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Effect of different sources of sulphur on uptake of nutrients and sulphur use efficiency by sunflower genotypes grown in black soils

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Abstract
An experiment was conducted to study the effect of different sources of sulphur (Elemental sulphur, gypsum and pyrites) on the uptake of nutrients by sunflower genotypes. The uptake of N, P, K, S and sulphur use efficiency by shoot at 45 DAS, harvest stage and by seed was significantly more with the gypsum > pyrites > elemental sulphur. The genotypes also significantly differed in the uptake. More nutrient uptake was observed in Ganga kalyani-2002 than 6460 PH-1.

Keywords: Sulphur, gypsum, pyrites, elemental sulphur, sunflower, nutrients uptake and sue

Introduction
Oilseeds, legumes, crucifers and forages are among the crops which have a relatively high requirement of sulphur and particularly sensitive to sulphur deficiency. Sunflower being an oilseed crop needs higher sulphur content as compared to cereals and legumes as sulphur is required for production of oil quality protein through synthesis of amino acids such as cystine, cysteine and methionine.

The intensification of agriculture with high yielding crop varieties and multiple cropping coupled with the use of high analysis sulphur free fertilizers along with restricted use of organic manures have accrued in depletion of the soil sulphur reserve. Hence, the present experiment was conducted to study the effect of indigenous sources of sulphur such as gypsum, pyrites and elemental sulphur on sunflower genotypes in order to recommend best source of sulphur to sunflower.

Materials and methods
This experiment was conducted using two genotypes (Ganga Kalyani-2002 and 6460 PH-1) in black soils having pH of 8.00 and E.C 0.48 dSm^{-1}. The soil is low in organic carbon (0.49 %) and has initial content of 214.30 kg ha^{-1} of available nitrogen, 19.46 kg ha^{-1} of phosphorus, 310.67 kg $ha^{-1}$of potassium and 20.16 kg ha^{-1} of sulphur. The experimental design adopted was RBD with factorial concept. Recommended dose of nitrogen @ 30 kg ha^{-1} in the form of urea di- ammonium phosphate (DAP), phosphorus @ 60 kg ha^{-1} P_2O_5 ha^{-1} in the form of DAP and potassium @ 30 kg K_2O ha^{-1} in the form of muriate of potash were applied as basal dose. Nitrogen @ 35 kg ha^{-1} was top dressed in two splits in the form of urea. Sulphur was applied @ 40 kg ha^{-1} through the above three sources. Treatments were replicated six times. Elemental sulphur and pyrites were applied one month before sowing while gypsum was applied before sowing of seeds. Plants were harvested from three replications at 45 DAS and plants from the remaining three replications were harvested at maturity stage. They were dried, powdered and were digested with diacid mixture (9:4). They were analysed for N, P, K and S both in shoot and seed by Microjeldahl method, Vanadomolybdo phosphoric yellow colour method, Flame photometer and Turbidity method, respectively. Uptake of various nutrients was computed by using the following formula:

$$\text{Uptake of nutrient Per pot (mg pot}^{-1}) = \frac{\text{Percent concentration of nutrient x dry weight of plant per pot}}{100} \times 1000$$

Sulphur use efficiency was calculated using the formula:

$$\text{SUE} = \frac{\text{Uptake of sulphur in treatment} - \text{uptake of sulphur in control}}{\text{Quantity of sulphur added}} \text{ X100}$$

The quantity of sulphur added is 40 kg ha^{-1} *i.e* recommended dose of sulphur to sunflower. The data were statistically analysed following the analysis of variance method described by Panse and Sukatme (1978). Statistical significance was tested by applying F-test at 0.05 level of probability. The data was represented in the respective tables as mean values of three replications both at 45 DAS and at harvest.

Results and discussions

Results (Table 1) indicated that the sulphur applied through different sources increased the uptake of nutrients (N, P, K and S) by different parts of sunflower (shoot and seed) at various stages of crop. Increased uptake of nutrients over control was mainly due to increase in drymatter, seed yield and concentration of nutrients in different plant parts with the application of sulphur through different sources.

Table 1: Effect of different sources of sulphur on the uptake of major nutrients by sunflower grown in black soil

Particulars	Dry matter (gpot^{-1})		Seed yield (gpot^{-1})	N-Uptake (mg pot^{-1})			P-Uptake (mg pot^{-1})			K-Uptake (mg pot^{-1})		
	At 45 DAS	At harvest		At 45 DAS	At harvest		At 45 DAS	At harvest		At 45 DAS	At harvest	
				Stalk	Stalk	Seed	Stalk	Stalk	Seed	Stalk	Stalk	Seed
Treatments												
Control (T1)	5.57	7.59	4.93	119.79	126.92	145.58	11.01	9.74	12.86	76.31	141.88	36.52
Elemental sulphur (T2)	6.63	9.41	6.02	157.07	179.20	188.57	15.41	15.00	19.98	107.61	193.05	46.91
Pyrites (T3)	7.15	10.15	6.48	178.57	210.00	212.73	17.74	18.23	24.05	121.69	216.23	51.87
Gypsum (T4)	8.54	12.31	8.08	228.23	280.26	288.00	23.30	26.21	34.08	159.63	281.54	67.13
S.Em+	0.23	0.23	0.12	6.90	8.98	7.77	0.71	0.95	1.26	4.53	7.59	1.60
C.D (0.05)	0.72	0.70	0.39	20.92	27.22	23.56	2.15	2.90	3.82	13.74	23.00	4.85
Genotypes												
6460 PH-1(V1)	6.60	9.45	5.86	159.17	186.40	189.66	13.41	13.47	19.68	104.08	190.69	46.05
Ganga Kalyani-2002(V2)	7.34	10.27	6.87	182.65	211.79	227.77	20.32	21.12	25.80	128.53	225.65	55.20
S.Em+	0.16	0.16	0.09	4.88	6.35	5.49	0.50	0.67	0.89	3.20	5.36	1.13
C.D (0.05)	0.51	0.49	0.27	14.79	19.25	16.66	1.52	2.05	2.70	9.71	16.26	3.43
Interaction												
T1V1	5.23	7.23	4.43	110.55	117.50	129.35	8.88	7.34	11.07	66.60	128.52	32.33
T1V2	5.91	7.95	5.43	129.03	136.35	161.81	13.15	12.15	14.66	86.02	155.25	40.72
T2V1	6.23	9.05	5.63	144.94	168.63	173.96	11.63	10.78	16.89	95.22	177.10	43.35
T2V2	7.04	9.78	6.41	169.32	189.77	203.19	19.20	19.22	23.07	120.00	209.00	50.63
T3V1	6.81	9.75	6.10	167.62	197.06	197.03	13.87	14.90	21.35	109.83	198.72	48.19
T3V2	7.49	10.55	6.86	189.52	222.95	228.43	21.62	21.57	26.75	133.56	233.74	55.56
T4V1	8.15	11.78	7.36	213.59	262.41	258.33	19.29	20.87	29.44	144.69	258.44	60.35
T4V2	8.93	12.82	8.80	242.88	298.11	317.68	27.32	31.55	38.72	174.57	304.64	73.92
S.Em+	0.33	0.32	0.18	9.76	12.70	10.99	1.00	1.35	1.78	6.41	10.73	2.26
C.D (0.05)	1.02	0.98	0.54	29.58	38.48	33.31	3.04	4.10	5.39	19.43	32.52	6.85

Increased uptake of nitrogen over control indicates the synergism between sulphur and nitrogen in nutrition, thus indicating the maintenance of ionic balance in the plant system for favorable increase in yield (Aulakh *et al*. 1977) [1]. More uptake of P resulted from enhanced mobilization of soil P in the presence of sulphur thereby enhanced efficiency of native and applied P due to decrease in pH and its utilization by crops. This was also reported by Raikhy *et al*. (1985) [8] and Tiwari *et al*. (1984) [17]. Similar results on increase in uptake of N, P and K by sulphur application were also reported by Sreemannarayana *et al.* (1998) [13] in sunflower, Das and Das (1994) [3] in rapeseed and Raikhy *et al*. (1985) [8] in cowpea.

It was also observed from the results (Table 2) that sulphur uptake and sulphur use efficiency (SUE) also increased with the application of different sources. Higher availability of sulphur with significant increase in protein content due to greater synthesis of sulphur containing amino acids might have resulted in more uptake of sulphur and thereby SUE with the application of sulphur. Further soil available sulphur increased markedly with corresponding increase in uptake with the added sources. This was also reported by Surender Singh *et al.* (1992) [16], Sreemannarayana and Sreenivasa Raju (1995) [5] and Sreemennarayana *et al.* (1998) [13] in sunflower.

Gypsum proved more effective than pyrites and elemental sulphur in the uptake of nutrients and SUE. This was because of easily available sulphate sulphur in gypsum than other two sources which helped in increasing drymatter. The superiority of pyrites over elemental sulphur may be due to its iron and other micronutrients as impurities which helped in better growth. Similar results of superiority of gypsum over pyrites were also reported by Karwasra and Raj (1984) [5] in greengram and superiority of gypsum over elemental sulphur was proved by Singh and Singh (1984) [12], and Sharma *et al*. (1991) [10] in mustard and Shivaraj and Gowda (1993) [11] in groundnut. Superiority of gypsum over both pyrites and elemental sulphur was proved by Hariram and Dwivedi (1992) [4] in chickpea.

From the results (Tables 1 & 2), it can be clearly observed that more uptake of nutrients were recorded at harvest than at 45 DAS on overall. More uptake of N at harvest was because of more biomass production. However, more P uptake recorded in shoot at 45DAS than at harvest even though increase in drymatter was observed at harvest. This was because of more translocation of P to seed compared to other nutrients. Unlike P, K uptake by shoot at harvest was much more than at 45 DAS and this was probably due to poor translocation of K to seed when compared to N and P. Peter *et al.*,(1983) [7] and Aulakh *et al.*, (1985) [2] also reported higher concentration of K in vegetative portion of plant.

Table 2: Effect of different sources of sulphur on sulphur uptake and sulphur use efficiency by Sunflower grown in black soils

Particulars	S-Uptake (mg pot^{-1})			Sulphur use efficiency (%)	
	At 45 DAS	At harvest		At 45 DAS	At harvest
	Stalk	Stalk	Seed		
Treatments					
Control (T1)	9.52	10.97	10.89	0.00	0.00
Elemental sulphur (T2)	14.14	17.69	16.28	9.63 (2.82)	15.40 (7.09)
Pyrites (T3)	15.81	19.89	18.83	11.24 (3.86)	18.29 (9.89)
Gypsum (T4)	21.03	27.11	25.92	15.34 (7.06)	25.23 (18.23)
S.Em+	0.52	0.71	0.81	0.49	0.90
C.D (0.05)	1.58	2.15	2.48	1.48	2.75
Genotypes					
6460 PH-1(V1)	13.71	17.25	15.95	11.70 (4.31)	19.06 (11.02)
Ganga Kalyani-2002(V2)	16.54	20.57	20.01	12.43 (4.85)	20.21 (12.45)
S.Em+	0.36	0.50	0.57	0.34	0.64
C.D (0.05)	1.11	1.52	1.75	NS	NS
Interaction					
T1V1	8.43	9.79	9.30	0.00	0.00
T1V2	10.62	12.15	12.48	0.00	0.00
T2V1	12.69	16.17	14.63	9.28 (2.60)	15.12 (6.85)
T2V2	15.60	19.22	17.94	9.98 (3.04)	15.68 (7.34)
T3V1	14.45	18.21	17.08	10.94 (3.68)	17.96 (9.50)
T3V2	17.17	21.57	20.58	11.54 (4.04)	18.63 (10.29)
T4V1	19.29	24.85	22.81	14.89 (6.66)	24.12 (16.72)
T4V2	22.77	29.37	29.04	15.79 (7.47)	26.34 (19.74)
S.Em+	0.73	1.00	1.15	0.68	1.28
C.D (0.05)	2.23	3.04	3.50	2.06	3.88

Note: Values in parenthesis are original values and without parenthesis are Transformed Arc Sin Percentage values

Uptake of sulphur by shoot at harvest was not much more than by shoot at 45 DAS even though increase in drymatter was recorded like phosphorus. This was because of reduction in sulphur content from flowering to maturity stage which can be attributed to higher quantity of sulphur activity at earlier stages (Sreemennarayana *et al.*, 1994) [14].

Sulphur use efficiency was more at harvest than at 45 DAS. Seed recorded higher sulphur content than straw which may be due to mobility of sulphur from straw to seed due to high demand resulted in more uptake and sulphur use efficiency at later stages. This more use efficiency corresponding with high sulphur uptake was also reported by Raju and Sreemannarayana (1997) [9] in a review article on castor which was more at maturity than at flowering.

Sunflower genotypes showed significant variation in nutrient uptake. Ganga Kalyani-2002 proved superior to 6460 PH-1. Differential response by genotypes may be due to their genetic variation and also their sulphur requirement (Tripathi and Sharma, 1993) [18].

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