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Impact of different sources of sulphur on micronutrient uptake by sunflower (*Helianthus annuus* L.) genotypes grown in alfisols and vertisols

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Abstract
An experiment was conducted to study the influence of different sources of sulphur such as gypsum, pyrites and elemental sulphur on micronutrients uptake by sunflower (*Helianthus annuus* L.) using two varieties such as Ganga Kalyani-2002 and 6460 PH-1 grown in Alfisols and Vertisols. Results indicated that the uptake of micronutrients such as iron, manganese, zinc and copper by sunflower shoot at 45 DAS, shoot and seed at harvest was significantly higher over control with the application of different sources of sulphur and followed the order gypsum>pyrites>elemental sulphur>control. Ganga Kalyani-2002 performed better than 6460 PH-1.

Keywords: Sulphur, gypsum, pyrites, elemental Sulphur, sunflower, alfisols, vertisols and micronutrient uptake

Introduction

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. 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.
A number of fertilisers are available to provide the sulphur to plants. But they are not sufficient to meet the requirements of sulphur. Hence, there is a need to evaluate some sulphate sources that are available as byproducts from industrial processes such as elemental sulphur, gypsum and pyrites for improving the sulphur nutrition and productivity of crops. Hence, the present experiment was conducted to study the effect of indigenous sources of sulphur such as gypsum, pyrites and elemental sulphur on micro nutrient uptake by sunflower (*Helianthus annuus* L.) genotypes grown in both Alfisols and Vertisols in order to recommend best source of sulphur to sunflower.

Methods and Materials

This experiment was conducted in two types of soils i.e. Alfisols and Vertisols using two genotypes (Ganga Kalyani-2002 and 6460 PH-1). Nutrient status of experimental soils are given in Table 1. The experimental design adopted was RBD with factorial concept. Recommended doses of N @ 30 kg ha^{-1} in the form of urea and DAP (Diammonium phosphate), P @ 60 kg ha^{-1} in the form of DAP and K @ 30 kg ha^{-1} in the form of mureate 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 the age of 45 DAS and plants from the remaining three replications were harvested at maturity stage, dried and powdered. Micronutrients were estimated from DTPA extract using Atomic Absorption Spectrophotometer. Uptake of nutrients was calculated using formula:

$$\text{Uptake of nutrient Per pot (mg pot}^{-1}) = \frac{\text{Percent concentration of nutrient x dry weight of plant per pot}}{100} \text{X1000}$$

Table 1: Physical, physico-chemical and chemical properties of the experimental soils

Property	Alfisols	Vertisols
PH (1:2.5 soil water ratio)	6.50	8.00
E C (dSm^{-1})	0.26	0.48
Texture	Sandy loam	Clay
Organic carbon (%)	0.40	0.49
Available nitrogen (kg ha^{-1})	195.52	214.30
Available phosphorus (kg ha^{-1})	16.20	19.46
Available potassium (kg ha^{-1})	300.29	310.67
DTPA extractable iron (ppm)	11.20	9.33
DTPA extractable manganese (ppm)	12.05	8.86
DTPA extractable zinc (ppm)	1.37	1.98
DTPA extractable copper (ppm)	1.82	2.20

Results Discussions

Application of different sources of sulphur increased the uptake of micronutrients such as Fe, Mn, Cu and Zn by shoot at 45 DAS and shoot and seed of sunflower at harvest significantly over control both in Alfisols (Table-3) and Vertisols (Table-4). Increase in nutrient concentration, drymatter yield and seed yield (Table 2) resulted in more uptake of micronutrient cations. Increased efficiency of sunflower with sulphur application utilized more nutrients because of increased growth and vigor (Sreemannarayana *et al.* 1998) [6]. The positive effect of sulphur might be due to more solubilisation and mobilization of zinc, iron and copper in the presence of sulphate ions (Singh and Ram, 1992) [3]. Further this increased uptake with sulphur application over control suggests a sort of synergism between sulphur and micronutrients. Similar results were also reported by Sreemannarayana and Sreenivasa Raju (1995) [5] and Gangadhara *et al.* (1990) [1].

The uptake was more at harvest than at 45 DAS. Among the sources, gypsum and pyrites are superior to elemental sulphur and there was no significant difference between gypsum and pyrites. The values were given in Table 3 for Alfisols and Table 4 for Vertisols. Increased uptake of micronutrients with gypsum and pyrites was might be due to the fact that the micronutrient concentration in plant tissues increased with the application of sulphur through gypsum and pyrites. As gypsum is having easily available sulphate sulphur, it increased the uptake of micronutrients more than other sources. Kaul *et al.* (1978) [2] also reported an increase in the concentration of these ions in the plant tissue due to the application of pyrites. This was because pyrites not only contains these micronutrients as impurities, but also enhances the availability of native nutrients which has got significance in the soils (Singh and Sinha, 1977 and Verma and Abrol, 1980) [4, 8].

Among the genotypes, Ganga Kalyani-2002 resulted in more uptake of micronutrients than 6460 PH-1. Differential response by genotypes may be due to their genetic variation and also their sulphur requirement (Tripathi and Sharma, 1993) [7].

Table 2: Effect of different sources of sulphur on drymatter and seed yield of sunflower grown in Alfisols and Vertisols

Particulars	Alfisols			Vertisols		
	Dry matter ($gpot^{-1}$)		Seed yield ($gpot^{-1}$)	Dry matter ($gpot^{-1}$)		Seed yield ($gpot^{-1}$)
	At 45 DAS	At harvest		At 45 DAS	At harvest	
Treatments						
Control (T1)	5.24	7.22	4.55	5.57	7.59	4.93
Elemental sulphur (T2)	6.21	8.82	5.45	6.63	9.41	6.02
Pyrites (T3)	6.92	9.74	6.21	7.15	10.15	6.48
Gypsum (T4)	8.17	11.85	7.65	8.54	12.31	8.08
S.Em±	0.22	0.30	0.23	0.23	0.23	0.12
C.D (0.05)	0.67	0.9	0.72	0.72	0.70	0.39
Genotypes						
6460 PH-1(V1)	6.22	9.02	5.41	6.60	9.45	5.86
Ganga Kalyani-2002(V2)	7.06	9.73	6.51	7.34	10.27	6.87
S.Em±	0.15	0.21	0.16	0.16	0.16	0.09
C.D (0.05)	0.48	0.65	0.51	0.51	0.49	0.27
Interaction						
T1V1	4.92	7.03	4.05	5.23	7.23	4.43
T1V2	5.57	7.41	5.06	5.91	7.95	5.43
T2V1	5.82	8.25	5.00	6.23	9.05	5.63
T2V2	6.66	9.12	5.90	7.04	9.78	6.41
T3V1	6.47	9.25	5.80	6.81	9.75	6.10
T3V2	7.37	10.24	6.63	7.49	10.55	6.86
T4V1	7.69	11.55	6.80	8.15	11.78	7.36
T4V2	8.65	12.15	8.45	8.93	12.82	8.80
S.Em±	0.31	0.43	0.32	0.33	0.32	0.18
C.D (0.05)	0.96	1.30	0.97	1.02	0.98	0.54

Table 3: Effect of different sources of sulphur on the uptake of micronutrients by sunflower grown in Alfisols

Particulars	Fe-Uptake (mg pot^{-1})			Mn-Uptake (mg pot^{-1})			Zn-Uptake (µg pot^{-1})			Cu-Uptake ((µg 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	Stalk	Stalk	seed
Treatments												
Control (T1)	2.51	3.80	1.50	1.52	2.27	1.41	108.16	122.95	200.92	90.14	98.39	100.71
Elemental sulphur (T2)	3.29	5.19	2.13	2.12	3.23	1.91	149.03	173.44	272.95	138.41	165.91	158.50
Pyrites (T3)	3.78	5.91	2.55	2.48	3.74	2.30	183.63	200.22	323.59	159.99	191.90	193.08
Gypsum (T4)	4.09	6.46	2.75	2.57	4.04	2.44	180.87	212.35	359.20	160.05	192.15	199.07

S.Em±	0.13	0.20	0.12	0.11	0.14	0.12	8.24	8.74	15.74	6.88	8.37	9.17
C.D (0.05)	0.40	0.63	0.36	0.34	0.43	0.36	24.97	26.50	47.71	20.86	25.36	27.80
Genotypes												
6460 PH-1(V1)	3.13	5.08	1.97	1.97	3.12	1.77	139.55	163.16	256.93	122.48	148.45	142.27
Ganga Kalyani-2002(V2)	3.70	5.60	2.49	2.37	3.51	2.25	171.29	191.31	321.39	151.83	175.71	183.42
S.Em±	0.09	0.14	0.08	0.08	0.10	0.08	5.82	6.18	11.13	4.86	5.91	6.48
C.D (0.05)	0.28	0.45	0.26	0.24	0.31	0.26	17.66	18.73	33.74	14.75	17.93	19.66
Interaction												
T1V1	2.31	3.65	1.29	1.38	2.15	1.21	96.83	113.81	174.15	79.99	89.85	85.05
T1V2	2.72	3.96	1.72	1.67	2.39	1.61	119.50	132.09	227.70	100.38	106.93	116.38
T2V1	3.02	4.95	1.90	1.93	3.05	1.70	133.92	160.16	245.00	124.00	152.88	140.00
T2V2	3.56	5.44	2.36	2.32	3.42	2.12	164.14	186.72	300.90	152.82	178.94	177.00
T3V1	3.45	5.53	2.32	2.25	3.47	2.08	164.70	181.70	295.80	142.74	173.80	174.00
T3V2	4.11	6.30	3.78	2.72	4.02	2.52	202.56	218.75	351.39	177.24	210.00	212.16
T4V1	3.77	6.20	2.38	2.34	3.84	2.10	162.75	197.00	312.80	143.22	177.30	170.00
T4V2	4.42	6.73	3.12	2.80	4.24	2.78	198.99	227.70	405.60	176.88	207.00	228.15
S.Em±	0.18	0.29	0.16	0.15	0.20	0.17	11.65	12.36	22.27	9.73	11.83	12.97
C.D (0.05)	0.56	0.90	0.52	0.48	0.62	0.52	35.32	37.47	67.48	29.50	35.86	39.32

Table 4: Effect of different sources of sulphur on the uptake of micronutrients by sunflower grown in Vertisols

Particulars	Fe-Uptake (mg pot^{-1})			Mn-Uptake (mg pot^{-1})			Zn-Uptake (µg pot^{-1})			Cu-Uptake ((µg 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	Stalk	Stalk	Seed
Treatments												
Control (T1)	2.70	4.06	1.68	1.66	2.44	1.53	118.75	135.45	222.35	100.06	109.71	113.89
Elemental sulphur (T2)	3.55	5.62	2.40	2.31	3.53	2.17	164.06	193.05	307.41	152.77	185.02	180.99
Pyrites (T3)	4.00	6.21	2.72	2.58	3.97	2.46	194.53	216.23	344.09	170.25	207.59	207.74
Gypsum (T4)	4.34	6.68	2.99	2.75	4.26	2.67	195.83	229.49	388.56	174.11	208.67	218.88
S.Em±	0.12	0.17	0.10	0.08	0.13	0.09	8.98	7.60	12.03	5.67	7.31	8.41
C.D (0.05)	0.37	0.52	0.30	0.25	0.40	0.27	27.23	23.00	36.45	17.20	22.15	25.50
Genotypes												
6460 PH-1(V1)	3.38	5.31	2.19	2.14	3.31	1.97	153.25	176.74	284.88	135.21	161.65	160.29
Ganga Kalyani-2002(V2)	3.91	5.97	2.70	2.51	3.79	2.44	183.49	210.37	346.32	163.37	193.84	200.45
S.Em±	0.08	0.12	0.07	0.05	0.09	0.06	6.35	5.36	8.50	4.01	5.17	5.95
C.D (0.05)	0.26	0.36	0.21	0.17	0.28	0.19	19.26	16.26	25.77	12.16	15.66	18.03
Interaction												
T1V1	2.46	3.80	1.46	1.50	2.26	1.33	106.56	122.40	194.92	88.80	97.92	97.46
T1V2	2.93	4.32	1.90	1.82	2.63	1.73	131.56	148.50	249.78	111.32	121.50	130.32
T2V1	3.27	5.31	2.19	2.11	3.31	1.97	148.12	177.10	281.50	137.54	169.40	163.27
T2V2	3.84	5.93	2.62	2.52	3.76	2.37	180.00	209.00	333.32	168.00	200.64	198.71
T3V1	3.75	5.87	2.50	2.42	3.72	2.25	179.18	198.72	317.20	156.06	190.44	189.10
T3V2	4.25	6.56	2.94	2.75	4.22	2.67	209.88	233.74	370.98	184.44	224.75	226.38
T4V1	4.06	6.26	2.64	2.55	3.97	2.35	179.14	208.74	345.92	158.47	188.86	191.36
T4V2	4.63	7.10	3.34	2.96	4.56	2.99	212.52	250.24	431.20	189.75	228.48	246.40
S.Em±	0.17	0.24	0.14	0.11	0.18	0.12	12.71	10.73	17.01	8.02	10.33	11.90
C.D (0.05)	0.52	0.73	0.42	0.35	0.56	0.38	38.52	32.52	51.54	24.32	31.32	36.06

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