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Interaction effect of sulphur and zinc in groundnut (*Arachis hypogaea*) and their availability in Tonk district of Rajasthan

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ABSTRACT

A field experiment was conducted during rainy (*kharif*) season 2001 and 2002 at research farm of Banasthali (Rajasthan), to evaluate the interaction effect of four levels each of sulphur (0, 20, 40 and 60 kg/ha) and zinc (0, 2.5, 5.0 and 7.5 kg/ha) on groundnut (*Arachis hypogaea* L.). From the groundnut-growing fields of Tonk district, 125 surface (0-15 cm) soil samples were collected randomly for estimating availabe of S and Zn. Total S and Zn contents in the soil varied from 142.0 to 232.0 kg/ha and 4.0 to 26.0 mg/kg with mean values of 170.2 kg/ha and 21.3 mg/kg respectively. The availability of 0.15 per cent $CaCO_3$-extractable S and DTPA-extractable Zn was 6.1-17.8 kg/ha and 0.31-0.81 mg/kg respectively. Out of the soils studied, 59 per cent were found deficient in S and 31 per cent in Zn. Application of 40 kg S/ha and 5 kg Zn/ha significantly increased the pod yield of groundnut. The positive and significant interaction between S and Zn resulted in highest pod yield of groundnut (2,251 kg/ha) at 40 kg S and 5 kg Zn/ha. Maximum benefit: cost ratio was recorded with the application of 40 kg S and 2.5 kg Zn/ha. The use effeciency of S and Zn decreased with increase in the level of S and Zn, and maximum use efficiency was recorded at lower levels of S and Zn application.

Key words: Groundnut, Sulphur, Zinc, Uptake, Availability

The increase in cropping intensity and accompanying changes in the soil and fertilizer-management practices have altered the S and Zn status of the soils and their availability. Groundnut (*Arachis hypogaea* L.) responds significantly to the application of S (Bahl *et al.*, 1986; Singh and Chaudhary, 1998), which is involved in the biosynthesis of primary metabolites for improving the yield and quantity of oilseed crops and for obtaining better yield under balanced fertilization. Sulphur is a constituent of some important amino acids, viz. cystein, cystine and methionine. It is necessary for chlorophyll formation and biosynthesis of oil, and plays an important role in synthesis for several enzyme systems that regulate growth in plants. Zinc is also vital for the oxidation processes in plant cells and helps in the transformation of carbohydrates and regulation of sugar in plants. Bahl *et al.* (1986) and Singh and Chaudhary (1998) reported that the combined application of S and Zn in groundnut has synergistic effect, whereas Shukla and Prasad (1979) reported antagonistic effect in pot studies of groundnut. Therefore an attempt was made to study the availability of S and Zn in the soils in groundnut-cultivated fields and their interaction effect on groundnut crop in old alluvial plains of Rajasthan.

MATERIALS AND METHODS

A field experiment was conducted on research farm of Banasthali on loamy-sand soil (Ustalfs) during rainy (*kharif*) season of 2001 and 2002. The test crop was groundnut 'RSB 87'. Physico-chemical composition of soil (0-15 cm) was: clay 14.2 per cent, silt 14 per cent, sand 71.1 per cent, pH 7.8, electrical conductivity (EC) 0.27 dS/m, organic carbon 0.29 per cent, $CaCO_3$ 0.67 per cent, alkaline $KMnO_4$-oxidizable N 114.0 kg/ha, available P 13.6 kg/ha, available K 262.0 kg/ha, available S 9.3 kg/ha and DTPA-extractable Zn 0.41 mg/kg. The treatments were four levels each of sulphur (0, 20, 40 and 60 kg/ha) and zinc (0, 2.5, 5.0 and 7.5 kg/ha). Each treatment was replicated thrice in randomized block design. The sources of S and Zn were gypsum and zinc sulphate respectively. Zinc was applied as per treatment mixed with 25 kg dry soil and was broadcast before the last ploughing. A basal recommended dose of 20 kg N/ha and 40 kg P_2O_5/ha was applied and the crop was sown on 3 July 2001 and 7 July 2002. The rainfall received during the crop season was 502 mm in 2001 and 447 mm in 2002. The pods (shell + kernel) were collected at maturity stage and analysed for S and Zn. The crop was harvested on 29 October 2001

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and 1 November 2002. The pod yield was recorded at harvest from each net plot (size 5 m × 5 m). Soil was sampled at 0-15 cm after harvesting the crop each year and was analysed for available S and Zn. The fertilizer use efficiency was calculated by the formula suggested by Carsesil and Godwin (1984). One hundred twenty four surface (0-15 cm) soil samples were collected randomly from groundnut-growing fields in Tonk district of Rajasthan. The total and available S were analysed by following the methods given by Tabatabai and Bremner (1970) and Chesnin and Yien (1951). Total Zn was analysed through digestion in perchloric acid, and available Zn was extracted with DTPA solution (Lindsay and Norvell, 1978) and estimated with the help of atomic-absorption spectrophotometer. Besides, the samples were analysed for pH, electrical conductivity, organic carbon and $CaCO_3$ content by using standard procedures.

RESULTS AND DISCUSSION

Availability of sulphur and zinc

The mean values and range for some selected soil properties, and the total and available S and Zn are given in Table 1. The soils of groundnut-cultivated fields were loamy sand, sandy loam and sandy in texture, and neutral to alkaline in reaction. In general, the soils were also low in soluble salts and organic carbon content.

The total and available S was 142.0 to 232.0 kg/ha and 6.1 to 17.8 kg/ha with mean values of 170.2 kg/ha and 9.7 kg/ha respectively. Considering less than 10 kg/ha of available S as critical limit (Mehta *et al.*, 1988), 59 per cent of the samples were deficient in available S. The total and available Zn content in the soil was 4.0 to 26.0 mg/kg and 0.31 to 0.81 mg/kg with mean values of 20.3 mg/ha and 0.72 mg/ha respectively. If the critical limit of 0.6 mg/kg is taken as the criterion, 31 per cent of the samples were deficient in Zn.

Pod yield of groundnut

Application of S up to 40 kg/ha significantly increased the pod yield in both the years, being on a par with that of 60 kg S/ha (Table 2). Application of 20, 40 and 60 kg S/ha increased the pod yield respectively by 16.5, 22.7 and 22.8 per cent during 2001 and by 19.1, 26.5 and 29.8 per cent during 2002 over the control. The application of S increased the yield mainly due to early flowering and greater pod setting. Addition of Zn also improved the pod yield of groundnut, but the effect was limited up to 5.0 kg Zn/ha, beyond which the response was almost static. The application of 2.5, 5.0 and 7.5 kg Zn/ha increased the pod yield respectively by 13.2, 18.7 and 23.1 per cent during 2001 and by 9.5, 16.7 and 16.8 during 2002 over the control. The interaction effect of S and Zn on the pod yield was significant and positive in both the years, the maximum yield (2,407 and 2,095 kg pods/ha in respective years) was obtained with the combined application of 40 kg S and 5.0 kg Zn/ha. Bahl *et al.* (1986) and Singh and Chaudhary (1998) also observed similarly.

Table 1. Chemical properties of surface (0-15 cm) soil in groundnut growing fields

Character	Range	Mean
pH	7.40-8.20	7.95
EC (dS/m)	0.12-0.56	0.23
Organic carbon (%)	0.12-0.65	0.21
$CaCO_3$ (%)	0.24-0.99	0.46
Total S (kg/ha)	142.0-232.0	170.70
Available S (kg/ha)	6.1-17.8	9.70
Total Zn (mg/kg)	4.0-26.0	20.30
Available Zn (mg/kg)	0.31-0.81	0.72

Table 2. Interaction effect of sulphur and zinc on pod yield (kg/ha) of groundnut

S (kg/ha)	Zn (kg/ha)				
	0	2.5	5.0	7.5	Mean
			2001		
0	1,580	1,802	1,982	2,025	1,847
20	1,935	2,220	2,237	2,217	2,152
40	2,017	2,264	2,407	2,380	2,267
60	2,061	2,306	2,381	2,325	2,268
Mean	1,898	2,148	2,252	2,337	
CD (P=0.05)		S and Zn = 69		S × Zn = 138	
			2002		
0	1,228	1,507	1,682	1,706	1,531
20	1,575	1,852	1,928	1,935	1,823
40	1,681	1,917	2,095	2,054	1,937
60	1,777	2,019	2,065	2,086	1,987
Mean	1,665	1,824	1,943	1,945	
CD (P=0.05)		S and Zn = 54		S × Zn = 108	

Sulphur and zinc uptake

The effect of S and Zn application on S uptake by groundnut pods increased significantly in both the years (Table 3). The increasing trend in S uptake was observed up to 60 kg S/ha and 5 kg Zn/ha. Further increase in the dose of Zn (7.5 kg/ha) did not affect its uptake. The S uptake was higher when it was applied in combination with Zn.

The application of Zn led to great increase in Zn uptake by pods (Table 4). The Zn uptake increased even with application of S alone. The interaction of S and Zn was significant for Zn uptake, which was maximum at higher levels of S and Zn. Singh and Chaudhary (1998) and Bahl *et al.* (1986) reported similar results in field experiments of groundnut. Shukla and Pradad (1979) reported that S application decreased the Zn uptake by groundnut grown

Table 3. Interaction effect of sulphur and zinc on uptake of sulphur (kg/ha) by pods (shell+kernel) of groundnut

S (kg/ha)	Zn (kg/ha)				
	0	2.5	5.0	7.5	Mean
			2001		
0	8.1	9.5	11.1	11.0	9.9
20	10.4	11.9	12.5	12.4	11.8
40	11.6	12.6	13.8	12.9	12.7
60	12.2	12.7	13.9	13.6	13.1
Mean	10.6	11.7	12.8	12.5	
CD (P=0.05)		S and Zn = 0.6		S×Zn = 1.1	
			2002		
0	8.2	10.1	11.0	11.2	10.0
20	10.1	11.6	11.9	11.7	11.3
40	11.7	12.0	12.6	12.4	12.2
60	12.1	12.4	12.8	12.9	12.6
Mean	10.5	11.5	12.1	12.1	
CD (P=0.05)		S and Zn = 0.4		S × Zn = 0.8	

Table 4. Interaction effect of sulphur and zinc on uptake of sulphur (kg/ha) by pods (shell+kernel) of groundnut

S (kg/ha)	Zn (kg/ha)				
	0	2.5	5.0	7.5	Mean
			2001		
0	94.7	130.2	141.3	158.9	131.1
20	110.4	133.5	170.5	175.4	147.5
40	116.1	155.8	177.8	180.7	157.6
60	120.2	165.7	180.7	179.4	161.6
Mean	110.4	146.3	167.6	173.6	
CD (P=0.05)		S and Zn = 10.9		S×Zn = 21.8	
			2002		
0	89.7	128.7	137.1	142.2	124.4
20	94.2	130.1	144.5	151.1	130.0
40	100.6	140.1	152.2	154.6	136.9
60	104.1	144.2	152.7	153.4	138.6
Mean	97.2	135.8	146.6	150.3	
CD (P=0.05)		S and Zn = 7.5		S × Zn = 15.0	

in pots.

Availability of sulphur and zinc

Application of S at 60 kg/ha significantly increased the available S status at harvest stage in the soil (Table 5). On an average, the available S increased from initial value of 9.3 to 10.3, 12.1 and 13.8 kg/ha respectively with the application of 20, 40 and 60 kg S/ha. Singh *et al.* (2000) reported increase in available S in the soil at harvest of lentil crop on its application. A decreasing trend of available S with Zn application up to 5 kg/ha was observed, after which it was almost static with 7.5 kg/ha.

Application of Zn significantly increased the available DTPA-Zn during both the years. Available Zn status at harvest was 0.36 to 0.38 mg/kg in the control plots and 0.77 to 0.87 mg/kg under 7.5 application. In addition of S, available Zn status significantly decreased up to 40 kg S/ha and thereafter it was on a par with that of 60 kg/ha.

Sulphur- and zinc-use efficiency

The S-use efficiency was highest (14.6 to 15.3 kg pod/kg S application) at 20 kg S/ha, but increase in its level showed a decreasing trend of S-use efficiency (Singh *et al.*, 2000). The S efficiency also decreased with increase in Zn level. Similarly, Zn-use efficiency was higher (99.9 to 103.4 kg pods/kg Zn applications) at 2.5 kg/ha, after which it decreased with increase in Zn level. Kumar and Singh (1979) also obtained similar results in soybean. Though S- and Zn-use efficiencies were high at low S and Zn levels, considering economic increase in the yield.

Benefit:cost ratio

The application of 20, 40 and 60 kg S/ha showed benefit:cost ratio (B:C) 12.5, 13.4 and 9.3 respectively (Table 5). Similarly, the application of 2.5, 5.0 and 7.5 kg

Table 5. Interaction effect of sulphur and zinc on its availability, use efficiency and benfit:cost ratio in groundnut

Treatment	Available S (kg/ha)		Avaialble Zn (kg/ha)		S-use efficiency (kg pods/kg S applied)		Zn-use efficiency (kg pods/kg Zn applied)		B:C ratio (mean of 2 years
	2001	2002	2001	2002	2001	2002	2001	2002	
S (kg/ha)									
0	8.8	8.5	0.79	0.84			76.2	88.7	
20	9.7	10.8	0.62	0.66	15.3	14.6	70.7	75.6	12.5:1
40	11.0	13.1	0.15	0.49	10.5	10.6	75.1	75.6	13.4:1
60	13.3	14.2	0.49	0.50	7.0	7.6	65.7	65.2	9.3:1
CD (P=0.05)	0.4	0.4	0.08	0.11					
Zn (kg/ha)									
0	11.7	13.4	0.38	036	12.2	12.6			
2.5	11.1	12.1	0.57	0.62	13.6	12.0	99.9	103.4	8.6:1
5.0	9.9	10.7	0.63	0.74	10.0	9.7	70.7	75.5	7.3:1
7.5	10.1	10.4	0.77	0.89	7.8	8.8	45.1	20.7	5.8:1
CD (P=0.05)	0.4	0.4	0.08	0.11					

Zn/ha showed B:C ratio 8.6, 7.3 and 5.8 respectively. Maximum B:C ratio was estimated with application of 40 kg S/ha, but increase in Zn level showed a decreasing trend of B:C ratio.

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