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RESEARCH PAPER

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Effect of inter-row and intra-row spacing on the growth and yield of sesame (*Sesamum indicum* L.) in Makurdi, Nigeria

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Key words: Row spacing, Seed yield, Sesame, Growth and yield components

Abstract

Field experiments were conducted from July to November, during 2013 and 2014 cropping seasons, at the Research Farm, University of Agriculture, Makurdi, Nigeria, to evaluate the performance of sesame to different inter-row and intra-row spacing. The trial was a 3 x 3 factorial experiment which consist of one sesame variety (Ex-Sudan) with three inter-row spacing of (50cm, 75cm and 100cm) and three intra-row spacings of (20cm, 30cm and 40cm) fitted in a randomized complete block design (RCBD) with three replications. Parameters measured includes plant height, number of leaves, number of branches, number of capsule/plant, number of seeds/capsule, 1000-seed weight, seed yield among others. Data collected were subjected to analysis of variance and the means were separated using least significant difference (LSD). Results of the study revealed that there were significant effect of row spacing on the growth and yield parameters of sesame as the wider spacing of 100cm x 40cm recorded highest plant height, number of branches, leaf area, number of capsule per plant, capsule length, number of seeds per capsule and 100-seed weight in both seasons. While the seed yield values shows that the spacing of 50cm x 20cm produced the highest seed yield. The implication of study showed that, to maximize seed yield of sesame, farmers should adopt the spacing of 50 x 20cm.This should therefore, be recommended for Makurdi location, Nigeria.

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Introduction

Sesame (*Sesamum indicum* L.) commonly known as beniseed is an annual crop which belongs to the family Pedaliaceae and in the genus *Sesamum* and is the oldest and important cultivated oil seed crop in the world (Purseglove, 1974; Dudley *et al.*, 2000). The world hectarage exceeds 6 million tonnes and world output stood at 2.4 million tonnes (Kafiriti and Deckers, 2001). Nigeria has about 3.5million hectares suitable for sesame production but only 300,000 hectares are being cultivated largely by small holder farmer who lack basic farm inputs such as fertilizers and lack of information on improved farm practices that can boost yield of the crop (Anon, 2009). In Africa, Nigeria is the second largest producer after Sudan (Chiezey, 2001). Sesame oil is of good quality (Alam *et al.*, 2007). According to Kamara *et al.*, (2005), the oil is used for cooking, baking, candy making, soaps, lubricant, hair treatment, industrial uses and alternative medicine (in the control of blood pressure, stress and tension). Leaves are used in vegetable soup, seeds are consumed when fried and mixed with sugar in most African countries, while stems are used in making paper, fuel wood and source of potash after burning (Alam *et al.*, 2007). Despite the potentials of sesame, Nigeria's sesame yield remain very low (367kg/ha) compared with Egypt and Ethiopia, 1323kg/ha and 825kg/ha respectively (FAO, 2009).

The low yield of sesame has been partly attributed to inappropriate plant density, planting time, and pest pressure (weeds, diseases and insect pests) (Gebremichael, 2011). The establishment of an adequate plant density is critical for utilization of available growth factors such as water, light, nutrients and carbon-dioxide and to maximize grain yield. Too wide spacing leads to low plant density per unit area and reduces ground cover, whereas too narrow spacing is related to intense competition between plants for growth factors (Singh *et al.*, 2004). It is observed that spacing of crop is important for good yield. Harper (1983) reported that with non-tillering (branching) crop varieties, higher yield per plant will give high total yield per hectare once the optimum population is not exceeded. Adeyemo *et al.,* (1992); Olowe and and Busari, (1994) reported that decrease in inter row spacing resulted in decreased yield per plant although yield per hectare increase significantly. On the other hand, the variation in plant density has been related to the variation in the number of capsules per plant, seed yield per plant and 1000-seed weight (Rahnama and Bakhshandeh, 2006), and plant height, number of branches per plant and seed yield (Ngala *et al.,* 2013).

The production of sesame has been remarkable in Nigeria with major sesame producing states as Yobe, Katsina, Kano, Kogi, Gombe and Benue states. However, there is limited knowledge on the optimum spacing of the crop in the study area. Hence this experiment was conducted to determine growth and yield performance of sesame under different intra and inter row spacing in Makurdi, a location in the southern guinea savannah agro-ecological zone of Nigeria.

Materials and methods

Study Location and Crop Varieties

The experiments were conducted from July to November during 2013 and 2014 cropping seasons at the Teaching and Research Farm of the University of Agriculture, Makurdi-Nigeria to evaluate the effect of inter-row an intra-row spacing on the growth and yield performance of sesame. The study location falls within the Southern Guinea Savanna Zone of Nigeria with mean rainfall of 1, 250 mm per annum and temperature of 25-30ºC. It is located between (Latitude 07º45` - 07º50`N, Longitude 08º45- 08º50`E) is at an altitude of 98m above sea level. The variety of sesame used was 'Ex-Sudan'. The variety of the crop show good adaptation to the local environment and is popularly grown by farmers in the locality.

Experimental design, plot size and treatments

The experiment was a 3 x 3 factorial combination of treatments, fitted in a randomized complete block design, replicated three times. The inter-row spacing (50cm, 75cm, and 100cm) constituted the main plots, while the intra-row spacing (20cm, 30cm and 40cm) were assigned to the subplots. The experimental area cultivated was 148.50m² (0.015 hectares equivalent), and consisted of 27 treatment plots. Each plot had an area of 16.0 m².

Land preparation and planting

The experimental field was manually cleared and ridged at 50cm, 75cm and 100cm apart. Each plot consisted of 4 ridges. A mixture of sesame and river sand was sown manually planted using dibbling method at intra-row spacings of 20cm, 30cm and 40cm as per treatments on ridges spaced at 50cm, 75cm and 100cm apart. The emerged plants were later thinned to two seedling per stand at two weeks after sowing (2WAS). The arrangement gave a plant population of 200,000, 133,333, 100,000, 133,333, 88,888, 66,667, 100,000, 66,667 and 50,000 plants per hectare for 20cm, 30cm and 40cm intra-row spacing respectively.

Cultural practices

Weeding was done with the native hoe at 3 and 6WAP. The recommended rate for mixed fertilizer NPK (15:15:15) for sole sesame: 30 Kg N ha-1, 30 Kg P ha-1 and 30 Kg K ha-1 (Enwezor *et al.*, 1989). The band method of fertilizer application was employed. The fertilizer was applied twice to each plot, at 3 and 6 weeks after planting (WAP).

Harvesting and Threshing

Harvesting of Sesame was harvested when capsules turned yellowish with shedding of leaves (Ijoyah *et al.*, 2014). The harvested plants were separately placed in a sack and allowed to fully dry before threshing. The fully dried harvest was threshed manually by gently beating the sack with a stick to separate the seeds from the capsules, after which it was followed by winnowing to separate the grains from the chaff.

Data Collection and Analysis

Data taken for sesame include days to attain 50 % flowering, plant height (cm), number of branches per plant, leaf area, number of capsules per plant, length of capsule, weight of capsule per plant, number of seeds per capsule, 1000-seed yield and seed yield (t/ha). All data collected were statistically analyzed using GENSTAT Release (Rothamsted Experimental Station) copy right 2011. Least Significant Difference (LSD) was used for mean separation (P <0.05) following the procedure of Steel and Torrie (1980). Direct treatment effects and the magnitude of interactions were also determined.

Results and discussion

Main effect of Inter-Row spacing and Intra-Row spacing on the Reproductive Parameters of Sesame in Makurdi

The main effects of inter row and intra-row spacing of sesame on the growth parameters in Makurdi, Nigeria, during 2013 and 2014 cropping seasons is given in Table 1.

Table 1. Main effect of Inter-Row spacing and Intra-Row spacing on the Growth Parameters of Sesame in Makurdi.

Treatments	Days to 50% Flowering		Plant Height (cm) 6WAP		Plant Height (cm) 9WAP		Number of Branches 6WAP		Number of branches 9WAP		Leaf Area (cm²)	
	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014
Inter-Row Spacing												
50cm	40.89	40.57	49.11	48.46	108.46	111.27	3.45	3.87	9.87	11.26	40.46	35.79
75cm	40.50	40.48	48.25	47.16	117.37	118.75	3.99	4.24	17.30	18.74	42.78	40.52
100cm	39.11	40.24	50.10	49.91	123.63	120.06	4.87	5.06	19.45	20.05	44.89	44.39
F-LSD (0.05)	0.19	0.18	NS	NS	4.08	2.07	1.02	0.26	3.12	4.39	1.32	2.87
Intra-Row Spacing												
20cm	40.44	40.57	50.32	51.66	103.22	106.00	3.10	3.99	14.65	16.59	38.44	36.96
30cm	40.12	40.54	48.87	49.31	117.98	121.07	3.89	4.30	18.76	21.06	40.89	40.40
40cm	39.67	40.18	43.22	44.57	120.62	122.41	4.34	4.88	20.78	22.40	44.09	43.34
F-LSD (0.05)	0.22	0.18	4.12	3.71	2.33	2.07	0.32	0.26	3.43	4.39	3.02	2.87

NS- Not significant.

Days to attain 50% flowering was significantly affected by inter and intra-row spacing in both years. The longer days was taken to attain 50 % flowering for sesame at the closer spacing (50cm x 20cm). This may be due to the intense overcrowding of the crop at closer spacing which might have induced competitive demands on available nutrients and moisture could have been responsible for prolonging days to attain 50 % flowering. Ijoyah *et al.,* (2015) reported similar findings in sesame and attributed the result to intensified competition in closely spaced plants. The interaction effects also showed 50cm x 20cm spacing producing the longer days for sesame to attained 50% flowering (Table 2).

Table 2. Interaction effect of Inter-Row spacing and Intra-Row spacing on the Growth Parameters of Sesame in Makurdi.

Inter –Row Spacing	Intra-Row Spacing	Days 50% flowering		Plant Height (cm) at 6WAP		Plant Height (cm) at 9WAP		Number of Branches at 6WAP		Number of Branches at 9WAP		Leaf Area (cm²)	
		2013	2014	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014
50cm	20cm	41.87	41.00	43.67	45.16	84.23	89.49	3.01	3.07	9.06	9.48	30.52	30.81
	30cm	40.34	40.44	46.66	46.23	104.56	113.40	3.48	3.56	12.56	13.39	35.08	36.02
	40cm	40.10	40.28	53.89	54.00	120.09	127.97	4.65	4.98	26.67	27.81	39.26	40.54
75cm	20cm	41.00	40.44	39.12	40.69	106.32	112.34	4.12	4.22	12.01	12.33	39.00	39.69
	30cm	40.76	40.28	44.32	44.74	117.90	121.90	4.24	4.07	18.98	21.89	39.87	40.53
	40cm	40.32	40.10	47.01	46.06	122.80	122.00	4.46	4.43	21.08	22.00	40.99	41.32
100cm	20cm	40.50	40.20	51.22	53.13	109.50	108.00	4.49	4.68	17.32	18.39	39.86	39.14
	30cm	40.34	40.00	56.34	56.96	120.87	123.82	4.90	5.23	20.87	23.96	40.78	40.37
	40cm	40.02	40.00	58.99	59.64	128.49	130.91	5.13	5.27	29.88	30.90	52.56	53.65
F-LSD (0.05)		0.28	0.30	2.98	3.03	8.02	7.60	0.56	0.44	6.87	7.60	4.87	4.98

Sesame plant height significantly ($P \leq 0.05$) increased as inter-row and intra-row spacing increased at 9WAP but inter-row spacing was not significant ($P \leq 0.05$) at 6WAP in both years with 100cm x 40cm produced the highest plant heights in both years. This could be linked to lesser competition for available nutrients at wider spacings. These results are in accordance with the findings of Caliskan *et al.* (2004) who reported taller plants with increase in plant population. The results also agreed with Mass *et al.,* (2007) who reported plant height of millet increased with wider row spacings in the south eastern coastal plains of America.

Number of branches and leaf area of sesame were significantly ($P \leq 0.05$) influenced as the inter-row and intra-row spacings increased. The wider spacing of 100cm x 40cm produced highest number of branches and leaf area, although at 9WAP number of branches was not significant when the inter and intra-row spacings increased from 75cm to 100cm and 30cm to 40cm.

This could be explained that plants sown at greater row and plant distance increased the biomass of the plant by producing healthy plant parts by receiving maximum sunlight for the process of photosynthesis. This result agreed with Fagam *et al.,* (2016) who reported that increasing the intra-row of sesame positively affects the growth and yield of sesame. This also agrees with the findings of Oad *et al.,* (2002) who reported increased in growth parameters of sunflower with wider spacing. While these findings were in contrast to those by Tiwari *et al.*, (1990), they agreed with those by Gamanmarty (1988) who reported maximum growth parameters of sesame with intra row spacing of 20cm.

The difference may be due to genetic makeup of the varieties used and the environmental conditions.

The highest number of plant height, number of branches and leaf area were obtained when the inter-row and intra-row spacings of sesame increased to the wider spacing of 100cm x 40cm (Table 2).

Effects of Inter-Row spacing and Intra-Row spacing on the Yield Parameters of Sesame in Makurdi

The main effects of inter row and intra-row spacing of sesame on the yield parameters in Makurdi, Nigeria, during 2013 and 2014 cropping seasons is given in Table 3.

Table 3. Main effect of Inter-Row spacing and Intra-Row spacing on the Yield Parameters of Sesame in Makurdi.

Treatments	Number of Capsules/plant		Length of Capsule (cm)		Number of Seeds/Capsule		1000-Seed Weight (g)		Seed Yield (t/ha)	
	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014
Inter-Row Spacing										
50cm	47.82	47.00	2.80	2.82	53.40	58.29	3.33	3.51	0.56	0.58
75cm	56.98	60.30	2.85	2.86	57.32	59.93	3.35	3.51	0.53	0.56
100cm	73.40	75.60	2.93	2.99	60.45	62.11	3.49	3.57	0.45	0.48
F-LSD (0.05)	7.01	6.36	0.06	0.04	2.84	2.27	0.04	0.05	0.06	0.05
Intra-Row Spacing										
20cm	43.23	42.40	2.67	2.80	55.12	57.05	3.37	3.49	0.55	0.58
30cm	66.56	68.90	2.88	2.92	58.19	58.89	3.48	3.54	0.52	0.55
40cm	70.12	71.50	2.91	2.95	60.78	64.42	3.52	3.57	0.48	0.53
F-LSD (0.05)	3.21	6.36	0.03	0.04	2.01	2.27	0.06	0.05	0.07	0.05

The significant increase in number of capsule/plant when spaced at wider spacing (100 x 40cm) agrees with the findings of Singh and Yadav (1987) who reported that increase in the number of capsules per plant might be attributed to wider row spacing and less inter or intra plant competition in the community as compared to narrow row spacing. Jakusko *et al.,* (2013) also reported higher number of capsules per plant at wider spacing (75cm x 10cm).

Wider inter-row and intra-row spacings (100cm x 40cm) and their interaction also increased the capsule length of sesame. This findings agrees with Kathiresan (2002) who reported that increase in row spacing decreased intra-specific competition and proper adjustment of plants in the field which facilitated more aeration and penetration of light which eventually caused increase in capsule length as compared to narrow spacing. This findings contradict the work of Jakusko *et al.,* (2013) who reported highest capsule length at narrow spacing (60cm x 10cm). This difference may be due to genetic composition of the varieties used and the study environment.

The number of seed per capsule was significantly affected by inter and intra-row spacings in both years (Table 3). The highest number of seed was recorded at wider spacings of 100cm x 40cm. This work confirms the earlier work reported by Jakusko*et al.,* (2013) who reported that the number of seeds per capsule increases significantly as spacing increases. The findings also is in line with Kathiresan (2002) who reported that decrease in row spacings increased intra-specific competition which eventually caused reduction in the number of seeds per capsules compared to wider spacing.

A 1000-seed weight was highly significantly affected by spacing (table 3). There was significant difference between the spacing and the highest weight value recorded on 100 x 40cm (table 4) showing wider spacing producing heavier seed weight while the minimum seed weight was recorded by narrow spacing. Similar findings was reported by Olowe and Busari (2003) that1000-seed weight was higher at wider row spacings compared to narrow row spacing, this could be due to higher plant population which reduces the seed size.

Table 4. Interaction effect of Inter-Row spacing and Intra-Row spacing on the Yield Parameters of Sesame in Makurdi.

Inter –Row Spacing	Intra-Row Spacing	Number of Capsules/plant		Length of Capsule (cm)		Number of Seeds/Capsule		1000-Seed Weight (g)		Seed Yield (t/ha)	
		2013	2014	2013	2014	2013	2014	2013	2014	2013	2014
50cm	20cm	18.98	17.80	2.70	2.72	56.32	55.17	3.53	3.56	0.68	0.72
	30cm	48.76	51.00	2.77	2.80	59.56	59.55	3.30	3.34	0.66	0.68
	40cm	69.09	71.10	2.90	2.94	64.03	65.08	3.59	3.64	0.57	0.58
75cm	20cm	57.90	57.80	2.68	2.75	48.98	49.89	3.38	3.41	0.63	0.65
	30cm	62.80	62.50	2.88	2.92	60.23	61.55	3.48	3.50	0.60	0.62
	40cm	64.21	63.60	2.90	2.91	62.80	63.84	3.60	3.62	0.57	0.56
100cm	20cm	51.08	51.70	2.89	2.94	56.11	57.61	3.40	3.42	0.58	0.60

Inter –Row Spacing	Intra-Row Spacing	Number of Capsules/plant		Length of Capsule (cm)		Number of Seeds/Capsule		1000-Seed Weight (g)		Seed Yield (t/ha)	
		2013	2014	2013	2014	2013	2014	2013	2014	2013	2014
	30cm	60.00	60.90	2.96	2.99	60.23	61.71	3.61	3.65	0.51	0.54
	40cm	71.23	74.10	3.00	3.04	65.21	67.02	3.64	3.66	0.48	0.51
F-LSD (0.05)		10.23	11.01	0.06	0.07	3.04	3.93	0.07	0.08	0.10	0.09

The effect of spacing on seed yield was significant in both years (Table 3). The significant effect recorded the highest seed yield at 50 x 20cm although the increase in row spacing from 50cm to 75cm and 20cm to 30cm was not statistically significant. The interaction effect also showed 50 x 20cm producing highest seed yield at 50 x 20cm spacing (Table 4). The high seed yield obtained at 50 x 20cm spacing may be attributed to higher number of harvestable capsules per unit area observed with sesame planted at narrow row spacing or at high population density as compared to fewer at wider row spacing or low population densities. Therefore, the higher number of capsules, length of capsule, number of seeds/capsule and 1000-seed weight per plant recorded at wider row spacing of 100 x 40cm was unable to compensate for higher number of threshed capsules obtained at narrow row spacing of 50 x 20cm. This agreed with the finding of Chimanshette and Dhole (1992); Adebisi, *et al.,* (2005) and Umar, (2011)

Conclusion

From the results obtained, this study indicated that growth and yield components – plant height, number of branches, leaf area, number of capsules per plant, length of capsule, and 1000-seed weight were significantly influenced by row spacing. Significantly higher seed yield was recorded with row spacing of 50 x 20cm in both 2013 and 2014 cropping seasons and hence it is recommended that for optimum seed yield, farmers should adopt the spacing of 50 x 20cm in Makurdi.

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