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RESEARCH PAPER

Study of sulphur and phosphorus application on physical characteristics of groundnut (*Arachis hypogaea* L.) for sustainable oil seed production in Indo-Gangetic Plains of Eastern Uttar Pradesh

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Abstract : The present experiment was conducted at N.D.U.A. and T., Kumarganj, Faizabad with the objective of, to study the impact of sulphur and phosphorus application on oil content of groundnut (*Arachis hypogaea* L.) for sustainable oil seed production in the Indo-Gangetic Plains of Eastern Uttar Pradesh. Biochemical analysis was carried out in the departmental laboratory as well as of biochemistry department and C.D.R.I. Lucknow. The experiment was laid out in Factorial Randomized Block Design having sixteen treatment combinations of sulphur and phosphorus levels (0, 20, 30, 40 S/ha and 0, 30, 40, 50 (P_2O_5/ha). Phosphorus dose @ 50kg/ha was found more effective. Similarly, highest dose of sulphur gave best response. Yield and yield contributing characters *i.e.* number of pods/plant, test weight (g), pod yield (q/ha) was affected by various levels of both fertilizers. Sulphur levels affect the oil and oil quality of groundnut.

Key Words : Groundnut, Sulphur, Phosphorus, Physical characteristics

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INTRODUCTION

The land of Indo-Gangetic Plains of Eastern Uttar Pradesh comes under low productive land. Assessing through the new approach for assessing the land class theoretically (Pandey *et al.*, 2006) and with the software as well (Pandey, 2016), it has been observed that the Land comes under Class V and subclass Vs *i.e.* the land needs soil management practices to enhance its productivity potential. Land with low productivity needs higher degree of management practices (Pandey *et al.*, 2007). Fertilizer management practices come under specified agri-management practices to maintain the soil and land productivity (Pandey and Sirothia, 2006).

Groundnut (*Arachis hypogaea* L.) is the crop of dry arid and semi arid regions and very popular in Indo-Gangetic Plains of Eastern Uttar Pradesh but the production is not upto the mark. India's per capita

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consumption of oils and fat is continuously increasing. The increase in demand for edible oils was mainly attributed to socio-economic factors. In addition, oilseeds can be introduced as intercrop in less remunerable traditional staple food crops whose replacement is possible. Groundnut is a major crop of rainfed area and its nutrient requirement is comparatively low and response is erratic. No residual effect of fertilizer application to groundnut is observed on succeeding crop (Khistaria *et al.,* 1998). Groundnut oil is primarily used in the manufacture of vegetable oil (Vanaspati ghee). Groundnut is a good source of all vitamins B except B_{12}. They are a rich source of thiamin, riboflavin, nicotinic acid and vitamin E (Singh, 1983). The nitrogen requirement of groundnut is much higher than cereals because of its high protein content inspite of the fact that almost all the soil, where groundnut is grown in India are deficient in nitrogen. The nitrogen is required for the vegetative and reproductive growth, nutrient absorption, photosynthesis and production of assimilates for developing sink (pod filling). Yellowing of older leaves, which later on die with the age of crop is the most common nitrogen deficiency (Singh and Abidi, 1989). Ammonium sulphate is preferred source of N (DOR, 1985) as it provides much needed sulphur. In rainfed groundnut, nitrogen should be applied as basal application. All plants need at least sixteen nutrients for their growth and development. The use of fertilizer is necessary to realize maximum yield potential of a crop and its variety. Sulphur and phosphorus are among the sixteen nutrient elements, which are essential for the growth and development of plants. Sulphur plays a significant role in crop production by virtue of its being a constituent of some commonly used nitrogen, phosphorus and potash fertilizers. Sulphur is now recognized as a fourth major nutrient in addition to N, P and K. Sulphur is an essential nutrient for plant growth, required by plants as plant nutrient in amount similar to the phosphorus and is important to the plant for protein synthesis and other metabolic function. Sulphur play a unique role in plant and animal metabolism as it is involved in the metabolic and enzymatic processes of all living cells. With the possible exception of nitrogen, no other element has been as critical in the growth of plants in the field as has phosphorus. It is essential for various plant processes such as photosynthesis, respiration, nitrogen metabolism, carbohydrate metabolism and fatty acid synthesis. The phosphorus is a component of certain enzymes and proteins ATP, RNA, DNA and involved in various energy transfer reaction and genetic informations.

Phosphorus limits nitrogen fixation, either directly by affecting nodule limitation, nodule development and nitrogen fixation or indirectly by affecting plant growth. A disturbing fact is that the fertilizer use efficiency is 20-50 per cent for nitrogen and 10-25 per cent for phosphorus (Manjunatha *et al.,* 2016). Phosphorus increases the shelling percentage, oil yield and nodulation in groundnut. Phosphorus is an important primary nutrient and enhances root growth there by facilitating absorption of water and nutrients from deeper layers. Phosphorus stimulates not only root growth but also hastens the maturity of oilseed crops. The groundnut crop requires judicious supply of phosphorus for its normal growth and development. This nutrient required for synthesis of oils, proteins, nucleic acids and is also involved in the formation of glucosinolates, which on hydrolysis increases the oil content which intern influences the final pod yield and oil yield (Jeetarwal *et al.,* 2015). Phosphorus deficiency causes disruption of general metabolism, particularly at the level of energy generation. Abnormalities cause anthocyanin pigmentation, yellowing and drying of lower leaves, root and shoot become slender. It promotes leaf fall and delay flowering deficiency of phosphorus results in slow growth and late maturity. Sulphur constitutes metheonine, cysteine and amino acids and increase oil synthesis in groundnut. It improved nodulation and pod yield besides reducing the incidence of disease and is as important as phosphorus for oil seed crop. Sulphur requirement of groundnut can be met through the number of sulphur containing materials such as gypsum, elemental sulphur, pyrite and phosphogypsum (Biswas *et al.,*1986). Potassium is involved in maintaining the water status of the plant and required for translocation of carbohydrate. It should be applied as basal dose in furrows. Sullivan *et al.* (1974) reported that gypsum improved seed germination, seedling survival, root growth, pod filling and production of large seed in groundnut. Indian agriculture needs to be more knowledge intensive in order to keep pace with the growing population pressure and diminishing land and energy source based. So there is an urgent need to step up oilseed production and sustain it. The doses of sulphur and phosphorus will be another need of the plan for increasing the yield and oil yield. Munaf *et al.* (2017) have also concluded in their study that sulphur sources have significant positive effects on yield and yield related parameters of groundnut genotypes. The application of elemental sulphur results significantly high yield, micro nutrient content and uptake in groundnut (Sisodiya *et al.*, 2017).

MATERIAL AND METHODS

Groundnut (*Arachis hypogaea* L.) variety G-201 has been selected for trial, which is recommended for eastern zone of Uttar Pradesh. Urea, potash and di ammonium phosphate were used as the source of N, P and K applied to the field at different levels at each plot. The experiment was planned in a Factorial Randomized Block Design with three replications at the Student Instructional Farm of Narendra Deva University of Agriculture and Technology, Narendra Nagar (Kumarganj) Faizabad (U.P.) located in the Indo-gangetic plains of Eastern Uttar Pradesh at latitude 26.47°N, longitude 82.12°E and altitude 113 m above the mean sea level. Each replication was randomly divided into 16 plots in length-wise. As the design adopted for the experiment was Factorial Randomized Block Design (F. R.B.D.) with three replications and 16 treatments. Row to row and plant to plant spacing were kept 30 cm and 60 cm, respectively. The groundnut was sown at the rate of 100 kg/ha. Fertilizer NPK were applied @ 20, 30, 40 kg sulphur/ha and 30, 40, 50 kg phosphorus/ha. Half dose of nitrogen, full dose of potash, full dose of sulphur were applied at the time of sowing between furrows. Remaining half dose of nitrogen was applied as top dressing after 25 days of sowing. Besides, the experimental crop was grown with the recommended package of agronomic practices to achieve a good crop. The crop of groundnut was harvested when the pods became mature. A plot soil sample was collected from experimental area before the layout the experiment. The available phosphorus content in the soil was estimated by the method of Olsson (1974). Available phosphorus in the soil sample was found 18kg/ha. The following 16 possible treatment combinations of phosphorus and sulphur are given (Table A).

Table A: Treatment combinations

Sr. No.	Symbol	Details
1.	$S_0 P_0 G_1$	0 kg sulphur + 0 kg phosphorus/ha in control plot
2.	$S_0 P_1 G_1$	0 kg sulphur + 0.260 kg phosphorus/ha
3.	$S_0 P_2 G_1$	0 kg sulphur + 0.350 kg phosphorus/ha
4.	$S_0 P_3 G_1$	0 kg sulphur + 0.440 kg phosphorus/ha
5.	$S_1 P_0 G_1$	0.360 kg sulphur + 0 kg phosphorus/ha
6.	$S_1 P_1 G_1$	0.360 kg sulphur + 0.260 kg phosphorus/ha
7.	$S_1 P_2 G_1$	0.360 kg sulphur + 0.350 kg phosphorus/ha
8.	$S_1 P_3 G_1$	0.360 kg sulphur + 0.440 kg phosphorus/ha
9.	$S_2 P_0 G_1$	0.520 kg sulphur + 0 kg phosphorus/ha
10.	$S_2 P_1 G_1$	0.520 kg sulphur + 0.260 kg phosphorus/ha
11.	$S_2 P_2 G_1$	0.520 kg sulphur + 0.350 kg phosphorus/ha
12.	$S_2 P_3 G_1$	0.520 kg sulphur + 0.440 kg phosphorus/ha
13.	$S_3 P_0 G_1$	0.730 kg sulphur + 0 kg phosphorus/ha
14.	$S_3 P_1 G_1$	0.730 kg sulphur + 0.260 kg phosphorus/ha
15.	$S_3 P_2 G_1$	0.730 kg sulphur + 0.350 kg phosphorus/ha
16.	$S_3 P_3 G_1$	0.730 kg sulphur + 0.440 kg phosphorus/ha

S= Sulphur; P= Phosphorus; G= Groundnut
Phosphorus levels: 0, 30, 40, 50; Sulphur levels: 0, 20, 30, 40

RESULTS AND DISCUSSION

Data pertaining to the number of pods/plant, test weight (seed size), yield q/ha in groundnut discussed below and the same have been depicted in Table 1, 2 and 3 and graphically explained through Fig. 1, 2 and 3.

Number of pods/plant:

During two *Kharif* seasons the number of pods/ plant as affected by various level of sulphur, phosphorus and their interactions have been presented in Table 1 and graphically presented in Fig. 1. Number of pods/ plant ranged from 16.17 to 22.50 during 1st year and in 2nd year, it ranged from 16.00 to 22.42. Maximum value 22.50 and 22.42 was observed in 1st year and 2nd year, respectively, when 50 kg phosphorus was applied. Minimum value was obtained in control treatment. Similar trend was observed in second year. The perusal of the data indicated that various levels of sulphur affected the

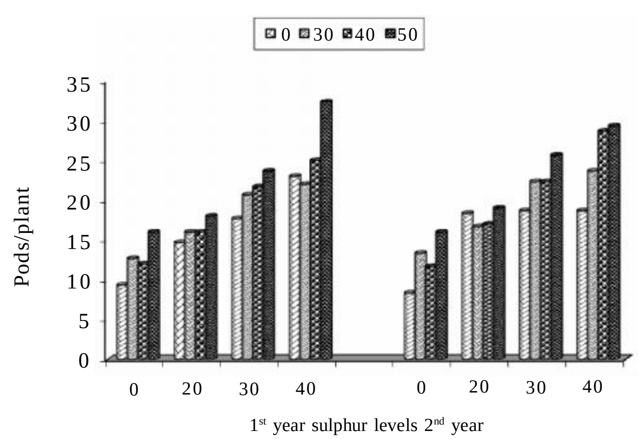

Fig. 1 : Response of sulphur and phosphorus fertilization on number of pods/ plant in groundnut

number of pods/plant, number of pods/plant ranged from 12.50 to 25.58 in 1st year and in 2nd year, it ranged from 12.33 to 25.08. Maximum value *i.e.* 25.58 recorded in 1st year and in 2nd year it was 25.08 and minimum value was observed in control plots. All the values varied significantly over control.

Interaction due to various doses of phosphorus and sulphur on the number of pods per plant did not vary significantly during both years. Data presented in Table 1 showed the number of pods/plant of groundnut during both years of investigation. Maximum number of pods/ plant 22.50 and 22.42 were observed during 1st year and 2nd year, respectively. Our results are in confirmation to those of Madhuwadia *et al.* (1981) and Nair *et al.* (1971).

The perusal of the data indicates that number of pods/plant increased with the treatment over that of control due to various doses of sulphur applied, maximum value *i.e.* 25.08 when sulphur is applied at the rate of 40 kg/ha. Our results are in agreement to these of Singh and Kalra (1983) and Dubey and Misra (1970).

Interaction data revealed that the combine effect of sulphur and phosphorus on number of pod plant did not vary significantly. The groundnut plant has ability to scavenage a considerable volume of soil and so obtained nutrients does not easily available to other crops. This ability is probably a major reason for the very irregular yield response obtained from added nutrients in many countries where groundnut is widely grown. (Weiss, 1983). The above results are in accordance to those of Shinde *et al.* (1981) and Maliwal and Tauk (1988).

Test weight of groundnut:

Observation recorded on account of seed size (test weight) as affected in various levels of sulphur and phosphorus and their interaction have been portrayed in Table 2 and graphically presented in Fig. 2.

Table 1 : Response of sulphur and phosphorus fertilization on number of pods/plant in groundnut (Two years data)

Phosphorus level	1st year					2nd year				
	Sulphur levels					Sulphur levels				
	0	20	30	40	Mean	0	20	30	40	Mean
0	9.33	14.67	17.67	23.00	16.17	8.33	18.33	18.67	18.67	16.00
30	12.67	16.00	20.67	22.00	17.83	13.33	16.67	22.33	23.67	19.00
40	12.00	16.00	21.67	25.00	18.67	11.67	17.00	22.33	28.67	20.75
50	16.00	18.00	23.67	32.33	22.50	16.00	19.00	25.67	29.33	22.42
Mean	12.50	16.17	20.92	25.58	18.79	12.33	17.35	25.33	25.08	19.54
	S.E. ±		C.D. (P=0.05)			S.E. ±		C.D. (P=0.05)		
S	0.74		2.13		S	1.23		3.56		S
P	0.74		2.13		S	1.23		3.56		S
S x P	1.47		4.26		NS	2.47		7.12		NS

NS= Non-significant

Table 2 : Response of sulphur and phosphorus fertilization on test weight (g) of groundnut (Two years data)

Phosphorus level	1st year					2nd year				
	Sulphur levels					Sulphur levels				
	0	20	30	40	Mean	0	20	30	40	Mean
0	331.31	336.93	352.62	383.36	351.55	337.93	343.66	349.67	393.00	358.58
30	336.01	350.39	363.39	383.96	358.44	342.72	357.39	370.65	391.64	365.60
40	354.51	335.71	367.91	376.76	358.60	361.59	342.42	375.26	383.78	365.76
50	334.99	342.08	376.11	336.41	359.90	341.68	348.92	383.63	394.13	367.09
Mean	339.20	341.28	365.11	385.00	357.12	345.98	348.10	372.30	390.65	364.26
	S.E. ±		C.D. (P=0.05)			S.E. ±		C.D. (P=0.05)		
S	2.71		7.84		S	2.75		7.95		S
P	2.71		7.84		NS	2.75		7.95		NS
S x P	5.43		15.68		S	5.50		15.90		S

NS= Non-significant

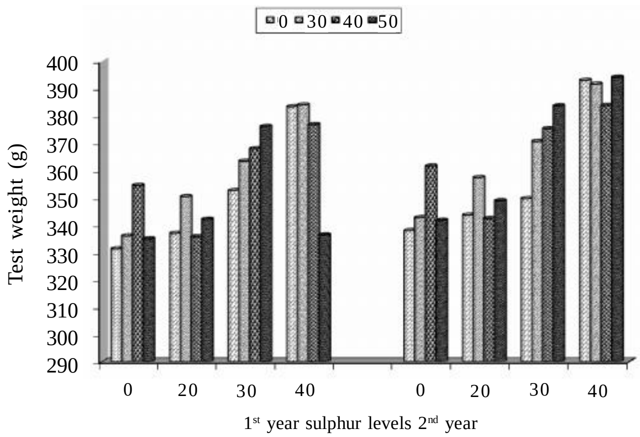

Fig. 2 : Response of sulphur and phosphorus fertilization on test weight (g) of groundnut

It is evident from the data presented in Table 2 that application of different levels of phosphorus influenced the mean test weight of groundnut kernels. Mean test weight of groundnut ranged from 351.55g to 359.90g in 1st year and 358.58.25g to 367.09g in 2nd year. Maximum mean value 359.90g recorded in 1st year when 50 kg phosphorus was applied. Similar trend was observed in second year also. All the values varied significantly over control.

The perusal of the data indicates that various level of sulphur effect the test weight of groundnut. Test weight of groundnut at various levels of sulphur ranged from 339.20g to 385.00g in 1st year and in 2nd year, it ranged from 332.64g to 381.83g. Maximum value *i.e.* 385.00g recorded in 1st year and 381.83g in 2nd year when 40 kg sulphur was applied. All the values varied significantly over control. Similar trend of results were obtained in next year also.

Critical analysis of the data showed that interaction due to confined use of sulphur and phosphorus were found significant. Maximum value of test weight 383.96g was recorded during 1st year when 30 kg phosphorus/ha + 40 kg sulphur/ha was applied in 2nd year. Maximum value 384.63 g observed by use of 50 kg phosphorus + 40 kg sulphur/ha which was significantly superior over control.

Maximum test weight 385.00 was recorded during 1st year and in 2nd year, it was 381.83g in the treatment where sulphur was applied @ 40 kg/ha. Sulphur plays a dominant role in improving the quality of cereals, oil seed crops and pulses. Test weight increased it may be due to sulphur doses showed beneficial effect on sulphate reducing bacteria which reduce inorganic sulphate in to hydrogen sulphide may diminish and thus influence agriculture production (Rao Subba, 1999). These results are also in accordance with Bhaskar and Shivashankar (1993).

Interaction due to sulphur and phosphorus found significant. Sulphur works as soil amendment amelioration of sodic soil find from improving the quality of irrigation water. As a plant nutrient for correcting sulphur deficiency, increasing crop yield and improving the quality of crop produce (Goswami, 1996). Increased level of phosphorus increased the quality of carbohydrate that is assimilated by different plant parts and translocated to developing kernels in plant (Mishra and Dixit, 1988). It may be due to higher test weight of groundnut. The results obtained in this investigation are in conformations with the findings of Sharma *et al.* (1992).

Pod yield q/ha:

Data in regard to pod yield (q/ha) as influenced by

Table 3: Response of sulphur and phosphorus fertilization on yield (q/ha) of groundnut (Two years data)

Phosphorus level	1st year					2nd year				
	Sulphur levels					Sulphur levels				
	0	20	30	40	Mean	0	20	30	40	Mean
0	12.44	13.29	14.29	17.80	14.46	12.65	13.75	14.57	17.94	14.73
30	12.51	13.86	16.27	18.27	15.23	12.23	13.93	16.06	18.55	15.19
40	13.51	14.47	17.82	18.56	16.00	13.40	14.46	17.87	19.48	16.30
50	13.86	14.68	17.94	18.98	16.36	14.09	14.36	17.87	19.73	16.51
Mean	12.99	14.07	16.58	18.40	15.51	13.09	14.13	16.60	18.92	15.68

	S.E. ±	C.D. (P=0.05)		S.E. ±	C.D. (P=0.05)	
S	0.16	0.46	S	0.17	0.48	S
P	0.16	0.46	S	0.17	0.48	S
S x P	0.32	0.91	S	0.34	0.97	S

various levels of sulphur, phosphorus and interaction on pod yield (q/ha) have been presented in Table 3 and graphically presented in Fig. 3. Maximum pod yield 16.36 (q/ha) was obtained during 1st year and in 2nd year, it was 16.51 (q/ha) when phosphorus was applied @ 50kg/ha. All the values varied significantly among treatments.

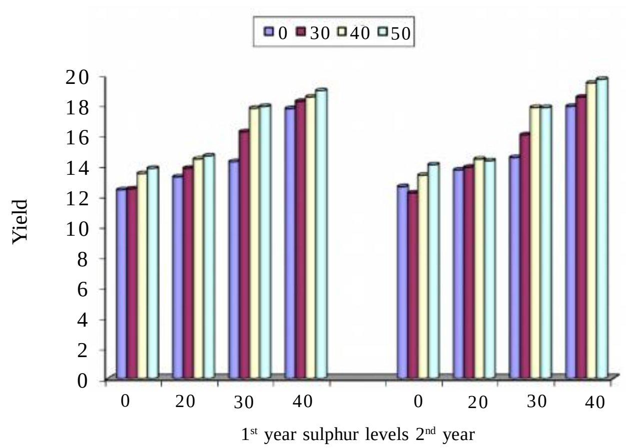

Fig. 3 : Response of sulphur and phosphorus fertilization on yield (q/ha) of groundnut

Application of sulphur significantly increased the yield (q/ha). Maximum yield of groundnut 18.40 (q/ha) was recorded during 1st year and 18.92 (q/ha) during 2nd year when sulphur was applied at the highest rate 40 kg/ha. All the values varied significantly over control.

Interaction of sulphur and phosphorus levels on groundnut pod yield varied significantly during both the years of investigation. Maximum pod yield 18.98 (q/ha) and 19.73 (q/ha) was noticed during 1st year and 2nd year, respectively. Combined application of 50 kg phosphorus and 40 kg sulphur/ha was significantly superior over other treatment combinations. Similar trend was also obtained in second year of investigation.

Data recorded to pod yield q/ha presented in Table 2 maximum pod yield was recorded 16.36 q/ha and 16.51 q/ha during 1st year and 2nd year, respectively. Pod yield increased with phosphorus because it influenced pod development and its filling in legume both directly effecting RNA and protein synthesis in plant and indirectly the nitrogen fixing capacity (Rao and Singh, 1985). Similar results were also reported by Jain (1983) and Kachot *et al*. (1984).

Sulphur @ 40 kg influenced the pod yield during both years of investigation. It was observed that effect of SSP was more due its sulphur content rather than phosphorus content and reported on marked influence of applied S on pod yield, oil and protein content of groundnut kernel. Pasricha (1988) reported work on response of groundnut to sulphur in India and noted that the increase of groundnut yield with applied S ranged from 0.75-5.0 q/ha. This may be due to this reason, that higher dose of sulphur increased pod yield q/ha. The findings are also in accordance to Singh and Kalra (1983) and Dimree *et al*. (1993).

As shown in Table 3, interaction due to combined effect of sulphur and phosphorus doses positively influenced the pod yield of groundnut. Maximum pod yield 18.98 q/ha and 19.73 q/ha was noticed during 1st year and 2nd year, respectively. It may be due to proper dose applied to the crop of groundnut. The results are in agreement to Chahal and Viramani (1973).

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