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Effect of sulphur, manganese and zinc on yield, quality and uptake of nutrients by wheat (*Triticum aestivum*)

MANOJ PANDEY AND MANOJ KUMAR

Department of Agricultural Chemistry and Soil Science, Raja Balwant Singh College, Bichpuri, Agra (U.P.) - 283105

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ABSTRACT

A field experiment was conducted to study the effect of sulphur, manganese and zinc on yield, quality and uptake of nutrients in wheat (Triticum aestivum) at R.B.S. College research farm, Bichpuri (Agra) during rabi season of 2014-15 and 2015-16. The experiment was laid out in randomized block design with three replications and seven treatments. The results revealed that the tallest plants (93.0 cm), maximum length of ear (8.8 cm) and test weight (45.6 g) were recorded with 100% NPK + 20 kg S ha^{-1}. The highest grain (5.98 t ha^{-1}) and straw (8.05 t ha^{-1}) yields were recorded with 100% NPK + 20 kg S ha^{-1}. Application of 100% NPK + 5 kg Zn ha^{-1} and 100% NPK + 10kg Mn ha^{-1} also proved significantly superior over 100% NPK alone in respect of grain and straw yield. All the treatments proved superior to 100% NPK with respect to content and yield of protein. Among all the treatments, 100% NPK + 20 kg S ha^{-1} proved significantly superior in respect of protein yield and content. The uptake of nutrients by wheat grain and straw was significantly affected with all the treatments over 100% NPK. Phosphorus uptake of wheat grain and straw was not affected with zinc application. The maximum values of S, Mn and Zn uptake were recorded with their respective application. The lowest values of nutrients uptake by wheat grain and straw were recorded with 100% NPK alone.

Keywords: Sulphur, manganese, zinc quality, yield, wheat

INTRODUCTION

The practice of intensive cropping with high yielding varieties for boosting food production caused nutrient depletions in soil, consequently macro and micronutrients deficiencies are reported in soils. Wheat (*Triticum aestivum*), an important cereal crop grown in western Uttar Pradesh is known to remove nutrients exhaustively. To increase or to sustain the productivity of wheat, there is a need for application of secondary and micronutrients as the addition of these nutrients is not common with the introduction of high analysis fertilizers. The alluvial soils of western Uttar Pradesh are poor in organic matter and deficient in secondary (Singh, 2015) and micronutrients. Use of sulphur, Mn and Zn can increase the productivity of the crops. Sulphur plays an important role in the formation of sulphur containing amino acids which act as building blocks in the synthesis of proteins. It has a role to play in increasing chlorophyll formation and aiding photosynthesis. Sulphur also plays a role in the activation of enzymes, nucleic acids and forms a part of biotin and thiamine. Manganese is an integral component of the water splitting enzymes association with photosynthesis II. It is a constituent of superoxide dismutase. Manganese acts as an important cofactor for a number of key enzymes involved in lignin synthesis. This function of Mn is reported to play a key role in imparting resistance to diseases. Manganese plays a role in the synthesis of carotenoids chlorophyll, gibberllic acid, sterols and quinines. Zinc is essential for propoting certain metabolic reactions. It is necessary for the production of chlorophyll and carbohydrates. Zinc is directly or indirectly required by several enzymes, auxin and protein synthesis. However, little work has been done on this aspect on wheat in Agra region of Uttar Pradesh. Therefore, an experiment was conducted to study the effect of sulphur, manganese and zinc on yield and uptake of nutrients in wheat.

MATERIALS AND METHODS

A field experiment was carried out at Raja Balwant Singh College, Research Farm Bichpuri, Agra (U.P.) during rabi season of 2014-15 and 2015-16. The soil of the experimental field was sandy loam in texture with pH 8.1, organic carbon 3.2 g kg^{-1} and available N, P, K, S, Zn

and Mn 170, 9.8, 102, 16.5 kg ha^{-1}, 0.55 mg kg^{-1} and 2.6 mg kg^{-1}, respectively. The treatments were: T_1 100% NPK, T_2 100% NPK + 10kg S ha^{-1}, T_3 100% NPK + 20 kg S ha^{-1}, T_4 100% NPK + 5 KG Mn ha^{-1}, T_5 100% NPK + 10 kg Mn ha^{-1}, T_6 100% NPK + 2.5 kg Zn ha^{-1} and T_7 100% NPK + 5 kg Zn ha^{-1}. These treatments were replicated thrice in randomized block design. The recommended dose of nitrogen, phosphorous and potassium (150, 60 and 40 kg ha^{-1}) were supplied through urea, di ammonium phosphate and muriate of potash, respectively at sowing time. The calculated amount of S (elemental sulphur), Zn (zinc oxide) and Mn (manganese chloride) were supplied well before sowing. The seeds of wheat (var.PBW 343) were sown in mid-November during both the years. The crop was harvested at physiological maturity and yield data were recorded. The growth and yield attributes were also recorded at harvest. The grain and straw samples were digested with di acid mixture of HNO_3 and $HClO_4$ in 9:1 ratio. Phosphorus was determined by vanadomolybdo phosphoric acid yellow colour method (Jackson 1973), S by turbidimetric method (Chesnin and Yien 1951), K by flame photometer, Mn and Zn by atomic absorption spectrophotometer. Nitrogen in grain and straw was determined by modified micro-kjeldahl method. The nutrient uptake was calculated by multiplying the concentration values with the respective grain and straw yield data.

RESULTS AND DISCUSSION

Growth and yield attributes

A perusal of the data (Table 1) reveals that the application of 20 kg S ha^{-1} improved the plant height over 100% NPK alone. The positive effect of sulphur on plant height may be due to poor fertility with regard to sulphur status of the soil, which facilitated better response to S application in term of plant height (Singh 2016). The supply of 5 kg Zn ha^{-1} along with 100% NPK recorded the greater height of the plants as compared to alone application of NPK level. This increase in plant height may be attributed to greater availability of zinc in soil with the application of zinc (Pandey and Chauhan (2016). The height of the plants ranged from 90.5 cm at 100% NPK to 92.0 cm at 10 kg Mn ha^{-1}. Similar results were reported by Chandel (2010). The tallest wheat plants were recorded under 100% NPK + 20 kg S ha^{-1} as compared to Mn and Zn. This finding indicated that the combined application of sulphur and optimum level of NPK fertilizers proved to be superior to sole inorganic fertilizer application. Application of 20 kg S ha^{-1} improved yield attributes over 100% NPK alone. This might be due to more requirements of sulphur. (Pandey and Rana 2016). Application of 5 kg Zn ha^{-1} resulted in an additive effect on these characters probably due to beneficial effect of Zn on zinc deficient soil (Mishra *et al.* 2017). Application of 10 kg Mn ha^{-1} produced relatively higher values of these yield attributes over 100% NPK alone Ali and Ram Lakhan (2011) observed that Mn in conjunction with 100% NPK resulted in higher yield attributes.

Yield

A study of Table 1 reveals that the lowest yields of grain and straw of wheat were recorded with 100% recommended dose of NPK treatment. The yield of grain and straw increased significantly with increase in the level of S up to 20 kg S ha^{-1}. The marked effect of S on grain and straw yield of wheat may be attributed to low status of S in soil. Similar results were also reported by Pandey and Rana (2016). The grain and straw yield of wheat increased significantly with the increase in the applied zinc level from 0 to 5 kg Zn ha^{-1}. The maximum grain yield of 5.52 t ha^{-1} was obtained with the application of 5 kg Zn ha^{-1} and minimum (5.13 t ha^{-1}) with no zinc. Similar trend was also noted in straw yield. This increased yield due to Zn may be attributed to its function as catalyst or stimulant in most of the physiological and metabolic processes and metal activator of enzyme, resulting in increased growth and development of plant, which ultimately gave higher grain and straw yields of wheat (Pandey and Chauhan 2016). The grain and straw yield of wheat increased significantly with Mn application over (100% recommended dose of NPK. The higher grain (5.75 t ha^{-1}) and straw (7.76 t ha^{-1}) yields were recorded at 10 kg Mn ha^{-1} over 100% NPK alone. The increases in yield due to manganese application may be attributed to increased availability of manganese in soil (Chandel 2010). The crop yields increased more due to S and Zn compared to Mn application. Similar results were reported by Singh and Singh (2007), Chandel (2010) and Ali and Ram Lakhan (2011).

Table 1: Effect of S, Mn and Zn on growth, yield and quality of wheat (mean of 2 years)

Treatment	Plant height (cm)	Length of ear (cm)	Test wt. (g)	Yield (t ha^{-1})		Protein %		Protein yield (kg ha^{-1})
				Grain	Straw	Grain	Straw	
T_1	90.5	7.0	44.5	5.13	6.90	11.9	3.3	610.5
T_2	91.7	7.6	45.0	5.55	7.46	12.5	3.6	693.8
T_3	93.0	8.8	45.6	5.98	8.05	12.9	3.8	771.4
T_4	91.5	7.5	44.9	5.45	7.37	12.4	3.4	675.8
T_5	92.6	8.4	45.3	5.75	7.76	12.9	3.6	741.8
T_6	91.3	7.3	44.7	5.39	7.28	12.4	3.4	668.4
T_7	92.4	8.0	45.0	5.52	7.50	12.8	3.6	706.6
SEm ±	0.75	0.75	0.13	0.11	0.15	0.14	0.07	11.0
CD (P=0.05)	1.52	0.52	0.28	0.23	0.31	0.29	0.15	23.0

T_1 100% NPK, T_2 100% NPK + 10 kg S ha^{-1}, T_3 100% NPK + 20 kg S ha^{-1}, T_4 100% NPK + 5 kg Mn ha^{-1}, T_5 100% NPK+10 kg Mn ha^{-1}, T_6 100% NPK+ 2.5kg Zn ha^{-1}, T_7 100% NPK + 5 kg Zn ha^{-1}

Quality

It is evident from Table 1 that the protein content increased from 11.9 to 12.9 per cent in wheat grain and from 3.3 to 3.8 per cent in straw as the dose of sulphur was increased from 0 to 20 kg ha^{-1}. The increase in protein content may be owing to higher nitrogen utilization by the crop with adequate supply of sulphur. (Singh *et al.* 2014).The protein percentage in wheat grain and straw increased from 11.9 to 12.8 and 3.3 to 3.6, respectively with 5 kg Zn ha^{-1}. The increase in protein content due to zinc addition may be attributed to its involvement in nitrogen metabolism of plant (Mishra *et al.* 2017). Crude protein content in wheat grain and straw increased significantly with increasing levels of manganese from 11.9 to 12.9 % and 3.3 to 3.6 % with 10 kg Mn ha^{-1}, respectively (Singh and Kumar, 2011). Increasing doses of sulphur increased gradually the protein yield of wheat and 20 kg S ha^{-1} produced significantly higher protein yield over control. The variations in protein yield were largely associated with grain and straw yield (Singh *et al.* 2014). Protein production by grain improved significantly from 610.5 kg ha^{-1} at control to 706.4 kg ha^{-1} 5 kg Zn ha^{-1}. This increase may be attributed to increased grain and straw production with Zn application. The manganese application to the soil also increased the protein yield of wheat grain over no manganese treatment (100% NPK). Application of S was more beneficial for protein production than those of zinc and manganese.

Uptake of nutrient

Increasing levels of sulphur increased the removal of nitrogen from the soil and 20 kg S ha^{-1} registered the maximum nitrogen uptake by wheat crop. This might have happened due to higher grain and straw production as well as higher nitrogen content. Similar results were also reported by Singh *et al.* (2014). With an increase in the level of added zinc up to 5 kg Zn ha^{-1}, nitrogen uptake by the grain and straw of wheat increased significantly over 100% NPK alone which may be attributed to increase in the yield as well as nitrogen content in the grain and straw of wheat. (Pandey and Rana 2016). The uptake of nitrogen increased significantly over 100% NPK with the application of manganese. Increase in nitrogen uptake was significant due to applied manganese upto 10 kg Mn ha^{-1}. The increase in N uptake may be attributed to increased grain and straw production with manganese addition (Chandel 2010).The sulphur tended to increase the uptake of phosphorus by wheat grain from 10.3 kg ha^{-1} at control to 15.0 kg ha^{-1} with 20 kg S ha^{-1}. The corresponding increase in P uptake by straw was from 7.0 to 12.1 kg ha^{-1}. These results are in agreement with the findings of Pandey and Chauhan (2016). The uptake of P by grain and straw of wheat was not affected significantly with 5 kg Zn ha^{-1} as compared to no zinc treatment. However, further increase in the zinc level tended to reduce the P uptake that is a consequence of reduced P content at this level (Panday and Rana 2016). The manganese application augmented the amount of phosphorus assimilated by wheat grain and straw. The beneficial effect of both levels of Mn

(5 and 10 kg ha^{-1}) on P uptake was statistically significant over control. (Chandel 2010). A progressive increase in S levels gradually increased the uptake of potassium by wheat crop. In all the cases the uptake of potassium under 10 and 20 kg S ha^{-1} was significantly more than the 100% NPK treatment. (Singh *et al.* 2014) also reported similar results.The uptake of K by wheat grain and straw increased with zinc application over no zinc. The uptake of K by grain and straw of wheat increased with manganese application over control and higher values of K uptake were recorded with 10 kg Mn ha^{-1} (Singh and Kumar, 2011).

Table 2: Effect of various treatments on N, P, K, S (kg ha^{-1}) and Mn and Zn (g ha^{-1}) and Mn and Zn (g ha^{-1}) uptake by wheat

Treatment	Nitrogen		Phosphorus		Potassium		Sulphur		Manganese		Zinc	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
T_1	97.5	36.6	10.3	7.6	26.7	131.1	9.2	6.2	223.1	186.3	106.2	144.9
T_2	111.0	42.5	12.8	9.7	30.0	144.0	11.7	8.2	249.7	212.6	144.3	149.2
T_3	123.8	48.3	15.0	12.1	32.9	157.0	13.8	10.5	279.2	241.5	152.4	155.3
T_4	108.5	40.5	11.4	8.8	28.3	140.8	10.4	7.4	276.3	245.4	141.7	154.7
T_5	118.5	45.0	11.5	8.5	29.3	149.0	10.4	7.0	327.8	310.4	147.8	154.4
T_6	106.7	39.3	10.8	8.0	27.5	138.3	10.2	7.3	229.6	200.2	175.4	187.0
T_7	113.2	42.8	10.5	7.5	27.6	141.8	9.4	8.3	242.9	210.0	198.7	217.5
SEm±	1.20	0.60	0.66	0.53	1.13	2.82	0.31	0.32	5.50	5.02	3.57	5.05
CD(P=0.05)	2.49	1.25	1.38	1.15	2.28	5.62	0.63	0.65	11.52	10.54	7.48	10.60

Increase in S content along with greater total grain and straw production resulted in the greater uptake of sulphur. The higher utilization of S at its higher level of application was a consequence of more root competition resulting in more exploitation of fertilizer S for absorption (Pandey and Chauhan, 2016). Zinc application favourably influenced the sulphur uptake by wheat grain and straw. This increase in S uptake may be ascribed to increased grain and straw yield of wheat. Pandey and Chauhan (2016) reported similar result. The sulphur uptake by wheat crop increased with manganese application upto 5 kg Mn ha^{-1}. The levels of Mn did not have any significant effect on sulphur utilization by wheat crop. Similar results were reported by Ali and Ram Lakhan (2011). The uptake of manganese by wheat grain and straw increased significantly with increasing levels of S upto 20 kg ha^{-1} Singh and Kumar (2011) reported similar results. The higher level of Zn proved significantly superior over 100% NPK control in respect of Mn uptake by wheat crop which may be attributed to increased grain and straw production.Manganese uptake by grain and straw of wheat crop increased significantly upto 10 kg Mn ha^{-1} level. The increase in Mn uptake by the wheat crop with its addition may be explained due increased concentration of manganese in plant tissue. Singh and Kumar (2011) also reported similar results.Increase in the amount of applied sulphur from 0 to 20 kg ha^{-1}, increased the zinc uptake by grain and straw of wheat crop over control. Thereafter, a reduction in zinc uptake was noted at 20 kg S ha^{-1} over10 kg S ha^{-1}. The increase in zinc uptake with lower level of S may be ascribed to increased grain and straw yield. Addition of zinc sulphate (5 kg ha^{-1}) increased the zinc uptake by grain and straw from 100.2 to 198.7 and from 144.9 to 217.5 g ha^{-1}, respectively. Application of zinc favours more absorption and consequently more accumulation of zinc in the grain and straw. Similar results were also reported by Pandey and Rana (2016).The uptake of zinc by wheat grain and straw was not affected significantly with manganese application. However, an increase in zinc uptake by wheat crop was noted with both levels of Mn over no Mn treatment. This increase in zinc uptake may be attributed to increased grain and straw production with manganese application.

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