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RESPONSE OF SESAME GROWTH AND PRODUCTIVITY TO VARYING NITROGEN RATES AND PLANTING GEOMETRY

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ABSTRACT

A field experiment was conducted to evaluate the effects of nitrogen levels and planting geometry on sesame (*Sesamum indicum* L.) growth, yield, and oil content. Three nitrogen rates (0, 35, and 70 kg ha⁻¹) and four planting geometries (flat sowing, paired row, ridge sowing, and bed sowing) were tested. Results indicated that nitrogen application significantly enhanced all growth and yield parameters. Plant height increased from 126.92 cm in the control to 137.05 cm at 70 kg ha⁻¹ nitrogen, while the number of capsules per plant, seeds per capsule, 1000-seed weight, and seed oil content also improved with higher nitrogen levels. Planting geometry significantly influenced yield and seed quality. Ridge (P₃) and bed sowing (P₄) produced taller plants (137.10 and 136.25 cm, respectively), higher capsule numbers, and greater seed weight compared to flat (P₁) and paired row planting (P₂). Seed oil content was highest in ridge and bed sowing, suggesting that wider spacing and improved aeration favor oil accumulation. The combined effects of nitrogen and planting geometry were pronounced. Bed sowing with 70 kg ha⁻¹ nitrogen (N₂) produced the highest seed yield (1.00 t ha⁻¹), followed by ridge sowing (0.91 t ha⁻¹). Overall, ridge and bed sowing, in combination with 70 kg ha⁻¹ nitrogen, optimized sesame growth, productivity, and oil quality, indicating these as the most effective agronomic practices for enhancing sesame performance.

Keywords: Planting geometry, Nitrogen rates, Growth and productivity, Sesame.

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INTRODUCTION

Sesame (*Sesamum indicum* L.) is a globally important oilseed crop valued for its high-quality edible oil and adaptability to diverse agro-ecological conditions (Laghari et al., 2024). However, its productivity is often constrained by low soil fertility and suboptimal crop management practices, particularly in low-input farming systems (Issahaku et al., 2023). Among mineral nutrients, nitrogen (N) plays a critical role in vegetative growth, reproductive development, and final seed yield of oilseed crops due to its involvement in chlorophyll synthesis, protein formation, and overall plant metabolism (Seehausen et al., 2017).

Previous studies have demonstrated that nitrogen application significantly enhances growth and yield attributes in sesame, resulting in increased plant height, number of capsules per plant, seed yield, and oil quality compared with unfertilized controls. Increasing nitrogen supply generally promotes simultaneous improvements in growth and yield traits (Ihsanullah et al., 2023). In addition to nutrient management, planting geometry—including row spacing as well as inter- and intra-row distances—plays a vital role in regulating crop microclimate, light interception, and interplant competition (Nadeem et al., 2015). Proper geometric arrangements optimize plant population density,

improve resource-use efficiency, and enhance yield components such as capsule number and seed weight. Recent agronomic studies indicate that spacing patterns significantly influence sesame growth and productivity by modifying canopy structure and resource availability per plant (Kumara et al., 2014). Research integrating nitrogen management with planting geometry has gained increasing attention, with modern studies emphasizing the interactive effects of nitrogen rate and plant spacing on sesame performance (Adisu et al., 2024). Investigations on nitrogen use efficiency (NUE) and planting density suggest that moderate nitrogen application combined with optimized plant density can substantially improve yield and seed quality traits, highlighting the importance of environment-specific agronomic management (Wang et al., 2026). Despite these advances, comprehensive field studies simultaneously evaluating different nitrogen levels and planting geometries remain limited. Therefore, the present study aimed to evaluate the combined effects of nitrogen fertilization and planting geometry on sesame growth, productivity, and oil content, with the objective of providing practical recommendations for improving sesame production systems.

MATERIALS AND METHODS

Field Experiment

A field experiment was conducted in 2025 at Kaleri Agriculture Farm, near Sindh Agriculture University (SAU), Tando Jam, Sindh, Pakistan. The experiment was arranged in a randomized complete block design (RCBD) with three replications, using a plot size of 15 m². Four planting geometries were evaluated: flat sowing (40 cm row spacing), paired-row planting (60/20 cm), ridge sowing (40 cm apart), bed sowing (50/30 cm; 50-cm-wide beds with 30-cm ditches between beds). Three nitrogen levels were applied: control (0 kg ha⁻¹), 35 kg ha⁻¹, and 70 kg ha⁻¹. Planting geometries were assigned to the main plots, while nitrogen treatments were allocated

to the subplots. **Statistical Analysis**
Data were subjected to analysis of variance (ANOVA) using Statistix 8.1 software. Treatment means were compared using the least significant difference (LSD) test at a significance level of $\alpha = 0.05$ (Steel et al., 1997).

RESULTS

The results presented in Table 1 indicated that nitrogen application significantly influenced growth and yield components of sesame. Increasing nitrogen levels from control (N₀) to 70 kg ha⁻¹ (N₂) progressively improved all measured parameters. Plant height at maturity increased significantly with higher nitrogen application. The tallest plants (137.05 cm) were recorded under N₂ (70 kg ha⁻¹), followed by N₁ (132.18 cm), while the control treatment produced the shortest plants (126.92 cm). This improvement may be attributed to enhanced vegetative growth due to increased nitrogen availability. Similarly, the number of capsules per plant showed a significant increase with nitrogen fertilization. The maximum number of capsules (98.45 plant⁻¹) was observed under N₂, compared with 93.10 under N₁ and 87.80 under control conditions. The number of seeds per capsule also improved slightly but significantly with increasing nitrogen levels, reaching the highest value (63.02 seeds capsule⁻¹) at N₂ treatment. This indicates improved reproductive development under adequate nitrogen nutrition. A consistent increase was observed in 1000-seed weight, where N₂ produced the highest seed weight (3.46 g), followed by N₁ (3.20 g), while the lowest value (2.94 g) was recorded in the control treatment. Seed oil content was markedly affected by nitrogen application. The highest oil content (46.12%) was obtained with 70 kg ha⁻¹ nitrogen, representing a substantial improvement over the control (39.12%). Overall, the results demonstrate that nitrogen fertilization enhanced sesame growth, yield attributes, and oil quality, with 70 kg ha⁻¹ nitrogen proving the most effective level among the treatments tested.

Table 1: Response of sesame growth and productivity to varying nitrogen rates and planting geometry.

Nitrogen Levels	Plant Height at Maturity (cm)	No. of Capsules plant ⁻¹	No. of Seeds capsule ⁻¹	1000-Seed Weight (g)	Seed Oil Content (%)
No (Control)	126.92 c*	87.80 c	60.95 c	2.94 c	39.12 c
N ₁ (35 kg ha ⁻¹)	132.18 b	93.10 b	62.10 b	3.20 b	44.05 b
N ₂ (70 kg ha ⁻¹)	137.05 a	98.45 a	63.02 a	3.46 a	46.12 a

Table 2 showed plant height, ridge sowing (P₃) and bed sowing (P₄) produced the tallest plants compared to flat sowing (P₁) and paired row planting (P₂), though the

difference between some treatments was not statistically significant. Number of Capsules per Plant: Bed sowing (P₄) resulted in the highest number of capsules per plant,

significantly higher than flat sowing (P_1). Seeds per Capsule: Differences among planting geometries were minor and mostly non-significant. 1000-Seed Weight: Ridge sowing (P_3) had the highest seed weight, indicating better

seed development under this geometry. Seed Oil Content: Ridge and bed sowing (P_3 and P_4) significantly improved oil content, suggesting that wider spacing and better aeration favor oil accumulation.

Table 2: Response of sesame growth and productivity to varying nitrogen rates and planting geometry.

Planting Geometry	Plant Height (cm)	No. of Capsules plant ⁻¹	No. of Seeds capsule ⁻¹	1000-Seed Weight (g)	Seed Oil Content (%)
P_1 (Flat sowing)	126.40 n.s	91.85 c	61.70 N.S	3.08 N.S	42.10 b
P_2 (Paired row planting)	130.05	92.40 bc	62.05	3.16	42.80 b
P_3 (Ridge sowing)	137.10	94.90 ab	62.70	3.33	44.25 a
P_4 (Bed sowing)	136.25	95.20 a	62.30	3.28	44.40 a

*Means not sharing a common letter differ significantly at $P \leq 0.05$ according to DNMR test. N.S. = Non-significant.

Table 3 presents all planting geometries, increasing nitrogen levels significantly enhanced sesame productivity. In flat sowing (P_1), seed yield increased from 0.52 t ha⁻¹ in the control (N_0) to 0.67 t ha⁻¹ at 70 kg ha⁻¹ nitrogen (N_2), with a mean of 0.59 t ha⁻¹. Paired row planting (P_2) showed a similar trend, with yields rising from 0.49 t ha⁻¹ (N_0) to 0.69 t ha⁻¹ (N_2) and a mean of 0.60 t ha⁻¹. Ridge sowing (P_3) demonstrated higher responsiveness, increasing from 0.65 t

ha⁻¹ (N_0) to 0.91 t ha⁻¹ (N_2), resulting in a mean yield of 0.79 t ha⁻¹. Bed sowing (P_4) consistently produced the highest yields, reaching 1.00 t ha⁻¹ at 80 kg ha⁻¹ nitrogen, with a mean of 0.87 t ha⁻¹. The overall means across nitrogen levels also showed a significant increase from 0.59 t ha⁻¹ at N_0 to 0.82 t ha⁻¹ at N_2 . These results indicate that ridge and bed sowing geometries, combined with higher nitrogen application, significantly enhance sesame productivity.

Table 3: Response of sesame growth and productivity to varying nitrogen rates and planting geometry.

Planting Geometry	N_0 (Control)	N_1 (35 kg ha ⁻¹)	N_2 (70 kg ha ⁻¹)	Mean
P_1 (Flat sowing)	0.52 f*	0.58 ef	0.67 d	0.59 c
P_2 (Paired row planting)	0.49 f	0.63 de	0.69 c	0.60 c
P_3 (Ridge sowing)	0.65 de	0.82 c	0.91 b	0.79 b
P_4 (Bed sowing)	0.69 d	0.91 b	1.00 a	0.87 a
Means	0.59 c	0.74 b	0.82 a	—

*Any two means not sharing a common letter differ significantly at $P \leq 0.05$ (DNMR test).

DISCUSSION

The present study evaluated the effects of varying nitrogen rates and planting geometries on sesame growth, yield components, and seed oil content. Nitrogen application significantly influenced all measured growth and yield parameters (Table 1). Plant height increased progressively with higher nitrogen levels, reaching the maximum of 137.05 cm under 70 kg ha⁻¹ nitrogen (N_2), compared to 132.18 cm at 35 kg ha⁻¹ (N_1) and 126.92 cm in the control. The increase in plant height can be attributed to enhanced vegetative growth resulting from higher nitrogen availability, consistent with findings by (Ansa et al., 2021) and (Ahmed et al., 2022), who reported that nitrogen promotes stem elongation and leaf development in sesame. Similarly, the number of capsules per plant showed a positive response to nitrogen fertilization, with the highest

number observed under N_2 (98.45 plant⁻¹). Seeds per capsule also increased slightly but significantly, indicating improved reproductive development with adequate nitrogen nutrition. The 1000-seed weight followed the same trend, increasing from 2.94 g in the control to 3.46 g at N_2 , reflecting better seed filling. Seed oil content was markedly enhanced by nitrogen application, achieving a maximum of 46.12% under N_2 , compared to 39.12% in the control. These results demonstrate that nitrogen not only improves vegetative and reproductive growth but also positively affects sesame oil quality, corroborating results reported by (Bijarnia et al., 2019) and (Jahan et al., 2019).

Planting geometry significantly affected sesame growth and productivity (Table 2). Ridge sowing (P_3) and bed sowing (P_4) produced taller plants (137.10 and 136.25 cm, respectively) compared to flat sowing (P_1) and paired row

planting (P_2). Bed sowing also resulted in the highest number of capsules per plant (95.20), significantly greater than flat sowing. Differences in seeds per capsule were minor and mostly non-significant, while 1000-seed weight was highest in ridge sowing (3.33 g), indicating improved seed development. Seed oil content was significantly higher in ridge and bed sowing (44.25–44.40%), suggesting that wider spacing and better aeration favor oil accumulation. These findings align with the work of (Hakeem et al., 2020) and (Oloniruha et al., 2021), who emphasized the importance of optimized planting geometry for enhanced growth and yield of sesame.

The combined effect of nitrogen levels and planting geometry on sesame productivity was significant (Table 3). Across all geometries, increasing nitrogen enhanced seed yield. Bed sowing with 70 kg ha⁻¹ nitrogen (N_2) produced the highest yield (1.00 t ha⁻¹), followed by ridge sowing (0.91 t ha⁻¹). Flat sowing and paired row planting responded moderately to nitrogen, producing 0.67 and 0.69 t ha⁻¹ at N_2 , respectively. The overall mean yields increased from 0.59 t ha⁻¹ at N_0 to 0.82 t ha⁻¹ at N_2 . These results indicate that both ridge and bed sowing geometries, combined with higher nitrogen application, optimize growth, yield, and seed quality. The findings are consistent with recent studies highlighting the importance of integrating nutrient management and spatial arrangement to improve sesame performance (Wang et al., 2024; Kaleri et al., 2025).

CONCLUSION

Overall, nitrogen fertilization and appropriate planting geometry independently and interactively enhance sesame growth, yield components, and seed oil content. Among the treatments tested, 70 kg ha⁻¹ nitrogen applied in bed or ridge sowing systems proved most effective in maximizing sesame productivity and oil quality.

AUTHOR CONTRIBUTIONS

All authors contributed equally in the manuscript.

COMPETING OF INTEREST

The authors declare that there is no conflict of interest regarding the publication of this paper.

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