



Effect of Intra Row Spacing on Okra (*Abelmoschus Esculentus* (L.) Moench) Varieties in Sudan Savannah Zone of Kebbi State, Nigeria

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Abstract

A Field trials were carried out during the 2023/2024 and 2024/2025 dry seasons in Jega, located in the Sudan Savannah Zone of Kebbi State, Nigeria, to assess the growth and yield performance of Okra varieties under varying intra-row spacing. The experiment involved three Okra varieties (NHAE 47-4, LD 88-1, and Clemson Spineless) and three intra-row spacings (20 cm, 40 cm, and 60 cm), arranged in a Randomized Complete Block Design (RCBD) with three replications. Data were collected on growth parameter plant height and yield attributes (fruit diameter, and total yield per hectare). Data were subjected to Analysis of variance (ANOVA) and means were separated using Duncan's Multiple Range Test (DMRT) at a 5% probability level. The results indicated that wider spacing (60 cm) significantly improved vegetative growth, resulting in taller plants with more and larger leaves across both seasons. In contrast, closer spacing (20 cm) produced the highest total yield per hectare due to increased plant density, although it resulted in smaller fruits. Wider spacing, however, enhanced fruit size, producing heavier fruits with larger diameters. Among the varieties, NHAE 47-4 consistently outperformed others in terms of fruit diameter and overall yield, while Clemson Spineless showed superior vegetative growth. Significant interactions between spacing and variety were observed for plant height, number of fruits per plant, and fruit yield. The study concludes that while wider spacing benefits individual plant growth and fruit size, a closer intra-row spacing of 20 cm is more suitable for maximizing yield per hectare. NHAE 47-4 is therefore recommended for optimal production under the agro-ecological conditions of the Sudan Savannah zone of Nigeria.

Keywords: Inter row, leaf length, Okra, plant height, Varieties.

INTRODUCTION

Okra (*Abelmoschus esculentus* (L.) Moench) is a member of the Malvaceae family. It is widely cultivated in the tropics and subtropics, and it is an important vegetable crop consumed worldwide (Olaniyi *et al.*, 2009; Omotoso *et al.*, 2018). Okra is an indigenous crop of Africa cultivated widely in West and Central Africa for its immature fruits (Varmudy, 2011; Komolafe *et al.*, 2021). Okra is a vital vegetable food item in human nutrition supplying minerals, vitamins, some hormones, protein and energy. Okra flowers can be very attractive and sometimes used in internal decoration of living rooms (Schippers, 2000). The fruits of okra are exported by some African and Caribbean countries to Europe and America where there is a ready demand from the resident ethnic groups from tropical and sub-tropical countries such as West Africans, Indians, Pakistanis, etc (Adetula and Denton, 2003).

World production of okra stood at about 9.4 million tons with 69%. As an indigenous crop of Africa, Okra is cultivated widely in Africa for its immature fruits used as vegetable with a yield of 4.18 million tons. In Nigeria, it is estimated at 1.82 million tons per year (FAOSTAT, 2020). The total area under cultivation has increased over the years. India has been known to be the highest producer of okra in the world, followed by Nigeria and Sudan (Komolafe *et al.*, 2021).

Okra thrives well in different soils, but it is best grown in well- drained sandy and clay loam soils, especially with rich organic matter (Sreenivasa *et al.*, 2010). It can tolerate slightly acidic soil. The crop can be grown in soils with pH range from 4.5 to 7. According to Iyagba *et al.* (2012), okra grows best on loams and sandy loams, but will produce good yields on heavier soils. It is a crop of tropical and sub-tropical climates requiring a long warm and humid growing season (Komolafe *et al.*, 2021). It is susceptible to frost and cannot thrive well in cold. It may be grown at elevations from sea level up to 30 m (Omotoso *et al.*, 2018) but can tolerate a wide range of rainfall (Omotoso *et al.*, 2015). Seeds fail to germinate below 20°C. Optimum temperature for seed germination is 29°C. Okra is a stout, erect annual herb that grows to about 4 m tall with spirally arranged leaves with leaf blades up to 50 cm in diameter (Olaniyi *et al.*, 2009). The fruit is a capsule and grows quickly after flowering. Fruits or pods are green, 5-35cm long and 1-5 cm in diameter (Adetuyi *et al.*, 2011). The crop is known in many English-speaking countries as ‘ladies’ finger’ or ‘ochro’ (Remison, 2005).

In Nigeria, it is made into soups, stews and sauces with or without palm oil; fish and other condiments, or it’s boiled as vegetable. The leaves of okra can also be cooked to make a popular soup called Ilesha in Nigeria (Cooke, 1998). Okra has a high fiber content which helps to stabilize blood sugar by regulating the rate at which sugar is absorbed in the body system (Udoh *et al.*, 2005; Ngok *et al.*, 2008). The adoption of high yield varieties is emphasized by farmers who still dwell on genotypes with poor yield (Agba *et al.*, 2011). Research studies on okra, point out that, varieties with high yielding ability should be recommended for food security (Adetuyi *et al.*, 2011).

In Nigeria, agricultural production is low due to lack of proper agronomic practices, infrastructure, low yields associated with poor soils, low-yielding and less stable varieties (Omoregie and Nwajei, 2015). In the study area, crop yield from farmers’ fields is low due to variety and plant density (Agba *et al.*, 2011; Umeri *et al.*, 2018). With regards to high yielding crop varieties, there is need to increase effort on research to cultivate varieties that can give high yield. Hence, this study is designed to evaluate the growth and yield of some okra varieties in Sudan Savannah zone of Kebbi State, Nigeria.

MATERIALS AND METHOD

Experimental Site

Field experiments were conducted at the Teaching and Research Farm of Abdullahi Fodio University of Science and Technology Aliero located at Jega (Lat. 12.29°N; Long.4.46°E) during 2023/24 and 2024/25 dry seasons. The treatments consisted of three varieties of okra (NHAE47-4, Clemson and LD 88-1) and three intra-row spacings (20cm, 40cm and 60cm) arranged in a Randomized Complete Block Design (RCBD) with three replications. The seeds were sourced from NIHORT Bagauda, Kano sub-station. The experimental area was harrowed to a fine tilt. The land was then marked into plots and replications. Border spaces of 0.5m between the plots and 1m between replicates was marked. The seeds were sown manually at the rate of three seeds per hole at a depth of about 2 cm. Spacing was done manually as per treatment basis. Weeding was done manually at 3 and 6 weeks after sowing (WAS). Water channels were constructed for effective supply of water to each furrow during irrigation 2 times per week. Karate (*lambda*cylhalothrin) was sprayed at 4 ml L⁻¹ of water against insect pests. NPK (15:15:15) fertilizer was applied in split doses to meet the nutrient requirement of 120 kg ha⁻¹ N, 80 kg ha⁻¹ P₂O₅ and 80 kg ha⁻¹ K₂O.

Data collection

Plant height (cm)

Plant height was measured from the base of each plant to the tip of the highest growing point from randomly selected five plants using a graduated meter rule and the values were recorded at 3, 6, and 9 WAS. The average height was then record for each plot.

Fruit Diameter (cm)

The diameters of the five randomly selected fruits were measured using a vernier caliper after which the diameter values of the five fruits were added and then divided by five for the mean diameter.

Yield (t/ha)

The harvested fruits from each net plot were weighed for each treatment plot using a mettler Toledo SB 16001 balance and expressed in kilogram per hectare.

Data analysis

Data collected was subjected to Analysis of Variance (ANOVA) using SAS software and means were separated using Duncan’s Multiple Test Range (DMRT) at 5 % level of significance.

RESULTS

Plant Height (cm)

There was no significant difference among the intra-row spacing across all the sampling stages in both years except at 10 WAS in 2025. 60cm spacing recorded the tallest plant height that differ significantly with 40cm spacing and the shortest plant height was recorded by 20cm spacing. However, significant difference exists among the varieties where Clemson Variety consistently recorded higher mean values for plant height than all other varieties except at 6 WAS in 2025 where there was no significant difference. The interaction between intra-row spacing and varieties was not significant across all the sampling stages in both Years.

There was a significant interaction between spacing and variety at 6WAS during 2024 dry season (table 4.1a). The result indicated that spacing of 60cm in conjunction with LD-88-1 and NHAE 47-4 recorded the tallest plant height and shortest was recorded by the intra row spacing of 20cm with LD-88-1. It was also observed that intra row spacing of 60cm in combination with LD-88-1 and Clemson variety produce the moderate plant height.

Table 4.1 Effect of intra row spacing on plant height of Okra varieties during 2024 and 2025 dry season.

Treatments	2024			2025		
	Plant height (cm)					
Spacing (cm)	4 WAS	6 WAS	10 WAS	4 WAS	6 WAS	10 WAS
20	29.33	44.08	78.95	28.26	37.57	49.64 ^c
40	31.71	47.55	77.77	28.80	38.37	68.30 ^b
60	32.01	52.04	78.58	29.06	38.95	79.95 ^a
SE	1.730	1.898	8.176	1.141	1.033	1.717
Varities						
Clemson	30.35^a	43.74^a	96.14^a	27.37^a	41.31	65.92^a
LD-88-1	28.33 ^b	40.45 ^b	67.87 ^b	25.92 ^b	42.41	58.33 ^b
NHAE 47-4	27.46 ^b	39.52 ^b	52.00 ^b	25.67 ^b	40.22	54.93 ^c
SE	1.030	1.091	1.126	1.043	1.024	1.027
S x V	NS	*	NS	NS	NS	NS

Means followed by the same letter (s) in a treatment group are not significantly different at 5% level using DMRT, *= Significant at 5% NS = not significant, WAS = Weeks after sowing.

Table 4.1a. Interaction Between Intra row Spacing and Variety on Plant Height during 2024 Dry Season.

Spacing (cm)	Variety		
	Clemson	LD-88-1	NHAE 47-4
20	41.27 ^b	36.03 ^d	34.21 ^c
40	39.24 ^c	42.01 ^b	32.48 ^c
60	42.37 ^b	44.84 ^a	43.43 ^a
SE±	0.251		

4.6 Fruit Diameter and Fruit yield (t/ha)

The results in Table 4.6 revealed that intra-row spacing had a significant effect on fruit diameter and fruit yield of okra during 2024 and 2025 dry season.

The widest spacing of 60 cm produced significantly larger fruits diameter in both seasons which was statistically at par with 40 cm spacing, while the narrow spacing of 20 cm recorded the smallest fruit diameter in both seasons. Significant differences were also observed among the okra varieties. The NHAE 47-4 variety recorded the highest fruit diameter in both seasons, followed by LD-88-1 that produce statistically similar with Clemson.

In contrast, fruit yield (t/ha) was highest at the narrow spacing of 20 cm in both seasons. The 40 cm and 60 cm spacings produced comparatively lower yields, with no significant difference between them in both seasons. On the other hand, significant differences were observed among the okra varieties. NHAE 47-4 produced the highest fruit yield in both seasons, while Clemson recorded the lowest yield.

There was a significant interaction between inter row spacing and variety in both 2024/2025 Dry season (Table 4.6a). In 2024, The Narrow spacing of 20cm in combination with Clemson recorded the Highest fruits while the lightest was obtained from the narrow spacing of 20cm in conjunction with LD-88-1 variety. Similarly in 2025, Clemson variety in combination with 20cm intra row spacing recorded the highest mean value of Fruit yield which was statistically at par

with NHAE 47-4 in conjunction with 60cm intra row spacing, while the least mean value of Fruit yield was recorded by LD-88-1 in combination with 40cm intra row spacing.

4.6 Effect of intra row spacing on Fruits Diameter and Fruits yield Plant of Okra varieties during 2024/2025 dry season at Birnin Kebbi and Jega

Treatment	Fruit Diameter (cm)		Fruit Yield (t/ha)	
	2024	2025	2024	2025
Spacing (cm)				
20	2.10 ^c	1.83 ^b	4.21 ^a	4.02 ^a
40	2.31 ^b	2.01 ^a	3.40 ^b	3.12 ^b
60	2.58 ^a	2.24 ^a	2.85 ^b	2.08 ^b
SE	0.032	0.031	0.238	0.190
Variety				
Clemson	1.90 ^b	1.65 ^b	3.12 ^b	.50 ^b
LD-88-1	2.03 ^b	1.77 ^{ab}	4.68 ^a	3.24 ^b
NHAE 47-4	2.13 ^a	1.85 ^a	4.20 ^a	4.36 ^a
SE	0.031	0.030	0.214	0.171
V x S	NS	NS	NS	NS

Means followed by the same letter (s) in a treatment group are not significantly different at 5% level using DMRT, *= Significant at 5% NS = not significant, WAS = Weeks after sowing.

Table 4.6a. Interaction Between Intra row Spacing and Variety on Fruit Yield (t ha⁻¹) during 2024 and 2025 Dry Season.

Spacing (cm)	2024		
	Variety		
	Clemson	LD-88-1	NHAE 47-4
20	6.32a	2.09e	2.86d
40	5.66b	5.71b	5.07c
60	4.21c	5.22b	5.23bc
SE±	0.212		
Spacing (cm)	2025		
	Clemson	LD-88-1	NHAE 47-4
	Clemson	LD-88-1	NHAE 47-4
20	5.23 ^a	3.66 ^c	3.51 ^c
40	4.42 ^b	2.45 ^d	4.32 ^b
60	3.45 ^c	3.61 ^c	5.12 ^a
SE±	0.311		

Means followed by the same letter (s) in a treatment group are not significantly different at 5% level using DMRT, *= Significant at 5% NS = not significant, WAS = Weeks after sowing.

DISCUSSION

5.1 Response of Varieties to Intra-row Spacing

Wider spacing (60cm) resulted in taller plants than the closer spacing in both seasons. The observed increase in plant height due to less population density could be due to less competition between and within plants which help their desire to reach the essentials life with available light energy. These results could also be due wider spacing available, which encourages growth of lateral branches and favors plants to grow upward with free competition for light. The finding of this research aligns with the findings of (Talaka, 2023), who reported that wider spacing can reduced intra-plant competition allowing lighter, nutrient and space for individual plant to grow taller and also disagree with the finding of Haile, (2016) who reported that, narrow spacing encouraged plant to grow tall due to high competition to overcome the barrier in attracting sun light.

The production of a greater number of leaves increased with wider spacing especially at later stages (6WAS and 8WAS), this could be most likely due to the availability of growth factors and better penetration of light at the wider spaced plants. This result is in conformity with the result of (Adebayo *et al.*, 2022) who reported that wider inter-and intra-row spacing significantly increased the number of leaves during the course of observation in sesame crop. Haile (2016) also reported increase in the number of leaves with increase both intra row and plant spacing up to 45 cm x 25 cm spacing combination.

Intra row spacing influenced yield component. Closer spacing (20cm) produced higher number of fruits per plant, where as wider spacing (60cm) resulted in significantly heavier fruits and larger fruit fruits diameter in both seasons. This can

be attributed to availability and utilization of growth factors (water, sunlight and soil nutrients), because of less competition. These results agreed with the findings of Moniruzzaman *et al.* (2007) who reported lower number of mature pods with closer spacing. They maintained that the lower number of pods obtained from the closer spacing might be due to competition for nutrients and space among the plants owing to high plant population. Ijoyah *et al.* (2010) also obtained similar results. Similar trend has been reported by (Adebayo, 2021; Ibrahim *et al.*, 2023) who observed that higher plant density increases fruit number due to more plant per unit area, while wider spacing enhances fruits weight because of reduced competition for nutrient, moisture and light allowing better fruit development.

5.2 Varietal Response

Clemson variety consistently produced taller plant than the rest of the varieties. Plant height is an important growth character that has direct bearing with the production potential in terms of fodder, grain and fruit yield (Omotosho and Shittu, 2007). The taller plants obtained at wider spacing of 60 cm over the years could be attributed to less competition for growth factors such as light, nutrient and water, which gave the okra plant access to these factors. The result obtained in this study is in agreement with the findings of Madisa *et al.* (2014) who reported that taller plant was obtained at wider spacing, which was the result of less competition for resources such as nutrients. Similarly, Ekwu and Nwokwu, (2012) reported that plant height increased as the plant spacing increased from 50cm x 25cm to 50cm x 50cm beyond which there was a decrease in plant height. The tallest plants were obtained at 50cm x 50cm while the shortest were at 50cm x 25cm (Ekwu and Nwokwu, 2012). This agrees with multiple agronomic studies showing significant varietal differences in growth trend like plant height. Sabo *et al.* (2016) reported that different okra varieties exhibit significant differences in growth and yield components with certain varieties outperforming other growth and yield parameters.

Clemson consistently had the highest leaf number across the time point. Findings in this study revealed that the number of leaves was significantly influenced by the treatments. Higher number of leaves recorded by Clemson variety could be attributed to availability of sunlight and soil nutrient for better performance of the plant. The availability of these factors aid photosynthesis which translates into bigger plants in terms of number of leaves, branches and others. This is in agreement with the work of (Mehla *et al.*, 2000) who reported that increase in number of leaves and other growth parameters was attributed to less competition. It is observed that the leaves number decreased with time, probably due to senescence. The result here is in agreement with the findings of Madisa *et al.* (2014) and Maurya *et al.* (2013). It also aligns with the findings of Bello *et al.* (2021), who reported that Genetic differences among okra varieties strongly influence leaf initiation and total leaf number, some cultivars inherently develop more leaves per plant under same environmental condition.

Varieties difference were also evident with Clemson producing significantly longer leaves than LD-88-1 and NHAE 47-4. This is line with the result of Bello *et al.* (2020) that genetic make-up strongly influenced leaf morphology including leaf length and expansion rate. Varieties with longer leaves are associated with improved photosynthetic capacity and vegetative growth.

Significantly varietal differences were observed in fruit diameter and fruit yield in the both seasons. NHAE 47-4 produced largest fruit diameter and highest fruit yield, followed by LD-88-1. This is in conformity with finding of Umar *et al.* (2019) who reported gene variability among okra variety significantly influence fruit size and total yield due to difference in assimilate partitioning and productive efficiency. The result is also in line with the finding of Muhammad *et al.* (2019), who reported that heavier fresh pods plant-1 was obtained from NHAE47-4 than Dogo which in turn was heavier than LD88.

Interaction Between Spacing and Variety

The significant interaction between the varieties and intra row spacing on plant height, Number of fruit plant⁻¹ and Fruit yield have clearly indicated the complimentary role of spacing and variety in achieving a required growth and yield attributes of Okra. The result obtained is in agreement with the finding of Ajala (2016) who reported that; the highest number of fruit and yield obtained by Clemson spineless at 20cm intra-row spacing could be because it is an improved variety planted at a wider spacing, causing minimum competition. These results agree with the findings of Ijoyah *et al.* (2010) as the two varieties they worked on have their highest weight and height at a wider spacing. They stated that plants grown at wider intra-row spacing might have received more nutrition and light for optimal growth and development thereby producing the highest pod number.

CONCLUSION

This study has revealed that the intra row spacing of 20cm and 60cm enhanced the growth and yield of okra when compared with the other treatment. However, variety NHAE47 4 has out-yielded Cleamson and LD88 in both 2024 and 2025 growing season. But Clemson variety outweighed all the other varieties in terms of growth parameters. From the results obtained, it may be concluded that, NHAE47-4 okra variety could be selected in conjunction with 20cm spacing when more produced is required. On the other hand, when quality and vegetative attributes are need Clemson variety in combination with 60cm intra raw spacing can provide the best.

RECOMMENDATIONS

From the findings of this study, the following recommendations could be made:

1. Intra row spacing of 20cm could be adopted for higher Okra Fruit yield in the study area.
2. Variety NHA47-4 could also be considered since it recorded superior performance among the treatment on in the study area.
3. When high quality is needed, intra row spacing 60cm should be adopted in the study area.

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