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RESEARCH PAPER

Yield, profitability, nutrient uptake of wheat and residual soil fertility as influenced by micronutrient nutrition

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Abstract **:** A field experiment was conducted during *Rabi* season of 2002-03 and 2003-04 at Crop Research Centre of G.B. Pant University of Agriculture and Technology, Pantnagar to study the effect of micronutrient cations on growth, yield, nutrient uptake of wheat and residual soil fertility. Application of $ZnSO_4$ @ either 10 kg or 5 kg/ha along with recommended NPK dose of 150 kg N+60 kg P_2O_5+40 kg K_2O/ha showed the best expression reflected through growth and yield attributes as well as yield. The highest grain yield of 46.8 q/ha was obtained by application of $ZnSO_4$ @ 10 kg /ha along with recommended NPK doses which was about 10.1 per cent more than the grain yield obtained with NPK alone. However, Application of 5 kg $ZnSO_4$/ha along with recommended NPK dose produced 46.2 q/ha of grain yield, statistically at par with this treatment. The uptake of nutrients *viz.,* Zn, Fe, Mn and Cu by wheat crop also showed superiority in the treatments having application of respective nutrients. Application of $ZnSO_4$ @ 10 kg/ha along with NPK also proved economically beneficial as it recorded highest net returns (Rs. 29,065/ha) and B:C ratio (1.61) statistically at par with that of $ZnSO_4$ @ 5 kg/ha+ NPK. Micronutrients in soil recorded maximum in their respective application along with inorganics. Antagonistic effect of Fe and P and synergistic effect of Cu on Zn availability in soil were remarked. Synergistic effect of Fe on improvement of Mn was noted in soil. Negative correlation between Fe and Cu adversely affected the Cu concentration in soil.

Key Words **:** Micronutrients, Soil fertility, Uptake, Wheat, Yield

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INTRODUCTION

In India, wheat is considered as one of the most important cereals next to rice. Crop needs micronutrients for optimum production apart from macronutrient fertilization. Wheat crop removes 34-50 g Cu, 232-1219 g Fe, 140-330 g Mn and 66-209 g Zn for producing 20 q grain/ha (Rashid, 1998). Due to imbalanced and intensive use of NPK fertilizers in rice-wheat cropping system has depleted the soil available micronutrient reserve, particularly available Zn, playing a crucial role in various enzymatic and physiological activities of wheat and helps in formation of chlorophyll and auxins and its deficiency, often leads to decline in crop productivity. The efficiency of micronutrients application in increasing wheat yield up to more than 30 per cent has been well documented (Saleque *et al.,* 2006). Hence, management of micronutrients is necessary for increasing the growth and yield characteristics of wheat. An integrated plant nutrient supply system is recommended for sustainable crop production and maintenance of soil health (Jain and Daharma, 2006). The present investigation was, therefore, undertaken to find out the effect of micronutrient cations on growth, yield, profitability, nutrient uptake by wheat and residual soil fertility status.

MATERIALS AND METHODS

A field experiment was conducted during *Rabi* season of 2002-03 and 2003-04 at Crop Research Centre, G.B. Pant University of Agriculture and Technology, Pantnagar. The soil of the experimental plot was silty clay loam having organic carbon (0.83%), available nitrogen (189.7 kg/ha), available P_2O_5

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(29.1 kg/ha) and available K_2O (279.5 kg/ha), available Zn (0.54 ppm), available Fe (5.4 ppm), available Mn (3.6 ppm) and available Cu (2.1 ppm) with pH 7.2. Ten treatments comprising four micronutrients *viz.,* Cu, Fe, Mn and Zn each with two doses (5 and 10 kg/ha) in addition to recommended dose of NPK were tested along with control and NPK alone in Randomized Block Design replicating thrice. The test wheat variety 'UP 2338', was sown on 4th and 6th December of 2002 and 2003, respectively. The row spacing of wheat was 23 cm having 100 kg/ha of seed rate. The crop was harvested on 28th and 30th April during 2003 and 2004, respectively. The sources of N, P, K, Zn, Fe, Cu and Mn applied were urea, single super phosphate (SSP), muriate of potash, zinc sulphate, iron sulphate, copper sulphate and manganese sulphate. Half of N and full dose of P_2O_5 and K_2O were applied as basal and remaining half N was top dressed after first irrigation *i.e.* at CRI stage of crop. All the micronutrients were applied as basal as per treatment. Crop was irrigated four times in addition to pre-sowing irrigation. In interculturing operations, one hoeing followed by hand weeding was done 30 days after sowing. Plant samples of grain and straw at harvest and soil samples at initial and after harvest of crop were analyzed for Cu, Fe, Mn and Zn content on Atomic Absorption Spectrophotometer (Shimadzu Model AA-670). The uptake of nutrients *viz.,* N, P, K, Zn, Fe, Mn and Cu were computed by standard procedures. The data obtained during two years were pooled and subjected to statistical analysis.

RESULTS AND DISCUSSION

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

Growth, yield attributes and yield of wheat:

Application of NPK (150:60:40 kg/ha) significantly increased plant height over control. Application of $ZnSO_4$ either 10 or 5 kg/ha along with recommended NPK recorded significantly higher plant height than other applications. Highest plant height (99.8 cm) was, however, registered by the application of $ZnSO_4$ @ 10 kg/ha which was 12.1 per cent taller than the plant height attained by recommended NPK dose alone. The highest number of effective tillers (91.0), spike length (11.4 cm), spikelets/spike (17.4) and grains/spike (45.4) were recorded with the application of NPK+ 10 kg $ZnSO_4$/ha. However, application of NPK+ 5 kg $ZnSO_4$/ha also exhibited statistical parity with this treatment. All micronutrients application either 5 or 10 kg/ha showed no any significant difference in influencing the growth and yield attributing characters (Table 1). Similar results were also reported by (Musandeand Palaskar, 1997). Since, Zn plays a pivotal role in regulating the auxin concentration and nitrogen metabolism in plant, might have improved these growth and yield attributes.

Grain yield ranging from 43.0 to 46.8 q/ha (avg. 44.4 q/ha) and that of straw ranging from 59.6 to 64.5 q/ha (avg. 61.6 q/ha) were also significantly increased with increasing levels of micronutrients from 5 to 10 kg/ha along with NPK over control and NPK alone. Recommended dose of NPK produced grain yield (42.5 q/ha) against control (21.5 q/ha), which was 71 per cent more over the control. Among micronutrients application along with NPK, application of $ZnSO_4$ @ either 10 or 5 kg/ha gave significantly highest grain and straw yields of wheat over rest of the combinations. A close perusal of (Table 1) also indicated that both the doses of micronutrients were equally effective. Data recorded about 10.1 per cent, 4.4 per cent, 3.5 per cent and 1.8 per cent higher grain yield of wheat with the application of Zn, Fe, Mn and Cu @ 10 kg/ha each

Table 1 : Effect of different treatments on growth, yield and yield attributes of wheat (pooled over 2 years)

Treatments	Plant height (cm)	Effective tillers/ m	Spike length (cm)	Grains/ spike	Spikelets/ spike	Test weight (g)	Grain yield (q/ha)	Straw yield (q/ha)
T_1 - Control	82.5	52	9.4	33.0	14.2	34.5	21.5	37.6
T_2 - NPK	89.0	78	10.7	42.8	15.4	36.1	42.5	58.6
T_3 - NPK+5 kg $CuSO_4$/ha	90.1	79	10.4	43.6	15.6	36.3	43.0	59.6
T_4 - NPK+10 kg $CuSO_4$/ha	91.3	84	10.6	43.7	15.8	36.8	43.3	60.0
T_5 - NPK+5 kg $FeSO_4$/ha	96.2	86	10.5	43.4	16.0	37.4	44.2	61.4
T_6 - NPK+10 kg $FeSO_4$/ha	96.6	88	10.6	43.9	16.4	37.6	44.4	62.0
T_7 - NPK+5 kg $MnSO_4$/ha	95.8	81	10.7	43.1	16.3	37.0	43.4	60.8
T_8 - NPK+10 kg $MnSO_4$/ha	94.7	83	10.7	43.8	16.7	37.1	44.0	61.5
T_9 - NPK+5 kg $ZnSO_4$/ha	97.7	90	11.2	45.0	17.0	38.8	46.2	63.4
T_{10}- NPK+10 kg $ZnSO_4$/ha	99.8	91	11.4	45.4	17.4	38.9	46.8	64.5
S.E.±	2.8	1.38	0.12	0.9	0.3	2.3	0.64	0.8
C.D. (P=0.05)	8.1	4.1	0.36	2.4	0.8	NS	1.96	2.3

NS=Non-significant

coupled with recommended NPK over NPK alone. The beneficial effects of $ZnSO_4$+ NPK application in increasing wheat yield may be attributed due to favourable effect of zinc in biosynthesis of indole butyric acid and initiation of primordial. Zinc deficiency affects protein synthesis due to reduction in RNA and deformation and reduction of ribosomes resulted in stunted growth and little leaf. Small anthers and pollen grains of wheat have been reported in Zn deficient soils. Zn also exerts an effect on carbohydrate metabolism through its effects on photosynthesis and sugar transformations and its deficiency causes reduction in net photosynthesis by 50-70 per cent.Similar findings were also in confirmatory with those of (Pervaiz *et al.*, 2003). Minimum grain and straw yields were recorded in control where no fertilizer was applied. Application of micronutrients (Cu, Fe and Mn) along with NPK did not show significant effect on grain and straw yields over NPK alone.

These data support our results as the soil under study was heavy, alkaline calcareous, poorly fertile and Zn deficient. Moreover, wheat is heavily fertilized with P fertilizers and farmers seldom apply organic manures in Uttarakhand State. All these factors could result in response of wheat to Zn. Thus, increased grain yield and improved uptake may be attributed to Zn content which is in line with the research findings highlighting the role of Zn in crop nutrition.

Nutrient uptake by wheat:

The significantly highest total N uptake (140.7 kg/ha) by crop was recorded with the application of 10 kg $ZnSO_4$ along with NPK except NPK+ 5 kg $ZnSO_4$ (136.5 kg/ha) and 10 kg NPK+ $FeSO_4$/ha (131.1 kg/ha). Higher N uptake by crop (Fig. 1) in these treatments might be due to more grain and straw yields obtained by their application. However, maximum P uptake (30 kg/ha) was calculated with the application of 10

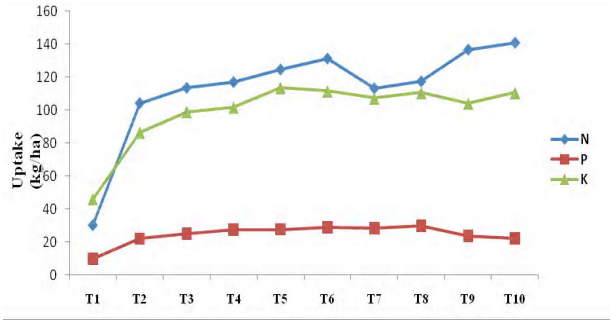

Fig. 1: Uptake of N, P and K as influenced by micronutrient nutrition in wheat

kg $MnSO_4$ along with NPK. Application of its lower (5 kg/ha) doses and higher (10 kg/ha) and lower doses of $FeSO_4$ as well as higher doses (10 kg/ha) of $CuSO_4$ were equally effective in increasing P uptake (Fig. 1), but were superior to NPK alone. It was also noticed that increase in levels of Zn decreased the P-uptake by crop, might be due to antagonistic effect of Zn with P. Similar results were also reported by (Sharma and Bapal, 2000). Contrary to this, the total K uptake (Fig. 1) was found maximum (113.5 kg/ha) with the application of lower doses (5 kg/ha) of $FeSO_4$ along with NPK. Although it's higher doses along with lower and higher doses of $MnSO_4$ and $ZnSO_4$ showed statistical parity. This may be due to synergistic interaction between Fe and K.

The uptake of micronutrients *viz.,* Zn, Fe, Mn and Cu by crop also showed their maximum removal in the treatments having application of respective micronutrients. Even their lower doses gave 61.2, 13.6, 66.5 and 45.0 per cent more uptakes of Zn, Fe, Mn and Cu than the uptake of these micronutrients obtained from recommended dose of NPK alone, respectively. Further increase in levels of Zn, Fe, Mn and Cu each at 10 kg/

Table 2 : Effect of different treatments on Zn, Fe, Mn and Cu uptake, profitability and residual soil fertility after harvest of wheat (pooled over 2 years)

Treatments	Uptake (g/ha)				Net return (Rs/ha)	B:C ratio	Residual soil nutrients (ppm)			
	Zn	Fe	Mn	Cu			Zn	Fe	Mn	Cu
T_1 Control	33.4	517.8	90.5	46.6	7,905	0.53	0.28	3.7	3.3	0.37
T_2 NPK	128.7	2071.0	239.5	158.0	25,140	1.42	0.42	5.6	4.1	0.58
T_3 NPK+5 kg $CuSO_4$/ha	140.7	2184.4	261.9	229.1	25,190	1.39	0.45	6.5	6.2	0.93
T_4 NPK+10 kg $CuSO_4$/ha	147.6	2239.8	280.0	253.6	24,990	1.34	0.53	7.7	4.7	0.99
T_5 NPK+5 kg $FeSO_4$/ha	145.5	2351.7	302.4	178.9	26,870	1.52	0.54	7.8	7.6	0.63
T_6 NPK+10 kg $FeSO_4$/ha	156.0	2400.4	328.2	183.9	27,070	1.53	0.62	9.3	9.3	0.67
T_7 NPK+5 kg $MnSO_4$/ha	156.8	2280.7	398.8	161.5	25,840	1.44	0.63	6.2	7.7	0.84
T_8 NPK+10 kg $MnSO_4$/ha	157.6	2290.6	420.8	178.2	26,075	1.42	0.66	6.9	11.3	0.90
T_9 NPK+5 kg $ZnSO_4$/ha	207.5	2094.8	300.3	171.2	28,620	1.60	0.64	5.7	6.2	0.72
T_{10}NPK+10 kg $ZnSO_4$/ha	225.0	2097.5	324.1	180.6	29,065	1.61	0.81	5.9	6.2	0.79
S.E.±	6.2	57.4	11.7	7.4			0.02	0.2	0.3	0.02
C.D. (P=0.05)	17.8	170.0	33.6	22.0			0.05	0.5	0.8	0.06

ha could not bring significant improvement in their nutrient uptake. Fertilizer application might have improved the availability of nutrients in the soil, which led to increased nutrient content in plant and ultimately their uptake (Table 2).

Residual soil fertility after harvest of wheat:

Maximum micronutrient concentrations in soil were recorded in their respective micronutrient application along with inorganics. There was decrease in availability of micronutrients in control over their initial values. Antagonistic effect of Fe and P and synergistic effect of Cu on Zn availability in soil were registered remarkably. Synergistic effect of Fe was noted on improvement of Mn content in soil. Negative correlation between Fe and Cu adversely affected the Cu concentration in soil (Table 2).

Economics:

Economic evaluation showed that application of $ZnSO_4$ @ 10 kg/ha along with NPK also proved economically beneficial as it recorded highest net returns (Rs. 29,065/ha) and B:C ratio (1.61) which was followed by $ZnSO_4$ @ 5 kg/ha along with NPK (Rs. 28,620/ha and 1.60) compared to net returns (Rs. 25,140 /ha) and B:C ratio (1.42) recorded under NPK application alone, indicating that micronutrients showed their economic viability over inorganics owing to higher yield potential. The net returns and B:C ratio in control treatment was marginally low because of relatively less yield (Table 2).

Conclusion may be drawn from results that use of 5 kg $ZnSO_4$/ha coupled with 150 kg N+60 kg P_2O_5+40 kg K_2O/ha enhanced wheat grain and straw yields and improved zinc nutrition of wheat, which responded to Zn. This leads to the sustainability of the crop production which is proved to be cost effective and feasible for adoption by farming communities.

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