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Effect of phosphorus and zinc application on the growth and yield of wheat (*Triticum aestivum*) in alluvial soil

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Abstract

Phosphorus and zinc are essential plant nutrients that play an important role in crop growth, quality and yield. A field experiment was conducted at R. B. S. College Research farm Bichpuri, Agra (U.P.) during Rabi season of 2019-2020 to study the response of wheat to phosphorus (0,30,60 and 90 kg ha^{-1}) and zinc (0,2.5,5.0 and 7.5 kg ha^{-1}) on growth and yield attributes and yields of wheat. The experiment was laid out in randomized block design with three replications. Results revealed that application of phosphorus improved the growth, yield attributes and yields of wheat. The per cent increase in grain yield due to 30, 60 and 90 kg P_2O_5 ha^{-1} was to the tune of 8.1, 17.6 and 21.5 over control, respectively. Significant response of zinc was recorded up to 5 kg Zn ha^{-1} on growth, yield attributes and yield as compared to without zinc. The maximum values of growth, yield attributes and yields were recorded with 5.0 kg zinc ha^{-1}. The percent increase in grain yield due to 5 kg Zn ha^{-1} was recorded to be 3.77, 5.81 and 11.46 over 7.5, 2.5 kg Zn ha^{-1} and without zinc, respectively.

Keywords: Phosphorus, zinc, growth, yield, wheat

Introduction

Wheat (*Triticum aestivum* L.) is considered as the second most significant cereal crop globally and nationally. In India it is the second most important crop after rice and ranks as second largest wheat producing nation at global level contributing approximately 13.88 per cent to the world's wheat production from 14.35 per cent of global area. Wheat contributes about 35 per cent to total food grain basket of our country from about 31.36 million hectares with a production of 107.25 million tonnes and productivity of 3.42 tonnes ha^{-1} **(Statista 2021).** The major area under wheat falls in the Indo-Gangetic Plains (IGP) which accounts for roughly 20 million hectares covering the states of Punjab, Haryana, Uttar Pradesh, Bihar and West Bengal. The states of Punjab and Haryana provide maximum contribution to the wheat buffer stock, an essential component of food security in our country. Among food grains wheat is the richest source of protein and it stands at second place after pulses. In general wheat contains carbohydrate (70%), protein (12%), lipid (2%), vitamins & minerals (2% each) and crude fibre (2%).

Phosphorus and zinc are essential nutrients for higher productivity of crops. Phosphorus, one of essential macronutrients, is a structural component of cell membrane, chloroplasts, mitochondria and constituent of sugar phosphates. Phosphorus plays an important role in energy transformation and metabolic process in plants. The most essential function of P in plants is in storage and transfer. Phosphorus is also an important structural component of nucleic acids, coenzymes, nucleotides, phosphoproteins, phospholipids and sugar phosphates. A good supply of P is associated with increased root growth. Ample P nutrition reduces the time required for grain ripening. It is known to be

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associated with nucleus formation, cell division and nitrogen fixation, fat and albumen formation of the heredity. Zinc is essential for promoting certain metabolic reactions. It is necessary for the production of chlorophyll and carbohydrates. Zinc is directly or indirectly required by several enzyme systems, auxin and protein synthesis, seed production and rate of maturity. Zinc is believed to promote RNA synthesis, which, in turn, is needed for protein production. Zinc disposal and uptake by the plant is adversely affected by increasing the phosphorus fertilizer (Salimpour, *et al.* 2010). 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 (Stukenholts, *et al.* 1996). This antagonism is known to cause yield reduction in many crops. The yield reduction is mainly caused by either P or Zn deficiencies.

Materials and Methods

The field experiment was conducted at the Agriculture Research farm of R.B.S. College Bichpuri, Agra (located in semi arid or gray steppe arid region of South-Western Uttar Pradesh. the intersect of 27.2 0 N attitude and 77.9 0E longitude), during Rabi season of 2019-2020 on sandy loam soil. The soil of the experimental field was sandy loam in texture, having pH 8.1, organic carbon 3.7 g kg^{-1} and available N, P, K, and Zn 183.0, 28.0, 290.0 kg ha^{-1}, and 0.58 mg kg^{-1}, respectively. The experiment was laid out in randomized block design with three replications. The treatments included four levels of phosphorus (0, 30, 60 and 90 kg P_2O_5 ha^{-1}) and four levels of zinc (0, 2.5, 5.0 and 7.5 kg Zn ha^{-1}). Recommended doses of nitrogen (120 kg N ha^{-1}) and potash (40 kg K_2O ha^{-1}) along with phosphorus as per treatment were applied through urea, MOP and SSP at the time of sowing as basal dressing. Zinc was applied as per treatment through zinc oxide at the same time. The wheat variety (Raj-3765) which is well suited for Agra region was sown in furrows 5 cm deep at the distance of 20 cm. with seed rate of 100 kg ha^{-1}. The yield and yield attributes were recorded at harvest and analyzed statistically. The mean of each parameter was compared statistically using analysis of variance. For various parameters the critical difference (CD) among the treatments was worked out.

Results and Discussion

Growth Studies

Plant height, tillers/plant and dry matter yield/ plant of wheat crop affected significantly with every increase in the level of phosphorus up to 60 kg P_2O_5 ha^{-1} when the level of phosphorus increased from 60 to 90 kg P_2O_5 ha^{-1} the increase was nominal and could not reach the level of significance (Table 1). The maximum plant height (92.16 cm) tillers/plant (7.33) and dry matter yield/plant (17.39 g) was recorded with 90 kg P_2O_5 ha^{-1}. The higher values of growth characters with application of phosphorus were 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 processes which contributed to

Table 1: Response of phosphorus and zinc application on plant height, tiller $plant^{-1}$, dry matter yield, ear length and grains ear^{-1}

Treatments	Plant height (cm)	Tillers/ plant	Dry matter yield /plant (g)	Ear length (cm)	No. Grains/ ear	Test weight (g)
Phosphorus						
0	79.02	6.15	12.32	7.31	43.56	36.30
30	82.92	6.6	13.78	7.68	45.00	38.10
60	89.47	7.15	16.28	8.20	46.21	40.60
90	91.16	7.33	17.39	8.41	47.60	42.05
SEm±	1.27	0.1	0.51	0.11	0.26	0.63
CD at 5%	3.70	0.29	1.47	0.31	0.76	1.83
Zinc						
0	82.44	6.64	13.7	7.61	44.90	44.92
2.5	84.52	6.89	15.08	7.84	45.72	39.27
5.0	89.42	7.16	17.0	8.34	46.81	41.41
7.5	87.18	6.3	14.79	7.82	44.93	38.92
SEm±	1.27	0.1	0.51	0.11	0.26	0.63
CD at 5%	3.7	0.29	1.47	0.31	0.76	1.83

Table 3: Grain and straw yield (q ha^{-1}) of wheat as affected by different levels of Phosphorus and Zinc application

Treatments	Grain yield (qha^{-1})	% response	Straw yield (qha^{-1})	% response
Phosphorus levels (kg P_2O_5 ha^{-1})				
0	42.64	-	50.55	-
30	46.09	8.1	54.47	7.8
60	50.13	17.6	59.16	17.0
90	51.83	21.5	61.06	20.8
SEm±	0.82		1.3	
CD at 5%	2.38		3.79	
Zinc levels (kg ha^{-1})				
0	44.92	-	52.85	
2.5	47.32	5.3	56.07	6.1
5.0	50.07	11.5	59.35	12.3
7.5	48.25	7.4	57.15	8.1
SEm±	0.82		1.3	
CD at 5%	2.38		3.79	

rapid cell division, cell elongation and thus resulted in higher growth of the plant. These results are close conformity with the findings of Sepat and Rai (2013) and Mishra *et al.* (2017).

Application of 5 kg Zn ha^{-1} being at par with 7.5 kg Zn ha^{-1} but recoded significantly taller plant, higher tillers and dry matter yield/plant as compared to 2.5 kg Zn ha^{-1} and without zinc application. 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. There was a reduction in plant height, number of tillers and dry matter yield/plant at 7.5 kg Zn ha^{-1} over 5 kg Zn ha^{-1}. This reduction may be attributed to adverse effect of higher levels of zinc on these growth parameters. Similar results were obtained by Mishra *et al.* (2017).

Yield attributes

Yield attributing characters like ear length (cm), grains ear^{-1} and test weight were affected significantly due to application of phosphorus and zinc (Table 2). Application of phosphorus up to 90 kg ha^{-1} increased significantly all the yield contributing characters over all lower levels and control. However, difference between 60 and 90 kg P_2O_5 ha^{-1} was 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 improve in yield attributes. Similar finding was reported by Septa and Rai (2012). The most beneficial effect was confined to P3 @ 90 kg ha^{-1} level of phosphorus and M3 @ 3 kg ha^{-1} level of molybdenum in respect to plant height of broad bean number of pods $plant^{-1}$, number of grains pod-1 and yield of broad bean (Munna et al.2019).

The significantly higher values of yield attributers viz. ear length (8.34 cm), grains/ear (46.81) and test weight (41.41 g) were recorded with 5 kg Zn ha^{-1} over all other levels of zinc application. However, difference between 5 and 7.5 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. These findings endorse the results of Sahay *et.al.* (2009) and Pandey and Chauhan (2016).

Yields

Application of phosphorus up to 60 kg ha^{-1} significantly improved the grain and straw yield over 30 kg ha^{-1} and control (Table 3). However, when the level of phosphorus increased from 60 to 90 kg P_2O_5 ha^{-1}, the increase in grain and straw yield was marginal and could not reached the level of significance. The mean yield of wheat grain increased by 8.1, 17.6 and

21.5 per cent over control due to 30, 60 and 90 kg P_2O_5 ha^{-1}, respectively. The corresponding increase in straw yield was 7.8, 17.0 and 20.8 per cent. The higher yield 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. Responses to P application in wheat crop have also been reported by Sepat and Rai (2013), Singh *et al*. (2017) and Mishra *et al.* (2017). The soil in this study was deficient in available phosphorus therefore significant response of wheat to applied phosphorus is quite understandable. The magnitude of response to wheat yield was more in case of phosphorus compared to zinc.

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