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Response of Sesame to varied Nitrogen and Phosphorus Levels under Irrigated conditions

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ABSTRACT: A field experiment was conducted on Sesame (*Sesamum indicum*) at Research Farm of Agronomy, CCSHAU, Hisar during Kharif, 2022. The trial was conducted in a randomized block design with four levels of nitrogen and four levels of phosphorus and replicated thrice. The four nitrogen levels were: 0, 15, 30, and 45 kg ha^{-1}, and the four phosphorus levels were 0, 15, 20, and 25 kg ha^{-1}. Nitrogen @ 45 kg ha^{-1} and phosphorus @ 20 kg ha^{-1} resulted in the maximum significant growth, physiology, yield, and yield attributes of the crop compared to the control. Treatment with nitrogen application @ 45 kg ha^{-1} increased dry matter per plant at harvest, CCM, and seed yield by 43.5, 37.8, and 17.8 percent respectively compared to the control. Among treatments of phosphorus levels, phosphorus application @ 20 kg/ha improved dry matter, seed yield, and biological yield by 23.8, 24.4, and 27.5 percent compared to the control.

Keywords: Agronomic efficiency, yield, fertilizer levels.

INTRODUCTION

Sesame (*Sesamum indicum* L.) is an annual, self-pollinated, indeterminate minor kharif edible oilseed crop and belongs to the family Pedaliaceae. It is an important oilseed crop, being used for a wide range of products in the food industry, such as cooking oil, paste (tahini), baking, and pharmaceutical (Mushtaq *et al*., 2020). For poultry and animals, sesame meal, which contains 40% high-quality protein, is an excellent feed. With 16.73 lakh acres and 6.5 lakh tonnes of output, India leads the world. In comparison to other nations in the world, India has a poor global sesame yield (391 kg/ha). Being grown as a rainfed crop with poor nutrient supply is the major reason for its low productivity. Some other concerns are unfertile soils, imbalanced use of fertilizers, low-yielding varieties, insect-pest, weed and disease infestation. The principal states for sesame cultivation include Rajasthan, Gujarat, West Bengal, Maharashtra, Uttar Pradesh, Madhya Pradesh, and Andhra Pradesh. There are 2.8 thousand hectares and 1.0 thousand tons of output in the Haryana region. The state of Haryana produces 357 kg/ha on average (Ranganatha, 2013). The crop is extremely sensitive to excessive moisture in soils and long-term water stagnation in a standing crop thus having a wholly negative impact on the crop.

Nitrogen and phosphorus are primary macro-nutrients essential for the profuse growth of plants. They increase the vegetative growth of plants and dry matter accumulations (Kalaliya *et al.,* 2022). Water availability, which promotes the transport of minerals into and across the root, is a major factor in the acquisition of N by plant roots. Nitrogen is particularly important to promote protein metabolism, cell division, leaf expansion, root development, and growth (Ahmad *et al*., 2018). Nitrogen is the most dynamic nutrient element and N nutrition may affect plant response to drought to the two extremes: synergism or antagonism (Albornoz, 2016). An increase in leaf area, carboxylases, and chlorophyll content, which determines the photosynthetic activities in plants leads to higher dry matter production and its allocation is observed when nitrogen supply is increased within its beneficial limits. Most of the sesame agriculture worldwide is rainfed, depending on summer rains or lingering soil moisture. Due to the dependence of the mass flow of N from the root on transpiration rates, greater water availability facilitates N acquisition. The natural medium known as the soil is what gives plants the necessary nutrients for healthy growth and development. Various researchers have reported significant yield increases in sesame with the application of N P K fertilizers in India, Pakistan, and Tanzania (NP). An ample supply of P is associated with increased root density and proliferation, helping in extensive exploration and supply of nutrients and water. N is the major contributor of all the nutrient inputs accounting for up to 50 percent, and therefore, it is a determinant of farmers' crop yield (Babajide *et al.,* 2014). A general thumb rule is that N is for leafy top growth, phosphorus is for root and fruit production, and potassium is for cold hardiness, disease resistance, drought tolerance, and general durability.

Phosphorus is necessary for the conversion of energy, cell storage, early root development, flowering, early maturation, and seed development in plants (Jahan *et al.,* 2019; Priyadarshini *et al.,* 2021). Shehu *et al.* (2010) reported the highest number of branches, leaves, seed/pod, seed yield, and dry matter against application rate of 112.5 kg N/ha, and application of 45 kg P/ha produced the highest seed yield of sesame. Haruna *et al.* (2010) were of the view that sesame production gave significantly better yields and economic returns with applications of 13.2 kg P/ha of phosphorus fertilizer.

Keeping in view the economic value and important constraints related to the existing low yield of the crop, a study was conducted to evaluate the effect of different levels of nitrogen and phosphorus on the growth and yield of sesame under agroclimatic conditions of Hisar.

MATERIALS AND METHODS

The field experiment was conducted on sesame crop grown under irrigated conditions at Research Farm of CCS, Haryana Agricultural University, Hisar, Haryana, India (125004) during *Kharif*, 2022. The coordinates of the location are 29°10' N latitude, 75° 46' E longitude, and an elevation of 215.2 m above mean sea level. Hisar experiences a semi-arid climate with a severe cold during winter and hot dry and desiccating winds during summer. The maximum temperature is about 45°C during the hot summer months of May and June, while during the winter months of December and January, the minimum temperature may be subzero. Annual rainfall of the area is around 450 mm of which 70-80 percent is received during monsoon periods *i.e*., July to September, and the rest is received in showers of cyclic rains during the winter and spring seasons. The mean relative humidity remains nearly constant at about 75 to 90 percent from July to March, steadily decrease in April, and remains around 40-50 percent during the hot summer months of May and June. The soil of the experimental field was sandy loam in texture, slightly alkaline in reaction with pH 8.0, soil organic carbon (0.34%), available N (162 kg/ha) were low, P_2O_5 medium (12.3 kg/ha), and; high in K_2O (330 kg/ha) and S (29 ppm). The experiment consisted of four nitrogen levels and four phosphorus levels with three replications laid out in factorial RBD. All recommended package practices of CCSHAU, Hisar for irrigated conditions of Haryana were followed for raising the crop. The crop was harvested on 15 September, 2022. Harvest index and Agronomic efficiency were calculated using the following formulas:

$$\text{Harvest Index (\%)} = \frac{\text{Grain yield (kg/ha)}}{\text{Biological yield (kg/ha)}} \times 100$$

$$\text{Agronomic efficiency (AE)} = \frac{\text{Grain yield in treatment plot - Grain yield in control}}{\text{Fertilizer N applied (kg/ha)}}$$

Data were further subjected to analysis of variance (ANOVA) using OPSTAT software and mean difference between treatments were compared by least significance difference at a 5% level of probability.

RESULTS AND DISCUSSION

Effect of N and P levels on growth parameter: The growth parameters *viz.* plants/meter row length, plant height (cm), and dry matter (g/plant) were improved with the increasing levels of nitrogen up to 45 kg/ha and phosphorous dose up to 20 kg/ha. Nitrogen is the major constituent of cells and is essential for cell division and elongation. Plant growth thus may have eventually improved as a result of increased vegetative expansion with increased nitrogen supply. Results for nitrogen levels were in coordination with the findings of Kithan and Singh (2017); Ahmed *et al*. (2023). Plant height at harvest was observed at par with different nitrogen and phosphorus levels. The plant's dry matter is significantly affected due to nitrogen levels. Significantly higher dry matter was documented under 45 kg N/ha over control and 15 kg N/ha and at par with 30 kg N/ha. 20 kg/ha phosphorus produced significantly higher dry matter (13.88 g/plant) and at par to 25 Kg P/ha (13.68 g/plant) (Table 1). Rapid solubilization and mobilization of phosphorus from its inorganic sources might have fulfilled the phosphorus needs for cell elongation and cell division at critical stages of plant growth. Improved growth of sesame grown in Ethiopia with increased NPS fertilizer dose was also observed by Zebene and Geleta (2022).

Effect of N and P levels on SPAD and CCM: CCM and SPAD at 60 DAS significantly differed due to different nitrogen and phosphorus levels. CCM and SPAD (17.48, 44.65) were significantly higher with 45 kg N/ha compared to other nitrogen treatments, respectively (Table 1). Among phosphorus levels, phosphorus @ 25 kg ha^{-1} was observed significantly over control and 15 kg P/ha for CCM. Phosphorus @ 20 kg/ha was observed significantly over only control for the SPAD values. Nitrogen fertilization increased chlorophyll content in sesame leaves (Shamsuzzoha *et al.,* 2019; Khuong *et al.,* 2022; Bijarnia *et al.,* 2022). Improved chlorophyll with phosphorus fertilization was also reported by Tulukcu and Baba (2019).

Table 1: Growth and physiological parameters influenced by different nitrogen and phosphorus treatments.

Treatments	Plants per meter row length	Plant height (cm)	Dry matter at harvest (g/plant)	CCM	SPAD
Nitrogen levels (kg/ha)					
0	8.8	120.5	10.10	12.68	38.93
15	9.0	121.33	12.96	14.24	40.09
30	9.5	121.52	13.63	14.79	41.23
45	9.8	121.98	14.50	17.48	44.65
CD at 5%	0.6	NS	0.54	1.01	3.28
Phosphorus levels (kg/ha)					
0	8.0	118.93	11.25	13.58	36.98
15	9.3	121.48	12.39	14.32	41.63
20	9.4	122.02	13.88	15.33	43.11
25	10.3	122.90	13.68	15.98	43.18
CD at 5%	0.6	NS	0.54	1.01	3.28

Effect of N and P levels on yield attributes and yield: The response of yield components to N levels varied among traits, P, and location. The seed yield of the plant is the constitution of capsules per plant, number of seeds per capsule, and 1000 seed weight. Maximum significant capsule length (2.86 cm), seed per capsule (31), seed yield (587 kg/ha), and biological yield (1457 kg/ha) were observed with 45 kg N/ha. Yield and yield attributes were increased with increased levels of nitrogen. However, no significant effect of nitrogen levels was observed on the harvest index. This could be due to that increased amount of nitrogen leads to activation of CO_2-fixing enzyme, high photosynthesis rate, and better dry biomass accumulation and partitioning to seeds. Noorka *et al.* (2011) reported that the number of seed weight plant^{-1} and 1000-seed weight was increased when N fertilizer was added. Ahmed *et al.* (2023) also observed that seed yield and yield attributes were improved when nitrogen was increased from 30 to 60 units/fed. Jouyban and Moosave (2011) stated about a significant increase in seed yield, pod diameter, number of auxiliary branches/plant, and capsule length was observed with an increase in N level from 0 to 200 kg/ha.

Maximum significant capsule length (2.62 cm) and seeds per capsule (29.6) were observed with phosphorus application @ 25 kg/ha while seed yield (596 kg/ha) and biological yield (1480 kg/ha) were observed with phosphorus @ 20 kg/ha and were significantly higher over control and 15 kg P/ha. The improvement in yield with P fertilization might have been attained mainly due to an adequate supply of phosphorus, which helped in maintaining better source-sink inter relationship by increasing sink capacity owing to its key role in energy transformation. Phosphorus is involved in root mass development, which performs an indirect function for the formation of hormones such as cytokinin that enhances flower initiation in several plants. Singh *et al.* (2017) reported an increase in yield due to P fertilization in sunflower. Kumar *et al.* (2022) reported improvement in yield attributes of sesame when phosphorus levels were increased from 15 to 60 kg/ha at Gwalior.

Effect of N and P levels on Agronomic efficiency: Among nitrogen levels, nitrogen application @ 45 kg/ha (1.98) resulted in the highest agronomic efficiency followed by 30 (1.70) and 15 kg/ha (0.80). Golan *et al.* (2022) also reported similar results in the sesame crop. Among phosphorus levels, phosphorus application @ 20 kg/ha (5.85) resulted in the highest agronomic efficiency followed by 15 (4.67) and 25 kg/ha (1.64).

Table 2: Yield attributes and yield influenced by different nitrogen and phosphorus treatments.

Treatments	Capsules length (cm)	Seeds/capsules (No.)	Seed yield (kg/ha)	Straw yield (Kg/ha)	HI (%)	Agronomic efficiency
Nitrogen levels (kg/ha)						
0	2.23	26.73	498	1268	28.25	
15	2.49	27.04	510	1288	28.42	0.80
30	2.74	27.71	549	1367	28.72	1.70
45	2.86	31.00	587	1457	28.78	1.98
CD at 5%	0.05	0.80	38	105	NS	
Phosphorus levels (kg/ha)						
0	2.54	26.47	479	1161	29.16	
15	2.57	27.69	549	1380	28.50	4.67
20	2.59	28.72	596	1480	28.75	5.85
25	2.62	29.60	520	1359	27.76	1.64
CD at 5%	0.05	0.80	38	105	NS	

CONCLUSIONS

Nutrient management is crucial for the profuse growth and yield of a plant. The right proportion of different nutrients is important for the good performance of the cell's biochemical and physiological functions. Nutrient requirements of a crop depend on whether the crop is grown rainfed or irrigated. Higher doses of nutrients than optimum result in detrimental effects on the growth of plants, thus reducing the yield and increasing the cost of cultivation. From the treatments of nitrogen and phosphorus levels in sesame grown under irrigated conditions, it can be concluded that nitrogen at the rate of 45 kg/ha and phosphorus @ 20 kg/ha was best to gain the highest yields.

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Conflict of Interest. None.

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