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Study on Optimizing Planting Geometry and Varietal Performance for Enhanced Yield in Sesame (*Sesamum indicum* L.)

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ABSTRACT

The aim of this research experiment was to identify the most suitable combination of sesame varieties and planting geometries that improves growth, resource-use efficiency, and seed yield under the existing agro-climatic conditions. This research investigation entitled *"Optimizing Planting Geometry and Varietal Performance for Enhanced Yield in Sesame (Sesamum indicum L.)"* was conducted scientifically under a split plot design *viz.*, variety and spacing each at four levels (V_1-TMV7, V_2-VRI3, V_3-VRI4, V_4- SVPR1 and S_1 - 30 cm x 10 cm, S_2 - 30 cm x 30 cm, S_3 - 45cm x 10 cm, S_4 - 45 cm x 15 cm) respectively. Significant differences were observed among the varieties for key growth and yield attributes, with the superior genotype VRI 3 constantly recorded greater plant height, biomass accumulation and seed yield. Planting geometry also had a marked influence on crop performance, as the wider spacing of 45 cm × 15 cm enhanced vegetative growth and through balanced plant growth, resulted in increased seed and stover yields and also the interaction effects further confirmed that the highest seed yield occurred when the top performing variety was cultivated under the most suitable spacing, demonstrating a strong varietal response to planting geometry. Thus, the study concluded that the combination of VRI 3 grown at 45 cm × 15 cm proved superior, as the wider spacing minimized intra plant competition and allowed the variety's inherent vigour to express fully, resulting in the highest yield and yield parameters.

Keywords: *Sesame, Planting geometry, Varietal performance, Inherent vigour, Highest yield*

Introduction

Sesame (*Sesamum indicum* L.) is one of the oldest oil-seed crops cultivated worldwide for its high-quality edible oil, nutritional value, and industrial importance. In India, sesame holds a significant place in rainfed agriculture due to its adaptability to diverse agro-ecological conditions, short duration, and drought tolerance. It is one of the most important oil seed crops grown in the tropical and subtropical areas of the world. Indian people use both the oil and seeds of sesame for traditional cooking methods, religious rituals, Ayurvedic medicine and topically for skin nourishment. Sesame is one of the major oil seed crops grown in the country and occupies top most position after groundnut, rapeseed and mus-

([1]Ph.D. Scholar, [2]Professor, [3]Associate Professor, [4]Professor) tard. It contains a considerable quantity of edible oil (48 to 55%), protein (20 to 21%), sugar (14 to 16%), fibre (6 to 8%) and minerals (5 to 7%). Sesame is grown across the world on an area of 12.84 million hectares, with a production of 6.74 million tonnes and a productivity of 525 kg ha^{-1}. In India, sesame is grown on an area of 16.27 lakh hectares with a production of 7.89 lakh tonnes and a productivity of 485 kg ha^{-1} (FAOSTAT, 2025).

Despite its potential, sesame productivity remains relatively low, primarily due to inadequate crop management practices, suboptimal plant population, and the use of varieties not well matched to specific field conditions. Among the agronomic practices influencing sesame production, planting geometry plays a decisive role, as it governs light interception, nutrient uptake, canopy structure, and ultimately seed and biomass yield. Sesame genotypes differ greatly in growth habit, branching pattern, capsule arrangement, and maturity duration. Therefore, identifying stable, high-yielding varieties across agro-ecological zones is essential for improving productivity (Dossa *et al.,* 2016). Varietal selection is a foundational component in improving sesame productivity, as genotypes differ significantly in traits such as branching pattern, capsule number, seed yield, and adaptability to environmental conditions (Gedifew, 2023). Assessments of sesame genotypes have repeatedly demonstrated significant variation for yield related traits, indicating the potential to select superior genotypes tailored for specific agronomic environments (Hatkar *et al.,* 2025). In addition to varieties, planting geometry plays a vital role in determining the expression of growth and yield traits in sesame, with wider spacings often enhancing individual plant performance by reducing inter-plant competition for light, nutrients, and moisture. Proper plant spacing plays a decisive role in determining growth and yield of sesame by regulating inter plant competition for light, nutrients, and moisture, thereby influencing overall crop architecture and productivity by efficient resource use efficiency (Sarkar and Banerjee, 2019). Adoption of optimum plant geometry, particularly wider row spacing with moderate plant density, significantly improves dry matter accumulation and assimilate partitioning in sesame crops" (Ramesh *et al.,* 2021). The interaction between variety and planting geometry can significantly affect crop expression, and understanding this relationship is essential for identifying combinations that maximize productivity. Varieties respond differently to spacing due to variation in height, branching tendency, and growth rate. Proper alignment of genotype and plant geometry maximizes nutrient uptake and radiation-use efficiency (Khan *et al.*, 2020). However, limited research has been conducted on evaluating different sesame varieties under varied spacing arrangements within a unified experimental framework.

Therefore, the present investigation, *"Optimizing Planting Geometry and Varietal Performance for Enhanced Yield in Sesame (Sesamum indicum L.)"*, was undertaken to assess the important growth parameters, yield attributes and seed yield and hence the study aims to identify an optimum varietal spacing combination that enhances productivity and thereby contributing to more sustainable sesame production systems.

Materials and Methods

The field experiment was conducted in GL 1 of the experimental farm, Department of Agronomy, Annamalai University, Annamalai Nagar during summer 2023. The geographical location of the experimental farm is located at 11° 24' N latitude, 79° 44' E longitude, at an altitude of + 5.79 m above mean sea level.The region enjoys a moderately warm climate, featuring hot summers and is located within the North East Monsoon zone.

During the summer seasons of 2023, the weekly mean maximum temperature varied between 34.2 and 36.8 °C, with an average of 35.5 °C. The weekly mean minimum temperature ranged from 19.4 to 21.1 °C, averaging 20.25 °C. Relative humidity levels fluctuated between 71 and 67 percent, with a mean of 69 per cent. The average annual rainfall recorded in this region is 1500 mm. The soil had a pH of 7.4 and found to be low in available nitrogen, medium in available phosphorous and high in available potassium, respectively. The experiment was laid out in split-plot design with four main plot treatments and four sub plot treatments replicated thrice *viz.*, main plot treatments comprising sesame varieties TMV 7 (V_1), VRI 3 (V_2), VRI 4(V_3), and SVPR 1 (V_4), and subplot treatments of planting geometry, namely 30 cm × 10 cm (S_1), 30 cm × 30 cm (S_2), 45 cm × 10 cm (S_3), and 45 cm × 15 cm (S_4). The sesame crop was fertilized as per the recommended fertilizer schedule of 35:23:23 kg N, P_2O_5 and K_2O ha^{-1} and recommended seed rate of 5 kg ha^{-1}was adopted. Biometric observations of growth and yield parameters were recorded in every plot for the five randomly tagged plants at various growth phases *viz.,* 30, 60 DAS and at harvest.

Results and Discussion

Growth components (Table 1)

The growth parameters of sesame, namely plant height, leaf area index (LAI), and dry matter production (DMP), were significantly influenced by varietal differences, spacing treatments, and their interactions, indicating that both genetic constitution and planting geometry play decisive roles in crop growth and development. Plant height exhibited a progressive increase from 30 DAS to harvest across all treatments, reflecting continuous vegetative growth. Among the varieties, VRI 3 consistently recorded the mean tallest plants at all growth stages (36.7, 99.8 and 102.6 cm at 30, 60 DAS and at harvest, respectively), highlighting its superior genetic vigour, enhanced nutrient uptake efficiency, and better assimilate translocation capacity. In contrast, SVPR 1 exhibited comparatively shorter stature, indicating lower inherent growth potential. Similar varietal differences in plant height have been reported by Zhou *et al.,* (2023), who emphasized that genetic makeup strongly governs stem elongation and overall plant architecture in sesame. Spacing significantly influenced plant height, with wider spacing (45cm × 15 cm) producing taller plants (36.0, 93.6 and 97.5 cm at 30, 60 DAS and at harvest, respectively) than closer spacings. This response can be attributed to reduced inter-plant competition for light, nutrients, and moisture, allowing uninterrupted vertical growth. These findings corroborate the reports of Kerau *et al.* (2025), who observed enhanced plant height under wider spacing due to improved light interception and root zone expansion. The significant interaction between variety and spacing further indicates that the expression of plant height is genotype-dependent and strongly influenced by planting geometry, as also reported by Vala *et al.* (2025) and the highest plant height was observed in VRI 3 under 45cm x 15 cm (V_2S_4) interaction while the lowest was recorded in SVPR 1 under 30 cm x 10 cm (V_4S_1) combination.

Leaf area index (LAI) showed significant variation among varieties, spacing levels, and their interactions. VRI 3 recorded the highest LAI (3.9) at 60 DAS, reflecting its superior canopy development and greater leaf production, which enhanced light interception and photosynthetic efficiency. In contrast, SVPR 1 exhibited lower LAI due to limited leaf expansion and reduced assimilatory surface. Similar varietal trends were reported by Kumari *et al.* (2025), who attributed higher LAI to improved genetic potential and efficient nutrient utilization. Wider spac-

Table 1. Effect of Varieties and Spacing on growth components

Treatments	Plant height (cm)			LAI	DMP (kg ha^{-1})		
Main plot (Varieties)	30 DAS	60 DAS	At harvest	60 DAS	30 DAS	60 DAS	At harvest
V_1 (TMV 7)	32.0	90.1	93.0	3.3	289.8	1900.2	2432.1
V_2 (VRI 3)	36.7	99.8	102.6	3.9	558.9	2627.1	3170.9
V_3(VRI 4)	34.8	94.5	98.4	3.2	373.9	2270.9	2707.2
V_4 (SVPR 1)	26.9	76.8	81.5	2.8	179.7	1620.0	2074.2
S.Ed	0.35	0.40	0.33	0.21	5.64	20.16	14.63
CD (5%)	0.73	0.82	0.67	0.42	11.59	41.40	30.05
Sub plot (Spacings)							
S_1 (30 cm × 10 cm)	29.3	87.0	90.5	2.0	300.1	1970.4	2362.2
S_2 (30 cm × 30 cm)	31.4	89.2	92.7	3.1	325.4	2041.5	2537.0
S_3 (45 cm × 10 cm)	33.7	91.4	94.9	3.6	364.8	2142.0	2665.0
S_4 (45 cm × 15 cm)	36.0	93.6	97.5	4.5	412.0	2264.3	2820.1
S.Ed	0.45	0.49	0.56	0.29	6.51	22.59	34.89
CD (5%)	0.93	1.01	1.15	0.60	13.37	46.40	71.67
Interactions							
S.Ed (V x S)	0.83	0.91	1.01	0.53	12.18	42.48	61.40
CD (5%) (V x S)	1.77	1.94	2.12	1.13	26.06	92.79	128.51
S.Ed (S x V)	0.90	0.99	1.12	0.59	13.02	45.18	69.78
CD (5%) (S x V)	1.85	2.03	2.30	1.20	26.74	96.36	143.34

ing (45cm × 15 cm) resulted in significantly higher LAI (4.5), likely due to reduced mutual shading and enhanced leaf expansion, enabling plants to maintain a more efficient canopy structure. This observation is consistent with the findings of Kerau *et al.* (2025), who reported improved LAI under wider plant spacing due to better light penetration. The significant interaction effect suggests that canopy development in sesame is highly dependent on the compatibility between genotype and planting geometry, as also observed by Rekhasree *et al.* (2025).

Dry matter production followed trends similar to plant height and LAI, with VRI 3 recording the mean highest biomass accumulation at all growth stages (558.9, 2627.1 and 3170.9 kg ha^{-1} at 30, 60 DAS and at harvest, respectively). This superior performance can be attributed to its enhanced photosynthetic efficiency, greater leaf area, and efficient assimilate partitioning. Conversely, SVPR 1 exhibited lower dry matter accumulation due to its limited growth potential. Comparable results were reported by Kerau *et al.* (2025), who observed significantly higher biomass production in vigorous sesame varieties. Spacing had a pronounced effect on DMP, with wider spacing (45cm × 15 cm) consistently producing mean higher biomass (412.0, 2264.3 and 2820.1 kg ha^{-1} at 30, 60 DAS and at harvest, respectively) due to reduced inter-plant competition and improved availability of growth resources. Similar trends were reported by Prashanth *et al*. (2025), who emphasized that optimal spacing facilitates sustained biomass accumulation throughout the crop growth period. The significant interaction between varieties and spacing further underscores that dry matter accumulation was maximized withVRI 3 under 45cm x 15cm (V_2S_4) where genetically superior varieties when grown under wider spacing conditions record higher biomass, as also highlighted by Yusuf and Musa (2024).

Yield components and Yield (Table 2)

The yield components of sesame, namely number of capsules per plant, number of seeds per capsule, seed yield, and stover yield, were significantly influenced by varietal differences, spacing treatments, and their interactions, highlighting the combined role of genetic potential and crop geometry in determining productivity. Among the varieties, VRI 3 consistently recorded superior performance across all yield attributes, indicating its greater reproductive efficiency and superior capacity to convert assimilates into economic yield. The higher number of capsules per plant observed in VRI 3 (95.3) can be attributed to its enhanced branching ability, improved flower retention, and efficient assimilate partitioning, which collectively contribute to in-

Table 2. Effect of Varieties and Spacing on yield components and yield

Treatments	Yield components			
Main plot (Varieties)	Number of capsules $plant^{-1}$	Number of seeds $capsule^{-1}$	Seed yield ($kgha^{-1}$)	Stover yield ($kgha^{-1}$)
V_1 (TMV 7)	70.1	49.4	918.5	1770.8
V_2 (VRI 3)	95.3	59.3	1130.5	1927.3
V_3(VRI 4)	85.9	53.4	944.6	1862.7
V_4 (SVPR 1)	54.9	43.1	833.4	1760.7
S.Ed	0.98	0.65	5.27	10.27
CD (5%)	2.02	1.33	10.84	21.10
Sub plot (Spacings)				
S_1 (30 cm × 10 cm)	67.8	48.2	899.0	1766.3
S_2 (30 cm × 30 cm)	73.5	49.9	920.3	1794.5
S_3 (45 cm × 10 cm)	80.5	54.8	970.4	1854.7
S_4 (45 cm × 15 cm)	84.4	52.3	1037.2	1905.9
S.Ed	1.16	0.78	12.83	24.29
CD (5%)	2.37	1.61	26.35	49.90
Interactions				
S.Ed (V x S)	2.16	1.56	22.57	42.74
CD (5%) (V x S)	4.75	3.21	47.22	89.44
S.Ed (S x V)	2.31	1.45	25.66	48.36
CD (5%) (S x V)	4.92	3.11	52.71	99.79

creased sink strength. Similar varietal superiority in capsule production has been reported by Kumar *et al.* (2022) and Rani and Ramesh (2023), who emphasized those genotypes with better branching architecture and reproductive stability tend to produce higher capsule numbers. In contrast, SVPR 1 recorded the lowest capsule count, reflecting its comparatively weaker growth habit and limited reproductive potential, as also observed by Patel *et al.*, (2024)

The number of seeds per capsule followed a trend similar to capsule production, with VRI 3 exhibiting significantly higher seed count (59.3) due to its superior seed-setting ability and efficient translocation of assimilates during the reproductive phase. Enhanced seed development in this variety may be attributed to better pollen viability and nutrient availability during capsule filling. Comparable findings were reported by Rao *et al.* (2022) and Sivakumar and Balasubramanian (2023), who highlighted that genotypes with higher physiological efficiency and stronger sink strength consistently record greater, seed numbers per capsule. Conversely, SVPR 1 showed reduced seed number (43.1), likely due to suboptimal assimilate supply and lower reproductive efficiency.Plant spacing exerted a marked influence on all yield components. Wider spacing (45 cm × 15 cm) resulted in significantly higher capsule number and seeds per capsule compared to closer spacing, primarily due to reduced inter plant competition, improved light penetration, and enhanced availability of nutrients and moisture. These conditions favored better canopy development, increased photosynthetic activity, and improved translocation of assimilate to reproductive organs. Similar trends were reported by Patel *et al.* (2022) and Mahapatra *et al.* (2023), who observed that optimal spacing, improves source sink balance and reproductive efficiency in sesame. In contrast, closer spacing restricted plant growth and reproductive development due to intense competition, resulting in lower yield attributes, as also noted by Das *et al.* (2024).

Seed and stover yield followed a pattern similar to that of yield components, with VRI 3 producing the highest seed and stover yield (1130.5 and 1927.3kg ha^{-1}, respectively) owing to its superior yield attributes and efficient conversion of biomass into economic yield. The increased seed and stover yield under wider spacing (1037.2 and 1905.9 kg ha^{-1}, respectively) further emphasizes the role of adequate plant geometry in optimizing resource utilization and reproductive success. These findings align with those of Sharma *et al.* (2022) and Mahapatra *et al.* (2023), who reported increased seed yield in sesame under optimal spacing regimes. Conversely, the lowest seed yield recorded under closer spacing reflects the adverse effects of competition induced stress on capsule formation and seed filling. The interaction between variety and spacing was significant for seed and stover yield, indicating that the expression of yield potential depends on the compatibility between genotype and planting geometry. The superior performance of VRI 3 under 45 cm × 15 cm spacing (V_2S_4) recorded the highest seed and stover yield while SVPR 1 under 30 cm × 10 cm (V_4S_1) recorded the lowest seed and stover yield which underscores the importance of selecting appropriate varietal spacing combinations to maximize sesame productivity, a trend also emphasized by Nagaraju *et al.* (2023) and Karthikeyan *et al.* (2024).

Conclusion

The present investigation clearly demonstrates that both varietal potential and planting geometry play decisive roles in determining the growth performance of sesame. VRI 3 (V) emerged as the most vigorous genotype, expressing superior plant height, leaf area index and dry matter production throughout the growth stages, thereby confirming its strong genetic adaptability and resource-use efficiency. The consistently higher LAI and biomass accumulation registered by VRI 3 underline its enhanced canopy architecture, improved radiation capture and effective photosynthetic activity and traits that directly support its growth dominance over other varieties.

The study also establishes 45 cm × 15 cm spacing (S_4) as the most favourable configuration for optimizing vegetative development. Wider spacing facilitated improved root spread, better access to soil nutrients and moisture, and increased light interception, all of which collectively strengthened individual plant performance. The significant varietal spacing interaction, with VRI 3 performing best under 45 cm × 15 cm (V_2S_4), confirms that a wider planting geometry is essential for the full expression of varietal potential.

Thus to conclude, the coordinated improvement in plant height, LAI and dry matter production across the superior treatments suggests a strong physiological basis for enhanced yield expression. These findings reinforce the importance of selecting a genetically vigorous cultivaranda well-matched spacing regime to maximize sesame productivity.

Conflict of Interest - None

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