https://doi.org/10.29321/MAJ.10.A01342

Studies on the interaction effect of Phosphorus and Sulphur on gingelly in Typic ustochrept

P. SARAVANA PANDIAN* and K. ANNADURAI

Agricultural Engineering College and Research Institute, Kumulur - 621712, Trichirappalli (Dt)

Abstract : To study the interaction effect of P and S on gingelly, field experiments were conducted during the year 1999 and 2000 at Agricultural Engineering College and Research Institute, Kumulur. The results revealed that the gingelly responded positively to both P and S application. Application of 100 kg P_2O_5 and 40 kg S ha^{-1} were found to be optimum to get the economic yield. The synergistic relationship of P and S were recorded upto 100 kg P_2O_5 and 40 kg S ha^{-1} beyond which an antagonistic relationship were noticed between P and S. Besides application of P increased the available S status irrespective of their levels.

Key words : Phosphorus, Sulphur, Gingelly, Balance

Introduction

Phosphorus and sulphur are the two major plant nutrients which increase oil seed production. Phosphorus is involved in normal establishment of root system, seed formation and hastening of maturity. Sulphur plays a vital role in metabolic activities of the plant especially by improving the activities of proteolytic enzymes and oil synthesis. Past studies had revealed that both synergistic and antagonistic relationship between P and S. But the recent research have shown that the nature of P and S relationship depends on the rate of application and crop species (Bapat *et al*. 1986). Though several studies have been conducted on various crops, the interaction studies of P and S on gingelly is lacking. Keeping these points in perspective, the present investigation was taken up.

Materials and methods

Field experiments were conducted during the year 1999 and 2000 under irrigated condition at the Agricultural Engineering College and Research Institute farm, Kumulur, Trichy District. The soil is classified taxonomically as Typic Ustochrepts. The composite soil samples were collected and analysed for basic physico-chemical properties and presented in Table 1. The experiment was laid out in a factorial randomized block design with three replications. The treatment structure comprises phosphorus 5 levels, M_0 - Control; M_1- 25 kg P_2O_5 ha^{-1}; M_2-50 kg P_2O_5 ha^{-1} ; M_3-75 kg P_2O_5 ha^{-1} and M_4-100 kg P_2O_5 ha^{-1} and 4 levels of sulphur - N_0 control; N_1 - 20 kg S ha^{-1}; N_2 - 40 kg S ha^{-1} and N_3 - 60 kg S ha^{-1}. The P and S were applied basally as DAP and Iron pyrite respectively. The N and K were applied as per blanket recommendation as urea and MOP respectively. After imposing the treatments, the gingelly seeds (variety TMV 4) were sown. Treatment wise soil samples were collected at 30 DAS, 60 DAS and after harvest of the crop and analysed for available P and S by Olsen (Olsen *et al*. 1954) and 0.15 per cent $CaCl_2$ (Williams and Steinbergs, 1959) methods respectively. Similarly plot wise plant samples were collected 30 DAS and after harvest of the crop and analysed for P and S contents and their uptake were computed. Plot wise gingelly seed and stover yields were recorded. The gingelly seeds were analysed for oil contents.

* Present Address: Horticultural College and Research Institute. Periyakulam - 625 604.

Table 1. Physico-chemical properties of the experimental soil

Properties	1999	2000
Mechanical analysis		
Sand	74.2	75.4
Silt	10.8	11.4
Clay	14.1	12.8
E.C. (dSm^{-1})	0.14	0.17
pH	7.08	7.14
CEC ($cmol(p+)kg^{-1}$)	8.2	8.8
Total N (%)	0.015	0.015
Total P (%)	0.020	0.022
Total S (ppm)	112	118
Alkaline $KMn0_4$-N($kg\ ha^{-1}$)	182	198
Olsen P($kg\ ha^{-1}$)	5.1	4.8
$NH_40Ac.K.$($kg\ ha^{-1}$)	242	256
0.15%$CaCl_2$-S($mg\ kg^{1}$)	6.2	5.4
Organic carbon (%)	0.29	0.34

Results and discussion

Effect of phosphorus and sulphur on gingelly seed and stalk yield

The seed and stalk yields were significantly favoured by the application of both P and S fertilizers. The seed yield ranged from 104 to 482 and 128 to 489 kg ha^{-1} during the year 1999 and 2000 respectively and were observed with the application of 100 kg P_2O_5 ha^{-1} and 40 kg S ha^{-1}. A positive response for the application of P was noticed irrespective of levels. With regard to S, a positive response in the seed yield was observed upto 40 kg S ha^{-1} beyond which it got declined. This might be due to the synergistic relationship of

Table 2. Effect of treatments on seed and stalk yield of gingelly crop ($kg\ ha^{-1}$)

Treatment	1999		2000	
	Seed	Stalk	Seed	Stalk
M_0N_0	104	764	128	792
M_0N_1	152	808	164	820
M_0N_2	175	840	182	860
M_0N_3	180	854	194	898
M_1N_0	184	868	198	926
M_1N_1	260	1036	274	1074
M_1N_2	315	1192	318	1200
M_1N_3	350	1274	345	1268
M_1N_0	208	954	215	950
M_2N_1	310	1174	321	1226
M_2N_2	340	1228	352	1290
M_2N_3	396	1300	414	1360
M_2N_0	264	1054	276	1085
M_2N_1	344	1232	354	1300
M_2N_2	372	1254	382	1348
M_2N_3	428	1306	440	1428
M_2N_0	308	1208	316	1260
M_2N_1	412	1298	418	1372
M_2N_2	482	1464	489	1492
M_2N_3	434	1316	442	1432
CD(P=0.05)				
M	9.8	20.8	8.4	21.
N	13.2	23.4	14.6	25.
MXN	27.4	47.2	29.2	49.8

Table 3. Effect of treatments on P uptake by the gingelly (kg ha^{-1})

Treatments	1999			2000		
	30 DAS	60 DAS	Post harvest	30 DAS	60 DAS	Post harvest
M_0N_0	2.62	5.12	6.51	2.89	5.57	6.63
M_0N_1	3.14	5.74	7.29	3.32	5.95	7.45
M_0N_2	3.38	6.97	7.92	3.74	7.35	7.90
M_0N_3	3.79	6.91	8.07	4.16	7.58	8.42
M_1N_0	4.08	7.06	8.62	4.06	7.43	9.02
M_1N_1	5.06	8.17	10.89	5.32	8.69	11.28
M_1N_2	5.79	9.83	12.66	5.97	10.23	12.91
M_1N_3	6.60	11.14	13.80	6.93	12.02	14.13
M_1N_0	5.27	9.70	9.99	5.76	10.12	10.66
M_2N_1	6.05	10.90	13.06	6.49	11.49	13.56
M_2N_2	6.94	13.20	13.48	7.22	14.03	14.24
M_2N_3	8.26	14.58	15.26	8.12	15.20	15.49
M_0N_0	6.40	11.22	11.86	6.62	12.19	12.56
M_3N_1	7.45	13.92	14.50	8.03	14.74	15.09
M_3N_2	8.14	14.20	14.96	8.20	15.78	15.98
M_3N_3	9.24	16.17	16.30	9.54	17.04	17.04
M_4N_0	7.01	12.42	14.55	7.53	14.08	15.72
M_4N_1	8.29	15.45	16.42	9.04	16.63	17.29
M_4N_2	9.71	17.69	18.88	10.56	18.72	19.24
M_4N_3	9.29	16.89	16.98	9.63	17.76	17.88
CD(P=0.05)						
M	0.13	0.18	0.20	0.14	0.19	0.19
N	0.16	0.22	0.24	0.15	0.23	0.25
M X N	0.30	0.46	0.50	0.29	0.47	0.5 I

P and S at lower levels of S and at higher levels due to the antagonistic effect of P and S, the seed yield would have been declined. These findings are in corroboration with the earlier reports of Aulakh and Pasricha (1977) and Dwivedi and Singh (1982).

Effect of phosphorus and sulphur on P uptake by the gingellly crop

Regarding the P uptake, a progressive increase in the uptake was evinced from 30 DAS to harvesting stage in both the years (Table 3). The highest P uptake of 9.71,17.69 and 18.88 kg ha^{-1} at 30 DAS, 60 DAS and at harvest stage were registered with the combined application of 100 kg P_2O_5 ha^{-1} and 40 kg S ha^{-1}. As registered in seed yield, the uptake of P was the highest with the application of 100 kg P_2O_5 ha^{-1} and 40 kg S ha^{-1} beyond which it got declined at all the three stages. The lowest uptake of P was noted on control. During the second cropping, the P uptake was significantly influenced both by P and S levels and their interaction and it ranged from 2.89 to 10.56,5.57 to 18.72 and 6.63 to 19.24 kg ha^{-1} at 30 DAS, 60 DAS and harvest stages respectively.

Table 4. Effect of treatments on S uptake by the gingelly (kg ha^{-1})

Treatments	1999			2000		
	30 DAS	60 DAS	Post harvest	30 DAS	60 DAS	Post harvest
M_0N_0	3.00	6.01	7.81	3.33	6.47	8.13
M_0N_1	3.67	6.82	8.64	3.88	7.07	8.82
M_0N_2	4.32	8.43	9.54	4.66	9.08	9.78
M_0N_3	5.06	8.99	10.13	5.42	9.92	10.58
M_1N_0	3.70	7.53	9.47	3.82	7.76	10.34
M_1N_1	4.78	8.89	12.31	5.03	9.15	12.79
M_1N_2	5.84	11.34	14.77	6.08	12.03	15.43
M_1N_3	6.89	13.62	16.89	7.36	14.63	17.16
M_1N_0	4.23	8.79	10.69	4.70	9.25	11.66
M_2N_1	5.23	9.79	14.25	5.80	10.48	14.63
M_2N_2	6.41	13.20	16.30	6.88	13.90	16.99
M_2N_3	7.65	15.10	18.31	8.05	16.03	18.79
M_0N_0	4.83	9.64	12.39	4.99	10.39	13.40
M_3N_1	6.16	12.72	15.44	6.75	13.33	16.07
M_3N_2	7.29	14.20	16.91	7.48	15.50	17.85
M_3N_3	8.45	16.73	19.07	8.99	17.78	19.93
M_4N_0	5.15	9.77	13.95	5.66	11.41	14.76
M_4N_1	6.84	13.42	16.42	7.58	14.84	16.58
M_4N_2	8.76	16.95	20.63	9.59	18.09	20.83
M_4N_3	8.32	16.05	18.55	8.76	17.02	19.15
CD(P=0.05)						
M	0.12	0.21	0.23	0.11	0.22	0.23
N	0.13	0.26	0.25	0.12	0.25	0.26
M X N	0.27	0.53	0.50	0.23	0.51	0.53

Effect of treatments on S uptake by the gingelly crop

The data depicted in Table 4 revealed that a progressive increase in the uptake of S was recorded from 30 DAS to harvest stage in both the cropping seasons. A positive response with regard to S uptake was noticed upto 40 kg S ha^{-1} in combination with 100 kg P_2O_5 ha^{-1}. Such a negative response with the increase in S levels were observed in soybean by Subba Rao and Ganeshamurthy (1994).

Effect of treatments on the available P status

While comparing the growth stages, a progressive decline in the available P status was recorded from 30 DAS to harvest upto 50 kg P_2O_5 beyond which an increasing trend was noticed from 30 DAS to harvest in both the cropping seasons (Table 5). A decline in available P status with increasing levels of S was registered upto 25 kg P_2O_5 ha^{-1} above which an improvement in the available P status with the corresponding increase in both P and S levels were observed. Similarly, the

Table 5. Available P status of the soil as influenced by the treatments (kg ha^{-1})

Treatments	1999			2000		
	30 DAS	60 DAS	Post harvest	30 DAS	60 DAS	Post harvest
M_0N_0	4.3	4.0	3.4	4.0	3.8	3.2
M_0N_1	4.2	4.0	3.4	4.0	3.6	3.2
M_0N_2	4.3	4.1	3.2	4.0	3.4	3.2
M_0N_3	4.1	3.8	3.1	3.8	3.4	3.0
M_1N_0	7.8	7.2	6.8	7.2	7.0	6.4
M_1N_1	6.0	5.6	5.0	5.8	5.4	5.0
M_1N_2	5.6	5.2	5.0	5.6	5.0	4.8
M_1N_3	5.2	5.0	4.8	5.0	4.6	4.6
M_1N_0	8.5	8.3	8.0	8.2	7.6	7.2
M_2N_1	9.6	8.8	8.5	8.8	8.2	7.6
M_2N_2	10.0	10.0	9.6	9.6	9.0	8.4
M_2N_3	10.4	10.0	9.6	9.6	8.8	8.0
M_0N_0	10.2	11.4	13.2	9.6	10.4	11.2
M_3N_1	11.6	13.4	14.0	10.4	11.2	13.0
M_3N_2	12.8	14.0	14.2	12.0	13.2	13.8
M_3N_3	12.8	14.2	14.8	12.4	13.6	13.6
M_4N_0	13.8	14.4	14.8	13.4	13.8	14.2
M_4N_1	14.6	15.2	15.6	13.8	14.4	14.8
M_4N_2	14.6	15.8	16.4	14.0	14.8	15.4
M_4N_3	15.0	16.0	16.6	14.0	14.8	15.8
CD(P=0.05)						
M	0.14	0.17	0.16	0.14	0.15	0.15
N	0.16	0.19	0.18	0.16	0.16	0.17
MXN	0.31	0.37	0.38	0.32	0.31	0.33

P and S levels had a buildup and depletion of available P status. While comparing the available P status of post harvest soil, a depletion of available P was observed in the treatments which have not received chemical P fertilizer. On the otherhand, a positive balance was observed in the treatments which have received P fertilizer. In the case of S levels, upto 25 kg S, ha^{-1} beyond which an increasing trend was noticed. Since at lower concentrations of S the SO_4^{2-} anion could not have replaced the $H_2PO_4^-$ from the sorbed complex, while at higher concentration due to the enrichment of SO_4^{2-} sorrounding the P fixed zone of sesquioxides and replaced the H_2PO_4 to the labile pool (Bolan *et al.* 1988).

Effect of treatments on available S status

The available S status was significantly influenced by the P and S levels and their interaction. As observed in available P, it got declined from 30 DAS to post harvest stage in both the years. This may be due to the dilution effect of S upon the growth of crop (Aulakh *et al.* 1977). While comparing the S balance, both positive and negative balance of available S was noticed (Table 6). A negative balance of available S was registered in control irrespective of the P levels. The interaction effect of P and S revealed that by increasing the P levels, the available S got increased irrespective of S levels. This might be due to the higher bonding

Table 6. Effect of treatments on the available S status of the soil (ppm)

Treatments	1999			2000		
	30 DAS	60 DAS	Post harvest	30 DAS	60 DAS	Post harvest
M_0N_0	5.4	4.6	4.0	5.2	4.6	4.0
M_0N_1	6.0	5.6	5.2	5.8	5.2	4.8
M_0N_2	8.2	7.6	7.2	7.6	7.0	6.4
M_0N_3	9.2	8.8	8.2	8.6	8.0	7.4
M_1N_0	5.8	5.0	4.8	5.4	4.8	4.4
M_1N_1	6.4	6.2	6.0	7.6	6.8	6.0
M_1N_2	8.8	8.6	8.6	9.0	8.6	8.2
M_1N_3	9.4	9.6	9.0	9.6	9.0	8.2
M_1N_0	6.0	5.4	5.0	5.8	5.0	4.8
M_2N_1	6.8	6.2	5.8	7.4	6.8	6.0
M_2N_2	9.0	8.6	6.8	9.6	8.6	8.2
M_2N_3	10.2	9.2	9.0	10.4	9.6	8.6
M_0N_0	6.0	5.4	5.4	6.2	5.4	5.0
M_3N_1	7.4	6.8	6.0	7.0	6.2	5.8
M_3N_2	9.4	8.8	7.2	9.6	8.8	8.4
M_3N_3	10.8	9.8	9.4	10.8	10.0	9.0
M_4N_0	6.0	5.6	5.2	6.4	5.6	5.0
M_4N_1	8.0	7.5	7.2	7.6	7.2	6.8
M_4N_2	9.6	9.4	9.0	9.8	9.0	8.6
M_4N_3	11.6	10.6	10.6	11.4	10.6	9.8
CD(P=0.05) M						
M	0.08	0.10	0.10	0.09	0.10	0.08
N	0.10	0.12	0.13	0.11	0.12	0.09
MXN	0.20	0.23	0.25	0.22	0.24	0.19

strength of P than S, the $H_2PO_4^-$ ion would have released the sorbed SO_4^{2-} from the sorption complex to the labile pool (Barrow, 1970; Bolan and Barrow, 1984).

From this study it can be concluded that gingelly responded positively to the P and S nutrition. Phosphorus and sulphur had a synergistic relationship with each other in registering the gingelly seed yield upto 40 kg S ha^{-1}. To get the highest seed yield of gingelly a combination of 100 kg P_2O_5 and 40 kg S ha^{-1} can be recommended in Typic Ustochrepts.

References

Aulakh, M.S. and Pasricha, N.S. (1977). Interaction effect of S and P on growth and nutrient content of moong. *Pl. Soil.* **47**:341-350.

Auakh, M.S., Pasricha, N.S. and Takkar, P.N. (1977). Response of different crops to sulphur fertilization in Punjab. *Fert. News.* 22:33-36.

Bapat, P.N., Sinha, S.B. and Tripathi; B.R. (1986). Effect of S and P on yield and nutrient content of blackgram *J. Indian Soc. Soil Sci.* **34**:82-86.

Barrow, N.J. (1970). Comparison of the adsorption of molybdate, sulphate and phosphate by soils. *Soil Sci.* **107**:282-288.

Bolan, N.S. and Barrow, N.J. (1984). Modeling the effect of adsorption of phosphate and other anions on the surface charge variable oxides. *J. Soil Sci.* **35**:379-388.

Bolan, N.S., Syers, J.K., Tillman, R.W. and Scoffer, D.R. (1988). Effect of liming and phosphate additions on sulphate leaching in soils. *J. Soil Sci.* **39**:493-504.

Dwivedi, G.K. and Singh, V.P. (1982). Effect of P and S application on the nutrition quality of different varieties of Bengal gram. *Indian J. Agron.* 27:7-12.

Olsen, S.R., Cole, C.V., Watanabe, F.S. and Dean, LA (1954). Estimation of available Phosphorus in soils by extraction with sodium bicarbonate. USDA Circ. 939.

Subba Rao, A. and Ganeshamurthy, AX (1994). Soybean responses to applied phosphorus and sulphur on Vertic Ustochrepts in relation to available phosphorus and sulphur *J. Indian Soc. Soil Sci.* **42**: 606-610.

Williams, C.H. and Steinbergs, A. (1959). Some soil sulphur fractions as chemical indices of available sulphur. *Aust. J. Agric. Res*, **10**:240-248.

(Received : December 2003 Revised : May 2005)