Madras Agric. J., 100 (7-9): 722-725, September 2013
https://doi.org/10.29321/MAJ.10.001391

Effect of Phosphorus and Sulphur Fertilization on Yield, Nutrient Removal and Quality Parameters of Sesame

R.K. Verma, S.S. Yadav*, M.M. Puniya and L.R. Yadav
Department of Agronomy, S.K.N. College of Agriculture
S.K. Rajasthan Agricultural University, Bikaner
Jobner, Rajasthan - 303 329

A field experiment was conducted at S.K.N. College of Agriculture, Jobner in Jaipur district of Rajasthan during *kharif* 2009 on loamy sand soil under semi-arid conditions. The experiment consisting of four levels each of phosphorus (0, 15, 30 and 45 kg ha^{-1}) and sulphur (0, 15, 30 and 45 kg ha^{-1}) thereby making sixteen treatment combinations was laid out in randomized block design and replicated thrice. Sesame variety 'RT-127' was used as a test crop. Results showed that every increase in level of phosphorus upto 30 kg ha^{-1} brought about significantly higher seed (933 kg ha^{-1}) and stalk yield (3385 kg ha^{-1}) in comparison to lower levels and control. Nitrogen, phosphorus and sulphur concentration in seed and stalk and their uptake, protein and oil content in seed as well as oil yield were also significantly improved under this level of phosphorus. However, it was found at par with 45 kg P ha^{-1}. Results further indicated that application of sulphur at 30 kg ha^{-1}, remaining at par with 45 kg ha^{-1} produced 9.8 and 32.5 per cent higher seed and stalk yield of sesame than 15 kg ha^{-1} and control, respectively. Nutrient concentration in seed and stalk and their uptake as well as protein and oil content in seed was also significantly higher at these levels of sulphur than lower levels. Sulphur fertilization at 30 and 45 kg ha^{-1} also recorded oil yields of 453.1 and 469.0 kg ha^{-1} that was 55.3 and 60.8 per cent higher than control, respectively. The economic optimum dose of phosphorus and sulphur as derived from response function was found to be 42.15 and 42.75 kg ha^{-1}, respectively.

Key words : Sesame, Phosphorus, sulphur, yield, nutrient uptake, quality

Sesame (*Sesamum indicum* L.) is an important edible oilseed crop next to groundnut, rapeseed and mustard. About 70 per cent of the sesame produced in the country is used for oil extraction. Its oil content generally varies from 46 to 52 per cent and protein content between 20-26 per cent. The fatty acid composition of sesame reveals that linoleic, oleic, palmitic and stearic acids are its major constituents. The oil is highly resistant to oxidative rancidity and characterized for its stability and quality. Because of excellent quality characters, sesame oil is also called as "poor man's substitute for ghee". Sesame cake or meal obtained as a byproduct of oil milling industry is rich in protein, carbohydrates, vitamin (niacin) and minerals (Ca and P). Sesame cake is also a valuable nutritious feed for milch animals and is ingredient of poultry feed because of its high methionine content. The cake contains 6.0-6.2 per cent N, 2.0-2.2 per cent P and 1.0-1.2 per cent K and can also be used as manure. Globally, sesame is grown on 6.57 million hectares with production of 2.94 million tonnes and productivity of 448 kg ha^{-1}. India is the largest producer and acreage holder (26%) of sesame in the world. In India, it is cultivated on 1.81 million hectares with total production of 0.64 million tonnes. The average productivity of the crop is 354 kg ha^{-1} (Anonymous, 2009). It is an important crop of arid and semi arid districts of Rajasthan. The crop occupied 5.21 lakh hectares in the state and produced 1.54 lakh tonnes.

*Corresponding author email: ssyadav107@yahoo.in

Despite its importance, the productivity in the state is very low (293 kg ha^{-1}). Cultivation of crop on marginal and sub marginal lands of poor fertility under very poor agronomic practices and inadequate or no use of fertilizers are the major factors responsible for its low productivity. The average N, P, K and S removal to produce a tonne of sesame is 51.7, 22.9, 64.0 and 11.7 kg, respectively and other micronutrients like Ca, Mg, Zn, Fe, Mn, and Cu are also important (Hegde, 1998). Phosphorus is among the major plant nutrients required for high sesame yields. It plays a significant role in the formation of energy rich phosphate bonds like ADP and ATP, nuclear protein and phospholipids and is essential constituent of nucleic acids (RNA and DNA), nucleoproteins, amino acids, protein, phosphatides, phytin and several co enzymes (NADP) . Phosphorus is also involved in energy transfer metabolic processes and basic reactions of photosynthesis, transformation of sugar and starch and nutrient movement in plants. It is known to stimulate extensive root system thereby enabling the plant to extract moisture and mineral nutrients optimally. Phosphorus is deficient in most of the soils of Rajasthan, particularly in light textured ones where most of the sesame is grown. Sulphur is another nutrient which plays an important role in synthesis of sulphur containing amino acids (cystine, cysteine and methionine), vitamins, co-enzyme-A and metabolism of carbohydrates, protein and fats. It also helps in development of root growth and increase drought and cold tolerance in oilseeds due to disulphide linkage. Availability of sulphur in soil usually does not exceed 10-15 ppm and is frequently lower than 5-10 ppm. In such soils, each unit of sulphur applied can augment the supply of edible oil by 3.5 units (Tandon, 1986). In view of these facts, this experiment was undertaken during *Kharif*, 2009.

Materials and Methods

A field experiment was conducted during *kharif* 2009 at the Agronomy farm, S.K.N. College of Agriculture, Jobner (Rajasthan) . The soil of the experimental field was loamy sand in texture, alkaline in reaction (pH 8.2), low in organic carbon (0.14%) and available nitrogen (132.7 kg ha^{-1}) and medium in available phosphorus (16.3 kg ha^{-1}), potassium (150.4 kg ha^{-1}) and sulphur (8.4 ppm). The experiment was laid out in randomized block design with sixteen treatment combinations comprised of four levels of phosphorus (0, 15, 30 and 45 kg ha^{-1}) and four sulphur levels (0, 15, 30 and 45 kg ha^{-1}). A uniform dose of 20 kg N ha^{-1} was applied to all the plots. After adjusting the N supplied by DAP, remaining N was applied through urea at the time of sowing and whole amount of phosphorus through DAP was drilled 10 cm deep at the time of sowing as per treatments. Sulphur was applied through gypsum of agriculture grade containing 12 per cent sulphur before sowing as per treatments and incorporated well into the soil. Sesame variety 'RT-127' was sown on 22th July, 2009 using seed rate of 3 kg ha^{-1} with a row spacing of 30 cm at a depth of 3 cm. The crop was harvested on 5th October, 2009. Usual crop husbandry practices were followed to raise a good crop. Seed and straw yields were recorded at harvest and subjected to statistical analysis. To assess the relationship, correlation and regression coefficients between seed yield of sesame (Y) and the independent variables
(X) were worked out using the procedure given by
Regression equations were also fitted and tested for significance. To describe the relationship of seed yield (Y) as a function of the simple effect of phosphorus and sulphur fertilization (X), correlation and regression studies were under taken. Response equations were fitted to the yield data to describe them mathematically. The following equation proved to be the best fit :

$$Y = b_0 + b_1X + b_2X^2$$

Where,

Y= Expected yield (kg ha^{-1})

X= Dose of P/S (kg ha^{-1})

b_0= Constant

b_1 and b_2 = Regression coefficients

After fitting response curve, optimum dose of phosphorus and sulphur were worked out by the following formula:

$$X_{opt} = \frac{Q/P - b_1}{2 b_2}$$

Where,

X_{opt} = Optimum dose of P/ S (kg ha^{-1})

P = Price per kg of seed yield (Rs)

Q = Cost per kg P/ S (Rs)

b_1 and b_2 = Coefficients of response

equation **Results and Discussion**

Seed and stalk yield

Results showed that seed and stalk yield of sesame was significantly improved due to application of graded levels of phosphorus (Table 1). Every increase in level of phosphorus upto 30

Table 1. Effect of phosphorus and sulphur fertilization on yield and quality parameters of sesame

Treatment	Seed yield (kg ha^{-1})	Stalk yield (kg ha^{-1})	Protein content in seed (%)	Oil content (%)	Oil yield (kg ha^{-1})
A. Phosphorus levels (kg ha^{-1})					
0	704	2758	17.63	41.48	292.1
15	850	3181	19.57	45.30	385.1
30	933	3385	21.13	48.63	453.7
45	959	3525	21.97	48.86	468.6
SEm$\pm$	21.9	80.02	0.45	1.07	10.48
CD (P=0.05)	63.4	231.1	1.29	3.10	30.22
B. Sulphur levels (kg ha^{-1})					
0	710	2693	18.00	41.09	291.7
15	853	3162	19.72	45.24	385.9
30	928	3457	21.19	48.83	453.1
45	955	3538	21.38	49.11	469.0
SEm$\pm$	21.9	80.02	0.45	1.07	10.48
CD (P=0.05)	63.4	231.1	1.29	3.10	30.22

kg ha^{-1} significantly enhanced the seed yield over preceding levels. It produced the seed yield of 933 kg ha^{-1} that was 9.8 and 32.5 per cent higher than 15 kg ha^{-1} and control, respectively. Significant increase in stalk yield was observed upto 15 kg P ha^{-1}, only. The highest seed and stalk yields (959 and 3525 kg ha^{-1}) were recorded with 45 kg P ha^{-1}. It improved the seed and stalk yield to the tune of 12.8 and 10.8 per cent over 15 kg ha^{-1} and 36.2 and 27.8 per cent over control, respectively. However, it showed statistical equivalence with 30 kg ha^{-1}. The increase in yield might be associated with improved nutritional environment in rhizosphere as well as in the plant system leading to higher plant metabolism and photosynthetic activity. Similar findings were also reported by Ravinder *et al*. (1996) and Patra (2001) in sesame. Sulphur fertilization also had positive influence on seed and stalk yield of sesame (Table 1). Application of sulphur at 30 kg ha^{-1} recorded significantly higher seed and stalk yield (928 and 3457 kg ha^{-1}) of sesame than that at 15 kg ha^{-1} and control.

It enhanced the seed and stalk yield by margin of 8.8 and 6.0 per cent over 15 kg ha-1 and 30.7 and 28.4 per cent over control, respectively. However, it was found at par with 45 kg S ha-1 wherein the highest yields were recorded. Increase in yield of sesame due to sulphur fertilization has also been reported by Saren *et al.* (2005) and Tripathi *et al.* (2007).

Nutrient concentration and uptake

Nutrient concentration in seed and stalk and their uptake by sesame was influenced to a considerable extent due to application of phosphorus (Table 2). Every increase in level of phosphorus upto 30 kg ha-1 brought about significantly higher concentration of N, P and S in seed and P concentration in stalk. Whereas, improvement in N and S concentration in stalk was observed upto 15 kg P ha-1, only. The highest concentration of all the nutrients was recorded with 45 kg P/ha. It also represented the highest uptake of 75.38 kg N, 13.98 kg P and 7.12 kg S ha-1. However, it remained statistically similar with 30 kg ha-1 that also registered increase of 13.8 and 48.1 per cent in N uptake, 34.8 and 88.4 per cent in P uptake and 19.0 and 72.5 per cent in S uptake over 15 kg ha-1 and control, respectively. Nutrient concentration and uptake were also influenced due to sulphur fertilization (Table 2). The highest concentration of all the nutrients as well as their uptake were noted with 45 kg S ha-1. Sulphur fertilization at 30 kg ha-1 recorded N, P and S uptake of 71.03, 12.81 and 6.70 kg ha-1 that was 13.8, 13.1 and 16.1 per cent higher than 15 kg ha-1 and 48.2, 45.2 and 66.7 per cent over control, respectively. However, it was found at par with 45 kg ha-1 that also registered 55.4, 52.0 and 78.1 per cent higher uptake of N, P and S over control, respectively. These findings conformed to the results of Mankar *et al.* (1995) and Thakur *et al*. (1998) in sesame.

Table 2. Effect of phosphorus and sulphur fertilization on nutrient concentration in seed and stalk and their uptake

Treatment	N conc. (%)		Total N uptake	P conc. (%)		Total P uptake	S conc. (%)		Total S uptake
	Seed	Stalk	(kg ha-1)	Seed	Stalk	(kg ha-1)	Seed	Stalk	(kg ha-1)
A. Phosphorus levels (kg ha-1)									
0	2.82	0.99	47.68	0.61	0.13	8.03	0.16	0.10	3.96
15	3.13	1.10	62.07	0.71	0.16	11.22	0.19	0.13	5.74
30	3.37	1.16	70.62	0.77	0.17	15.13	0.21	0.14	6.83
45	3.52	1.17	75.38	0.80	0.18	13.98	0.21	0.14	7.12
SEm+	0.07	0.02	1.87	0.02	0.04	0.33	0.01	0.04	0.22
CD (P=0.05)	0.21	0.07	5.41	0.05	0.11	0.95	0.02	0.13	0.64
B. Sulphur levels (kg ha-1)									
0	2.88	0.99	47.92	0.66	0.148	8.82	0.16	0.11	4.02
15	3.16	1.10	62.41	0.72	0.159	11.33	0.19	0.13	5.77
30	3.38	1.14	71.03	0.76	0.167	12.81	0.21	0.14	6.70
45	3.42	1.16	74.47	0.76	0.171	13.41	0.22	0.14	7.16
SEm+	0.07	0.02	1.87	0.02	0.01	0.33	0.06	0.04	0.22
CD (P=0.05)	0.21	0.07	5.41	0.05	0.01	0.95	0.16	0.13	0.64

Quality parameters of sesame

Quality parameters of sesame *viz.* protein and oil content in seed as well as oil yield were significantly improved due to phosphorus fertilization. Data presented in Table 1 showed that phosphorus fertilization at 30 kg ha-1 significantly improved the crude protein content in sesame seed by 8.0 and 19.9 per cent over 15 kg ha-1 and control, respectively. However, the difference between 30 and 45 kg P ha-1 was not significant. Similarly, oil content in seed also showed positive response to phosphorus fertilization. Application of phosphorus at 30 and 45 kg ha-1 represented the oil contents of 48.63 and 48.86 per cent and thus enhanced it by 7.4 and 7.9 per cent over 15 kg ha-1 and 17.2 and 17.8 per cent over control, respectively. The corresponding increase in oil yield was 17.8 and 21.7 per cent over 15 kg ha-1 and 55.3 and 60.4 per cent over control. However, they were found at par with each other. Results further revealed that protein and oil content in sesame seed increased with sulphur fertilization. Progressive increase in level of sulphur upto 30 kg ha-1 brought about significantly higher protein and oil content in seed over preceding levels. It represented the protein and oil contents of 21.19 and 48.83 per cent that were 7.5 and 7.9 per cent higher than 15 kg ha-1 and 17.9 and 18.8 per cent than control, respectively. It also gave oil yield of 453.7 kg ha-1 that was 17.4 and 55.3 per cent higher than 15 kg ha-1 and control, respectively. However, it showed statistical equivalence with 45 kg S ha-1 wherein the maximum values of protein (21.38%), oil content (49.11%) as well as oil yield (469.0 kg ha-1) were recorded. Thakur *et al.* (1998) and Raja *et al.* (2007) also reported improvement in these quality characters of sesame due to phosphorus and sulphur application.

Correlation and regression studies

Correlation coefficients and regression equations were worked out between seed yield and number of capsules per plant, number of seeds per capsule,

Table 3. Correlation coefficients and linear regression equations showing relationship between independent variables (yield attributes)

Dependent variable (Y)	Independent variable (X)	Correlation coefficient (r)	Regression equation $Y = a + byx X$
Seed yield (kg ha^{-1})	Capsules per plant	0.984**	$Y = 30.86 + 21.70 X_1$
	Seed per capsule	0.994**	$Y = - 59.12 + 14.90 X_2$
	Test weight	0.995**	$Y = -716.38 + 586.38 X_3$
	Total N uptake	0.998**	$Y = 263.76 + 9.35 X_4$
	Total P uptake	0.954**	$Y = 387.67 + 40.01 X_5$
	Total S uptake	0.999**	$Y = 390.40 + 79.68 X_6$

** Significant at 1 % level of significance

test weight and total uptake of nitrogen, phosphorus and sulphur. The values calculated are presented in Table 3. The results of correlation coefficients revealed that seed yield was significantly and positively correlated with number of capsules per plant (r = 0.984), number of seeds per capsule (r =

Table 4. Seed yield as a function of phosphorus and sulphur fertilization ($Y = b_0 + b_1 X + b_2 X^2$)

Study parameter	Values	
	Phosphorus	Sulphur
Partial regression coefficients		
b_0	704.05	711.09
b_1	11.653**	11.2**
b_2	-0.133*	-0.129*
Coefficient of		
(i) Determinations (R^2)	0.945**	0.958**
(ii) Multiple correlation (R)	0.972**	0.979**
Optimum level (kg/ha)	42.15	42.75
Yield at optimum level (kg/ha)	958.93	954.13
Response of optimum level (kg/ha)	254.88	243.04

** Significant at 1 per cent level of significance

* Significant at 5 per cent level of significance

0.994), test weight (r = 0.995), total nitrogen uptake (r = 0.998), total phosphorus uptake (r = 0.954) and total sulphur uptake (r = 0.999). The regression equations (Table 3) showed that every unit increase in number of capsules per plant, number of seeds per capsule, test weight and total nitrogen, phosphorus and sulphur uptake increased the seed yield by 21.70, 14.90, 586.38, 9.35, 40.01 and 79.68 kg ha^{-1}, respectively.

Optimum dose of phosphorus and sulphur

The response of seed yield to varying levels of phosphorus and sulphur was worked out and found to be quadratic. The functional form of yield response to phosphorus and sulphur is given in Table 4. The perusal of data showed that economic optimum dose of phosphorus and sulphur was 42.15 and 42.75 kg ha^{-1}, respectively with their corresponding seed yields of 958.93 and 954.13 kg ha^{-1}.

References

Anonymous, 2009. Fertilizer and Agricultural Statistics North Region, Fertilizer Association of India, New Delhi.

Hegde, D.M. 1998. Integrated nutrient management for production sustainability of oilseed - A review. *J. Oilseeds Res.,***15**: 1-17.

Mankar, D.D., Satao, R.N., Solanke, V.M. and Ingole, P.G. 1995. Effect of nitrogen and phosphorus on quality, uptake and yield of sesamum. *PKV Research J.,* **19** : 69-70.

Patra, A.K. 2001. Yield and quality of sesame (*Sesamum indicum* L.) as influenced by N and P during post rainy-season. *Ann. Agric. Res.,* **22**: 249-252.

Raja, A., Hattab, K.O., Gurusamy, L., Vembu, G. and Suganya, S. 2007. Sulphur application on growth, yield and quality of sesame varieties. *Int. J. Agrl. Res.* **2**: 599-606.

Ravinder, N., Satyanarayana, V., Rao, V.P., Latchanna, A. and Varaprasad, P.V. 1996. Influence of irrigation and fertilization on seed yield, nutrient uptake and fertilizer use efficiencies in summer sesame (*Sesamum indicum L.*). *J. Oilseeds Res.,* **13**: 173-177.

Saren, B.K., Nandi, P. and Tudu, S. 2005. Effect of irrigation and sulphur on yield attributes and yield, oil content and oil yield and consumptive use efficiency of summer sesame (*Sesamum indicum* L.). *J. Oilseeds Res.* **22** : 383-384.

Tandon, H.L.S. 1986. Sulphur research and agricultural production in India. Fertilizer Development and Consultation Organization, New Delhi.

Thakur, D.S., Patel, S.R. and Lal, N. 1998. Yield and quality of sesame (*Sesamum indicum* L.) as influenced by nitrogen and phosphorus in light textured inceptisols. *Indian J. Agron.* **43**: 325-328.

Tripathi, M.L. and Rajput, R.L. 2007. Response of sesame (*Sesamum indicum* L.) genotypes to levels of fertilizers. *Adv. Plant Sci.,* **20**: 521-522.

Received: March 27, 2013; Accepted: August 28, 2013