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Influence of phosphorus and sulphur fertilization on productivity and oil yield of groundnut (*Arachis hypogaea*) and sunflower (*Helianthus annuus*) in intercropping with simultaneous and staggered planting

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ABSTRACT

Results of field experiment conducted at New Delhi during the rainy seasons of 1999 and 2000 revealed that number of total and developed pods and pod weight/plant of groundnut (*Arachis hypogaea* L.) remained unaffected due to simultaneous sown sunflower (*Helianthus annuus* L.) intercrop. However, 1 month delayed sowing of sunflower intercrop caused significant improvement in these parameters of groundnut. However, the highest pod and oil yields were recorded from sole groundnut owing to its higher plant population. Application of 40 kg P_2O_5/ha and 30 kg S/ha individually caused highest pod yield in groundnut with 28 and 27% increase over respective controls. Significant positive interaction of P and S on pod yield of groundnut was noted with the combined application of 40 kg P_2O_5/ha and 30 kg S/ha. Oil yield of groundnut was the highest with the application of 40 kg P_2O_5/ha and 30 kg S/ha with respective nutrients. In sunflower, significant increase in seed and oil yields was recorded owing to application of 80 kg P_2O_5/ha and 30 kg S/ha with respective nutrients.

Key words : Groundnut, Sunflower, Phosphorus, Sulphur, Interaction, Staggered planting

Groundnut and sunflower intercropping system is instrumental to maximize the oilseed production per unit area and time. The system provides 50 to 57% yield advantage and net profit (Samui and Roy, 1990). More often groundnut yield is reported to decline due to presence of sunflower intercrop. Presumable adverse effects of sunflower like shading and allelopathic effect may be attenuated with manipulation of the planting pattern of the intercropping system. Delaying the sowing of sunflower intercrop by 1 month may provide groundnut plant almost two-month period of competition-free environment. One such idea has been tried in the present experiment. These energy-rich groundnut and sunflower oilseed crops require special attention to their nutrition, specially for phosphorus and sulphur besides nitrogen. Application of P and sulphur is important to groundnut, a leguminous crop, because of their positive role in root nodulation process and oil synthesis as well. Both the nutrients interact each other differentially at their varying levels of application. Hence an experiment was conducted to study the influence of P and sulphur on yield and oil content of groundnut and sunflower in intercropping with simultaneous and staggered planting and to find out optimum level of combined application of P and S for groundnut and sunflower crops in intercropping.

MATERIALS AND METHODS

The field experiment was conducted at the Indian Agricultural Research Institute, New Delhi, during the rainy season of 1999 and 2000. The experiment was laid out in split-plot design with 3 replications. The main-plot treatment comprised 3 cropping systems, i.e. sole groundnut (GN_{sole}), groundnut intercropped with simultaneously sown sunflower ($GN+SF_{simul.}$) and groundnut intercropped with sunflower sown 1 month later ($GN + SF_{stag.}$). In both the intercropping systems groundnut and sunflower were sown in 2:1 row ratio in replacement series with 33.3 cm row spacing maintaining 67 and 50% sole stand of groundnut and sunflower respectively. Combinations of 3 levels each of P (0, 40 and 80 kg P_2O_5/ha) and S (0, 30 and 60 kg S/ha) formed the sub-plot treatments. The P and S were applied through diammonium phosphate (46% P_2O_5 and 18% N) and gypsum (Agricultural grade containing 18.6% S) respectively. Required proportions of urea (45.6% N) were added to different treatments to make up N dose of 30 kg/ha. All the fertilizers were broadcast as basal. A top-dressing of N @ 20 kg/ha was done to sunflower rows only at 30 days after sowing. The soil of the experimental site was sandy loam in texture, analysed low in available nitrogen (132.4 kg N/ha), medium in available phosphorus (48.1 kg P_2O_5/ha), available sulphur (48.2 kg

SO_4-S/ha) and available potassium (292 kg K_2O/ha) with pH 7.3. The groundnut variety 'SG 84' (semi-spreading Spainish type) and sunflower hybrid 'MSFH 8' were used as test crops.

RESULTS AND DISCUSSION

Groundnut

Yield attributes and yield: Yield-attributing parameters and yield of groundnut were significantly influenced owing to intercropping of sunflower and application of P and S (Table 1). Highest number of total and developed pods and pod weight/plant were recorded in groundnut with staggered sown sunflower intercrop. Sole groundnut being statistically at par with those in groundnut with simultaneous sown sunflower recorded the lowest number and weight of pods. Intra-plant competition in sole groundnut system might be the reason for lower values of pods/plant and pod weight/plant. However, poor growth of sunflower in intercropping system might have failed to exert strong competition with groundnut leaving an advantage for the crop. In staggered sown system, the space left for the sowing of sunflower might have been successfully utilized by the groundnut crop during its early growth stage. Significant reduction in shelling outturn of groundnut was observed due to simultaneous sown sunflower intercrop, while values of other 2 systems remained at par. However, 100-kernel weight of groundnut was not affected due to intercropping of sunflower in either of the systems.

Pod yield was the highest in sole groundnut owing to its high plant stand. Pod yields of both the intercropping systems were statistically at par, though staggered planting system recorded the higher value. With 67% of sole stand, groundnut in simultaneous and staggered sown sunflower system recorded 76 and 84% of sole groundnut yield respectively.

The application of both P and S significantly enhanced yield attributes and pod yield of groundnut (Table 1). Application 40 kg P_2O_5/ha recorded the highest number of pods and pod weight/plant, shelling outturn and 100-kernel weight and pod yield as well. At 40 kg P_2O_5/ha, pod yield of groundnut was increased by 28% over the control. Vasisht and Pandey (1999) also reported the highest pod yield of groundnut at 40 kg P_2O_5/ha.

Application of 30 kg S/ha significantly enhanced yield attributes as well as pod yield of groundnut. Further increase in the dose brought significant decline in pod yield. With the application of 30 kg S/ha, the pod yield of groundnut was increased by 27% over the control. Improvement in yield-attributing parameters and yield of groundnut owing to S fertilizer was reported by Chaubey *et al.* (2000).

Content and yield of oil : Oil content in groundnut kernel remained unaffected due to intercropping of sunflower in either of the systems (Table 1). However, oil yield of groundnut was the highest in sole groundnut. This was due to higher pod yield from sole groundnut. Both P and S played significant role in enhancing oil content as well as its yield. Though application of P up to 80 kg P_2O_5/ha significantly improved kernel oil content, application of 40 kg P_2O_5/ha recorded significantly higher oil yield over the control. Role of P in seed-development process might have resulted improvement in kernel oil content. The oil

Table 1. Yield attributes, pod yield, oil content and oil yield groundnut as affected by cropping systems and levels of phosphorus and sulphur (pooled over 2 years)

Treatment	Pods/ plant	Developed pods/plant	Pod weight/ plant (g)	Shelling outturn (%)	100-kernel weight (g)	Pod yield (q/ha)	Kernel-oil content (%)	Oil yield (q/ha)
Cropping system								
GN_{sole}	36.3	24.3	19.5	72.7	38.5	30.1	52.6	11.7
$GN+SF_{simul.}$	38.6	28.2	21.4	70.9	38.2	23.0	52.6	8.7
$GN+SF_{stag.}$	46.9	31.8	24.7	72.6	38.2	25.4	52.7	9.8
CD(P=0.05)	4.1	3.0	3.9	0.9	NS	2.9	NS	1.4
P_2O_5 (kg/ha)								
0	37.5	25.1	19.3	68.7	35.4	22.9	49.6	8.0
40	44.1	31.3	24.6	74.2	40.1	29.3	53.8	11.7
80	40.2	27.9	21.7	73.2	39.3	26.3	54.4	10.5
CD(P=0.05)	2.0	1.6	1.8	0.6	0.8	1.8	0.4	0.9
S(kg/ha)								
0	39.3	24.5	19.2	68.4	35.2	22.9	49.3	7.9
30	42.7	31.2	24.4	74.1	40.1	29.1	54.3	11.7
60	39.8	28.7	22.1	73.7	39.5	26.5	54.3	10.6
CD (P=0.05)	2.0	1.6	1.8	0.6	0.8	1.8	0.4	0.9

Details of cropping system are given under Materials and Methods content in kernel as well as oil yield were the highest at 30 kg S/ha. Direct involvement of S in oil bio-synthesis might be attributed to this improvement in oil content in groundnut kernel due to application of S.

Interaction effect: Interaction between P and S on pod weight/plant and pod yield was significant (Table 2). Application of either of the nutrients, i.e. P and S, alone increased the pod weight with increasing levels of the nutrients up to their highest levels, though increments at the highest level were not significant. At the highest level of either of the nutrients, application of other nutrients did not cause significant change in pod weight/plant. Combination of 40 kg P_2O_5/ha and 30 kg S/ha recorded the highest increase (97%) in pod weight/plant. But further increase in the level of either of the nutrients brought significant reduction. The reduction was the highest when the highest doses of both P and S were combined.

Table 2. Interaction effect of phosphorus and sulphur on pod weight/plant and pod yield of groundnut (pooled over 2 years)

Levels of S (kg/ha)	Levels of P kg (P_2O_5/ha) 0	40	80	Mean
	Pod weight/plant (g)			
0	15.4	19.9	22.3	19.2
30	20.4	30.3	22.5	24.4
60	22.3	23.6	20.4	20.1
Mean	19.4	24.6	21.7	
CD (P=0.05)	3.2			
	Pod yield (q/ha)			
0	17.6	23.6	27.4	22.9
30	24.8	36.3	26.2	29.1
60	26.4	27.9	25.2	26.5
Mean	22.9	29.3	26.3	
CD (P=0.05)	3.1			

The pod yield of groundnut significantly increased with the increasing rate of P_2O_5 to 80 kg/ha when no S was applied. But at 30 kg S/ha, pod yield increased with the application of P_2O_5 up to 40 kg/ha, thereafter, it declined significantly. However at 60 kg S/ha, there was no significant response to P. At 0 and 40 kg P_2O_5, pod yield significantly increased with the application of S up to 30 kg/ha only. Further increase in S level up to 60 kg/ha caused significant reduction at 40 kg P_2O_5/ha. But at 80 kg P_2O_5/ha, groundnut pod yield remained statistically at par due to varying doses of S. Therefore, the highest pod yield was recorded with the combined application of 40 kg P_2O_5 and 30 kg S/ha with an increment of 106% over the absolute control.

Positive interaction between P and S at their lower level of application could be attributed to the complimentary role played by the nutrients in successful growth and development of groundnut. In plants, P is essential components of nucleic acids. It has its own role in improving total carbon fixation, synthesis of starch and its translocation and partitioning into different plants parts (Marschner, 1986). Whereas, S is the integral part of amino acids like cysteine, cystine and methionine which are the building blocks of proteins. It is well-known fact that both nucleic acid and proteins are essential pre-requisites for cell division. Sulphur is also important for regulation of chlorophyll synthesis, thereby, improving photosynthetic active in plants. Phosphorus is important for development of root

Table 3. Yield attributes, seed yield, oil content and oil yield of sunflower intercrop as affected by cropping systems and levels of P and S (pooled over 2 years)

Treatment	Capitulum diameter (cm)	Filled capitulum diameter (cm)	Seeds/ capitulum	Seed weight/ capitulum (g)	1,000-seed weight (g)	Seed yield (q/ha)	Seed oil content (%)	Oil yield (q/ha)
Cropping system								
GN + $SF_{simul.}$	10.7	9.0	423	13.0	30.9	5.05	35.6	1.78
GN + $SF_{stag.}$	8.1	4.4	283	6.5	24.0	2.41	32.1	0.76
CD (P=0.05)	NS	1.2	88	1.9	4.8	0.62	NS	0.32
P_2O_5 (kg/ha)								
0	8.2	5.8	321	8.2	25.4	3.12	32.7	1.03
40	9.9	7.1	357	10.0	28.2	3.92	33.8	1.33
80	10.1	7.2	380	11.1	29.0	4.15	34.9	1.46
CD (P=0.05)	0.5	0.5	34	1.0	2.4	0.22	1.7	0.12
S (kg/ha)								
0	8.0	5.6	340	8.9	25.8	3.34	33.4	1.13
30	10.2	7.2	358	10.3	28.7	3.88	33.6	1.31
60	9.9	7.3	361	10.1	28.0	3.97	34.5	1.37
CD(P=0.05)	0.5	0.5	NS	1.0	2.4	0.22	NS	0.12

Details of cropping system are given under Materials and Methods system in groundnut, whereas S is important for nodulation.

The negative interaction between P and S at their higher levels of application might be due to competition for the same adsorption site or pathway of uptake, thereby mutually inhibiting uptake and translocation of each other adversely (Sinha *et al.,* 1995). Secondly high level of S application may increase availability of P in soil due to formation of sulphuric acid on oxidation of S in soil (Marok and Dev, 1980). This may increase solubilization of phosphate in rhizosphere. Lowering of solution pH due to formation of sulphuric acid creates favourable conditions for more uptake of phosphate (Marschner, 1986). It is understood that high concentration of inorganic P has suppressing effect on total fixation of carbon at molecular level of chloroplants (Marschner, 1986). This could lead to retarded growth and yield of groundnut.

Sunflower

Yield attributes and yield: All the yield-attributing parameters and seed yield of sunflower were significantly influenced by staggered planting and levels of P and S (Table 3). The simultaneous sown sunflower intercrop consistently recorded higher values of all the yield parameters as well as seed yield over staggered sown sunflower intercrop. In staggered sown system, the sunflower intercrop might have been suppressed by vigorous growth of groundnut due to utilization of space left for the sowing of sunflower at its early growth stage.

All the yield parameters were increased with the successive increase in P_2O_5 level up to 80 kg/ha, however, increments at the highest level of P_2O_5 was significant for seed weight/capitulum only. Important role of P in determining sink size and supply of assimilates in sunflower (Rodriguez, 1998) could be the reason for improved yield attributes of the crop due to P fertilization. The highest seed yield of sunflower was recorded at 80 kg P_2O_5/ha. The increments in seed yield over the control were 26 and 33% at 40 and 80 kg P_2O_5/ha levels respectively. Since sunflower was grown in intercropping with groundnut, there might be more competition for P between 2 crops at 40 kg P_2O_5, as groundnut is more efficient in P utilization. This might be the reason for significant increase in sunflower yield with up to 80 P_2O_5/ha.

The application of sulphur also significantly influenced the yield attributes of sunflower except seeds/capitulum. However, significant response was noted at 30 kg S/ha only. This observation corroborates the findings of Legha and Giri (1999). The seed yield of sunflower was significantly increased with the application of S up to 30 kg/ha with an increase of 16% over the control.

Content and yield of oil: Oil content in sunflower seeds remained unaffected due to staggered planting. Hence oil yield followed the trend similar to seed yield.

Application of P significantly improved seed oil content of sulflower, but only 80 kg P_2O_5/ha attained the level of significance. This might be due to vital role of certain P-containing enzymes in fatty acid synthesis in seed. Highest oil yield of sunflower was recorded at 80 kg P_2O_5/ ha.

Application of sunflower did not show significant effect on oil content of sunflower seed which could be attributed to the poor seed development, as indicated from very low 1,000-seed weight due to adverse weather conditions. Oil yield of sunflower was significantly increased with the application of 30 kg S/ha with an increments of 16% over the control.

REFERENCES

Chaubey, A.K., Singh, S.B. and Kaushik, M.K. 2000. Response of groundnut (*Arachis hypogaea*) to source and level of sulphur fertilization in mid western plains of Uttar Pradesh. *Indian Journal of Agronomy* **45**(1) : 166–169.

Legha, P.K. and Giri, G. 1999. Influence of nitrogen and sulphur on growth, yield and oil content of sunflower (*Helianthus annuus*) grown in spring season. *Indian Journal of Agronomy* **44**(2) 408–412.

Marok, A.S. and Dev, G. 1980. Phosphorus and sulphur inter-relationship in wheat. *Journal of Indian Society of Soil Science* **28** : 184–188.

Marschner, H. 1986. *Mineral Nutrition of Higher Plants*. p. 674. Academic Press, London.

Rodriguez, D. 1998. 'Understanding growth limitation in wheat and sunflower under low phosphorus conditions,' Thesis Abstract. Wageningen Agricultural University, Wageningen, Netherlands.

Samui, R.C. and Roy, A. 1990. Possibilities of increasing production of oilseeds through intercropping system. *Journal of Oilseeds Research* **7** : 14–21.

Sinha, R.B., Sakal, R. and Kumar, S. 1995. Sulphur and phosphorus nutrition of winter maize in calcareous soil. *Journal of Indian Society of Soil Science* **43**(3) : 413–418.

Vasisht, R. and Pandey, U.C. 1999. Effect of phosphorus and sulphur on productivity in groundnut. *Annals of Agricultural Research* **20**(4) : 524–525.