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RESPONSE OF WHEAT TO SULPHUR AND ZINC NUTRITION IN ALLUVIAL SOIL

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ABSTRACT

A field experiment was conducted at Raja Balwant Singh College, Research Farm Bichpuri, Agra (U.P.) during rabi seasions of 2013-15 to study the effect of sulphur and zinc on yield, quality and uptake of nutrients in wheat (Triticum aestivum). The treatments consisted of four levels each of sulphur (0, 10, 20 and 30 kg ha^{-1}) and zinc (0, 2.5, 5.0 and 7.5 kg ha^{-1}) were tested in randomized block design with three replications. The results revealed that the growth and yield attributes of wheat increased significantly up to 30 kg S ha^{-1} over no sulphur. The mean grain (46.60 q ha^{-1}) and straw yield (65.43 q ha^{-1}) with 20 kg S ha^{-1} was 17.2 and 12.0 % higher in comparison to control, respectively. Application of 20 kg S ha^{-1} recorded significantly higher content and yield of protein in wheat grain over control. Increasing levels of zinc up to 5.0 kg Zn ha^{-1} showed significant improvement in growth and yield attributes over control. Similarly, application of 5.0 kg Zn ha^{-1} resulted in 9.4 % higher grain yield (46.70 q ha^{-1}) than the yield obtained in control (42.69 q ha^{-1}). The corresponding increase in straw yield with 5 kg Zn ha^{-1} over control was 12.9 per cent. Uptake of N,P,K,S and Zn in wheat crop increased significantly with increasing levels of sulphur over control. But zinc uptake by grain tended to decrease at 30 kg S ha^{-1} over 20 kg S ha^{-1}. Protein content and yield increased significantly with the addition of Zn up to 5 kg ha^{-1}. The uptake of nutrients (N, P, K, and Zn) in wheat except that of S increased with Zn application. Sulphur and zinc levels also had variable effects on the status of organic carbon and available nutrients in soil after harvest of the crop.

***Keywords*:** Sulphur, zinc, quality, uptake of nutrients, yield, wheat.

INTRODUCTION

Wheat is the most important food grain crop among cereals and stands next only to rice in our country. But it stands first in productivity amongst the cereals. By 2020, India will have a population of about 1.3 billion and there will be a substantial pressure on land to produce more food. Stagnation in wheat production, lower productivity and inferior quality of the produce is due to various constraints including inadequate and imbalanced nutrient application. There is a great scope for increasing the production of wheat applying balanced fertilization and maintaining soil fertility and status Singh (2016). Survey of Indian soils under AICRP Micronutrients has revealed that, on an arrange, 41 and 49% of the Indian soils are deficient in available S and Zn, respectively with widespread occurrence in the coarse textured soils. Adoption of intensive cropping system with high yielding varieties has leads to the emergence of zinc deficiency. Sulphur has been found to be yield limiting factor in cereals (Singh etal.2014) as it is involved in the synthesis of essential ameno acids like cysteine, cystine and methionine. Sulphur has been known for its role in the synthesis of carbohydrates, proteins, vitamins and flavour compounds. Sulphur deficiency is observed mainly due to high crop yield and therefore higher rate of sulphur removal by the crops and lesser use of S containing fertilizers. Zinc plays an important role as a metal component of enzymes (alcohol dehydrogenase, superoxide dismutase, carbonic anhydrase and RNA polymerase) or as a functional, structural or regulator cofactor of a large number of enzymes. It is cousidened to be the most yields limiting micronutrient in crop production. Both synergistic and antagonistic results between sulphur and zinc have been reported and the relationship between these two is not very clear (Pandey and Chauhan, 2016). A suitable combination of secondary (S) and micronutrient (Zn) is, by and large, the most important single factor that affects the yield and quality of the crops. Therefore, present study was undertaken to assess the effect of sulphur and zinc application on yield, quality and nutrient uptake of wheat.

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METERIALS AND METHODS

A field experiment was conducted at Raja Balwant Singh College, Reserch Farm Bichpuri, Agra (U.P.) during rabi seasons of 2013-2015. The soil of the experiment field was sandy loam in texture with pH 8.1, organic carbon 3.0 g kg^{-1} and available N,P,K,S and DTPA Zn 145 8.5, 110, 15 $kgha^{-1}$ and 0.51 $mgkg^{-1}$respectively. The treatments comprised of four levels each of sulphur (0, 10, 20 and 30 kg ha^{-1}) and zinc (0, 2.5, 5.0 and 7.5 kg ha^{-1}) were replicated thrice in randomized block design. The recommended doses of N, P_2O_5 and K_2O (150, 60 and 40 kg ha^{-1}) were supplied through urea, diammonium phosphate and muriate of potash, respectively. Half amount of nitrogen and total quantity of P and K were applied at the time of sowing, while remaining N was applied after one month of sowing. Zinc and S were applied as zinc oxide and elemental S to soil as per treatments at the time of sowing. The seeds of wheat (PBW 502) were sown in furrows on November 20, using 100 kg seed ha^{-1} in both the years.Other agronomic management practices were followed as per standard recommendations. The crop was harvested at physiological maturity and yield data were recorded. The grain and straw samples were collected for chemical analysis of nitrogen, phosphorus, potassium, sulphur and zinc. The grain and straw samples were digested in HNO_3 and $HClO_4$ mixture and sulphur and zinc were determined by turbidimetric method (Chesnin and Yien 1951) and atomic absorption spectrophotometer, respectively. Phosphorus and potassium in the acid digest were determined by vanadomolybdate yellow colour method and flame photometer, respectively. The nitrogen content was determined by Kjeldahl method (Jackson 1973). The protein content was calculated by multiplying N content with 6.25. The nutrients uptake was calculated by multiplying the grain and straw yield with the per cent nutrient content in grain and straw. The soil samples collected after harvest of the crop were analyzed for organic carbon, available N (Subbiah and Asija 1956), P (Olsen *et al.* 1954), K (Hanway and Heidel 1952), available S (Chesnin and Yien 1951) and DTPA- Zn (Lindsay and Norvell 1978).

RESULTS AND DISCUSSION

Yield and attributes

Addition of sulphur levels showed a positive and significant effect on plant height. The supply of 30 kg S ha^{-1} recorded the greater height of the plants at harvest stage of the crop. The positive effect of S levels of plant height may be due to low status of S in Soil. Singh *et al.* (2014) also reported similar results. The positive effect of zinc levels on plant height may be due to low status of zinc which facilitated better response to Zn application in terms of plant height. The supply of 5 kg Zn ha^{-1} recorded the taller plants over other levels of zinc (Singh *et al.* 2015). Ear length increased significantly up to 5 kg Zn ha^{-1} and thereafter decreased non significantly at 7.5 kg S ha^{-1}. Increase in the ear length with of S and Zn application might be due to their low availability in experimental field. These results corroborated with the findings of Sahay *et al.* (2009). Grain and straw yields increased significantly with the addition of S up to 30 kg S ha^{-1} However, yields at 20 and 30 kg S ha^{-1} were found statistically at par. The highest grain and straw yields were recorded (46.81 and 68.56 q ha^{-1}) at 30 kg S ha^{-1} and were computed 17.7 and 17.39% higher over lowest grain (39.77q ha^{-1} and straw yield of 58.40 q ha^{-1} at control, respectively. On addition of Zn, grain and straw yields increased significantly up to 5.0 kg Zn ha^{-1} level and thereafter decreased non significantly at 7.5 Zn level. The highest grain (46.70 q ha^{-1}) and straw yield (66.58 q ha^{-1}) at 5.0 kg Zn level was recorded 9.39 and 12.88 % higher than the lowest grain (42.69 q ha^{-1}) and straw yield (58.98 q ha^{-1}) at control, respectively. Thus, it seems that the application of S was more beneficial to that of Zn. The increase in grain and straw yield with applied S and Zn might be due to their low availability in the soil. The increase in grain and straw yields are also in accordance with the yield attributes. The favourable influence of Zn application on wheat yield may be attributed to its role in enzymatic activities, harmone production, protein synthesis and seed production (Kulhare *et al.* 2014). These results lie in the line of findings reported by Sahay *et al.*(2009) and Singh *et al.* (2014).

Table 1: Effect of sulphur and zinc levels on yield and quality of wheat (mean of two years)

Treatment	Plant height (cm)	Ear length (cm)	Yield (q ha^{-1})		Protein content (%) in grain	Protein Yield (kg ha^{-1}) in grain
			Grain	Straw		
Sulphur (kg ha^{-1})						
0	100.4	15.7	39.77	58.40	12.60	501.5
10	102.0	16.5	44.25	61.58	12.80	567.0
20	104.0	17.2	46.60	65.43	12.93	602.9
30	105.4	18.1	46.81	68.66	13.02	610.1
CD (P=0.05)	0.86	0.14	1.57	4.22	0.20	25.40
Zn (kg ha^{-1})						
0	101.7	16.4	42.69	58.98	12.57	524.5
2.5	102.4	17.1	44.50	63.11	12.70	565.7
5.0	103.6	17.5	46.70	66.58	12.95	605
7.5	103.6	16.6	44.70	65.30	13.10	586.3
CD (P=0.05)	0.86	0.14	1.57	4.22	0.20	25.40

Quality

A study of the data (Table 1) reveals that the protein content in grain of wheat improved with S application and increase was from 12.60% at control to 13.02% with 30 kg ha^{-1} Similar results were reported by Singh *et al.* (2014) The protein content in the grain was also significantly improved with zinc application over control (Singh *et al.* 2015). Increasing levels of sulphur from 0 to 30 kg S ha^{-1} increased the protein production significantly over control. However, the maximum protein yield (610 kg ha^{-1}) was accrued with 30 kg S ha^{-1}. This increase in protein yield may be attributed to increased grain yield and improvement in protein content due to sulphur application. Similar results were reported by Singh *et al.* (2014). The protein production in wheat grain also increased significantly with Zn application over control. The protein yield ranged from 524.5 kg ha^{-1} at control to 605.0 kg ha^{-1} at 5 kg ha^{-1}. This increase in protein yield may be attributed to higher grain production and protein percentage due to zinc application. Singh *et al.* (2015) reported similar results in wheat.

Table 2: Effect of sulphur and zinc levels on uptake of nitrogen, phosphorus, potash, sulphur (kg ha^{-1}) and Zinc (g ha^{-1}) in wheat (mean of two years)

Treatment	Nitrogen		Phosphorus		Potassium		Sulphur		Zinc	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
Sulphur (kg ha^{-1})										
0	80.3	33.1	10.1	7.2	20.3	114.2	9.3	7.8	141.4	139.6
10	90.7	35.6	11.0	8.4	23.1	121.6	11.8	9.5	154.6	145.9
20	96.5	38.7	12.8	9.9	25.6	130.1	13.5	11.1	159.1	152.4
30	97.6	41.4	13.1	11.3	26.1	137.3	14.0	13.2	158.2	157.2
CD (P=0.05)	4.90	1.92	0.46	0.40	1.40	10.09	0.96	1.17	7.07	12.71
Zn (kg ha^{-1})										
0	84.0	33.2	11.4	8.4	21.9	116.7	11.5	9.3	129.6	118.6
2.5	90.5	36.6	12.3	9.8	24.2	125.3	12.5	11.0	149.2	149.9
5.0	96.8	39.5	12.3	9,4	25.3	132.3	12.8	11.2	167.40	162.1
7.5	93.8	39.5	11.6	8.8	23.7	128.9	11.9	10.2	167.20	174.5
CD (P=0.05)	4.90	1.92	0.46	0.40	1.40	10.09	0.96	1.17	7.07	12.71

Uptake of Nutrients

It is evident from the data (Table 2) that the addition of S and Zn, in general, increased significantly the uptake of N,P,K and S up to 30 kg and 5.0 kg ha^{-1} level of S and Zn, respectively. Whereas S and Zn application increased their uptake up to highest level i.e. 30 kg S and 5.0 kg Zn, respectively. A marked increase in N uptake by grain (97.6kg ha^{-1}) and straw (41.4 kg ha^{-1}), P (13.1 and 11.3 kg ha^{-1}), K (26.1 and 137.3 kg ha^{-1}), S (14.0 and 13.2 kg ha^{-1}) and Zn by straw (157.2 g ha^{-1}) was recorded with the application of 30 kg S ha-^{1}.The maximum uptake of Zn by grain (159.1g ha^{-1})

was recorded with 20 kg S ha^{-1}. Since, the nutrient uptake is a function of their contacts in crop plants and yield of crop. The increase in these parameters due to application of S led to an increased uptake of nutrients are in conformity with the findings of Singh etal.(2014) who reported increased uptake of nutrients by wheat. A perusal of data (Table 2) revealed that N, P, K, S and Zn uptake increased significantly with Zn application over control. The highest uptake of N in grain (96.8 kg ha^{-1}) and straw (39.5 kg ha^{-1}) was associated with 5 kg Zn ha^{-1}. Significant increase in P uptake by grain (12.3 kg ha^{-1}) and straw (9.4 kg ha^{-1}) of wheat was also found with 5 kg Zn ha^{-1} as observed by Singh *et al.*(2015) and Pandey and Chauhan (2016). The highest uptake of K by grain (25.3 kg ha^{-1}) and straw (132.3 kg ha^{-1}) was recorded with 5 kg Zn ha^{-1}. The uptake of S and Zn by wheat crop increased along with rise in level of Zn up to 5 and 7.5 kg ha^{-1}, respectively. The increase in nutrient uptake may be due to increase in nutrient content and yield. Zinc plays structural and regulatory roles in large number of enzyames and protein synthesis, which directly affects the nutrient absorption from the soil (Singh *et al.* 2015 and Pandey and Chauhan 2016).

Table 3: Effect of sulphur and zinc level on organic carbon (g Kg^{-1}) available N,P,K,S (kg ha^{-1}) and Zn (mg kg^{-1}) in soil after harvest of wheat (mean of two years)

Treatment	Organic Carbon	Nitrogen	Phosphorus	Potassium	Sulphur	Zinc
Sulphur (kg ha^{-1})						
0	2.7	116.0	8.1	104.0	13.7	0.53
10	2.9	130.5	8.2	105.5	16.2	0.53
20	3.1	139.0	8.3	109.0	17.5	0.52
30	3.4	146.2	8.4	110.5	18.9	0.51
CD (P=0.05)	0.20	8.41	NS	2.93	1.01	NS
Zn (kg ha^{-1})						
0	2.9	129.0	8.4	108.5	16.6	0.47
2.5	3.0	136.0	8.3	108.0	16.7	0.50
5.0	3.1	139.0	8.2	106.7	16.5	0.55
7.5	3.0	127.8	8.0	105.7	16.4	0.58
CD (P=0.05)	NS	NS	NS	NS	NS	0.02

Soil Fertility

Application of S to the soil significantly improved the amount of organic carbon in soil which increased from 2.7 to 3.4 g kg^{-1} with 30 kg S ha^{-1} (Table 3). Application of 5 kg Zn ha^{-1} proved beneficial in improving the status of organic carbon from 2.9 to 3.1 g kg^{-1} in the soil. The status of available N improved with S and Zn application. It increased from 116.0 kg ha^{-1} at control to 146.2 kg ha^{-1} with 30 kg ha^{-1}.The maximum amount of available N was recorded with 30 kg S ha^{-1}. The lower levels (2.5 and 5 kgha^{-1}) of zinc increased the amount of available N in soil and maximum value (139.0 kg ha^{-1}) was noted with 5 kg Zn ha^{-1}. The higher level (7.5 kg Zn ha^{-1}) tended to decrease the available N in soil over lower level of zinc. Available P content in soil improved from 8.1 kg ha^{-1} in control to 8.4 kg ha^{-1} with of 30 kg S ha^{-1}. Similar results were observed by Sahay *et al.* (2009) and Pandey and Chauhan (2016). Application of zinc did not affect the status of available P significantly in the soil but it tended to decrease with increasing levels of zinc. Available K content in soil increased with S addition and decreased with Zn levels. The maximum value of available K content in soil was recorded at 30 kg S ha^{-1}. The increase in available K status due to 30 kg S ha^{-1} over control was from 104.0 to 110.5 kg S ha^{-1}. Application of Zn decreased the available K status in the soil and minimum amount was noted with 7.5 kg Zn ha^{-1}. There was a significant increase in available S content with its levels. The available sulphur status in soil increased from 13.7 to 18.9 kg ha^{-1} with 30 kg S ha^{-1} level. Application of zinc tended to decrease the status of available sulphur in soil over control. Available Zn content in soil decreased with higher levels of S over control. Application of Zn tended to increase the status of available Zn in soil significantly over control (Table 3). The maximum value of available Zn content in soil after the crop harvest was recorded with 7.5 kg Zn ha^{-1}. Pandey and Chauhan (2016) also reported similar results.

It may be concluded from the results that the application of S and Zn increased the grain and straw yield, quality and uptake of nutrients in wheat. Application of 20 kg S and 5 kg Zn ha^{-1} gave the highest values of grain and straw yields and protein content in wheat.

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