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Optimizing grain and oil yields of sesame (*Sesamum indicum* L.) through variety selection and intra-row spacing in the Sudan Savanna, Nigeria

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Abstract

To optimize the grain and oil yields of sesame (*Sesamum indicum* L.), field trials were conducted during the 2025 wet season to investigate the performance of different varieties as influenced by intra-row spacing. The experiments were carried out at the teaching and research farms of the Basic Vocational Agriculture School, Tambu-Daura, and Hassan Usman Katsina Polytechnic, Katsina. The treatments consisted of three sesame varieties (EX-SUDAN, KENANA-4, and E8) and four intra-row spacings (10, 15, 20, and 25 cm). A split-plot design was employed, with variety assigned to the main plots and intra-row spacing to the sub-plots, replicated four times. Data were subjected to analysis of variance (ANOVA) using SAS version 9.0, and treatment means were separated using Duncan's Multiple Range Test (DMRT). Results indicated that EX-SUDAN significantly outperformed other varieties in terms of number of capsules, seeds per capsule, 1000-seed weight, seed yield per plant, and oil yield. Specifically, EX-SUDAN produced the highest seed yields in Tambu (700.86 kg ha⁻¹) and Katsina (616.92 kg ha⁻¹). Increasing intra-row spacing from 10 cm to 25 cm resulted in a significant yield increase, rising from 557.74 to 716.00 kg ha⁻¹ in Tambu and from 507.17 to 659.09 kg ha⁻¹ in Katsina. The maximum oil content (49.25%) was recorded at the 25 cm spacing in Tambu, while the highest crude protein contents (24.77% and 23.05%) were achieved at the same spacing across both locations. In conclusion, the EX-SUDAN variety sown at an intra-row spacing of 25 cm is recommended for maximizing yield in the study area.

Keywords: Intra-row spacing, parameters, crude protein, variety and yield

Introduction

Sesame (*Sesamum indicum* L.), commonly known as beniseed, is one of the most ancient oilseed crops known to humanity, with domestication dating back over 3,000 years (Ashri, 2017) ^[1]. Primarily a rain-fed crop, it is cultivated throughout the tropics and subtropics. While characterized as a short-day plant, it exhibits broad adaptability to long-day environments. Sesame is highly valued for its superior oil quality, often distinguished as the "queen of oilseeds" due to its stability and nutritional profile.

Globally, sesame is ranked sixth in oilseed production and eighth in vegetable oil production (FAO, 2018) ^[2]. In 2018, global production reached approximately 6 million metric tons, with Myanmar, Sudan, and India leading as the primary producers (FAO, 2020) ^[3].

In the Nigerian context, sesame was introduced following World War II. While initially cultivated as a minor crop in the Northern and Central regions, it gained significant prominence as a major commercial crop after 1974 (Madina, 2020) ^[4]. Currently, it is a vital cash crop across several northern states, including Benue, Jigawa, Nasarawa, and Taraba, with additional production in Borno, Gombe, Kano, Katsina, Kogi, Plateau, and Yobe (Arora, 2024) ^[5]. Nigeria produces over 580,000 tonnes of sesame annually. As of the end of 2018, sesame seeds emerged as Nigeria's largest agricultural export, with the potential to generate over US\$4 billion in annual revenue through expanded export activities (Stan, 2020) ^[6].

Nigeria possesses high potential for sesame production, driven by increasing domestic and international demand for the crop and its derivatives. Sesame is regarded as the "queen of oilseeds" due to its exceptional oil content and quality (Olawuyi *et al.*, 2023) ^[7].

The popularity of sesame is attributed to its diverse health and industrial applications. Notably,

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the seeds contain a higher oil concentration than most other oilseed crops. Sesame oil is extensively utilized in the cosmetic industry for the formulation of lotions and creams. Furthermore, the oil possesses insecticidal and antifungal properties, allowing it to function as a surfactant and protective coating in agricultural formulations (Yahaya, 2023)^[8]. The agronomic performance of sesame is influenced by climatic conditions, nutrient and water availability, inter- and intra-specific competition, and biotic stresses such as pests and diseases, alongside socioeconomic factors. Usman *et al.* (2021)^[9] noted that traditional growers seldom utilize improved varieties; however, research indicates that improved cultivars significantly enhance yield potential. Additionally, inadequate spacing constrains the rhizosphere and photosphere, limiting the plant's ability to capture resources for growth. This restriction inhibits the development of growth parameters and hinders dry matter accumulation (Adesoji *et al.*, 2020)^[10]. Consequently, low sesame yields are frequently attributed to suboptimal plant density, improper planting dates, and high pest pressure (Yahaya, 2023).^[8] Maximizing sesame productivity is essential for enhancing agricultural profitability and addressing food security challenges. A comprehensive understanding of how variety selection and intra-row spacing interact to influence performance enables the adoption of cultivation practices that optimize yield. Maximum light interception is achievable only when optimal plant spacing is provided from the early stages of vegetative growth (Rajesh *et al.*, 2017)^[11]. Furthermore, establishing an appropriate plant density is critical for the efficient utilization of growth factors—including water, light, nutrients, and carbon dioxide to maximize grain yield (Fetene and Alemayehu, 2016)^[12]. According to Oloniruha (2021)^[13], planting geometry is a decisive factor in crop performance, as it dictates plant population and canopy architecture, which in turn affects solar radiation interception. To improve sesame yields in the study area, the integration of suitable varieties and precise spacing is necessary. Intra-row spacing directly modulates inter-plant competition for essential resources, thereby influencing resource-use efficiency. Identifying the optimal intra-row spacing for specific varieties allows for the minimization of resource wastage while enhancing dry matter accumulation and overall yield. Consequently, this research was conducted to evaluate the yield performance of sesame varieties as influenced by intra-row spacing within the Sudan Savanna of Nigeria,

based on the hypothesis that varieties respond differentially to spatial arrangements.

Materials and Methods
Experimental Site and Soil

The experiment was conducted during the 2025 wet season at two locations: the Teaching and Research Farm of the Basic Vocational Agriculture School, Tambu-Daura (12° 59' 34" N, 8° 16' 58" E; 549 m above sea level) and the Teaching and Research Farm of the College of Agriculture, Hassan Usman Katsina Polytechnic, Katsina (11° 49' N, 7° 23' E; 428 m above sea level). During the study period, the total annual rainfall was 412.4 mm and 398.1 mm for Tambu and Katsina, respectively. Prior to planting, composite soil samples were collected at a depth of 0–30 cm from both experimental sites and subjected to physical and chemical analyses using standard laboratory procedures. The soil textural classes were identified as sandy clay for Tambu and sandy loam for Katsina. The experimental treatments comprised three sesame varieties (EX-SUDAN, KENANA-4, and E8) and four intra-row spacings (10, 15, 20, and 25 cm). The trials were laid out in a split-plot design with four replications; varieties were assigned to the main plots, while intra-row spacings were allocated to the sub-plots.

Agronomic Practices
The experimental field was cleared, harrowed, and ridged prior to sowing. The field layout consisted of twelve main plots, each subdivided into four sub-plots. Each sub-plot comprised six ridges, with a gross plot size of 4m x 4.5m long (18m²) and the net plot was 4m x 3m (12m²). Each main plot contained four (4) sub-plots of 4 m x 4.5 m. Sesame seeds were sown according to the specified intra-row spacing treatments. At three stands per hole, the target plant populations were 399,000, 265,734, 199,500, and 159,600 plants ha⁻¹ for the 10, 15, 20, and 25 cm spacings, respectively. Fertilizer was applied via side placement at a total rate of 60:30:30 kg ha⁻¹ of N, P₂O₅, and K₂O. A basal application of NPK 15:15:15 (providing 30:30:30 kg ha⁻¹) at 3 weeks after sowing (WAS), followed by a top-dressing of 30 kg N ha⁻¹ at 6 WAS, as recommended by Bassam (2024)^[14]. Weed control was maintained through manual hoeing at 3, 6, and 9 WAS, with earthing-up carried out at 6 WAS. Harvesting was performed manually when the leaves and stems transitioned from green to yellow. Plants were cut at the base, bundled, and inverted over tarpaulins for two weeks to facilitate drying and minimize seed shattering.

Table 1: Summary of agronomic advantages of each variety

Verities	E8	EX-Sudan (NCRIBEN-04E)	Kenana-4 (NCRIBEN-05E)
Performance	primarily known for its high-yield potential	high grain yield, high oil content and early maturity	The seeds are noted for their high fat/oil content.
Outstanding features	i) combined performance in growth and yield-related traits. ii) exhibits favourable performance in several morphological traits, including days to germination, plant height, number of leaves, and number of branches.	It is known for being drought-tolerant and adaptable to savanna ecologies	it possesses good overall growth attributes and yield components it possesses good overall growth attributes and yield components The seeds produced by Kenana-4 are predominantly milky-white in colour.
Leaves	dark-green leaves and milky-white flowers.	Broad green leaves, ovate and lanceolate in shape	Large and broad leaves but fewer with higher branches
Maturity	within 100 - 115 days	reaches maturity early (within 85 - 90 days).	maturity relatively early (within 90-100 days).
Potential yield	1.0 tonnes per hectare	typically yielding around 1.3 tons per hectare.	high potential grain yield, up to 1.2 tons per hectare.

Source (Anon,2024)^[15]

Data Collection

Data for the number of capsules, number of seeds per capsule, 1,000-seed weight, and seed yield per plant were obtained from five randomly tagged plants within each net plot. For seed yield per hectare, all plants within the net plot area were harvested, threshed, and weighed; the resulting net plot yields were then extrapolated to kg ha⁻¹. From the harvested seed lot, a 20 g representative sample was collected from each plot to determine oil and crude protein contents following AOAC (2012) ^[16] procedures. Seed oil content was determined gravimetrically using the Soxhlet extraction method with petroleum ether as the organic solvent. Following extraction, the solvent was evaporated, and the recovered oil was weighed. Crude protein was determined via the Kjeldahl method: seed nitrogen was digested with concentrated sulfuric acid to form ammonium sulfate. The ammonia released during distillation was trapped in boric acid and titrated against a standard acid solution. Total nitrogen was then multiplied by a conversion factor of 6.25 to calculate the crude protein percentage. Both oil and protein contents were recorded as percentages. Analysis was done at analytical laboratory of Soil Science Department, Bayero University, Kano, Nigeria.

Data Analysis

Data on yield and quality parameters were subjected to Analysis of Variance (ANOVA) following the procedures for a split-plot design as described by Gomez and Gomez (1984) ^[17]. All statistical analyses were performed using SAS software version 9.0 (SAS Institute, 2002) ^[18]. Significant differences among treatment means were separated using Duncan’s Multiple Range Test (DMRT) at 5% and 1% levels of probability ($P \leq 0.05$ and $P \leq 0.01$) (Duncan, 1955) ^[19].

Results

Soil Sampling and Analysis

The physico-chemical properties of the soil at the two experimental sites (Tambu and Katsina) are presented in Table 2. The results indicate that the textural class at both locations was sandy loam. Chemical analysis revealed soil pH values of 6.42 and 6.32 for Tambu and Katsina, respectively, indicating that the soils were slightly acidic at both sites. Total nitrogen (N) and organic carbon (OC) levels were higher in Tambu than in Katsina. Regarding exchangeable cations, Tambu exhibited higher concentrations of potassium (K), calcium (Ca), sodium (Na), and a higher Cation Exchange Capacity (CEC); however, magnesium (Mg) levels were higher at the Katsina site.

Table 2: Physico-chemical properties of the soil at the Tambu and Katsina experimental sites during the 2025 growing season

Soil Parameters	Tambu	Katsina
Particle size distribution Cmol (+) kg ⁻¹		
Clay	235	177
Silt	200	178
Sand	565	645
Textural class	Sandy loam	Sandy loam
pH in water	6.42	6.35
Organic Carbon Cmol (+) kg ⁻¹	4.58	4.12
Total N Cmol (+) kg ⁻¹	0.78	0.32
Available P Cmol (+) kg ⁻¹	11.18	7.20
K Cmol (+) kg ⁻¹	0.80	0.76
Mg Cmol (+) kg ⁻¹	2.45	2.65
Ca Cmol (+) kg ⁻¹	4.92	4.28
Na Cmol (+) kg ⁻¹	0.52	0.46
CEC Cmol (+) kg ⁻¹	2.83	2.60

Table 3: Meteorological data showing Rainfall, temperature, relative humidity and sunshine during the 2025 growing season at Tambu-Daura

Month	Rainfall (mm)	Temperature °C			Relative Humidity (Muggy) (%)	Sunshine (hours)
		Minimum	Maximum	Average		
April (1days)	11.90	26.00	41.00	33.50	33	12.4
May (4days)	60.80	25.40	40.20	32.30	47	12.7
June (12 days)	119.80	24.60	36.60	30.60	58	12.9
July (19days)	207.80	23.20	33.10	28.10	68	12.8
August (21days)	267.00	22.20	32.00	27.10	74	12.5
September (11days)	103.40	22.30	34.10	28.20	70	12.2
October (3day)	28.70	20.4	35.9	28.15	50	11.8
November	0.00	15.8	33.2	24.5	26	11.5

Source: Katsina State Agriculture and rural Development Authority (KTARDA) Weather Station.

Table 4: Meteorological data showing rainfall, temperature, relative humidity and sunshine during the 2024 growing season at Katsina

Month	Rainfall (mm)	Temperature °C			Relative Humidity (Muggy) (%)	Sunshine (hours)
		Minimum	Maximum	Average		
April (1day)	9.10	23.10	37.90	30.50	37	12.4
May (3days)	55.00	24.00	36.90	30.40	52	12.7
June (10 days)	106.00	22.70	34.00	28.30	62	12.8
July (15 days)	191.00	21.40	30.80	26.10	72	12.8
August (18days)	241.00	20.80	29.90	25.30	77	12.5
September (12 days)	131.00	20.6	31.6	26.1	73	12.6
October (2days)	19.00	19.00	34.10	26.50	55	12.8

Source: Katsina State Agriculture and rural Development Authority (KTARDA) Weather Station.

Number of Capsules per plant

Varietal treatments significantly influenced growth and yield at both Tambu and Katsina ($P<0.05$). Specifically, the EX-SUDAN variety recorded significantly higher values than the other varieties (Table 5). Similarly, the influence of intra-row

spacing on the number of capsules was highly significant ($P<0.05$) at both locations. Sowing sesame at an intra-row spacing of 25 cm resulted in a significantly higher number of capsules compared to the other spacing treatments (Table 5; $P<0.05$).

Capsule length

The impact of variety and intra-row spacing on the capsule length of sesame at Tambu and Katsina is presented in Tables 5. Varietal differences were significant ($P<0.05$) at both locations. In Tambu, EX-SUDAN and KENANA-4 performed similarly (statistically at par) but were significantly ($P<0.05$) superior to the E8 variety. However, in Katsina, EX-SUDAN significantly ($P<0.05$) outperformed all other varieties.

The effect of intra-row spacing on capsule length was also significant ($P<0.05$) across both sites. Sowing at an intra-row spacing of 25 cm yielded significantly higher capsule lengths compared to the other spacing levels.

Number of seeds per capsule

The influence of variety and intra-row spacing on the number of seeds per capsule during the 2025 growing season at Tambu and Katsina is presented in Table 5. The varietal effect was significant ($P<0.05$) at both locations, with EX-SUDAN producing a significantly higher number of seeds per capsule ($P<0.01$) compared to the other varieties. Additionally, the effect of intra-row spacing was significant ($P<0.05$) at both sites; specifically, the 25 cm spacing produced a significantly greater number of seeds per capsule than the narrower spacing levels.

1000 seed weight (SW)

The response of sesame 1,000-seed weight (1,000-SW) to variety and intra-row spacing during the 2025 growing season at Tambu and Katsina is presented in Table 6. The varietal effect was significant ($P<0.05$) at both locations, with EX-SUDAN recording a significantly higher 1,000-SW than the other varieties. Intra-row spacing also had a highly significant ($P<0.01$) influence on 1,000-SW across all sampling stages and locations. The results indicate that an intra-row spacing of 25 cm resulted in a significantly higher 1,000-SW compared to the other spacing treatments.

Seed Yield plant⁻¹ (g plant⁻¹)

The response of seed yield per plant to variety and intra-row spacing during the 2025 growing season at Tambu and Katsina is presented in Table 6. The varietal effect was significant ($P<0.05$) at both locations, with EX-SUDAN producing a significantly higher seed yield per plant than the other varieties. Similarly, intra-row spacing significantly ($P<0.05$) influenced seed yield per plant at both sites. At both locations, sesame sown at an intra-row spacing of 25 cm resulted in significantly higher yields per plant compared to the narrower spacing treatments.

Seed Yield per hectare (kg ha⁻¹)

The response of seed yield per hectare to variety and intra-row spacing during the 2025 season at Tambu and Katsina is presented in Table 6. The varietal effect was significant ($P<0.05$) at both locations, with EX-SUDAN recording a significantly higher yield than the other varieties. Intra-row spacing also had a highly significant ($P<0.05$) influence on seed yield per hectare at both sites; specifically, sowing at 25 cm resulted in significantly higher yields compared to all other spacing levels.

The interaction effect between variety and intra-row spacing on seed yield per hectare at Tambu is presented in Table 7. The results indicate that the EX-SUDAN variety sown at 25 cm produced the highest seed yield ($P<0.05$), while the lowest yield was recorded for E8 at 10 cm (539.27 kg). Similarly, the significant interaction at Katsina is shown in Table 8. Here, EX-SUDAN at 25 cm again produced the highest seed yield ($P<0.01$), whereas the lowest yield was observed in KENANA-4 sown at 10 cm (490.55 kg).

Seed oil analysis (%)

The influence of variety and intra-row spacing on the seed oil yield of sesame during the 2025 growing season at Tambu and Katsina is presented in Table 9. The varietal effect was significant ($P<0.05$), with EX-SUDAN achieving a significantly higher oil yield than the other varieties. Intra-row spacing had a highly significant ($P<0.05$) influence on oil yield at both locations. The results demonstrate that an intra-row spacing of 25 cm resulted in a significantly higher oil yield compared to the other spacing levels.

Crude protein analysis (%)

The influence of variety and intra-row spacing on the crude protein content of sesame during the 2025 growing season at Tambu and Katsina is presented in Table 9. The varietal effect was significant ($P<0.05$) across both locations, with EX-SUDAN recording significantly higher crude protein levels than the other varieties. Intra-row spacing also significantly ($P<0.05$) affected crude protein content at both sites. In Tambu, the 25 cm and 20 cm spacings were statistically at par. However, in Katsina, sowing sesame at an intra-row spacing of 25 cm resulted in a highly significant ($P<0.05$) increase in crude protein compared to all other spacing treatments.

Table 5: Influence of Variety and Intra-row spacing on number of capsules, Capsule length and seed per capsule of sesame at Tambu and Katsina in 2025 growing seasons

	Tambu			Katsina		
Treatment	No. CAP	CLEN	CSEED	No. CAP	CLEN	CSEED
Varieties (V)						
E8	71.02c	3.32b	71.44c	68.74c	3.26c	68.15c
EX-SUDAN	126.51a	3.50a	125.23a	101.21a	3.62a	100.29a
KENANA – 4	121.86b	3.48a	82.24b	97.13b	3.51b	70.16b
SE±	0.60	0.02	1.31	0.60	0.01	1.58
Intra-row Spacing(s)						
10 cm	86.96d	3.23d	60.15d	80.16d	3.30d	60.47d
15 cm	99.04c	3.35c	74.00c	85.80c	3.41c	66.22c
20 cm	107.26b	3.44b	78.94b	90.06b	3.50b	75.00b
25 cm	116.82a	3.60a	110.20a	99.43a	3.62a	98.21a
SE±	0.76	0.04	1.51	0.65	0.03	1.89
Interaction						
V x S	NS	NS	NS	NS	NS	NS

Means followed by the same letter(s) within the same column and treatment are not significantly different at 5% level of probability using DMRT. NS: Not-significant.

No. CAP: Number of capsules per plant, CLEN: Capsule length, CSEED: Number of Seed per capsule,

Table 6: Influence of Variety and Intra-row spacing on 1000 SW, Seed yield per plant and Seed yield per hectare of sesame at Tambu and Katsina in 2025 growing seasons

Treatment	Tambu			Katsina		
	1000 SW	SEEDYP	SEEDYH	1000 SW	SEEDYP	SEEDYH
Varieties (V)						
E8	3.81 ^c	2.26 ^c	601.92 ^c	3.42 ^c	2.06 ^b	546.28 ^c
EX-SUDAN	5.83 ^a	2.64 ^a	700.86 ^a	5.05 ^a	2.32 ^a	616.92 ^a
KENANA – 4	4.99 ^b	2.34 ^b	620.56 ^b	4.88 ^b	2.16 ^b	574.86 ^b
SE±	0.02	0.01	1.55	0.04	0.02	2.46
Intra-row spacing (s)						
10 cm	4.63 ^d	2.10 ^d	557.74 ^d	3.87 ^d	1.92 ^d	507.17 ^d
15 cm	5.29 ^c	2.35 ^c	624.67 ^c	4.23 ^c	2.11 ^c	557.07 ^c
20 cm	5.62 ^b	2.51 ^b	666.04 ^b	4.69 ^b	2.25 ^b	603.74 ^b
25 cm	5.87 ^a	2.70 ^a	716.00 ^a	5.00 ^a	2.46 ^a	659.09 ^a
S. E±	0.03	0.03	1.78	0.05	0.04	4.31
Interaction						
V x S	NS	NS	*	NS	NS	*

Means followed by the same latter(s) within the same column and treatment are not significantly different at 5% level of probability using DMRT. NS: Not-significant.

SEEDYP: Seed yield per plant, SEEDYH: Seed yield per hectare WAS: Weeks after sowing.

Table 7: Interaction between variety and intra-row spacing on sesame seed yield per hectare at Tambu in 2025 growing season

	Intra-row spacing			
	10 cm	15 cm	20 cm	25 cm
Varieties E8	539.27 ^h	594.33 ^g	633.44 ^e	687.22 ^c
EX-SUDAN	629.33 ^e	676.22 ^d	724.22 ^b	791.67 ^a
KENANA – 4	540.11 ^h	625.44 ^f	659.44 ^d	686.11 ^c
SE±	3.11			

Means followed by the same letter(s) within the same column

Table 9: Influence of Variety and Intra-row spacing on Seed Oil and Crude Protein Contents of sesame at Tambu and Katsina in 2025 growing season

Treatment	Tambu		Katsina	
	Oil content	CPT	Oil content	CPT
Varieties (V)				
E8	44.14 ^b	21.38 ^c	45.65	20.02 ^c
EX-SUDAN	49.55 ^a	23.75 ^a	43.46	22.14 ^a
KENANA – 4	43.24 ^c	22.09 ^b	42.64	21.52 ^b
SE±	0.15	0.14	5.09	0.15
Intra-row spacing (s)				
10 cm	42.31 ^d	19.81 ^c	53.25	19.66 ^d
15 cm	44.23 ^c	21.55 ^b	42.22	20.31 ^c
20 cm	47.20 ^b	24.58 ^a	44.63	22.12 ^b
25 cm	49.25 ^a	24.77 ^a	47.66	23.05 ^a
SE±	0.45	0.20	5.76	0.17
Interaction				
V x S	NS	NS	NS	NS

Means followed by the same latter(s) within the same column and treatment are not significantly different at 5% level of probability using DMRT: Not-significant. CPT: Crude protein.

Discussion

Appropriate soil quality and adequate moisture are vital for the growth and development of sesame in the Sudan Savanna. The sandy loam texture of the experimental sites is suitable for sesame cultivation; however, the soils were deficient in organic carbon, total nitrogen, available phosphorus, and CEC. These deficiencies are characteristic of Savanna soils, which are typically low in primary nutrients and exchangeable

and treatment are not significantly different at 5% level of probability using DMRT

Table 8: Interaction between variety and spacing on sesame seed yield per hectare at katsina in 2025 growing seasons

	Intra-row spacing			
	10 cm	15 cm	20 cm	25 cm
Varieties E8	527.92 ^f	531.22 ^f	583.17 ^e	633.00 ^c
EX-SUDAN	580.00 ^e	601.22 ^d	632.21 ^c	698.64 ^a
KENANA – 4	490.55 ^g	580.37 ^e	611.38 ^d	650.47 ^b
SE±	4.95			

Means followed by the same letter(s) within the same column and treatment are not significantly different at 5% level of probability using DMRT.

cations (Singh, 1987) ^[20]. Consequently, the split application of NPK fertilizer at 3 and 6 weeks after sowing was essential to support crop growth. This aligns with the observations of Adesoji *et al.* (2020) ^[10], who noted that Nigerian Savanna soils rarely support viable crop production without fertility enhancement through organic or inorganic amendments. The results of this study revealed that varietal effects were significant across all measured yield parameters, likely due to inherent genetic variations. This is consistent with Audu *et al.* (2021) ^[21], who attributed sesame development to improved genetic composition. The EX-SUDAN variety significantly outperformed KENANA-4 and E8 in terms of capsule number,

capsule length, 1,000-SW, seed yield per plant, total seed yield, and oil and protein content. The superiority of EX-SUDAN is characterized by its high yield potential and early maturity, with potential yields of 1.3 t ha⁻¹ compared to 1.2 and 1.0 t ha⁻¹ for KENANA-4 and E8, respectively (Anon, 2024) ^[15]. These findings corroborate those of Mohammed *et al.* (2019) ^[22], who reported that EX-SUDAN was superior to local varieties such as TUMKUR and GULBARGA. Similarly, Ibrahim *et al.* (2016) ^[23] and Rufai *et al.* (2024) ^[24] observed that EX-SUDAN consistently recorded higher yield components including capsule counts and grain yield than KENANA-4 and E8.

The intra-row spacing significantly influenced performance, with the 25 cm spacing outperforming narrower options. This was evidenced by significant increases in the number of capsules, seeds per capsule, seed yield per plant, yield per hectare, and oil and crude protein contents.

These results indicate that at lower plant populations, the efficiency of light, moisture, and nutrient utilization was improved, allowing the sesame crop to maximize resource capture at both experimental sites. These findings corroborate the results of Fetene and Alemayehu (2016) ^[12], who reported that increase in intra row spacing from 5 to 25 cm, plant height (cm), primary branches per plant, capsules per plant, seed yield per plant (g), 1000-seed weight (g) and seed yield (kg/ha) increased from 101.31 to 117.8729 to 43, 73 to 138, 2.51 to 3.63, 2.01 to 3.27 and 648 to 1114 respectively. Similarly, these results align with Galadima *et al.* (2019), who attributed lower yields at closer spacings to intense inter-plant competition within higher-density populations.

Conclusion

Based on the results of this study, it is concluded that the EX-SUDAN variety achieved significantly higher seed yields of 700.86 kg ha⁻¹ in Tambu and 616.92 kg ha⁻¹ in Katsina. Furthermore, this variety recorded superior quality parameters, with oil contents of 49.55% and 43.46%, and crude protein levels of 23.75% and 22.14% in Tambu and Katsina, respectively, significantly outperforming the other varieties. Compared to narrower spacings, an intra-row spacing of 25 cm resulted in significantly higher values for oil content (49.25% and 47.66%), crude protein (24.77% and 23.05%), and seed yield (716.00 kg ha⁻¹ and 659.09 kg ha⁻¹) across both the Tambu and Katsina locations.

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