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EFFECT OF NITROGEN, PHOSPHORUS AND SULPHUR ON GROWTH, YIELD AND ECONOMICS OF BLACK SESAME [*Sesamum radiatum* (L.)]

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ABSTRACT

A field experiment was carried out at Research Farm, College of Agriculture, Bharuch, NAU, (Gujarat) during pre-*rabi* 2022 to study the effect of nitrogen, phosphorus and sulphur on growth, yield and economics of black sesame. The experiment consisted of twelve treatment combinations, which includes two levels of nitrogen (25 and 50 kg ha^{-1}), two levels of phosphorus (12.5 and 25 kg ha^{-1}) and three levels of sulphur (0, 20 and 30 kg ha^{-1}). These treatments were tested in factorial randomized block design with three replications. Plant height, number of capsules plant^{-1}, number of seeds capsule^{-1}, seed yield, stover yield, net return as well as B: C ratio of black sesame were significantly increased with the application of 50 kg N ha^{-1}, 25 kg P_2O_5 ha^{-1} and 30 kg S ha^{-1}.

(Key words: Nitrogen, phosphorus, sulphur, sesame and yield)

INTRODUCTION

Oilseed crops play the second important role in the Indian agricultural economy next to food grains in terms of area and production. Sesame is an important edible oilseed crop next to groundnut, rapeseed and mustard in India. It is known as 'the queen of oilseeds' due to its high nutritional, medicinal, cosmetic and cooking qualities (Sabannavar and Lakshman, 2008). Sesame is a rich source of edible oil (48-55 %) and protein (20-28 %) compared with 20 per cent seed oil in other oil seed crops. Sesame is cultivated in almost all parts of country during different season of the year. India ranks first in world with 19.47 lakh ha area and 8.66 lakh tonnes production with productivity of 413 kg ha^{-1} (Anonymous, 2022). Gujarat alone accounts for 20 per cent of the national production. Sesame cultivated in the area of 2.09 lakh hectare with the production of 133.90 million tonnes with productivity of 642 kg ha^{-1} in Gujarat (Anonymous, 2021).

The area, production and productivity of sesame are higher in summer season than those of post-*kharif* and *kharif* season, but the productivity of sesame in general is much lower than its potential yield. Lower productivity is due to use of sub-optimal rate of fertilizer, poor management and cultivation of sesame in marginal and sub-marginal lands, where deficiency of macronutrient such as nitrogen, phosphorus, potassium and micronutrient is predominant. Balanced fertilization with N, P, K and S is proved beneficial in all the oilseed crops to minimize the unfavourable exploitation of soil fertility and plant nutrient, thus maintain the soil health and plant nutrient at optimum level. Nitrogen, phosphorus and sulphur play a vital role in the nutrition of plants. In fact, these nutrients are lacking mostly in the soils. Fertility analysis of Indian soils has indicated that the soils are deficient in microorganisms and nutrients.

MATERIALS AND METHODS

The field experiment was carried out at College Farm, Navsari Agricultural University, Bharuch (Gujarat) during pre-*rabi* season of 2022. The soil was clayey in texture and slightly alkaline in reaction. The soil was low in available N (243 kg ha^{-1}), low in available P_2O_5 (26.13 kg ha^{-1}), low in available sulphur (7.96 mg kg^{-1}) and high in available K_2O (327 kg ha^{-1}). The field experiment was laid out in FRBD with 12 treatment combinations consisting of three factors *viz.*, Nitrogen [N_1: 25 kg ha^{-1}, N_2:50 kg ha^{-1}], Phosphorus [P_1: 12.5 kg ha^{-1}, P_2: 50 kg ha^{-1}] and Sulphur [S_1: 0 kg ha^{-1}, S_2: 20 kg ha^{-1}, S_3: 30 kg ha^{-1}] with three replications. Sesame variety GT-10 was sown by opening of furrow at distance of 45 cm × 10 cm. Application of fertilizers was given before the sowing of seeds in the open furrow. The half dose of nitrogen and full dose of phosphorus and sulphur was applied at the time of sowing and the remained half dose of nitrogen was applied at 30 DAS. The different dose of nitrogen, phosphorus and sulphur was applied in form of urea, DAP and elemental sulphur, respectively as per the treatment in each plot. For all the growth and development studies during the crop growth period, five plants were selected randomly from net plot and tagged in each plot for recording plant height at harvest, number of capsules plant^{-1}, length of capsule and number of seeds capsule^{-1}. 1000 seeds were randomly taken from the bulk produce of each net plot and were counted and weighed. The weight was expressed as

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1000- seed weight in grams. The data on seed and stover yield were recorded from net plot and converted on hectare basis. The net realization and B:C ratio were calculated. The data were statistically analyzed by the procedure suggested by Panse and Sukhatme (1985).

RESULTS AND DISCUSSION

Effect of nitrogen

Growth parameter

Among the different doses of nitrogen, 50 kg N ha^{-1} gave significantly higher plant height (Table 1), which was closely followed by 25 kg N ha^{-1}. The significantly maximum plant height (127.99 cm) at harvest was recorded with nitrogen dose of 50 kg ha^{-1}. Nitrogen plays a crucial role in promoting plant height and overall growth. It stimulates cell division and cell elongation. It stimulates growth of shoot apical meristems, the regions of plant tissue responsible for producing new cells. By promoting cell division and elongation in these meristems, nitrogen enhances the growth of shoots and contributes to increase plant height. Nitrogen availability influences internode elongation, leading to longer and taller stem. Increased nitrogen level promotes the production of auxins, plant hormone that regulate cell elongation, resulting taller plants. The results are in close conformity with finding of Sawant *et al.* (2013). They reported that significantly the highest plant height of summer sesame was observed with the application of 75 kg N ha^{-1}, which was found at par with the application of 50 kg N ha^{-1}. Ezung and Jamir (2019) reported that the maximum plant height was recorded with the application of 100 % RD of N through vermicompost, however, it was found at par with the application of 75 % RD of N through vermicompost in Maize. Ram *et al.* (2022) also reported that application of 180 kg N ha^{-1} recorded significantly highest plant height (143.8, 181.8 and 191.2 cm at 60, 90 DAS and at harvest, respectively) but it was at par with the application of 150 kg N ha^{-1} in Maize.

Yield attributes and yield

The nitrogen application at increasing levels showed significant effect on number of capsules $plant^{-1}$, number of seeds $capsule^{-1}$, capsule length, seed yield and stover yields. Application of nitrogen @ 50 kg ha^{-1} produced significantly higher number of capsules $plant^{-1}$ (83.73), number of seeds $capsule^{-1}$ (71.91), capsule length (2.86 cm), seed yield (880 kg ha^{-1}) and stover yield (2186 kg ha^{-1}) over all the other treatments. Nitrogen has a significant role in nutrient partitioning within plants. Adequate nitrogen supply fevers the allocation of nutrients towards reproductive structures, such as developing capsules and seeds. It ensures that sufficient resources are directed toward seed formation, resulting in a yield attributing character. The results are in conformity with those of Sawant *et al.* (2013). They reported that significantly the highest number of capsules $plant^{-1}$ (54.4). length of capsule (2.74 cm), number of seeds $capsule^{-1}$ (59.34), test weight (3.34 g), seed yield (1331 kg ha^{-1}) and stalk yield (2894 kg ha^{-1}) with the application of 75 kg N ha^{-1}, but it was found at par with the application of 50 kg N ha^{-1}. Ezung and Jamir (2019) reported that the highest number of grains cob^{-1} (464.43), test weight (80.54 g), grain yield (25.78 q ha^{-1}) and stover yield (75.42 q ha^{-1}) were recorded with the application of 100 % RD of N through vermicompost in Maize. Ram *et al.* (2022) also reported that application of 180 kg N ha^{-1} recorded numerically the highest test weight (23.42 g) and significantly the highest number of cobs $plant^{-1}$ (1.69) number of grains cob^{-1} (476.8), cob length (20.71 cm), cob girth (14.63 cm), grain yield (51.58 q ha^{-1}) and straw yield (103.69 q ha^{-1}) in Maize.

Economics

An appraisal of data given in Table 1 indicated that the maximum net return (₹ 71468 ha^{-1}) was secured with the application of nitrogen 50 kg ha^{-1} along with B:C ratio of 3.60. The increase in net return is due to higher seed yield obtained under these treatment as compared to cost involved under these treatments. Similar view in the direction of present finding was also expressed by Sharma *et al.* (2018). They reported that application of 70:40:00 N: P_2O_5: K_2O kg ha^{-1} gave the maximum net return (₹ 42,545 ha^{-1}) and B:C ratio of 3.34 followed by application of 70:00:00 kg N:P_2O_5:K_2O ha^{-1} and 70:40:15 kg N:P_2O_5:K_2O ha^{-1} and minimum net return (₹ 15,407 ha^{-1}) and B:C ratio (1.76) was recorded with control treatment.

Effect of phosphorus

Growth parameter

The mean data presented in Table 1 indicated that plant height at harvest was significantly affected due to different phosphorus level. Significantly taller plant at harvest (128.76 cm) was registered under application of 25 kg P_2O_5 ha^{-1}. Phosphorus is involved in cell division and elongation processes, which are essential for plant growth and height. It is necessary for photosynthesis, the process by which plant convert sunlight into energy. Efficient photosynthesis leads to enhance biomass accumulation, resulting in taller plants. Similar results have been reported by Kalegore *et al*. (2018). They reported that the maximum plant height (104.2 cm) was recorded due to the application of 30 kg phosphorus ha^{-1} which was significantly superior over the 20 and 25 kg P_2O_5 ha^{-1}. Lal *et al*. (2022) also found highest plant height with the application of phosphorus @ 70 kg ha^{-1} at 30, 60, 90 DAS and at harvest, however the results were at par with 70 kg P_2O_5 ha^{-1} at all growth stages on field pea. Lyngkhoi *et al*. (2020) also reported that the maximum plant height of 56.95 cm was recorded with 40 kg P_2O_5 ha^{-1} in soybean.

Yield attributes and yield

Significantly higher number of capsules $plant^{-1}$ (85.32), number of seeds $capsule^{-1}$ (72.91), test weight (3.33 g), seed yield (854 kg ha^{-1}) and stover yield (2180 kg ha^{-1}) were recorded with the application of phosphorus 25 kg ha^{-1}. Increased number of capsules $plant^{-1}$, number of seeds $capsule^{-1}$, test weight, seed and stover yield might be due to phosphorus, it does play a role in flowering and fruit development. Phosphorus availability affects the initiation and development of flowers, leading to improvement in flower formation and potentially higher fruit yield. These findings are in agreement with Akter *et al.* (2013), who reported that the highest number of pods plant $^{-1}$ (27.73) and stover yield (2.94 t ha^{-1}) was recorded with the application of 50 kg P_2O_5 ha^{-1} in soybean, however the lowest number of pods plant $^{-1}$ (24.57) and stover yield (2.47 t ha^{-1}) was recorded in no phosphorus treatment. They also found that the highest seeds plant^{-1} (80.21), test weight (93.57 g) and grain yield (2.046 t ha^{-1}) were recorded with the application of 30 kg P_2O_5 ha^{-1} which was statistically at par with that obtained from 50 kg P_2O_5 ha^{-1}. Lal *et al.* (2022) also found that the application of phosphorus @ 70 kg ha^{-1} resulted the maximum number of pods plant^{-1}, number of seeds pod^{-1}, test weight and grain yield, however, application of phosphorus at 60 kg ha^{-1} showed at par results in terms of yield and yield attributes except in case of straw yield of field pea. The highest straw yield of field pea was observed with the application of phosphorus @ 60 kg ha^{-1}. Lyngkhoi *et al.* (2020) also reported that the maximum number of filled pods (36.91), seed yield (11.26 g pot^{-1}) and stover yield (17.37 g pot^{-1}) was recorded with the application of 60 kg P_2O_5 ha^{-1} in soybean.

Economics

The data from Table 1 reflected that maximum net return (₹ 72167 ha^{-1}) was secured when sesame crop was fertilized with phosphorus 25 kg ha^{-1} along with B:C ratio of 4.01. The increase in net return is due to higher seed yield obtained under these treatments as compared to cost involved under these treatments. Similar view in the direction of present finding was also expressed by Ram *et al.* (2022). They reported that the maximum net realization (Rs. 81,803 ha^{-1}) and BCR (2.44) was recorded with the application of 60 kg P_2O_5 ha^{-1}, while the minimum net realization (Rs. 74,424 ha^{-1}) and BCR (2.31) was recorded with the application of 30 kg P_2O_5 ha^{-1} in maize.

Effect of sulphur

Growth parameter

The data in respect of plant height of sesame as influenced by different treatments are presented in Table 1. The higher dose of sulphur (30 kg ha^{-1}) recorded significantly taller plant (129.31 cm) at harvest as compared to control, but which was at par with 20 kg S ha^{-1}. Sulphur is a constituent of certain amino acid, proteins, enzymes and vitamins necessary for plant growth. Proteins from the structural components of cells and are involved in various physiological processes, including cell division and elongation, adequate sulphur availability promotes protein synthesis, which can contribute to increased plant height. Sulphur is a crucial component of chlorophyll, the pigment responsible for photosynthesis. Sufficient sulphur levels ensure the production of healthy chlorophyll, which supports optimal photosynthesis and can contribute to enhanced plant height. Similar result was reported by Kalegore *et al.* (2018). They reported that the maximum plant height (102.5 cm) was recorded due to the application of 30 kg sulphur ha^{-1} which was at par with the application of 25 kg sulphur ha^{-1} and significantly superior over the application of 20 kg sulphur ha^{-1}. Lyngkhoi *et al.* (2020) and Patel *et al.* (2023) also recorded highest plant height of 57.28 and 64.89 cm in soybean and summer cow pea, respectively with the application of 30 kg sulphur ha^{-1}.

Yield attributes and yield

There was a significant effect of sulphur on yield attributes and yield of sesame (Table 1). The yield attributing characters *viz.* number of capsules plant^{-1}, test weight, seed yield and stover yield increased significantly with the increase in sulphur levels. Among the different levels of sulphur, application of sulphur 30 kg ha^{-1} (S_3) recorded significantly the highest number of capsules plant^{-1} (84.37), test weight (3.50), seed yield (873 kg ha^{-1}) and stover yield (2253 kg ha^{-1}) which was at par with 20 kg ha^{-1} (S_2). Sulphur plays vital and important role in energy transformation, carbohydrate metabolism and activation of enzymes as well as respiration, photosynthesis which in turn accelerated development of yield attributes. One more reason is that application of suitable dose in crop increases the sulphur amount and available sulphur to plant which helps in increasing bold seed and adjective full capsules which improved seed yield. Similar result was also found by Kalegore *et al.* (2018). They reported that higher number of branches (4.3), number of capsules plant^{-1} (54.9) and dry matter production plant^{-1} (19.9 g), were recorded due to the application of 30 kg sulphur ha^{-1} which was significantly superior over the application of 20 and 25 kg sulphur ha^{-1}. Lyngkhoi *et al.* (2020) and Patel *et al.* (2023) also noticed that the maximum number of filled pods (38.95) and number of pods plant^{-1} (24.26) in soybean and summer cow pea, respectively were recorded with the application of 30 kg S ha^{-1} as compared to control. They also observed significantly higher stover yield (17.88 g pot^{-1}) as well as seed yield (1393 kg ha^{-1}) and stover yield (2508 kg ha^{-1}) in soybean and summer cow pea, respectively with the application of 30 kg S ha^{-1} as compared to control. Chaudhari *et al.* (2023) also reported that application 40 kg S ha^{-1} recorded significantly the highest seed yield (1163.5 kg ha^{-1}) and (2334.5 kg ha^{-1}) over application of 30 and 20 kg S ha^{-1}.

Economics

The data from Table 1 reflected that maximum net return (₹ 71132 ha^{-1}) was secured when sesame crop is fertilized with 30 kg ha^{-1} along with B:C ratio of (3.62). The increase in net return is due to higher seed yield obtained under these treatments as compared to cost involved under these treatments. Similar view in the direction of present finding was also expressed by Bainade *et al.* (2018). They reported that the highest NMR (₹ 34434 ha^{-1}) and B:C ratio (3.30) were recorded by the application of RDF + 25 kg S ha^{-1} through bensulf followed by the application of RDF + 25 kg S ha^{-1} through gypsum and RDF + 20 kg S ha^{-1} through bensulf in linseed.

Table 1. Effect of nitrogen, phosphorus and sulphur on growth, yield attributes and yield of sesame

Treatments	Plant height at harvest (cm)	Number of capsules $plant^{-1}$	Number of seeds $capsule^{-1}$	Capsule length (cm)	Test weight (g)	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Net return (Rs. ha^{-1})	B:C ratio
Nitrogen level (N)									
N_1 : 25 kg ha^{-1}	116.63	74.85	67.39	2.51	3.19	700	1962	51768	2.90
N_2 : 50 kg ha^{-1}	127.99	83.73	71.91	2.86	3.32	880	2186	71468	3.60
SE(m) ±	3.33	1.96	1.46	0.06	0.05	20.9	56.36	-	-
CD (5 %)	9.77	5.76	4.29	0.19	-	65.0	165.00	-	-
Phosphorus level (P)									
P_1 : 12.5 kg ha^{-1}	115.85	73.27	66.38	2.61	3.18	725	1967	58498	3.52
P_2 : 25 kg ha^{-1}	128.76	85.32	72.91	2.76	3.33	854	2180	72167	4.01
SE(m) ±	3.33	1.96	1.46	0.06	0.05	20.9	56.36	-	-
CD (5 %)	9.77	5.76	4.29	-	0.15	80.0	165.00	-	-
Sulphur level (S)									
S_1 : 0 kg ha^{-1}	113.89	75.38	67.25	2.58	3.05	699	1929	56333	3.51
S_2 : 20 kg ha^{-1}	123.79	78.12	70.28	2.65	3.23	797	2039	64112	3.50
S_3 : 30 kg ha^{-1}	129.31	84.37	71.41	2.83	3.50	873	2253	71132	3.62
SE(m) ±	4.08	2.40	1.79	0.08	0.06	25.6	69.03	-	-
CD (5 %)	11.97	7.05	-	-	0.18	74.0	202.00	-	-
N X P X S									
SE(m) ±	8.16	4.81	3.58	0.16	0.12	54.4	138.1	-	-
CD (5 %)	-	-	-	-	-	-	-	-	-

Selling price of seed : ₹ 110.0 kg^{-1}, Stover : ₹ 1.0 kg^{-1}

From the results, it can be inferred that pre-*rabi* sesame (GT-10) should be fertilized with 50 kg N (50 % basal and 50 % at 30 DAS), 25 kg P_2O_5 and 30 kg S ha^{-1} for getting growth, yield and monetary returns under south Gujarat Agro-climatic condition.

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