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GROWTH PERFORMANCE OF SESAME (*Sesamum indicum* L.) VARIETIES AS INFLUENCED BY SOWING DATE AND INTRA-ROW SPACING IN THE SUDAN SAVANNA OF NIGERIA

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ABSTRACT

Bilocation trials were conducted in 2023 wet season to investigate the growth performance of sesame (S*esamum indicum* L.) varieties as influenced by sowing date and intra-row spacing in Nigerian Sudan Savanna at the Teaching and Research Farm of Federal University Dutsin-Ma and College of Agriculture, Hassan Usman Katsina Polytechnic, Katsina. The treatments consisted of three sesame varieties (EX-SUDAN, KENANA-4 and E8), three sowing dates (1st week of July, 2nd week of July and 3rd week of July), and four intra-row spacings (10cm, 15cm, 20cm and 25cm). The treatments were laid out in a split plot design with sowing dates and intra-row spacing as main plot treatments and variety as sub-plot treatment and replicated three times. EX-SUDAN performed significantly higher than other varieties on number of leaves, CGR, RGR, and days to 50% flowering, while KENANA-4 performed significantly ($P<0.05$) higher than other varieties on number of branches, plant height and total dry matter. Sowing of sesame at 2nd week of July performed significantly ($P<0.05$) higher than any other sowing date on number of leaves, total dry weight, CGR, RGR and days to 50% flowering while sowing of sesame at 3rd week of July produced significantly ($P<0.05$) higher on number of branches and plant height than any other sowing date. Intra-row spacing of 25cm performed significantly ($P<0.05$) than other intra-row spacings on the growth parameters. Conclusively, sowing EX-SUDAN at 2nd week of July with 25cm intra-row spacing seems to be most suitable for sesame growth in the study area.

Key words: Growth, Intra-row spacing, Sowing date, Variety, Sesame

INTRODUCTION

Sesame (*Sesamum indicum* L.) otherwise known as benniseed belongs to the division Spermatophyte and family Pedaliaceae in the genus Sesamum. The importance of sesame lies in its high-quality oil which is often referred to as the "queen" of vegetable oil. The outstanding characteristic of sesame oil is its stability and keeping quality as well as resistance to rancidity (Haruna *et al*., 2012). Sesame (*Sesamun indicum* L.) has been recognized as a crop with a high economic potential in Nigeria, both as a source of raw materials for industries and a reliable foreign exchange commodity (Alegbejo, 2003; NCRI, 2008). The potentials for sesame production in Nigeria were high, this has led to the growth in demand for sesame and its products both at the national and international levels. (Olawuyi *et al*., 2023). Despite the economic importance of sesame, the yield is low

Nigeria produces over 580,000 tonnes of Sesame Seeds every year. Sesame Seeds have now become Nigeria's largest exported agricultural product as at the end of the year 2018, with the potential to generate over $4 billion US dollars in revenue on a yearly basis by the activities of sesame seeds exporters in Nigeria (Stan, 2020). Data obtained from the National Bureau of Statistics show that sesame seeds ranked the fourth-biggest non-oil export product in the first quarter of 2022. According to Statista, Nigeria is the third-largest producer of sesame seeds in Africa, with about 490,000 metric tonnes produced in 2020 (Ashinze, 2022). The plants are highly tolerant to drought and grown as annuals from seed, reaching maturity in three to five months

The performance of the crop is affected by factors such as climatic, nutrients, water availability, inter- and intra-specific competitions, pests and diseases, as well as socio-cultural and socioeconomic factors. The relationship between different parts of the crop significantly influences the seed yield (Haruna *et al*., 2012). Peter *et al*., (2012) reported that the variability in crop performance arising from different sowing dates is a consequence of changes in the factors of environment in time, therefore, it is good to determine the optimum time of sowing sesame in this zone and to identify variety responses to the different planting dates. Erratic rainfall pattern in the zone makes it of absolute importance to determine when it will be a suitable time to sow sesame, it should be noted that improper timing can affect the growth and yield performance of the crop. Lack of proper crop spacing is another significant issue that is limiting sesame production in the Sudan Savanna ecological zone. It has been reported that inadequate spacing obstructs or shrinks the rhizosphere and photosphere available for the plant to explore and exploit for growth, invariably decreases full expression of growth parameters and thereby hinders accumulation of dry matter (Adesoji e*t al*., 2020). Maximum light interception is realizable when optimum plant space is made available beginning from the early stage of growth of the plant (Rajesh *et al*., 2017)

Maximizing sesame productivity is crucial for enhancing agricultural profitability and addressing food security challenges. Understanding the influence of varieties, sowing date and intra-row spacing on sesame productivity

will enable farmers to adopt appropriate cultivation practices and optimize the growth and development of sesame in this region. This knowledge gap hinders farmers from adopting appropriate cultivation practices, resulting in suboptimal yields and reduced profitability. To raise sesame production in the study area, the use of suitable varieties, appropriate sowing dates and adequate spacing must be adopted. Given this, the research was conducted to determine the growth performance of sesame varieties as affected by sowing date and intra-row spacing in the Sudan Savanna of Nigeria

MATERIALS AND METHODS

Experimental Site and Soil

The Experiment was conducted during the 2023 wet season at two different locations: Research and Teaching Farm of Faculty of Agriculture, Federal University Dutsin-Ma permanent site (11^0 68'N, 8^0 36'E and 443m above sea level) and the Research and Teaching Farm of College of Agriculture, Hassan Usman Katsina Polytechnic, Katsina ($11^0$49`N, $7^0$ 23`E and 428 m above sea level). The annual rainfall of the study duration was 422.4 and 388.1mm for Dutsin-Ma and Katsina, respectively. The 30cm top soil samples of the experimental sites were taken before planting and analysed for physical and chemical analysis following the standard procedures. The textural class of the experimental sites was sandy clay and sandy loam for Dutsin-Ma and Katsina, respectively.

Treatment and Design of the Experiment

The treatments consisted of three different sesame varieties (EX-SUDAN, KENANA-4 and E8), three sowing dates (1st week of July, 2nd week of July and 3rd week of July), and four different levels of intra-row spacings (10cm, 15 cm, 20 cm and 25 cm). The treatments were out laid out in a split plot design with sowing dates and intra-row spacing as main plot treatments and variety as sub-plot treatment and replicated three times. The main plot treatments were randomized among the main plots, while plot treatments were randomized among the sub-plot.

Agronomic Practices

The land for the experiment was cleared, harrowed and ridged. It was divided into twelve main plots and three sub-plots. The plot made of six (6) ridges where the gross plot was 4m x 4.5m long ($18m^2$) and the net plot was 4m x 3m ($12m^2$). The sesame seeds were sown with intra-row spacing according to the treatment, with inter row spacing of 0.75m. The fertilizer was applied using side placement. Each plot was given N.P.K 15:15:15 fertilizer at 60:30:30 kg ha^{-1}. A blanket application of the NPK fertilizer at 30:30:30 kg ha^{-1} was applied at 3 WAS and the remaining 30 kg N ha^{-1} at 6 WAS. The hoe weeding was done using at 3, 6 and 9WAS. The earthen-up operation was done at 6WAS.

Data Collection

Data on growth parameters such as number of leaves, number of branches, plant height, total dry matter per plant, crop growth rate (CGR) and relative crop growth rate (RGR) were taken. Samplings were taken at 6 and 9 weeks after sowing (WAS) from five randomly tagged plants per net plot. Data on total dry weight per plant were taken from three randomly selected plants from the border. The samples were oven-dried at 70^oC to a constant weight and the weight was measured on a top-loading Metler-P weight balance. The average weight was recorded.

Data Analysis

Data on growth parameters were recorded and subjected to statistical analysis of variance (ANOVA) as described by Gomez and Gomez (1984) using SAS package version 9.0 of statistical analysis (SAS, 2002) and the differences among treatment means were separated using Duncan's Multiple Range Test (DMRT) (Duncan, 1955) at 5% level of probability.

RESULTS

Soil Sampling and Analysis

Table 1 presents Data on the physico-chemical properties of soil in two studied areas (Dutsin-Ma and Katsina). The result shows that the textural class of the soil at the experimental sites sandy clay and sandy loam for Dutsin-Ma and Katsina, respectively. The result for the chemical properties shows that soil pH was 6.30 and 6.28 at Dutsin-Ma and Katsina, respectively, which indicates the soil was slightly acidic at the two studied areas. Total nitrogen and organic carbon were higher in Dutsin-Ma. For exchangeable cations, amounts of K, Ca, Na and CEC were higher at Dutsin-Ma except Mg, which was higher at Katsina.

Table 1: - Result of the soil analysis from the experimental sites of Dutsin-Ma and Katsina during the 2023 growing season

Soil Parameters	Dutsin-Ma	Katsina
Clay	230	180
Silt	175	170
Sand	540	570
Textural class	Sandy clay	Sandy loam
pH in water	6.30	6.28
Organic Carbon (g kg-1)	4.60	4.10
Total N (g kg-1)	0.76	0.30
Available P (mg kg-1)	11.20	6.50
K (cmol kg-1)	0.76	0.70
Mg (cmol kg-1)	2.41	2.60
Ca (cmol kg-1)	4.95	4.30
Na (cmol kg-1)	0.54	0.45
CEC (cmol kg-1)	2.73	2.50

Analysis was done at analytical laboratory of Soil Science Department, Bayero University, Kano, Nigeria.

Number of Leaves per Plant

The varietal effect in Dutsin-Ma was only significant (P<0.05) at 9 WAS, where EX-SUDAN produced significantly (P<0.05) higher number of leaves per plant than KENAN–4 and E8. At Katsina, varietal effect was significant (P<0.05) at both 6 and 9 WAS where E8 and EX-SUDAN were at par at 6WAS but produced significantly (P<0.05) higher number of leaves than KENANA-4 while at 9WAS in Katsina, EX-SUDAN gave significantly (P<0.05) higher number of leaves than KENAN–4 and E8 but both was at par on number of leaves per plant (Table 2). Sowing date was significant (P<0.05) on the number of leaves per plant of sesame at both sampling stages and locations, where sowing sesame at the 2nd week of July produced significantly (P<0.05) higher number of leaves than other sowing dates (Table 2). The influence of intra-row spacing was significant (P<0.05) on number of leaves at both sampling stages and locations (Table 2). At both locations, sowing of sesame at intra row spacing of 25cm gave significantly higher number of leaves than other intra row spacings, but was at par with 20cm intra row spacing at 9WAS in Dutsin-Ma (Table 2). The interactions were not significant.

Number of branches per plant

Varietal effect was significant (P<0.05) at both sampling stages and locations (Table 3) where EX-SUDAN and KENANA-4 were at par with the number of branches per plant at 6 and 9WAS in Dutsin-Ma and 6WAS in Katsina but produced significantly (P<0.05) higher number of branches per plant than E8 while at 9WAS in Katsina, KENANA-4 produced significantly (P<0.05) higher number of branches than other varieties. Sowing date was significant (P<0.05) on number of branches per plant at both 6 and 9WAS and both locations (Table 3), where 3rd week of July produced significantly higher number of branches than other sowing dates, except at 6WAS in Dutsin- Ma where it was at par at 2nd week July sowing dates. The influence of intra-row spacing was significant (P<0.05) on number of branches per plant at both sampling stages and locations (Table 2). At both locations, sowing of sesame at intra row spacing of 25cm gave significantly higher number of branches than other intra row spacings, but was at par with 20cm intra row spacing at 6WAS in Dutsin-Ma (Table 3). Significant (P<0.05) interaction between variety and intra-row spacing was recorded at 6 WAS on number of branches in Dutsin-Ma where sowing EX-SUDAN at intra-row spacing of 20cm gave the highest number of branches than any other combination while sowing E8 and KENANA-4 at intra-row of 10cm produced the lowest number of branches (Table 4). Interaction between variety and intra-row spacing was significant (P<0.05) at 9WAS in Katsina where sowing EX-SUDAN at intra-row spacing of 25cm gave the highest number of branches than any other combination while sowing E8 and KENANA-4 at intra-row of 10cm produced the lowest number of branches (Table 5).

Plant height (cm)

Table 6 shows the influence of variety, sowing date and intra-row spacing on plant height per plant of sesame in the 2023 growing season at Dutsin-Ma and Katsina. The varietal effect was significant at 9WAS in Dutsin-Ma and 6 and 9WAS in Katsina, where sowing of KENANA produced significantly taller sesame plants than sowing of other varieties (Table 6). Sowing date was significant (P<0.05) on plant height at both sampling stages and locations where sowing sesame at the 3rd week of July produced significantly (P<0.05) taller sesame plants than other sowing dates (Table 6). The influence of intra-row spacing was significant (P<0.05) on plant height at both sampling stages and locations (Table 2) on plant height. At both locations, sowing of sesame at intra row spacing of 25cm gave significantly taller plants than other intra row spacings, but was at par with 20cm intra row spacing

at 6WAS in Dutsin-Ma (Table 6). Table 7 shows the significant (P<0.05) interaction between variety and intra-row spacing on plant height at 9 WAS in Dutsin-Ma during 2023 growing season, where sowing KENANA-4 at the intra-row spacing of 25cm gave the tallest plants than any other combination, while sowing EX-SUDAN and KENANA-4 at an intra-row spacing of 10cm produced the shortest sesame plants (Table 7).

Total dry matter per plant

The varietal effect was only significant on plant dry weight at 9WAS in Katsina where KEANA-4 variety produced significantly (P<0.05) higher total dry matter than other varieties planted (Table 8). The sowing date was significant at 9WAS in Dutsin-Ma and 6 and 9WAS in Katsina, where sowing sesame at the 2nd week of July produced significantly (P<0.05) higher total dry matter per plant than other sowing dates (Table 2) except at 9WAS in Dutsin-Ma where it was statistically similar to sowing of sesame at 1st week of July (Table 8). The influence of intra-row spacing was significant (P<0.05) on total dry matter per plant at both sampling stages and locations (Table 8). At both locations, sowing of sesame at intra row spacing of 25cm gave significantly higher total dry matter than other intra row spacings, but was at par with 20cm intra row spacing at 9WAS in Dutsin-Ma (Table 8). Interactions were not significant.

Crop growth rate (CGR)

Table 9 shows the influence of variety, sowing date and intra-row spacing on crop growth rate sesame in 2023 growing season at Dutsin-Ma and Katsina. The varietal effect was significant (P<0.05) at 9 WAS in Dutsin-Ma and 6 and 9 WAS in Katsina; where EX-SUDAN produced significantly (P<0.05) higher CGR than other varieties. Sowing sesame in the 1st week of July and 3rd week of July was at par on CGR but produced significantly (P<0.05) higher CGR than sowing at the 2nd week of July while at 9WAS in Dutsin-Ma, sowing sesame in the 2nd week July produced significantly higher CGR than other sowing dates (Table 9). At both 6 and 9WAS in Katsina, sowing sesame in the 2nd week July produced significantly higher CGR than other sowing dates (Table 8). The influence of intra-row spacing was significant (P<0.05) on CGR at both sampling stages and locations (Table 9). At both sampling stages and locations, sowing of sesame at the intra-row spacing of 25cm gave significantly(P<0.05) higher CGR than other intra-row spacings, while sowing of sesame at 10cm gave significantly lower CGR than other sowing dates at both sampling stages and locations. Interactions were not significant.

Relative crop growth rate (RGR)

Table 10 shows the influence of variety, sowing date and intra-row spacing on relative crop growth rate of sesame in 2023 growing season at Dutsin-Ma and Katsina. The varietal effect on RGR was significant (P<0.05) at 6 and 9 WAS Dutsin-Ma and at 6 WAS Katsina; where EX-SUDAN produced significantly higher RGR than the other varieties (Table 10). Sowing date was significant on RGR at 9WAS only in Dutsin-Ma, where sowing of sesame at 2nd week of July produced significantly (P<0.05) higher RGR than other sowing dates, while sowing sesame at 3rd week of July gave significantly (P<0.05). Intra-row spacing was significant on RGR of sesame at 6 and 9WAS in Dutsin-Ma and 6WAS in Katsina (Table 10). The sowing of sesame at intra-row spacing of 15, 20 and 25cm did not show a significant difference but produced significantly (P<0.05) higher RGR than sowing at the intra-row spacing of 10cm. However, at 9WAS in Dutsin-Ma and 6WAS in Katsina, sowing of sesame at the intra-row spacing of 25cm gave significantly (P<0.05) higher RGR than other intra-row spacings, while sowing of sesame at 10cm gave significantly lower RGR. Interactions were not significant.

Days to 50% flowering

The varietal effect was significant (P<0.05) on days to 50% flowering, where sowing of KENANA-4 significantly delayed flowering of sesame plants compared with the other varieties which were faster in flowering than KENANA-4 (Table 10). The sowing date was not significant (P>0.05) at both locations. The intra-row spacing was significant (P<0.05) in Katsina only, where sowing of sesame at the intra-row spacing of 25cm significantly (P<0.05) delayed days to 50% flowering compared with other intra-row spacings, while sowing at the intra-row spacing of 10cm significantly hastened flowering of sesame plants compared with other intra-row spacing (Table 10). Interactions were not significant.

Table 2: Influence of variety, sowing date and intra-row spacing on number of leaves per plant of sesame in 2023 growing season at Dutsin-Ma and Katsina

	Number of Leaves			
	Dutsin-Ma		Katsina	
Treatment	6 WAS	9 WAS	6 WAS	9 WAS
Varieties (V)				
E8	25.03	48.75c	28.61a	38.67[b]
EX-SUDAN	26.02	52.00a	28.42[a]	41.52 [a]
KENANA – 4	26.02	50.61b	27.89 [b]	43.94[b]
SE(+)	0.32	0.21	0.21	0.26
Significant	NS	*	*	*
Sowing date (T)				
1st week of July	23.58 [c]	45.17[c]	27.19[c]	39.17[c]
2nd week of July	27.64 [a]	56.14[a]	30.25[a]	44.72[a]
3rd week of July	26.58 [b]	50.06[b]	27.47[b]	40.25[b]
SE(+)	0.32	0.21	0.21	0.26
Significant	**	**	*	**
Intra-row Spacing				
10 cm	23.07[d]	42.96[c]	23.07[d]	35.74[d]
15 cm	24.52[c]	50.70[b]	26.70[c]	39.52[c]
20 cm	27.52[b]	54.04[a]	29.19[b]	43.48[b]
25 cm	28.63[a]	54.11[a]	34.26[a]	46.78[a]
SE(+)	0.40	0.24	0.24	0.30
Significant	**	*	**	**
Interaction				
V x T	NS	NS	NS	NS
V x S	NS	NS	NS	NS
T x S	NS	NS	NS	NS
V x T x S	NS	NS	NS	NS

WAS: Weeks after sowing. *: Significant at 5% level of probability. **: Significant at 1% of probability. NS: Not-significant. Means followed by the same superscript(s) within the same column and treatment are not significantly different at 5% level of probability using DMRT

Table 3: Influence of variety, sowing date and intra-row spacing on number of branches per plant of sesame in 2023 growing season at Dutsin-Ma and Katsina

	Number of Branches			
	Dutsin-Ma		Katsina	
Treatment	6 WAS	9 WAS	6 WAS	9 WAS
Varieties (V)				
E8	20.39[b]	40.97[b]	19.25[b]	32.22[c]
EX-SUDAN	21.44[a]	42.36[a]	20.94[a]	33.50[b]
KENANA – 4	21.25[a]	42.72[a]	21.06[a]	36.03[a]
SE(+)	0.27	0.39	0.20	0.29
Significant	*	*	*	**
Sowing date (T)				
1st week of July	19.28 [b]	39.06 [c]	19.42 [c]	32.22[c]
2nd week of July	22.22a	41.75 [b]	20.36 [b]	33.50[b]
3rd week of July	21.58a	45.25 [a]	21.47 [a]	36.02 [a]
SE(+)	0.27	0.39	0.20	0.29
Significant	*	**	**	**
Intra-row Spacing				
10 cm	15.70[c]	33.26[d]	17.74[d]	29.85[d]
15 cm	20.63[b]	41.85[c]	19.37[c]	32.41[c]
20 cm	23.70a	45.22[b]	20.63[b]	35.33[b]
25 cm	24.07[a]	47.74[a]	23.93[a]	38.07[a]
SE(+)	0.31	0.45	0.23	0.34
Significant	*	**	**	**
Interaction				
V x T	NS	NS	NS	NS
V x S	NS	NS	*	*
T x S	NS	NS	NS	NS
V x T x S	NS	NS	NS	NS

WAS: Weeks after sowing. *: Significant at 5% level of probability. **: Significant at 1% of probability. NS: Not-significant. Means followed by the same superscript(s) within the same column and treatment are not significantly different at 5% level of probability using DMRT

Table 4: Interaction between variety and intra-row spacing on number of branches plant^{-1} at 6 WAS in Dutsin-Ma during 2023 growing season

	Intra-row Spacing			
	10 cm	15 cm	20 cm	25 cm
Varieties				
E8	16.33 [f]	19.44 [e]	23.67 [c]	22.11[d]
EX-SUDAN	14.33[g]	20.22 [e]	27.78 [a]	23.44 [c]
KENANA – 4	16.44 [f]	22.22[d]	19.67 [e]	26.67 [b]
SE(+)		0.32		

WAS: Weeks after sowing. Means followed by the same superscript(s) within the same column and and treatment are not significantly different at 5% level of probability using DMRT

Table 5: Interaction between variety and intra-row spacing on number of branches plant^{-1} at 9 WAS in Katsina in 2023 rainfed season

	Intra-row Spacing			
	10 cm	15 cm	20 cm	25 cm
Varieties				
E8	28.89[g]	31.67[e]	33.67 [d]	37.33[b]
EX-SUDAN	31.89[d]	35.33[c]	38.44 [b]	41.00[a]
KENANA – 4	28.78[g]	30.22[f]	33.89 [d]	35.89 [c]
SE(+)		0.59		

WAS: Weeks after sowing. Means followed by the same superscript(s) within the same column and treatment are not significantly different at 5% level of probability using DMRT

Table 6: Influence of variety, sowing date and intra-row spacing on plant height per plant of sesame in 2023 growing season at Dutsin-Ma and Katsina

	Plant Height			
	Dutsin-Ma		Katsina	
Treatment	6 WAS	9 WAS	6 WAS	9 WAS
Varieties (V)				
E8	72.05	136.83[b]	56.33[b]	110.06b
EX-SUDAN	71.47	138.11[b]	55.22[b]	109.64b
KENANA – 4	71.27	141.64[a]	61.61[a]	112.47a
SE(+)	0.45	0.72	0.83	1.05
Significant	NS	*	*	*
Sowing date (T)				
1st week of July	69.03 [c]	133.67 [c]	54.38 [b]	101.61[c]
2nd week of July	71.16 [b]	139.50 [b]	53.88 [b]	110.00 [b]
3rd week of July	74.61[a]	143.42 [a]	64.88 [a]	118.56 [a]
SE(+)	0.45	0.72	0.83	1.05
Significant	*	**	*	**
Intra-row Spacing				
10 cm	63.15[c]	120.37[d]	51.18[d]	96.37[d]
15 cm	71.00[b]	133.30[c]	55.22 [c]	108.11[c]
20 cm	75.81[a]	144.22[b]	58.41[b]	112.07[b]
25 cm	76.44[a]	157.56[a]	66.07[a]	126.33[a]
SE(+)	0.51	0.83	0.96	1.21
Significant	**	**	**	**
Interaction				
V x T	NS	NS	NS	NS
V x S	NS	*	NS	NS
T x S	NS	NS	NS	NS
V x T x S	NS	NS	NS	NS

WAS: Weeks after sowing. *: Significant at 5% level of probability. **: Significant at 1% of probability. NS: Not-significant. Means followed by the same superscript(s) within the same column and treatment are not significantly different at 5% level of probability using DMRT

Table 7: Interaction between variety and intra-row spacing on plant height at 9 WAS in Dutsin-Ma during 2023growing season

	Intra-row Spacing			
	10 cm	15 cm	20 cm	25 cm
Varieties				
E8	117.44[h]	137.33[e]	146.67[d]	151.00 [c]
EX-SUDAN	122.22[g]	128.00[f]	159.00 [b]	157.33 [b]
KENANA – 4	121.44[g]	134.56[e]	127.00[f]	164.33 [a]
SE(+)		1.43		

WAS: Weeks after sowing. Means followed by the same superscript(s) within the same column and and treatment are not significantly different at 5% level of probability using DMRT

Table 8: Influence of variety, sowing date and intra-row spacing on total dry per plant of sesame in 2023 growing season at Dutsin-Ma and Katsina

	Dry Weight per plant			
	Dutsin-Ma		Katsina	
Treatment	6 WAS	9 WAS	6 WAS	9 WAS
Varieties (V)				
E8	2.74	10.73	2.49	9.03 [b]
EX-SUDAN	2.77	10.64	3.43	9.15 [b]
KENANA – 4	2.76	10.59	2.45	9.57 [a]
SE(+)	0.04	0.13	0.57	0.14
Significant	NS	NS	NS	*
Sowing date (T)				
1st week of July	2.79	10.59[a]	2.30[b]	8.56[c]
2nd week of July	2.72	11.04[a]	3.63[a]	10.24 [a]
3rd week of July	2.76	10.33[b]	2.43[b]	8.96 [b]
SE(+)	0.04	0.13	0.57	0.14
Significant	NS	*	*	*
Intra-row Spacing				
10 cm	2.37[d]	8.53 [c]	2.03 [b]	7.92 [d]
15 cm	2.75 [c]	9.87 [b]	2.40 [b]	8.75 [c]
20 cm	2.90[b]	11.96 [a]	2.60 [b]	9.62 [b]
25 cm	3.00[a]	12.25 [a]	4.14 [a]	10.72 [a]
SE(+)	0.04	0.15	0.65	0.16
Significant	*	*	*	**
Interaction				
V x T	NS	NS	NS	NS
V x S	NS	NS	NS	NS
T x S	NS	NS	NS	NS
V x T x S	NS	NS	NS	NS

WAS: Weeks after sowing. *: Significant at 5% level of probability. **: Significant at 1% of probability. NS: Not-significant. Means followed by the same superscript(s) within the same column and treatment are not significantly different at 5% level of probability using DMRT

Table 9: Influence of variety, sowing date and intra-row spacing on crop growth rate per plant of sesame in 2023 growing season at Dutsin-Ma and Katsina

	Crop growth Rate per plant			
	Dutsin-Ma		Katsina	
Treatment	6 WAS	9 WAS	6 WAS	9 WAS
Varieties (V)				
E8	2.67	9.32^{c}	1.96^{c}	8.24^{c}
EX-SUDAN	2.62	10.68^{a}	2.96^{a}	10.45^{a}
KENANA – 4	2.64	9.95^{b}	2.64^{b}	8.82^{b}
SE(+)	0.04	0.04	0.03	0.16
Significant	NS	*	**	**
Sowing date (T)				
1st week of July	2.73^{a}	9.78^{a}	2.28^{c}	8.83^{c}
2nd week of July	2.50^{b}	10.10^{a}	2.64^{a}	9.59^{a}
3rd week of July	2.72^{a}	10.07^{b}	2.42^{b}	9.00^{b}
SE(+)	0.04	0.04	0.03	0.16
Significant	*	*	**	*
Intra-row Spacing				
10 cm	2.21^{c}	8.38^{d}	2.36^{d}	8.22^{d}
15 cm	2.70^{b}	9.66^{c}	2.42^{c}	8.92^{c}
20 cm	2.67^{b}	10.47^{b}	2.46^{b}	9.47^{b}
25 cm	3.00^{a}	11.43^{a}	2.52^{a}	10.08^{a}
SE(+)	0.07	0.04	0.04	0.19
Significant	*	*	**	*
Interaction				
V x T	NS	NS	NS	NS
V x S	NS	NS	NS	NS
T x S	NS	NS	NS	NS
V x T x S	NS	NS	NS	NS

WAS: Weeks after sowing. *: Significant at 5% level of probability. **: Significant at 1% of probability. NS: Not-significant. Means followed by the same superscript(s) within the same column and treatment are not significantly different at 5% level of probability using DMRT

Table 10: Influence of ariety, sowing date and intra-row spacing on relative crop growth rate and days to 50% flowering (DTF) of sesame in 2023 growing seasons at Dutsin-Ma and Katsina

	Dutsin-Ma			Katsina		
	RGR		DTF	RGR		DTF
Treatment	6 WAS	9 WAS		6 WAS	9 WAS	
Varieties (V)						
E8	0.83[b]	1.36[b]	48.58[b]	0.81[b]	1.31	52.67[b]
EX-SUDAN	0.84[a]	1.38[a]	48.42[b]	0.86[a]	1.32	51.86[b]
KENANA – 4	0.83[b]	1.36[b]	48.67[a]	0.78[b]	1.32	56.19[a]
SE(+)	0.04	0.03	0.07	0.02	0.05	0.31
Significant	*	*	*	*	NS	*
Sowing date (T)						
1st week of July	0.84	1.33[c]	49.00	0.81	1.35	54.36[a]
2nd week of July	0.83	1.40[a]	45.00	0.82	1.34	54.14[b]
3rd week of July	0.83	1.38[b]	49.00	0.83	1.34	54.36[a]
SE(+)	0.04	0.03	0.07	0.02	0.05	0.31
Significant	NS	*	NS	NS	NS	*
Intra-row Spacing						
10 cm	0.79[b]	1.23[d]	48.67	0.75[d]	1.22	50.33[d]
15 cm	0.84[a]	1.36[c]	48.22	0.81[c]	1.30	52.51[c]
20 cm	0.84[a]	1.41[b]	48.33	0.88[b]	1.37	54.33[b]
25 cm	0.86[a]	1.46[a]	49.00	0.93[a]	1.40	57.11[a]
SE(+)	0.04	0.03	0.08	0.01	0.06	0.36
Significant	*	**	NS	*	NS	**
Interaction						
V x T	NS	NS	NS	NS	NS	NS
V x S	NS	NS	NS	NS	NS	NS
T x S	NS	NS	NS	NS	NS	NS
V x T x S	NS	NS	NS	NS	NS	NS

RGR: Relative crop growth rate, DTF: Days to 50% Flowering, WAS: Weeks after sowing.
*: Significant at 5% level of probability. **: Significant at 1% of probability. NS: Not-significant. Means followed by the same superscript(s) within the same column and treatment are not significantly different at 5% level of probability using DMRT

DISCUSSION

Good soil and adequate moisture are important for the growth and development of sesame in the Sudan savannah. Soils of the experimental sites were sandy clay and sandy loam, which are suitable for the growth of sesame. However, the soils of the experimental sites were found to be low in organic carbon, total nitrogen, available phosphorus and CEC. This indicates the characteristic nature of soils in savanna. Soils of savanna are known to be low in total nitrogen, available phosphorus, organic carbon, effective CEC and exchangeable cations with clay and silt content (Singh, 1987). Hence, it made it absolutely necessary the NPK fertilizer that was applied in the experimental soils. Adesoji *et al*. (2018) reported that soils of Nigerian savanna do hardly support worthwhile crop production in the absence of any approach to enhance their fertility status through the addition of fertilizer, either organic or inorganic.

The result of the study revealed that varietal effect was significant in the measured growth parameters, which could be attributed to the differences in genetic constitution of these varieties. KENANA-4 variety performed significantly higher than EX-SUDAN and E8 variety on number of branches, plant height and total dry matter, while EX-SUDAN performed significantly higher than other varieties on number of leaves, CGR, RGR, and days to 50% flowering. It has been reported that the variation in growth characters of crops could be linked to their genetic makeup (Ibrahim *et al*., 2000; Sajjan *et al*., 2002). earlier than KENANA-4 and E8 varieties. This conforms with the findings of Ibrahim *et al*. (2016) reported that KENANA-4 variety was taller than GWOZA and EX-SUDAN but EX-SUDAN variety recorded a higher number of capsules per plant and grain yield compared with KENANA-4 and GWOZA varieties.

Sowing date determines the duration of the growing season, exposure to moisture, and the crop's ability to escape or tolerate drought stress. The experiment further revealed that growth and development of sesame was greatly influenced by the time of sowing The sowing of sesame at 2nd week of July demonstrated better performance than sowing sesame at 3rd week of July on most of the characters such as number of leaves, total dry weight, CGR, RGR and days to 50% flowering while Sowing of sesame at 3rd week of July showed higher performance on number of branches and plant height

than the sowing of sesame at 2nd week of July. This is in conformity with findings of Ladan (2015) who reported: sowing date had a significant effect on the number of branches plant^{-1}, dry weight CGR, RGR, days to 50% flowering and days to maturity, with middle July sowing date producing high mean value.

The intra-row spacing was significant where sowing of sesame at an intra-row spacing of 25cm outperformed other intra-row spacings, as exemplified by significant increases observed on numbers of leaves, number of branches, plant height, total dry matter, CGR, RGR, and days to 50% flowering. This showed that at low plant population densities, proper use of light, moisture, and nutrients was higher, allowing sesame cops to fully utilize light and nutrients in the two sites under study. This corroborates the findings of Adam *et al*. (2013) that reported that most of the parameters studied showed that the 50 cm × 25 cm spacing with 4 - 6 plants per stand (320,000 – 480,000 plants/ha) was the best combination for optimizing the agronomic performance of sesame in the study area. The report further stated that the tallest plants were recorded for 25 cm at 3 and 6 WAS (weeks after sowing), dry stalk weight increased significantly with the increase in spacing and plant density.

CONCLUSION

Based on the results obtained from the study, it can be concluded that variety EX-SUDAN is the most suitable for the study area because it demonstrated superior growth performance compared with E8 and KENANA-4 varieties. The sowing of sesame in the 2nd week of July was found to be the most appropriate date for sowing of sesame. Intra-row spacing of 25 cm proved to be the most productive intra-row spacing for the growth performance of sesame in the Sudan savanna ecological zone.

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