to phosphorus and zinc nutrition in eastern Uttar Pradesh.

MATERIALS AND METHODS

Field Experiment was conducted at the Agronomy Research Farm of Narendra Deva University of Agriculture & Technology, Kumarganj, Faizabad (U.P.) $26^0 47'$N latitude, 82^0 $12'$E longitude and an altitude of 113 meters above mean sea level during rabi season of 2012-13. The soil of experimental site was siltyloam having low organic carbon (3.8 g kg^{-1}), nitrogen (203 kg ha^{-1}) medium in phosphorus (15 kg ha^{-1}) and potassium (265 kg ha^{-1}). The treatments comprised of 4 levels of phosphorus (60, 80, 100 and 120 kg ha^{-1}) and 3 levels of zinc (0, 5 and 10 kg ha^{-1}) were tested in factorial randomized block design with three replication. Wheat variety HUW-234 was sown on December 25, 2012 at 20 cm apart rows using 100 kg seed ha^{-1}. Wheat crop was fertilized with a common does of 120 kg N ha^{-1} keeping 50% N as basal and rest of nitrogen was top dressed in two splits i.e. after 1st and IInd irrigation. The calculated amounts of phosphorus and zinc were applied plot wise as basal. The data on plant height and tillers were recorded from the area already marked by tagged. Sample for dry matter accumulation was recorded by cutting of plants from 25 cm row length. The fresh samples were first sun dried and then kept in electric oven at 65-70^{0}c till the constant dry weight attained. Yield attributes were recorded from 10 spikes selected randomly from each plot. The harvest index was calculated as grain yield divided by total biological yield and multiplied by hundred. The dried grain and straw samples were digested with nitric and perchloric acid (Johnson and Ulrich, 1959). Nitrogen was determined by micro kjeldahl method. Phosphorus was estimated in aliquot calorimetrically using venadomolybdate yellow color method (Jackson 1973), K with flame photometer and zinc by atomic absorption spectrophotometer. The uptake of nutrients was calculated as nutrient content in grain and straw multiplied by respective yield. The data so obtained on various parameters were analyzed as per standard statistical procedures.

RESULT AND DISCUSSION

Growth Studies

Plant height, tillers and dry matter accumulation of wheat crop were affected significantly due to application of Phosphorus and Zinc (Table 1). Wheat crop fertilized with 60 to 120 kg P_2O_5 ha^{-1} increased the plant height, tillers and dry matter accumulation significantly up to 120 kg P_2O_5 ha^{-1} over 60 kg P_2O_5 ha^{-1}, however difference between 80 and 100 kg P_2O_5 ha^{-1}, 100 and 120 kg P_2O_5 ha^{-1} were not significant. The maximum plant height (95.3 cm), tillers (415 m^{-2}) and dry matter accumulation (84.25q ha^{-1}) was recorded with 120 kg P_2O_5 ha^{-1}. The higher values of growth characters with application of phosphorus was mainly due to rapid growth caused by maintenance of adequate and continuous supply of nutrients to crop resulted in maintaining better establishment of roots and various metabolic process which contributed to rapid cell division, cell elongation and thus resulted in higher growth of the plant. These results are close conformity with the findings of Deshmukh et al (1994).

Application of 10 kg Zn ha^{-1} being at par with 5 kg Zn ha^{-1} but recoded significantly taller plant, higher tillers and dry matter accumulation as compared to without zinc sulphate . The favorable influence of zinc application on growth may be due to its role in various enzymatic reactions, growth processes, hormone production and protein synthesis and also translocation of photosynthates in various plant parts leading to higher growth of crop. Similar results were obtained by Singh *et al.* (2011) and Chaudhary *et al.* (2014). Days to 50% flowering, maturity and harvest index were not affected significantly due to supply of phosphorus and zinc. However, minimum days taken to 50% flowering and maturity was recorded with 60 kg P_2O_5 ha^{-1} and without zinc application which was mainly attributed to lower supply of nutrients to crops resulted in advance flowering and maturity as compared to adequate supply of plant nutrients with higher level of phosphorus and zinc caused delayed flowering and maturity of crops.

Table 1: Growth characters of wheat as affected by phosphorus and zinc

Treatments	Plant height (cm)	Tillers m^{-2}	Dry matter accumulation (q ha^{-1})	Days to 50% flowering	Days to maturity
Phosphorus (kg ha^{1})					
60	80.93	352	73.40	68	120
80	89.70	391	80.22	68	121
100	93.48	407	82.88	69	122
120	95.30	415	84.25	70	123
SEm±	1.93	11.30	2.01	1.6	3.0
CD (P=0.05)	5.68	33.10	5.88	NS	NS
Zinc (kg ha^{1})					
0	83.48	364	75.41	69	119
5	91.70	399	81.61	69	122
10	94.39	411	83.54	69	123
SEm±	1.68	9.8	1.73	1.4	2.6
CD (P=0.05)	4.92	28.6	5.09	NS	NS

Yield attributes

Yield attributing characters like spikes m^{-2}, spikelet $spike^{-1}$, grains $spike^{-1}$, grain weight $spike^{-1}$ and test weight were affected significantly due to application of phosphorus and zinc except test weight (Table 2). Application of phosphorus up to 120 kg ha^{-1} increased significantly the all yield contributing characters over 60 kg ha^{-1}. However, difference between 80 and 100kg P_2O_5 ha^{-1}, 100 and 120 kg P_2O_5 ha^{-1} were not significant. The higher values of all yield attributing characters with increased supply of phosphorus were due to more proliferation of roots buildup higher concentration of nutrients in soil that hasten cell division and elongation. This favours the root branching accompanied by higher tiller development, plant height and dry matter production which contributed to higher yield attributes through increase photosynthetic activity of leaves. Besides translocation of assimilates from source to sink also increased under higher phosphorus supply which led to improved yield attributes. Similar finding were reported by, Septa and Rai (2012). The significantly higher values of yield attributers were recorded with 10 kg Zn ha^{-1} over without zinc.

However, difference between 5 and 10 kg Zn ha^{-1} was not significant. Significant response of zinc application on yield attributes of wheat was due to its favorable influence on various enzymatic reactions, growth processes, hormone production, protein synthesis and also the translocation of photosynthates to reproductive parts, thus leading to better yield attributes. Singh *et al.* (2011) and Chaudhary *et al.* (2014) also reported similar findings.

Table 2: Yield attributing characters and yields of wheat as affected by phosphorus and zinc

Treatments	Spike m^{-2}	Spikelet $Spike^{-1}$	Grains $Spike^{-1}$	Grain weight $Spike^{1}$ (g)	Test weight (g)	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})	Harvest Index (%)
Phosphorus (kg ha^{1})								
60	262.5	37.67	34.23	1.20	34.87	30.72	42.33	42.03
80	292.2	41.85	38.03	1.36	35.50	34.00	45.83	42.57
100	304.2	43.47	39.52	1.42	35.83	35.38	47.08	42.90
120	310.0	44.30	40.30	1.47	36.30	36.05	47.79	42.98
SEm±	7.25	0.96	0.99	0.03	0.88	0.71	1.11	1.02
CD (P=0.05)	21.27	2.83	2.09	0.09	NS	2.08	3.27	NS
Zinc (kg ha^{1})								
0	271.35	38.90	35.36	1.25	35.25	31.63	43.41	42.13
5	298.03	42.65	38.78	1.40	35.75	34.78	46.44	42.80
10	307.30	43.93	39.93	1.44	35.88	35.71	47.33	42.94
SEm±	6.28	0.83	0.85	0.02	0.76	0.61	0.96	0.89
CD (P=0.05)	18.42	2.45	2.51	0.07	NS	1.80	2.83	NS

Yields

Application of phosphorus up to 120 kg ha $^{-1}$ improved significantly the grain and straw yield over 60 kg ha^{-1} (Table 2). However, difference between 80 and 100 kg P_2O_5 ha $^{-1}$,100 and 120 kg P_2O_5 ha $^{-1}$ were found non-significant. The maximum grain yield (36.05q ha^{-1}) and straw yield (47.79 q ha^{-1}) was recorded with 120 kg P_2O_5 ha^{-1} P_2O_5 followed by 100, 80 and 60 kg P_2O_5 ha^{-1}. The per cent increase in grain yield due to 120 kg P_2O_5ha^{-1} was recorded to be 1.8, 6.0 and 17.4 over100 , 80 and 60 kg P_2O_5 ha^{-1}., respectively. The higher yields with increasing levels of phosphorus was mainly due to adequate supply of phosphorus to plants which is turn contributed to better growth and yield attributes, thus led to higher yield. Application of 60 kg P_2O_5 ha^{-1} gave the lowest yield due to poor growth, metabolic processes and yield attributes. Similar findings were reported by Sharma *et al.* (2012).

Grain and straw yield was significantly affected due to zinc application (Table-2). Wheat crop received either 5 or 10 kg Zn ha^{-1}being at par with each other but produced significantly higher grain and straw yield over without zinc. The maximum grain yield (35.71q ha^{-1}) and straw yield (47.33 q ha^{-}1) was recorded with 10 kg Zn ha^{-1} followed by 5 kg Zn ha^{-1}. The per cent increase in grain yield due to 10 kg Zn ha^{-1} was recorded to be 2.7 and 12.9 over 5 kg Zn ha^{-1} and without zinc, respectively. The higher grain yields obtained with 5 or 10 kg Zn ha^{-1} over without zinc might be due to favorable influence of zinc application owing to its role in various enzymic reaction, growth processes, hormone production and protein synthesis and also the translocation of photosynthates to reproductive parts thereby leading to higher growth and yield attributes and finally grain and straw yield. Singh *et al.* (2011), Chaudhary *et al.* (2014) and Singh *et al.* (2016) also reported similar results.

Table 3: Uptake of N, P, K (Kg ha^{-1}) and Zn (g ha^{-1}) through grain and straw by wheat as affected by phosphorus and zinc

Treatments	Nitrogen		Phosphorus		Potassium		Zinc	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
Phosphorus (kg ha^{1})								
60	49.8	16.7	8.7	5.9	12.7	62.2	80.2	80.6
80	56.6	18.9	10.9	7.3	14.3	69.9	88.1	88.9
100	59.4	19.8	12.1	8.1	14.9	73.1	92.4	92.7
120	61.4	20.5	13.4	9.1	15.4	75.3	99.2	98.4
SEm±	1.5	0.8	0.9	0.6	0.4	2.8	2.7	3.3
CD (P=0.05)	4.4	2.5	2.7	1.8	1.2	8.7	8.1	9.8
Zinc (kg ha^{1})								
0	52.2	17.4	10.1	6.7	13.3	64.9	78.6	78.7
5	51.1	19.3	12.2	7.9	14.6	71.2	93.2	93.3
10	60.3	20.1	12.3	8.2	15.1	73.9	94.5	94.7
SEm±	1.29	0.7	0.21	0.20	0.50	1.3	0.5	0.6
CD (P=0.05)	3.80	2.2	0.62	0.59	1.60	4.1	1.5	1.7

Nutrient uptake

The uptake of N, P, K and Zn by grain and straw increased significantly with increasing phosphorus and zinc level (Table-3). Application of phosphorus beyond 60 kg ha^{-1} increased the uptake of N and K by grain and straw up to 120 kg ha^{-1}. However, the differences between 80 and 100 kg P_2O_5 ha^{-1} and 100 and 120 kg P_2O_5 ha^{-1} were found not significant. The maximum uptake of N (61.4 and 20.5 kg ha^{-1}) and K (15.4 and 75.3 kg ha^{-1}) by grain and straw was recorded with 120 kg P_2O_5ha^{-1} followed by 100, 80 and 60 kg P_2O_5ha^{-1}. Applications of phosphorus from 60 kg to 120 kg P_2O_5 increased significantly the uptake of phosphorus by grain and straw. The maximum values of phosphorus uptake (13.4 and 9.1 kg ha^{-1}) by grain and straw, respectively were recorded with 120 kg P_2O_5 ha^{-1} followed by 100 , 80 and 60 kg P_2O_5 ha $^{-1}$. Significant response of phosphorus application on uptake of zinc was recorded only up to 80 kg ha $^{-1}$. The maximum uptake of zinc (99.2 and 98.4 gha $^{-1}$) through grain and straw, respectively was recorded with 120 kg P_2O_5ha $^{-1}$ followed by 100kg, 80kg and 60 kg P_2O_5ha $^{-1}$. Improvement in uptake of N, P, K and Zn by grain and straw due to application of phosphorus was mainly attributed the fact that added phosphorus increased N, P, K and Zn content in grain and straw by providing balanced nutritional environment inside the plant and high photosynthesis efficiency which favored the growth and crop yield. The increase uptake of nutrients with and P –fertilization was also reported by Sharma *et al.* (2012) and Septa and Rai (2013).

Application of zinc sulphate from 0 to 50 kg ha^{-1} increased significantly the uptake of N, K and Zn through grain and straw over without zinc application. However, difference between 10 and 5 kg Zn ha $^{-1}$ was found non- significant. The maximum uptake of N (60.3 and 20.1 kg ha^{-1}), K (15.1 and 73.9 kg ha^{-1}) and Zn (94.5 and 94.7 g ha^{-1}) through grain and straw, respectively was recorded with 10 kg Zn ha $^{-1}$ followed by 5 kg Zn ha^{-1}. The uptake of phosphorus through grain and straw was significantly higher with 5 kg Zn ha^{-1} as compared to without zinc application. The higher nutrient uptake with 5 or 10 kg Zn ha^{-1} over without Zn was mainly due to improved content of N, P, K and Zn coupled with higher grain and straw yield resulted higher uptake of nutrient. Maurya *et al.* (2015) also reported higher uptake of N, P, K and Zn in wheat due to zinc application.

Table 4: Economics of wheat as affected by phosphorus and zinc

Treatments	Cost of cultivation (Rs.ha^{-1})	Gross return (Rs. ha^{-1})	Net return (Rs. ha^{-1})	B:C ratio
Phosphorus (kg ha $^{-1}$)				
60	25456	56401	30945	1.22
80	26326	62026	35700	1.36
100	27195	64313	37118	1.36
120	28064	65439	37375	1.33
Zinc (kg ha^{-1})				
0	24710	58004	33294	1.34
5	26760	63260	36500	1.36
10	28810	64619	35809	1.24

Economics

The gross and net return was increased with increasing supply of phosphorus from 60 to 120 kg ha^{-1} but benefit: cost ratio was increased up to 80kg P_2O_5 ha^{-1}. This improvement in benefit: cost ratio with 80 kg P_2O_5 ha^{-1} as compared to 100 or 120 kg P_2O_5 ha^{-1} was mainly due to the fact that increase in yield with above levels was less than the additional cost incurred as compared to 80 kg P_2O_5 ha^{-1} which resulted in lower down the BCR beyond 80 kg P_2O_5 ha^{-1}. The maximum gross return (`.65439 ha$^{-1}$) and net returned (`.37375 ha^{-1}) was recorded with application of 120 kg P_2O_5 ha^{-1} followed by100, 80 and 60 kg P_2O_5 ha^{-1}. Application of either 80 or 100 kg P_2O_5 ha^{-1} recorded similar benefit: cost ratio (1.36). Application of zinc from 0 to 10 kg ha^{-1} increased the gross and net return while, benefit: cost ratio was increased up to 5 kg Zn ha^{-1}. The maximum gross return (`.64619 ha$^{-1}$) was recorded with 10 kg Zn ha$^{-1}$but net return (`.36500 ha^{-1}) and benefit: cost ratio (1.36) was highest with 5 kg Zn ha^{-1}. This was due to increase in grain yield beyond 5 kg Zn ha^{-1} was less as compared to cost incurred with this level of zinc resulted in lower BCR at 10 kg Zn ha^{-1} . Similar results were reported by Chaudhary *et al.* (2014).

It can be concluded from the above results that wheat crop should be fertilized with 80 kg P_2O_5 ha^{-1} along with 5 kg Zn ha^{-1} to obtain higher yields and maximum profit in eastern U.P. condition.

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