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Research Article

EFFECT OF SOURCES AND LEVELS OF SULPHUR ON YIELD AND MICRONUTRIENT (Fe, Mn, Zn and Cu) ABSORPTION BY GROUNDNUT (*Arachis hypogaea* L.)

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Abstract- The pot experiment comprising 20 treatment combinations was laid out in factorial CRD design with four different sources of sulphur (Cosawet sulphur, Gypsum, Bentonite sulphur and Elemental sulphur) with five levels of sulphur (0, 5, 10, 15, and 20 mg kg^{-1}). Groundnut variety GG-7 was tested in the experiment, in respect of yield, concentration and uptake of micro nutrient (Fe, Mn, Zn and Cu) at different growth stages of groundnut crop and their availability in post harvest soil. The experimental soils were *vertic haplustepts* medium black calcareous clayey which was slightly alkaline in reaction pH (7.8) and EC (0.58 dSm^{-1}) low available nitrogen (242 kg ha^{-1}) whereas, available phosphorus in medium range (39.20 kg ha^{-1}) and high available potash (336 kg ha^{-1}). The application of elemental sulphur resulted significantly highest yield, micro nutrient content and uptake except Mn in plant at 60 DAS and harvesting stage. Significantly highest micro nutrient concentration and uptake in plant were observed with 20 mg kg^{-1} (L_5) sulphur level. Based on the results obtained from the present investigation, it is concluded that maximum yield of *kharif* groundnut can be obtained with application of elemental sulphur at 20 mg kg^{-1} on medium black calcareous soil of South Saurashtra.

Keywords- Groundnut, yield, Sulphur, Sources, Levels, Content, uptake, micro nutrient.

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Introduction

Groundnut (*Arachis hypogaea* L.) is a major commercial oilseed crop of India, China, Brazil, Nigeria, and USA, In India; it is grown in about 35 % of the area and accounts for 40 % of the production of total oilseeds in the country. The total area under groundnut cultivation in India during 2011-12 was 5.26 million hectares and total production was 6.96 million tonnes with the productivity of 1323 Kg ha^{-1} and in Gujarat, it is grown on 1.68 million hectares area with production of 2.71 million tones and 1662 Kg ha^{-1} productivity. Wide spread Sulphur deficiencies have been reported in soils of India [1] as well as in Gujarat ranging from 15 to 56 percent as an average of 37 percent [2]. In recent survey, the status of available sulphur in soil of groundnut growing area is depleted in considerable amount because of less use of sulphur source fertilizers and intensive cultivation with high yielding varieties. Sulphur is become critical element not only for quality but also economic yield of crops. Sulphur is known to play an inevitable and imperative role in the synthesis of oil and is a constituent of proteins, vitamins and sulphur containing amino acids i.e. cysteine, cystine and methionin. Sulphur nutrition to crop is vital both from quality and quantity point of view. Sulphur lowers the HCN content of certain crops, promotes nodulation in legumes and produces heavier grains of oilseeds. Sulphur deficiency responsible for poor flowering, fruiting, and cupping of leaves, reddening of stem and petiole and stunted growth. Besides these, it is also used as soil management and uptake of another nutrient. Groundnut is main oilseed crops of Saurashtra region which occupy about 15 lakh ha, but its productivity is low and unstable (300 to 1600 kg/ha.) [3].

Materials and methods

A pot experiments was conducted during *kharif* 2012, to study the "effect of sources and levels of sulphur on yield and micronutrient (fe, mn, zn and cu) absorption by groundnut (*Arachis hypogaea* l.)" at Department of Agricultural Chemistry and Soil Science, College of Agriculture, Junagadh Agricultural University, Junagadh.

The experiments consisted of four sources of sulphur like Cosawet sulphur (S_1), Gypsum (S_2), Bentonite sulphur (S_3) and Elemental sulphur (S_4) with five levels (L_1:0, L_2:5, L_3:10, L_4:15, L_5:20 mg kg^{-1}.). The selection of sulphur sources based on the available sulphur percentage of that particular source. The available sulphur percentage of different sources are Cosawet sulphur (90 % sulphur), Gypsum (20 % sulphur), Bentonite sulphur (90 % sulphur) and Elemental sulphur (100 % sulphur). The experiment was laid out in a factorial completely randomized design with three replication. The levels of different sulphur sources @ (L_1:0, L_2:5, L_3:10, L_4:15, L_5:20 mg kg^{-1}.) apply at the time of sowing. There were 20 treatment combinations, each replicated three times. Sixty pots were filled in with each soil bulk of 15 kg soil, were the required quantity of sulphur was calculated on the basis of 15 kg bulk soil for each level.

All possible Treatment combinations

S_1L_1	S_2L_1	S_3L_1	S_4L_1
S_1L_2	S_2L_2	S_3L_2	S_4L_2
S_1L_3	S_2L_3	S_3L_3	S_4L_3
S_1L_4	S_2L_4	S_3L_4	S_4L_4
S_1L_5	S_2L_5	S_3L_5	S_4L_5

The plant samples were collected randomly at 60 DAS and at harvest. The plant samples oven dried at 55 to 65^{0}C till a constant weight was obtained. The plant sample was ground in a grinder cum mixer and the powdered samples were

stored in polyethylene bags for their chemical analysis. The known quantities of powdered samples were digested in a Diacid mixture. The micro nutrients content were determined by the flame photometer method described by Johnson and Ulrich (1969) [4]. The nutrient uptake was calculated by multiplying the concentration values with the respective total biological values of plant.

Results and Discussion

Effect of sulphur sources

Significantly the highest pod yield (13.14 g plant^{-1}) was registered with application of elemental sulphur (S_4) as compared to other sources. Application of elemental sulphur (S_4) produced significant effect on Fe (415.77 ppm and 397.07 ppm) and Zn (59.15 ppm and 57.47 ppm) content at 60 DAS and at harvesting stage respectively whereas, the increases in Mn (108.15 ppm and 106.26 ppm) content with application of bentonite sulphur (S_3). The effect of sulphur sources on Cu content in plant at 60 days and at harvest was found non-significant. The significantly highest uptake of Fe (8.62 mg plant^{-1} and 14.28 mg plant^{-1}), Zn (1.23 mg plant^{-1} and 2.08 mg plant^{-1}), and Cu (0.706 mg plant^{-1} and 1.20 mg plant^{-1}) with elemental sulphur (S_4) application at 60 DAS and at harvesting stage respectively. It is known that addition of elemental S due to microbial decomposition gets converted to sulphuric acid which inturn reduces soil PH and increases Fe availability. Elemental sulphur (S_4) produced significantly higher Mn uptake (2.19 mg plant^{-1}) at 60 DAS, whereas bentonite sulphur (S_3) produced significantly higher Mn uptake (3.80 mg plant^{-1}) at harvesting stage and it was remaining at par with elemental (S_4) sulphur (3.77 mg plant^{-1}).

Effect of sulphur levels

Application of 20 mg kg^{-1} (L_5) sulphur level produced significantly the highest pod yield (13.56 g plant^{-1}). The application of sulphur might have helped in the release of available nutrients from soil and thus higher uptake by the crop was noticed, higher nutrients uptake increased vegetative growth of the plant. Significantly increased the Fe content (419.01 ppm and 394.62 ppm), Mn content (109.96 ppm and 107.97 ppm) and Zn (60.89 ppm and 59.25 ppm) at 60 DAS and at harvesting stage with application of 20 mg kg^{-1} sulphur (L_5) respectively over control. The significantly higher Cu content was obtained with application of 15 mg kg^{-1} (L_4) sulphur (34.31 ppm) at 60 DAS. The significantly highest uptake of Fe (8.70 mg plant^{-1} and 14.93 mg plant^{-1}), Mn (2.28 mg plant^{-1} and 4.13 mg plant^{-1}), Zn (1.26 mg plant^{-1} and 2.27 mg plant^{-1}) and Cu (0.688 mg plant^{-1} and 1.27 mg plant^{-1}) with application of sulphur @ 20 mg kg^{-1} (L_5). Application of sulphur resulted in increased concentration of micronutrients in groundnut crop, which might have caused synergistic effect on the availability of these nutrients and hence resulted in increased concentration of these micronutrients in groundnut crop.

Interaction effect of sulphur sources and levels

Interaction effects between sources and levels of sulphur for yield indicated that increase level of sulphur through elemental sulphur more yield obtained over use of other remained sources. The Fe and Zn content obtain significantly highest with application of elemental sulphur @ 20 mg kg^{-1}, whereas Mn and Cu content was non-significant at both the stage of crop. Application of elemental sulphur @ 20 mg kg^{-1} produced significant effect on uptake of micronutrient (Fe, Mn, Zn, and Cu). This increase in uptake of nutrients by the crop was attributed to improved physical and chemical properties of the rhizosphere of the crop which resulted due to application of sulphur.

Table-1 *Interaction effect of sulphur sources and levels on pod yield (g/plant) of groundnut*

Treatment	S_1 (Cosawet)	S_2 (Gypsum)	S_3 (Bentonite)	S_4 (E.sulphur)	Mean of levels
L_1-0 mg kg^{-1}	9.87	9.58	10.90	10.40	10.19
L_2-5 mg kg^{-1}	10.71	9.94	10.98	12.35	11.00
L_3-10 mg kg^{-1}	11.39	10.96	11.99	13.79	12.03
L_4-15 mg kg^{-1}	11.62	11.59	11.90	14.20	12.33
L_5-20 mg kg^{-1}	12.68	13.81	12.78	14.95	13.56
Mean of sources	11.25	11.18	11.71	13.14	
Treatment	Levels (L)		Sources (S)		L X S
S.Em.+	0.11		0.10		0.22
C.D. (P=0.05)	0.32		0.29		0.64
C.V.%	3.28				

Table-2 *Effect of sulphur sources and levels on micro nutrient (Fe, Mn, Zn and Cu) content (ppm) of groundnut*

Treatments	Fe content (ppm)		Mn content (ppm)		Zn content (ppm)		Cu content (ppm)	
	60 DAS	At harvest	60 DAS	At harvest	60 DAS	At harvest	60 DAS	At harvest
Sulphur Sources (S)								
S_1 (Cosawet) sulphur)	412.15	381.79	104.75	103.93	58.00	56.28	31.84	32.83
S_2 (Gypsum)	411.43	386.31	106.08	103.71	57.98	56.31	32.48	32.54
S_3 (Bentonite) sulphur)	409.21	385.38	108.15	106.26	58.14	56.77	32.58	31.82
S_4 (E.sulphur)	415.77	397.07	105.73	103.85	59.15	57.47	33.84	33.00
S.Em.+	0.51	0.71	0.64	0.66	0.11	0.11	0.67	0.52
C.D. (P=0.05)	1.47	2.02	1.83	1.88	0.33	0.32	NS	NS
Sulphur levels (L)								
L_1-0 mg kg^{-1}	404.98	379.20	102.46	101.16	53.55	53.26	30.20	30.92
L_2-5 mg kg^{-1}	408.90	386.44	104.44	102.30	58.09	55.80	32.38	31.41
L_3-10 mg kg^{-1}	412.52	388.18	106.23	104.60	59.03	57.05	33.44	33.25
L_4-15 mg kg^{-1}	415.25	389.73	107.80	106.18	60.30	58.18	34.31	33.82
L_5-20 mg kg^{-1}	419.06	394.62	109.96	107.97	60.89	59.25	33.10	33.35
S.Em.+	0.57	0.79	0.72	0.74	0.13	0.12	0.75	0.58
C.D. (P=0.05)	1.64	2.26	2.04	2.10	0.37	0.36	2.13	1.66
S x L Interaction								
S.Em.+	1.15	1.58	1.43	1.47	0.26	0.25	1.49	1.16
C.D. (P=0.05)	3.28	4.51	NS	NS	0.75	0.73	NS	NS
C.V.%	0.48	0.71	2.33	2.44	0.78	0.78	7.92	6.19

Table-3 *Effect of sulphur sources and levels on micro nutrient (Fe, Mn, Zn and Cu) uptake (mg plant^{-1}) by groundnut*

Treatments	Fe uptake (mg plant^{-1})		Mn uptake (mg plant^{-1})		Zn uptake (mg plant^{-1})		Cu uptake (mg plant^{-1})	
	60 DAS	At harvest	60 DAS	At harvest	60 DAS	At harvest	60 DAS	At harvest
Sulphur Sources (S)								
S_1 (Cosawet) sulphur)	6.64	13.65	1.684	3.55	0.935	1.922	0.514	0.033
S_2 (Gypsum)	7.67	12.87	1.978	3.45	1.083	1.876	0.606	1.089
S_3 (Bentonite) sulphur)	8.03	13.78	2.124	3.80	1.145	2.030	0.641	1.132
S_4 (E.sulphur)	8.62	14.28	2.194	3.77	1.230	2.088	0.706	1.200
S.Em.+	0.08	0.08	0.012	0.02	0.013	0.015	0.003	0.011
C.D. (P=0.05)	0.23	0.23	0.036	0.07	0.037	0.043	0.009	1.119
Sulphur levels (L)								
L_1-0 mg kg^{-1}	6.21	11.94	1.568	3.18	0.821	1.670	0.463	0.973
L_2-5 mg kg^{-1}	7.51	13.81	1.913	3.46	1.065	1.883	0.595	1.065
L_3-10 mg kg^{-1}	8.02	13.54	2.065	3.64	1.147	1.985	0.651	1.155
L_4-15 mg kg^{-1}	8.29	14.02	2.150	3.81	1.196	2.090	0.688	1.210
L_5-20 mg kg^{-1}	8.70	14.93	2.280	4.13	1.263	2.270	0.688	1.273
S.Em.+	0.09	0.09	0.014	0.02	0.014	0.017	0.003	0.012
C.D. (P=0.05)	0.26	0.26	0.041	0.08	0.041	0.048	0.010	0.036
S x L Interaction								
S.Em.+	0.18	0.18	0.028	0.05	0.029	0.034	0.007	0.025
C.D. (P=0.05)	0.52	0.52	0.082	0.17	0.083	0.097	0.021	0.073
C.V.%	4.08	2.31	2.506	2.84	4.623	2.989	2.112	3.940

Conclusion

it is concluded that maximum yield and micronutrient absorption of *kharif* groundnut can be obtained with application of elemental sulphur at 20 mg kg^{-1}.

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Abbreviations:

@ : At the rate of
C.D. : Critical difference
C.V. : Coefficient of variation
CEC : Cation Exchange Capacity
Cu : Copper
CEC : Cation Exchange Capacity
Fe : iron
g : gram
ha : Hectare
NS : Non-significant
Mn : Manganese
Mg : Milligram
S.Em. : Standard Error of means

Conflict of Interest: None declared

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