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EFFECT OF SULPHUR AND ZINC ON YIELD, QUALITY AND UPTAKE OF NUTRIENTS IN BARLEY

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ABSTRACT

A field experiment was conducted during rabi seasions of 2011-13 to study the effect of sulphur and zinc on yield, quality and uptake of nutrients in barley (Hordeum vulgare). The experiment was laid out in randomized block desgh with four levels of sulphur (0, 10, 20 and 40 kg ha^{-1}) and four levels of zinc (0, 2, 4 and 6 kg ha^{-1}) and three replications.The results revealed that the growth and yield attributes of barley increased significantely up to 20 kg S ha^{-1}, which were statistically at par with 40 kg S ha^{-1}. The mean grain (59.75q ha^{-1}) and straw yield (130.8q ha^{-1}) with 20 kg S ha^{-1} was 15.2 and 14.8% higher in comparison to control, respectively. Application of 20 kg S ha^{-1} recorded significantely higher protein content and yield and starch content in barley grain over control. Increasing levels of zinc up to 4 kg Zn ha^{-1} showed significant improvement in growth and yield attributes over control. Similarly, application of 4 kg Zn ha^{-1} resulted in 9.8% higher grain yield (57.77 q ha^{-1}) than the yield obtained in control (52.59q ha^{-1}). Uptake of N,P,K,S and Zn in barley crop increased significantely with increasing levels of sulphur. Protein content and yield increased significantely with the addition of Zn up to 4 kg ha^{-1}. The uptake of nutrients (N, P, K, S and Zn) in barley except those of S increased with Zn application. Sulphur and zinc levels also had variable effects on the status of organic carbon Uptake of N,P,K,S and Zn in barley crop increased significantely with increasing levels of sulphur. Protein content and yield increased significantely with the addition of S up to kg ha^{-1}. The uptake of nutrients (N, P, K, S and Zn) in barley except those 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: Barley sulphur, zinc, quality, uptake of nutrients, yield

INTRODUCTION

Barley (*Hordeum vulgare*) has the widest ecological range of adoptation among the cereals, which is grown throughout the temprate and tropical regions of the world. It has low cost of production and input requirement, so it is preferred by the resource poor farmers in the country. Barley grain is considered as an important raw material for food industries in addition to its consumption for chapati making. Its straw is a good quality fodder for livestock. Although, it is a major cereal crop yet its productivity in tha Agra region of Uttar Pradesh is lower than its realizable yield potential. Thus, there is a great scope for increasing the production of barley by applying balanced fertilization and maintaining soil fertility status. Survey of Indian soils under AICRP Micronutrients has revealed that, on an average, 41 and 49 % of the Indian soils are deficiant 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 Zn deficiency.Sulphur has been found to be yield-limiting factor in many cases and Zn in some. Both these elements along with N, P, and K provided good yield responses of maize, wheat and rice crops (Singh, 2000). There is possibility of raising the production per unit area by efficient use of sulphur and zinc. Both synergistic and antagonistic results between sulphur and zinc have been reported and the relationship between these two is not very clear (Kothari *et al.* 2005). Therefore, the present study was undertaken to assess the effect of sulphur and zinc application on yield attributing characters, yield and nutrient uptake of barley (*Hordeum vulgare*).

MATERIALS AND METHODS

A field experiment was conducted at Raja Balwant Singh College, Research Farm Bichpuri, Agra (U.P.) during rabi seasons of 2011- 2013. The soil of the experimental field was sandy loam in texture with pH 7.9, organic carbon 3.8 g kg^{-1} and available N,P,K,S and DTPA Zn 165, 9.5, 120, 17 kgha^{-1} and 0.46 mgkg^{-1}, respectively. The treatments comprised of four levels each of sulphur (0, 10, 20 and 40 kgha^{-1}) and zinc (0, 2, 4 and 6 kgha^{-1}) were replicated thrice in randomized block desion. The recommended doses of N, P_2O_5 and K_2O (100, 60 and 40 kgha^{-1}) were supplied through urea, diammonium phosphate and muriate of potash, respectively as basal dressing at the time 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 barley (RD2052) were sown in furrows on November 25, using 100 kg seed ha^{-1} in both the years. The crop was harvested at physiological maturity and yield data were recorded. Plant samples (grain and straw) 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 detedmined by turbidimetric method (Chesnin and Yien 1951) and atomic absorption spectrophotometer, respectively. Phosphorus and potassium in the acid dijest were determined by vanadomolybdate yellow colour method and flame photometer, respectively. The nitrogen was determined by Kjeldahl method (Jackson 1973). The protein content was calculated by multiplying N content with 6.25. Starch content in barley grain was determined by Fehling solution method. The nutrients uptake per hectare 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 analysed for organic carbon, available N, P,K,S and Zn by adopting standard procedures (Jackson 1973).

RESULTS AND DISCUSSION

Yield and attributes

Addition of sulphur levels showed a positive and significant effect on plant height. The supply of 20 kg S ha^{-1} recorded the greater height (107.6 cm) of the plants at harvest stage of the crop. However, both the higher levels of S did not differ significantly from each other in respect of plant height. The positive effect of S levels on 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 4 kg Zn ha^{-1} recorded the taller plants over other levels of zinc (Singh *et al.* 2015). Ear length increased significantly with the application of S up to 40 kg S ha^{-1}. Addition of Zn also increased significantly the ear length up to 4 kg Zn ha^{-1} and thereafter decreased non significantly at 6 kg Zn 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 Singh (2000) and Sahay etal. (2009).

Table 1: Effect of sulphar and zinc levels on yield, protein content and yield and starch content in barely (mean of two years)

Treatment	Plant height (cm)	Ear length (cm)	Yield (q ha^{-1})		Protein content in gram	Protein yield in gram	Starch content in gram
			Grain	Straw			
Sulphar (kg ha^{-1})							
0	100.9	15.85	50.11	116.79	11.9	592	52.0
10	103.0	16.80	55.47	123.25	12.1	670	52.7
20	107.6	17.05	57.75	130.86	12.3	713	53.2
40	107.1	17.97	58.02	137.12	12.3	722	53.8
CD(P=0.05)	1.01	0.14	1.63	4.14	0.2	25	NS
Zn (kg ha^{-1})							
0	103.2	16.85	52.59	117.96	11.1	620	52.9
2	104.4	17.02	56.02	126.21	12.2	668	53.0
4	106.8	17.4	57.77	133.26	12.3	716	52.9
6	104.1	16.4	55.25	130.59	12.4	694	52.8
CD(P=0.05)	1.01	0.14	1.63	4.14	0.20	25	NS

Grain and straw yields increased significantly with the addition of S up to 40 kg S ha^{-1}. However, yields at 20 and 40 kg S ha^{-1} were found statistically at par. The highest grain and straw yields were recorded (58.02 and 137.12 q ha^{-1}) at 40kg S ha^{-1} and were computed 15.7 and 17.4 % higher over lowest grain (50.11q ha^{-1} and straw yield of 116.79 q ha^{-1} at control, respectively. On addition of Zn, grain and straw yields increased significantly up to 4.0 kg Zn ha^{-1} level and thereafter decreased non significantly at 6.0 kg Zn level. The highest grain (57.77q ha^{-1}) and straw yield (133.26q ha^{-1}) at 4.0 kg Zn level was recorded 9.8 and 12.9 % higher than the lowest grain (52.59 q ha^{-1}) and straw yield (117.96 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 increases in grain and straw yields are also in accordance with the yield attributes. These results lie in the line of findings reported by Sahay *et al.* (2009), Singh (2010) and Singh *et al.* (2014).

Quality

A study of the data (Table 1) reveals that the protein content in grain of barley improved with S application and increase was from 11.9% at control to 12.3% with 40 kg S 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. The maximum value of protein content was recorded at 6 kg Zn ha^{-1}. Similar results were reported by Singh *et al.* (2015). Increasing levels of sulphur from 0 to 40 kg S ha^{-1} increased the protein production significantly over control (Table 1). However, the maximum protein yield (722 kg ha^{1}) was accrued with 40 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 barley grain also increased significantly with Zn application over control. The protein yield ranged from 620 kg ha^{-1} at control to 716 kg ha^{-1} at 4 kg Zn ha^{-1}. This increase in protein yield may be attributed to higher grain production and protein percentage due to zinc application. Singh etal. (2015) reported similar results. In general, starch content in barley grain tended to increase progressively with increasing levels of sulphur. However, this increase in starch content with S application was statistically non-significant. The maximum value (53.8%) of starch in barley was recorded with 40 kg S ha^{-1}. The starch content in grain was not affected significantly with zinc application. However, the maximum value (53.0%) of starch was recorded at 2 kg Zn ha^{-1}followed by a reduction at 4 and 6 kg Zn ha^{-1}.

Table 2: Effect of sulphar and Zinc levels on uptake of nitrogen, phosphorous, potash, sulphar (kgha^{1}) and zinc (g ha^{1}) in barley (mean of two years)

Treatment	Nitrogen		Phosphorus		Potassium		Sulphur		Zinc	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
Sulphar (kg ha^{-1})										
0	94.8	60.4	10.1	9.8	22.9	222.5	9.2	9.8	127.0	220.8
10	107.2	65.0	11.7	11.9	26.1	237.1	12.0	12.9	136.7	230.6
20	114.1	71.0	13.0	14.6	29.1	253.9	14.0	15.6	140.7	239.4
40	115.6	76.4	13.4	17.0	29.3	267.7	14.8	20.1	139.4	245.8
CD(P=0.05)	4.90	1.92	0.46	0.40	1.40	10.09	0.96	1.17	7.07	12.71
Zinc (kg ha^{-1})										
0	99.1	61.1	11.6	13.0	24.7	227.4	11.8	13.3	108.8	245.8
2	107.0	66.9	12.6	11.7	27.2	244.3	12.8	15.6	130.9	216.7
4	114.6	72.4	12.3	13.4	28.7	258.3	13.1	15.8	150.9	257.9
6	111.1	72.5	11.7	12.4	26.8	251.1	12.2	13.8	153.2	283.8
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

The data (Table 2) show the effects of S and Zn addition on the uptake of nutrients (N,P,K,S and Zn) in grain and straw of barley.It is evident from the data that the addition of S and Zn, in general, increased significantly the uptake of N,P,K and S up to 40kg and 4.0 kg ha^{1} level of S and Zn, respectively.Whereas S and Zn application increased their uptake upto highest level i.e.40 kg S and 6.0 kg Zn, respectively.However,the uptakes of these nutrients were found statistically at par at 20 and 40 kg S and 4.0 and 6.0 kg Zn ha^{1} levels.The uptake values in grain and straw commensurate with the grain and straw yields at different levels of S and Zn.The highest total uptake of N,P,K and S at 40 kg S ha^{1} were 21.9, 32.7, 27.9 and 60.8 % higher than those of the lowest uptake values at control, respectively. Similar results were reported by Singh (2000) and Singh *et al.* (2014). This increase in uptake of nutrients may be attributed to incresed grain and straw yield with S addition. The Zinc uptake by grain and straw of barely increased with S addition over control.The Zn uptake increased from 127.0 g ha^{1} at central to 140.7 g ha^{1} with 20 kg S ha^{1}.The corresponding increase in straw was from 220.8 to 245.8 g ha^{1}.Zinc uptake by grain was reduced with 40kg S ha^{1} over 20kg S ha^{1}.Similar results were recorded by Kothori *et al.* (2005).The utilization of zinc by the crop increased significantly with increasing levels of zinc up to 6.0 kg Zn ha^{1}.This increase may be asscribed to higher yield of crop as well as improvement in zinc content of the crop due to zinc addition (Singh, 2010., Tripathi *et al.* 2015).

Table 3: Effect of sulphar and zinc levels on organic carbon (g kg^{1}) available N,P,K,S ($kgha^{1}$) and Zn($mgkg^{1}$) in soil after harvest of barley (mean of two years)

Treatment	Organic Carbon	Nitrogen	Phosphorus	Potassium	Sulphur	Zinc
Sulphar (kg ha^{-1})						
0	3.5	115.7	9.1	114.0	13.8	0.48
10	3.7	129.6	9.2	115.5	16.2	0.48
20	3.9	139.2	9.3	119.0	17.5	0.47
40	4.2	146.2	9.4	120.5	19.6	0.46
CD(P=0.05)	0.20	11.20	NS	2.93	1.02	NS
Zinc (kg ha^{-1})						
0	3.7	130.7	9.4	118.5	17.2	0.42
2	3.8	134.5	9.3	118.0	17.1	0.45
4	3.9	137.4	9.2	116.7	16.5	0.50
6	3.8	128.2	9.0	115.7	16.3	0.53
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 3.5 to 4.2 g kg^{-1} with 40 kg S ha^{-1}.Application of 4 kg Zn ha^{-1} proved beneficial in improving the status of organic carbon from 3.7 to 3.9 g kg^{-1} in the soil. The status of available N improved with S and Zn application. It increased from 115.7 $kgha^{-1}$ at control to 146.2 kg ha^{-1} with 40kg Sha^{-1}.The maximum amount of available N was recorded with 40 kg S ha^{-1}.The lower levels (2 and 4 $kgha^{-1}$) of zinc increased the amount of available N in soil and maximum value (137.4 kg ha^{-1}) was noted with 4 kg Zn ha^{-1}.The higher level (6kg Zn ha^{-1}) tended to decrease the available N in soil over lower level of zinc. Available P content in soil improved from 9.1 kg ha^{-1} in control to 9.4 kg ha^{-1} with of 40 kg S ha^{-1}.Similar results were observed by Sahay etal. (2009). 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 40 kg S ha^{-1}.The increase in available K status due to 40 kg S ha^{-1} over control was from 114.0 to 120.5 kg S ha^{-1}.Application of Zn decreased the available K status in the soil and minimum amount was noted with 6 kg Zn ha^{1}. There was a significant increase in available S content with its levels. The available sulphar status in soil increased from 13.8 to 19.6 kg ha^{-1} with 40 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 S levels over control. Application of Zn tended to increase the status of available Zn in soil significantly over control and maximum value of available Zn content in soil after the crop harvest was recorded with 6 kg Zn ha^{-1}. Singh (2000) 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 barley. Application of 20 kg S and 4 kg Zn ha^{-1} gave the highest values of grain and straw yields and protein content in barley.

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