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Effect of phosphorus and copper on yield and uptake of nutrients in wheat (*Triticum aestivum*)

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ABSTRACT

A field experiment was conducted at research farm, R.B S. College, Bichpuri (Agra) during rabi seasons of 2013-15 to study the response of wheat (Triticum aestivum (L.) emend Fiori & Paol) to phosphorus and copper in alluvial soil. Treatments consisted of four levels each of phosphorus (0, 30, 60 and 90 kg P_2O_5 ha^{-1}) and copper (0, 1, 2 and 4 kg ha^{-1}) were evaluated in randomized block design with three replications. Results revealed that the application of 90 kg P_2O_5 ha^{-1} improved the grain and straw yields of wheat over control. The per cent mean increases in grain and straw yields were 25.7 and 23.7 over control, respectively with 90 kg P_2O_5 ha^{-1}. Significant response of copper was recorded up to 2 kg Cu ha^{i1} on yield of wheat as compared to without copper. The mean increases in grain and straw yield due to 2 kg Cu $ha^{-1}$was recorded to be 7.8 and 7.0 per cent over control, respectively. The content of protein in wheat grain and straw increased significantly with P up to 90 kg P_2O_5 ha^{-1} and tended to decrease with copper up to 4.kg Cu ha^{-1}. Protein yield of wheat grain increased significantly with P and copper application over control. But the higher level of Cu (4 kg ha^{-2}) decreased protein yield over 2 kg Cu ha^{-1}. The uptake of nutrients by wheat grain and straw increased significantly with increasing levels of P up to 90 kg P_2O_5 ha^{-1} over control. Copper application tended to increase the uptake of copper by wheat crop up to 4 kg Cu ha^{-1}. Copper application did not affect the uptake of N, P and K by wheat crop significantly over control and decreased S uptake by the crop.

Keywords: Phosphorus, copper, quality, nutrients uptake, yield, wheat.

INTRODUCTION

The advent of high yielding wheat varieties, frequent use of high levels of Fertilizers and irrigation has resulted in to increased cropping intensity and crop productivity in India. In the areas of intensive cropping, application of micronutrients is almost ignored that leads to imbalance in the nutrient management. Inspite of heavy inputs the crop yields are declining because of limitation of one or more micronutrients. Among the micronutrients, copper has been noted to be a limiting element (Kumar and Singh 2013). Copper is a constituent of cytochrome oxidase besides being a component of many enzymes such as ascorbic acid oxidase, phenolase, laccase etc. It also promotes the formation of vitamin A in plants. Phosphorus is an important nutrient needed for normal growth and development of the plants (Singh 2017). It plays an important role in energy transformation and metabolic processes in plants. It is known to be associated with nucleus formation, cell division, nitrogen fixation and transfer of heredity. Application of phosphorus usually decreased the availability of copper in soils and thereby decreased the uptake by the plants showing the possibility of interaction between P and Cu in plants. Such information may be of interest as the soils are becoming deficient in Cu as a result of intensive cropping, continuous application of phosphorus fertilizers and thus declining the productivity of the crops. Hence, a field experiment was conducted to study the relationship between P and Cu in wheat crop in a sandy loam soil.

MATERIALS AND METHODS

A field experiment was laid out during rabi seasons of 2013-14 and 2014-15 at Raja Balwant Singh College, Research farm Bichpuri (Agra) with wheat (Triticum aestivum) variety, PBW 343.. The soil was sandy loam in texture having pH 8.2, EC 0.12 dSm^{-1}, organic carbon 2.8 g kg^{-1}, available nitrogen 169 kg ha^{-1}, available phosphorus 9.6 kg ha^{-1} and DTPA extractable-Cu 0.25 mg kg^{-1}. Sixteen treatment combinations consisted of four levels each of P (0, 30, 60, and 90 kg ha^{-1}) as triple superphosphate and Cu (0, 1, 2 and 4 kg ha^{-1}) as $CuSO_4.2H_2O$ were replicated three times in

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randomised block design. Recommended doses of 120 kg N and 60 kg K_2O ha^{-1} were applied through urea and muriate of potash, respectively. Half dose of nitrogen and entire dose of potassium was applied at the time of sowing and remaining N fertilizer was applied in the equal splits at tillering and flowering stage wheat (PBW 343) was sown in the second week of November in both the years at 25 cm apart row using 100 kg seed ha^{-1}. At maturity, grain and straw yields were recorded. Grain and straw samples were washed properly with distilled water followed by 0.1 HCl and then in glass distilled water. The samples were dried in an oven at 70^0 C, ground and digested in di-acid mixture and copper was determined on an atomic absorption spectrophotometer. Phosphorus and sulphur content in the extract were determined by vanadomolybdate yellow colour method (Jackson 1973) and turbidimetric method (Chesnin ana Yien 1951), respectively. Nitrogen in the grain and straw was determined by modified kjeldahl method. The uptake of nutrients was calculated by multiplication of concentrations of nutrients with the respective yield data (gram and straw). The data so obtained on various parameters were analysed as per standard statistical procedures.

RESULTS AND DISCUSSION

The results indicate that the increase in the level of P from 0 to 90 kg ha^{-1} resulted in significant increase in the grain yield of wheat from 38.01 to 48.12 q ha^{-1} in 2013-14 and from 37.22 to 46.48 q ha^{-1} in 2014-15 (Table 1). The corresponding increases in straw yield were from 56.74 to 64.62 q ha^{-1} and 53.97 to 67.35 q ha^{-1}. The per cent mean increases in grain and straw yield due to 90 kg P_2O_5 ha^{-1} were recorded to be 25.7 and 23.7 % over control, respectively. The higher yield with phosphorus was mainly due to adequate supply of P to plants which in turn contributed to better growth and yield attributes, thus led to higher yield of wheat. Similar findings were reported by Sharma *et al.* (2012) and Mishra *et al.* (2017). The grain and straw yield of wheat increased significantly with the addition of copper up to 2 kg ha^{-1}. The grain yield increased from 42.34 to 45.43 q ha^{-1} in first year and from 40.81 to 44.20 q ha^{-1} in second year with an increase in the level of copper (Table 1) from 0 to 2 kg ha^{-1}. The corresponding increases in straw yield were from 61.38 to 65.40 and 59.16 to 63.64 q ha^{-1}. The results indicated a beneficial effect of lower level of copper on wheat grain and straw production. Sharma *et al.*(2012) and Kumar and Singh (2013) also reported an increase in yield of wheat crop with copper application.

Quality

The protein contend in wheat grain and straw increased significantly with phosphorus application and maximum values of protein content in grain (12.00%) and straw (3.57%) were recorded with 90 kg P_2O_5 ha^{-1}. This increase in protein content is attributed to more fixation of nitrogen in soil. Similar results were reported by Dewal and Pareek (2004) and Mishra *et al.* (2017). Protein yield in wheat grain also increased significantly with phosphorus application which ranged from 443.8 kg ha^{-1} at control to 576.6 kg ha^{-1} with 90 kg P_2O_5 ha^{-1}. This increase in protein yield may be attributed to increased grain yield and protein content in grain with phosphorus application (Mishra *et al.* 2017). There was a significant reduction in protein content in wheat grain and straw and minimum values of protein content in grain (3.33%) and straw (11.82%) were recorded with 4 kg Cu ha^{-1}. The results indicated an adverse effect of copper levels on protein content in wheat. On the other hand, protein yield of grain increased significantly up to 2 kg Cu ha^{-1} This increase in protein yield may be attributed to increased grain production with lower levels (1 and 2 kg Cu ha^{-1}) of copper over control (Baril *et al.* 2001).

Table 1: Effect of copper and phosphorus levels on grain and straw yield and quality of wheat (mean of 2 years)

Treatments	Grain yield (q ha^{-1})		Straw yield (q ha^{-1})		Protein content (%)		Protein yield (kg ha^{-1})
	2013-14	2014-15	2013-14	2014-15	Grain	Straw	
Phosphorus (kg ha^{-1})							
0	38.01	37.22	56.74	53.97	11.80	3.33	443.8
30	41.62	41.13	60.35	59.62	11.88	3.40	491.5
60	44.79	43.92	64.65	63.46	11.96	3.48	530.4
90	48.12	46.48	69.62	67.35	12.00	3.57	576.6
SEm±	0.46	0.54	0.58	0.78	0.006	0.005	4.05
CD (P=0.05)	1.26	1.48	1.60	2.14	0.016	0.014	11.09
Copper (kg ha^{-1})							
0	42.34	40.81	61.38	59.16	12.00	3.51	498.8
1	43.23	42.46	62.68	61.32	11.95	3.51	510.6
2	45.43	44.20	65.40	63.64	11.88	3.43	532.3
4	42.46	41.23	62.03	60.26	11.82	3.33	494.5
SEm±	0.46	0.54	0.58	0.78	0.006	0.005	4.05
CD (P=0.05)	1.26	1.48	1.60	2.14	0.016	0.014	11.04

Uptake of nutrients

The data on nitrogen uptake (Table 2) revealed that phosphorus application enhanced the nitrogen uptake by wheat crop over control. Nitrogen uptake by grain increased from 76.6 kg ha^{-1} at control to 96.6 kg ha^{-1} with 90 kg P ha^{-1}. Nitrogen uptake by straw was found to increase due to the nitrogen application from 30.2 to 39.2 kg ha^{-1}.This increases in N uptake with phosphorus addition seems to be associated with increased nitrogen availability with a concomitant increased N uptake by the crop Singh *et al.* (2010) also reported similar results. The mean nitrogen uptake by wheat grain and straw increased at lower level of copper over control. Thereafter, a reduction was noted at 4 kg Cu ha^{-1} which might be due to depressive effect of copper on yield and nitrogen content in wheat crop. The mean phosphorus removal by the wheat grain and

Table 2: Effect of phosphorus and copper on the uptake of N, P, S (kg ha^{-1}) and Cu (g ha^{-1}) by wheat (mean of two years)

Treatments	Nitrogen		Phosphorus		Sulphur		Copper	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
Phosphorus (kg ha^{-1})								
0	76.6	30.2	7.2	5.0	6.3	4.4	36.3	33.6
30	84.0	34.0	8.7	6.2	6.6	4.9	38.6	34.7
60	89.8	36.6	10.2	7.7	7.1	5.5	39.7	33.8
90	96.6	39.2	12.0	9.1	7.6	5.3	41.9	34.1
CD(P=0.05)	3.18	1.59	1.88	1.37	0.32	0.31	NS	NS
Copper (kg ha^{-1})								
0	85.4	35.3	9.9	7.6	7.5	5.7	30.7	24.2
1	87.1	35.4	9.9	7.4	7.1	5.6	36.3	32.0
2	88.4	35.6	9.3	6.9	6.8	4.7	40.3	35.4
4	86.1	33.8	8.9	6.1	6.1	4.0	49.3	44.4
CD(P=0.05)	NS	NS	NS	NS	0.32	0.31	6.05	1.69

straw increased from 7.2 to 12.0 kg ha^{-1} and from 5.0 to 9.1 kg ha^{-1} respectively, as the dose of phosphorus increased from 0 to 90 kg ha^{-1} (Table 2). This increase can invariably be attributed to increased grain and straw yield and higher nutrient demand for plant growth. Similar

results were reported by Singh *et al.* (2010). Application of lower level of copper increased phosphorus uptake and a reduction was noted at higher levels of copper due to lower grain and straw yield. However, the effect of copper on P uptake by wheat crop was statistically non-significant The improvement in phosphorus uptake with lower level of Cu was mainly due to higher production of grain and straw.

Sulphur uptake by wheat grain and straw increased from 6.3 and 4.4 kg ha^{-1} at control to 7.6 and 5.3 kg ha^{-1} with 90 kg ha^{-1} respectively. This increase in S uptake by wheat crop may be attributed to increased yields with P application. The lower levels of copper had a synergistic effect on S uptake by the wheat crop. The higher levels of copper had an adverse effect on sulphur uptake as compared to lower levels, which may be due to decline in yields of grain and straw and sulphur content in crop. The uptake of copper by wheat grain and straw increased with phosphorus application over control due to increase in grain and straw yields. Also, application of copper significantly increased the average copper uptake by wheat grain and straw from 30.7 to 49.30 and 24.2 to 44.4 g ha^{-1}.The increase in copper uptake with its addition may be ascribed to greater grain and straw production. Similar results were reported by Kumar and Singh (2013).

It can be conducted that there was a significant increase in yields of wheat due to application of both P and Cu. The uptake of nutrients by the crop was also influenced by their application. These results indicate that in sandy soil of Agra Cu could be yield limiting nutrient in near future.

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