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EFFECTS OF PLANT SPACING AND DIFFERENT LEVELS OF NITROGEN FERTILIZER ON THE GROWTH AND YIELD OKRA (*ABELMOSCHUS ESCULENTUS* (‘L.) MOENCH) IN MUBI, NORTHERN GUINEA SAVANNAH, NIGERIA

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ABSTRACT

The experiment was conducted at the Teaching and Research Farm of Food and Agricultural Organization / Tree Crop Plantation (FAO/TCP) Faculty of Agriculture, Adamawa State University Mubi, during the 2024 rain fed cropping season to determine the effects of plant spacing and different levels of nitrogen fertilizer on the growth and yield of okra (Abelmoschus esculentus L' Moench) *in Mubi Northern Guinea Savannah. State. The main treatment (plant spacing) consisted of 4 intervals viz: S_1 (30 × 60), S_2 (40 × 60), S_3 (50 × 60) and S_4 (60 × 60), 4 rates of: the sub-treatment (nitrogen fertilizer) equally had 4 application rates: 0 kg N ha^{-1} (N_1), 50 kg N ha^{-1} (N_2), 100 kg N ha^{-1} (N_3) and 150 kg N ha^{-1} (N_4) factorial combined and arranged in Split Plot Design replicated 3 times. Data collected on plant height, number of branches, days to 1^{st} and 50% flowering, fruit length, fruit diameter, number of fruits per plant (g). Other parameters studied are average fruit weight (g), hundred seeds weight (g) and fresh fruit yield per hectare. These data were subjected to analysis of variance (ANOVA) using Statistical Analysis System (SAS, 2010) package and means separated by F test using Duncan Multiple range Test (DMRT). The results revealed is that plant spaced 50 × 60 and fertilized with nitrogen fertilizer at 100 kg ha^{-1} (S_3 N_3) Significantly ($P \geq 0.05$) improved plant height at 6 WAS (27.40 cm), number of branches at harvest (22.11), number of fruits per plant (29.80). Significant influence of spacing and rate of nitrogen at $P \geq 0.05$ level under S_3 N_3 treatment also observed on number of seeds per fruit, average fruit weight, 100 seeds weight, and fresh fruit yield ton per hectare with highest mean values of (*356.33, *29.80 g; 15.67 g and 1.87 t ha^{-1}) accordingly. The study observed that plant spacing of 50 × 60 and fertilized with nitrogen at 100 kg ha^{-1} (S_3 N_3) treatment was the best among all the treatments in this trial. Therefore, this study suggested the adoption and cultivation of okra under S_3 N_3 treatment to farmers in Mubi and its environs for optimum fruit yield.*

Keywords: Effects, spacing, Nitrogen, Growth, Yield and Okra.

INTRODUCTION

Okra, (*Abelmoschus esculentus* (L.), Moench) is an annual herbaceous plant of the Malvaceae family, indigenous to tropical Africa and growth all over the West African (Schippers, 2000). This valuable vegetable play a vital role in human nutrition and stands as a key component in human diet providing necessary vitamins, minerals, carbohydrates and fiber for good health. Okra is one of the priority vegetables in crops in Nigeria and ranks above other vegetables including cabbage, amaranthus and lettuce (Babatunde *et al.*, 2007). It is a popular crop in Nigeria, cultivated in many states due to its ability to thrive under various environmental conditions (Ghosh and Jana, 2022). Its rich dietary fibre content and versatility in culinary applications make it a staple in local diets (Lamont, 1999). Okra has good nutritive and medicinal value including high export potential due to its favour. The fruits are consumed immature or can be used in salads, soups and stews fresh or dried, fried or cooked (Gemede *et al.*, 2013). Mucilage from okra have been reported to be effective as blood volume expander and has the potential to alleviate renal disease, reduce proteinuria and improve renal function (Siemonsma and Koume, 2004). Although, okra is a very important vegetable crop with outstanding quantities, but yield obtained from farmers' fields are often very low. Average yield per hectare in Nigeria is 2.10 tons / hectare, which is less than half of those in other countries like India (10.12 ton / hectare) and world average (7.65 tons / hectare).

Studies identified low soil fertility, use of low yielding varieties, weed infestation, plant spacing as some of the major production constraints attributed to low yields of okra in Nigeria (Adeyemi *et al*., 2008; Iyagba *et al*., 2012). Unfortunately, crops complete among themselves for all growth resources such as space, light, nutrients, water etc. However, study by (Amjad *et al*., 2002) indicated that, appropriate plant spacing can lead to optimum fruit yield whereas too high or low plant spacing could result in relatively low yields and quality. (Birbal and Malik 1995) warned that, to get good quality green fruit, okra is required to be sown at optimum plant spacing. Palanisamy and Ramaswamy (1993) reported to have achieved higher pods and seeds yield in okra through closer spacing of 60 x 20 cm) over wider spacing. Appropriate plants spacing can lead to optimum fruit yield while, too wide or narrow spacing could result in relatively low yields and quality (Amjad, *et al*., 2002). On the other hand, nitrogen is the most important nutrient to the plant and its rate depends on the amount available to the plant and plant density. Most plants require nitrogen for normal growth and production yet, very few soils contain enough native nitrogen to sustain high yields in most crops (Elhag and Ahmed, 2014).

Limited research exists on the effects of plant spacing and nitrogen fertilizer application rates, particularly in northern guinea savannah zone, Nigeria hence, more comprehensive studies are needed to determine the precise plant spacing and nitrogen requirements for different varieties of in the region okra. Khanal *et al*., (2020) reiterated that proper plant spacing and suitable fertilization doses are required to achieve maximum yield and quality, as both factors may influence crop production, quality, and economy. This research works therefore, was carried out to determine the best plant spacing and appropriate rate of nitrogen fertilizer application rate in Mubi, northern guinea zone, Nigeria.

MATERIALS AND METHODS

Study Area

The experiment was conducted at the Teaching and Research Farm of Food and Agricultural Organization / Tree Crop Plantation (FAO / TCP), Faculty of Agriculture Adamawa State University, Mubi during the 2024 rain fed cropping season. Mubi is geographically located on Latitude (10^0 06′ and 10^0 29′ N) and Longitude (13^0 01′ – 10^0 30′ E) and also found at an altitude of 696 m above sea level with the annual mean rainfall between 700 – 1050mm and the minimum temperature of 18 ^{0}C during the harmattan period and 40 ^{0}C maximum in April (Adebayo *et al.,* 2014 and 2021; Adebayo and Tukur, 2020). The soil is largely of sandy clay loam, sandy loam or loam textured. Mubi has a traditional alternating dry and rain season which last for 5 months: November – Match duration, the rain season stretches between 7 months: (April – October) predominant vegetation is that of savannah consisting of shrubs, eucalyptus, locus bean, grass and Acacia amongst others (Adebayo, 2020).

Soil Analysis

Prior to transplanting, soil samples to a depth of 0 −30 cm were randomly collected from 5 different places of the experimental field. The composite samples were then analyzed for physico−chemical properties of the soil mainly for organic carbon, total N, soil pH, available phosphorus, cat ion exchangeable capacity (CEC) and texture (Table 1). Soil pH is determined using a soil−water medium at a cat ion of 1.2 with digital electronic pH meter (Ibbitoye, 2006). Walkely and Black (1934) method was used to determine the organic matter content, total nitrogen content obtained following Kjedahl digestion, distillation and titration procedure as described by Cotlenie. Available phosphorous determined by Olscen method whereas cat ion exchangeable capacity (CEC) was measured using Mneutral ammonium acetate. Soil particle size distribution obtained using hydrometer techniques. Calcium and magnesium were determined by atomic absorption spectrophotometer (Perkin−Elmer Corp, 1969) and lastly sodium determined using flame emission photometry profound by Doll and Lucas, 1973.

Treatments and Experimental Design

The experiment was laid out in split plot design with two factors namely: 'Plant spacing' signified by (S) and 'Nitrogen' indicated by (N). plant spacing which is the main treatment consisted of 4 intervals: S_1 (30 × 60), S_2 (40 × 60), S_3 (50 × 60) and S_4 (60 × 60) and Nitrogen, the sub-treatment equally had 4 application rates: 0 kg N ha^{-1} (N_1), 50 kg N ha^{-1} (N_2), 100 kg N ha^{-1} (N_3) and 150 kg N ha^{-1} (N_4) replicated 3 times.

Experimental Procedures and Crop Management

The experimental site were manually cleared; shrubs, debris and left over plants residues from the previous harvest present on the field were collected by one site of the farm and burn. Herbicide; (Glyphosate and Diron) were applied to control weeds and soil borne diseases. Later the field were harrowed by tractor to create good tilt soil conditions for easy roots penetration and then ridges formed. The field were divided in to 3 blocks and each block consisted of 16 plots given the total of 48 plots. A path way of 1 m both between plots and replications to allow for easy movement during data collection created. The total land area for the experimental site was 441.45 m^2 with gross plot size of 3 m × 2.1 m (6.3 m^2) and the net plot size of 2.25 m x 1.8 m (4.05 m^2). There were 5 ridges in each plot, each ridge contained 7 plant stands given the total number of 35 stands in each plot. Healthy and viable seeds sown by placing the seeds in a moist soil condition at the rate of 2 – 3 seeds / stand using 3 - 4 cm depth and later thinned down to 1 seedling/ stand at 2 weeks after sowing. The seeds were sown at varying spacing intervals: (30 × 60), (40 × 60), (50 × 60) and (60 × 60) in accordance with the research design. During plots construction, first dose of nitrogen fertilizer was applied and incorporated with the soil in each case. While the 2nd dose of nitrogen applied to seedlings at the age of 5 weeks. Weeds were controlled throughout the growth period. Karate lambda insecticide (Lambda cyhalothrin) diluted with water applied 4 time at 5 days intervals to guard against insect pests. Harvesting of fresh green fruits commenced 1 weeks after 1st flower and continued every 3 days, fruit yield recorded and analyzed.

Data Collection

Five (5) crops from the center of each plot randomly selected and tagged as sampled plants on which data were collected regularly. Data collected on plant height at 3, 6 and 9 weeks after sowing by measuring the length of sampled plants from the ground level to the main shoot apex using a meter rule graduated in cm average taken and recorded. Number of branches per plant determined once at harvest by physical counting of branches from the sampled plants. Days to 1st and 50% flowering determined by daily observation, data taken and recorded. Fruit length measured using a measuring tape graduating in cm while fruit diameter determined with the aid of digital venire caliper. Number fruits per plant and seeds per fruits by physical counting whereas, for average fruit weight: ten (10) fruits were randomly selected and weight determined using electronic weighing balance, similarly, hundred (100) seeds weight counted from the sampled fruits after manual threshing and weighed electronically as above. Fresh fruit yield per hectare (ton ha^{-1}) determined by multiplying the yield per plot by conversion factor (10,000 m^2) and the values recorded.

$$\text{Fruit Yield (kg ha)} = \frac{\text{Fruits per plot (kg)}}{\text{Net plot size } (m^2)} \times 10{,}000 \ m^2$$

Data Analysis

Data collected were subjected to analysis of variance (ANOVA) using SAS, 2010 Statistical Analysis System package. Means separated by F test using Duncan Multiple Range Test (DMRT). at 5% probability.

RESULTS AND DISCUSSIONS

Physico-chemical Properties of Soil of the Experimental Site before Cropping

Physico-chemical properties of soil in the experimental site, before cropping showed that the soil was slightly acidic in nature, having a pH values of 5.9. The soil organic carbon content (3.70 %) fall under the category of very high in accordance with the rating of Bello *et al,* (2006); who classified soil organic percentages as: < 1.0, 1.0 – 1.71; 1.72 – 3; 3.1 – 4.29 and > 4.3 as very low, low, medium high and very high respectively. The total nitrogen content of 0.67 g kg^{-1} was within the medium total nitrogen content in accordance with the rating of London (1991); who classified soils having total nitrogen of greater than 1.0 % as very low, 0.5 - 1 % high, 0.2 – 0.5 % medium, 0.1 – 0.2 % low and less than 0.1 % as very low in total nitrogen content. The level of potassium (0.45) cmol kg^{-1} was equivalent to the critical level of 0.45 cmol kg^{-1} as earlier revealed by (Emezu, 2013). The phosphorus of 6.67 ppm which is medium soil according to the classification of Bray and Kurzt (1945) who classified available P < 5 ppm as: very high, high, medium, low and very low accordingly. The magnesium, sodium and calcium (0. 47, 0.38 and 1.93) contents were all within the critical levels for soils in the guinea savannah region. The experimental site has Carbon exchange capacity (CEC) of 3.25 meg/100, which is very low according to rating of the London (1991) who classified soils having CEC of > 40, 25 – 40, 15 – 25, 5 - 15 < 5 meg/100g as very high, high, medium, low and very low.

Effects of Plant Spacing and Different levels of Nitrogen Fertilizer on Plant Height, Numbers of Branches at Harvest and Days to 1st Flowering of okra

Results for the effects of Plant spacing and nitrogen fertilizer application rates on plant height was significant ($P \geq 0.05$) at 6 WAS (Table 2). The data from the analysis of variance ANOVA showed that, plots planted at the spaced of 50 × 60 and fertilized with 100 kg N ha^{-1} (S_3 N_3) produced the tallest plants measured 27.40 cm height followed by plots spaced 40 × 60 and sprayed with 100 kg N ha^{-1} (S_2 N_3) (24.07 cm) whereas the shortest plant (16.53 cm) obtained from plots spaced 30 × 60 but no fertilizer applied (0 kg N ha^{-1}) i.e., S_1 N_1.being the lowest response treatment. At 3 and 9 WAS plant height did not significantly ($P \leq 0.05$) affected by plant spacing and the rates of nitrogen fertilizer. However, differences among the treatment mean values observed, the highest (14.07 and 73.19 cm) recorded from S_3 N_3 then, S_2 N_3 (9.40 and 68.00 cm) whereas, the shortest plants (6.27 and 42.65 cm) height obtained from S_1 N_1 accordingly. This result is in closed harmony with the earlier findings of Ashraf, *et al* (2016) who recorded significantly taller plants of: 14.0, 13.8 and 13.9 cm height in plots spaced 60 × 30 and received 60, 80 and 100 kg N ha^{-1}. This implied that, .moderate plant spacing is critical, reduces competition for growth resources such as light, nutrients, air etc. whereas, sufficient amount of nitrogen encourages rapid vegetative growth. This assertion was confirmed by researchers like Brar and Singh, (2016); Adlan, *et al, (*2017); Singh *et al, (*2020) and Amin (2022). This result is in line with the earlier finding of Amin, (2022) who posited that, optimum plant spacing and nitrogen levels influence plant height in okra.

Plant spacing and nitrogen fertilizer application rates significantly ($P \geq 0.05$) increased the number of branches of okra at harvest (Table 2). The mean data for the analysis indicated that, S_3 N_3 treatment gave the greatest number of 22.11 branches closely followed S_2 N_3 having recorded 19.36 branches while S_1 N_1 produced plants with lowest number of 9.81 branches. Similar result was reported by Momruzzaman, *et al.* (2007) who recorded maximum number of branches per plant at a moderate spacing of 60 × 40 cm and minimum branches at closer spacing of 30 ×35 cm while Jana *et al.* (2012) obtained significantly higher number of 43 branches at 50 kg N ha^{-1}.

The same (Table 2) shows the data for the effects of plant spacing and nitrogen fertilizer application rates which had no significant effect on days to 1st flowering but slight difference in the treatment mean values observed. First flower was noted from S_3 N_3 treatment within 54.33 days, the 2nd flower recorded form S_2 N_3 treatment (55.33 days and the longest 60.33 days observed from S_1 N_1 treatment. The data obtained from the present study is in total disagreement with the one recorded by Amjad *et al.* (2002) who report lesser (43.54 days) to flowering in okra at plots spaced

60 × 45 cm. In another related study by Jana, *et al.* (2010) achieved minimum 44.99 day's to flower at the rate of 50 kg N ha^{-1}.

Effects of Plant Spacing and Different levels of Nitrogen fertilizer on Day's 50% Flowering, Fruit Length, Fruit Diameter and the Numbers of Fruit / Plant of okra

The results for the above yield and yield components of okra as affected by plant spacing and nitrogen fertilizer rates on is presented in (Table 3). The finding revealed that Days' to 50 % flowering, fruit length and fruit diameter were not significantly affected by the rates of spacing and nitrogen fertilizer. Nevertheless, variations in the treatment mean values exist with the minimum (64.33 days) to 50% flowering recorded from S_3 N_3 and S_2 N_3 treatments closely followed by S_4 N_4 treatment having attained 50% flowering within the shortest period of 65.33 days (S_4 N_4) whereas, the longest (72.33 days) being the lowest response obtained from S_1 N_1 treatment. This result contradicts the one obtained by Parmar, *et al.* (2016) who reported significant reduction to achieved 50% flowering within the shortest (43.90 days) at 75 kg N ha^{-1} meanwhile, nitrogen at the rate of 125 kg N ha^{-1} at 0.01 significant level was found to decreased day's to 50% flowering in okra by Nacdeep and Daljeet (2016).

Plant spacing and nitrogen fertilizer application rates have no significant ($P \leq 0.05$) influenced on fruit length and fruit diameter, as shown in (Table 3). However, differences among the treatment mean observed. Treatment S_3 N_3 gave the longest and thickest fruits measured 9.80 and14.33 cm followed by S_2 N_3 which gave 9.07 and 13.00 cm while S_1 N_1 produced the shortest and thinness (6.74 and 6.67 cm) fruits. Plant spaced 60 × 30 cm and fertilized with 60 kg N ha^{-1} was reported to significant increase fruit length up to 5.5.cm (Ashraf *et al.* 2024) and Tejaswini *et al.* (2021) recorded best results of fruit length and fruit diameter with wider spacing of 60 × 60 cm while, Norman *et al.*, (2019) obtained (7.40 cm) fruit length at the spacing of 60 × 45 cm.

The number of fruits per plant measured in this study significantly ($P \geq 0.05$) increased due to the differences in plant spacing and nitrogen fertilizer application rates (Table 3). The data analyzed revealed that, S_3 N_3 treatment recorded the greatest number of 29.80 fruits per plant then, S_2 N_3 recorded up to 25.53 fruits and the lowest (14.87) fruits being the least obtained from S_1 N_1 treatment. The result of the present study agreed with that obtained by Amjad *et al.* (2002) who recorded 16.70 number of fruits per plant under plots spaced 60 × 45 cm), Bishnoi *et al.*, (2019) recorded greatest number (17.35) fruits per plant and 11.23 fruits obtained from the wider spacing of 75 × 25 (Padhiyar *et al*, .2023). Moreover, nitrogen fertilizer applied at the rate of 69 kg ha^{-1} significantly accounted to higher number of (8.00) fruits per plant.

Effects of Plant Spacing and Different levels of Nitrogen Fertilizer on the Number of Seeds per Fruit, Average Fruit Weight, Hundred seeds Weight and Fresh fruit Yield per Hectare of okra

Data for the analysis of variance for the effects of plant spacing and rates of nitrogen fertilizer significantly ($P \geq 0.05$) affected all the above yield characters of okra (Table 3). As displayed on table, treatment S_3 N_3 produced the greatest number of 356.33 seeds per fruit then, S_2 N_3 (324.67) seeds and the lowest (251.00) obtained from S_1 N_1 treatment accordingly. This result can be compared with the previous findings of Sajid *et al.* (2012) who reported significantly higher number of seeds per fruit at different nitrogen levels. The significant performance showed in this study might be as a result of key role played by nitrogen in plants metabolic system just as emphasized previously by Shah, *et al.* (2017) that, vitals processes in plants are associated with proteins of which nitrogen is an important constituent.

In respect to average fruit weight, the result was found to be significant at $P \geq 0.05$ (Table 4). The mean data for the analysis showed that treatment S_3 N_3 gave the heaviest fruits weighed 29.80 g followed by S_2 N_3 (25.53 g) whereas, the lightest fruits (14.87 g) collected from S_1 N_1 being the least treatment. Our results is in closed harmony with previous findings of Alen *et al.,* (2019) who recorded significantly heaviest fruits measured (14.73 g) at 80 × 50 cm plant spacing, then, 14.63

cm at 75 × 45 and lightest fruit (13.75 g at the narrow spacing of 45 ×15 cm while, Tejaswini, *et al.*, (2021) achieved best result at a wider spacing of 50 × 60 cm. Saraswata, *et al.*, (2024) figure out an average fruit weight (15.84 g) where plants were treated with 100 kg N ha^{-1} and Amin, (2022) recorded 27.50 g at nitrogen application rate of 69 kg ha^{-1}.
The same significant trend followed with regard to the effects plant spacing and nitrogen fertilizer application rates on hundred seeds weight with treatment S_3 N_3 looked superior in terms of hundred seed weight producing heaviest seeds with the highest mean values of 15.67 g closely followed by S_2 N_3 weighted 12.67 g while the lowest 7.67 g obtained from treatment S_1 N_1 as well (Table 4). This interesting result could be attributed to proper spacing and optimum fertilization which applied to the field and hence the crop made immediate and efficient utilization of the available resources.
Equally on the same (Table 4) fresh fruit yield per hectare recorded the greatest yield of 1.87 ton per hectare from treatment S_3 N_3, closely followed by S_2 N_3 having recorded 1.73 ton per hectare while the minimum yield (0.87 ton per hectare) recorded from S_1 N_1 treatment. This result corroborated the earlier findings of Nacdeep and Daljeet, (2016) who reported significantly higher fruit yield per hectare with the application of 100 kg N ha^{-1}.whereas, on Indian soil, plant treated with 100 kg N ha^{-1}.recorded the highest fruit yield per hectare of 14.74 ton ha^{-1}.and the lowest (8.12 ton ha^{-1}.) obtained from the control plots (0 kg N ha^{-1}) (Saraswata *et al.*, 2024). Alen *et al.* (2019) recorded significantly higher fruit yield of up to 5.793 ton ha^{-1} at the spacing distance of 60 × 30 cm then, 5.557 ton ha^{-1} recorded at 55 × 35 cm and the lowest yield (4.250 ton ha^{-1}) obtained at the 80 × 50 cm. Firoz, *et al.* (2009) registered highest fruit yield per hectare at plant spacing of 60 × 30 cm. This tremendous achievement might not be unconnected to the roles of nitrogen in plants nutrition. It was asserted that, to obtain higher okra fruit yield, nitrogen application is critical and unavailable (Dauda *et al.*, 2005). Affirming the above statement, Adigun *et al.* (2018) further explained that optimum rate of nitrogen improves photosynthetic processes, leaf production as well as net assimilation rates.

RECOMMENDATIONS

Based on the findings of this study, the following recommendations were made:
i). Farmers in Mubi and its environs are advised to cultivate okra at plant spacing distance of 50 × 100 and fertilized with 100 kg N ha^{-1} for optimal fruit yield,.
ii). Further research is recommended to examine and ensure appropriate plant spacing and nitrogen fertilizer application rate that will give desired fruit yield of okra is determined in the study area.

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Table 1: Physico-chemical Properties of Soil of the Experimental Site before Cropping

S/No.	Particular	2018
	Physical properties	
A	**Particle size distribution (%**	
.	Clay	14.2
	Silt	31.6
	Sand	54.2
B.	**Textural Class**	Sandy-loam

C.	**Chemical properties**	
	pH (1 – 2 soil: water solution)	5.9
	Organic carbon (kg^{-1})	3.70
	Cation exchange capacity (c mol (+) kg^{-1})	3.25
	Available nitrogen (g N kg^{-1})	0.67
	Available potassium (c mol (+) kg^{-1})	0.45
	Available phosphorus (mg P kg^{-1})	6.67
	Available magnesium (c mol (+) kg^{-1})	0.47
	Available sodium (c mol (+) kg^{-1})	0.38
	Available calcium (c mol (+) kg^{-1})	1.93

Source: laboratory experiment, 2024

Table 2: Effect of Plant Spacing and Different levels of Nitrogen Fertilizer on Plant Height, Numbers of branches at Harvest and Day's to 1st Flowering of okra during the 2024 Cropping Season in Mubi

Treatments Spacing	Plant Height (cm) 3 WAS	6 WAS	9 WAS	Numbers of Branches	Days to 1st Flowering
S_1 N_1	6.27	16.53^{c}	42.65	9.81^{e}	60.33
S_1 N_2	7.87	18.67^{bc}	62.66	10.53^{de}	58.67
S_1 N_3	7.20	19.40^{bc}	44.78	11.16^{de}	57.67
S_1 N_4	7.00	20.13^{bc}	57.11	11.31^{de}	58.33
S_2 N_1	7.80	18.67^{bc}	54.00	11.22^{de}	59.67
S_2 N_2	7.27	23.60^{bc}	64.49	12.40^{cd}	59.33
S_2 N_3	9.40	24.07^{b}	68.00	19.36^{ab}	55.33
S_2 N_4	7.73	19.93^{bc}	64.44	16.32^{bc}	56.67
S_3 N_1	6.67	20.13^{bc}	47.89	12.27^{cd}	59.00
S_3 N_2	6.80	18.67^{bc}	54.22	14.68^{cd}	58.67
S_3 N_3	14.07	27.40^{a}	73.19	22.11^{a}	54.33
S_3 N_4	8.87	21.20^{bc}	57.11	16.48^{bc}	58.00
S_4 N_1	6.87	20.47^{bc}	54.55	16.76^{bc}	59.33
S_4 N_2	7.63	18.13^{bc}	59.34	17.55^{abc}	59.33
S_4 N_3	6.60	20.47^{bc}	63.78	17.88^{abc}	57.67
S_4 N_4	8.67	23.60^{bc}	62.66	14.53^{cd}	57.00
SE±	2.70	2.504	8.498	0.04	3.949
LOS	NS	*	NS	*	NS

Keys: a,b,c, - d Mean within the same column bearing different superscript (s) is significantly ($P < 0.05$), S_{1-4} = means (Plant spaced at: 30 × 60, 40 × 60, 50 × 60 and 60 × 60), N_{1-4} = Means (0, 50, 100 and 150 kg Nitrogen $hectare^{-1}$. WAS = Weeks after Sowing, SE = Standard Error, LOS = Level of significant, *, = P<0.05, ** = P<0.01, NS = not significant

Table 3: Effect of Plant Spacing and Different levels of Nitrogen Fertilizer on Day's 50% Flowering, Fruit Length, Fruit Diameter and the Numbers of Fruit / Plant of okra during the 2024 Cropping Season in Mubi

Treatments	Days 50% Flowering	Fruit Length (cm)	Fruit Diameter (cm)	No. of Fruit / Plant
$S_1 N_1$	72.33	6.74	6.67	14.87[c]
$S_1 N_2$	68.33	6.93	6.67	17.83[cb]
$S_1 N_3$	66.00	7.63	7.00	19.67[bc]
$S_1 N_4$	68.67	7.77	9.33	19.33[bc]
$S_2 N_1$	69.67	8.11	7.67	20.00[abc]
$S_2 N_2$	67.00	7.46	8.00	20.33[bc]
$S_2 N_3$	64.33	9.07	13.00	25.53[ab]
$S_2 N_4$	66.67	7.00	9.67	24.74[ab]
$S_3 N_1$	69.33	7.64	7.00	20.66[cb]
$S_3 N_2$	69.00	8.06	8.33	23.80[ab]
$S_3 N_3$	64.33	9.80	14.33	29.80[a]
$S_3 N_4$	66.00	8.15	13.00	25.07[ab]
$S_4 N_1$	69.33	8.19	7.67	20.41[bc]
$S_4 N_2$	68.67	7.19	8.00	20.67[cb]
$S_4 N_3$	68.33	8.73	8.00	23.40[abc]
$S_4 N_4$	65.33	8.24	8.33	22.63[abc]
SE±	3.996	0.88	2.99	3.54
LOS	NS	NS	NS	*

Keys: [a,b,c, - d] Mean within the same column bearing different superscript (s) is significantly ($P < 0.05$), S_{1-4} = means (Plant spaced at:, 40 × 60, 50 × 60 and 60 × 60), N_{1-4} = Means (0, 50, 100 and 150 kg Nitrogen hectare $^{-1}$. WAS = Weeks after Sowing, SE = Standard Error, LOS = Level of significant, *, = P<0.05, NS = not significant

Table 4: Effect of Plant Spacing and Different levels of Nitrogen Fertilizer on the Yield Characters of okra during the 2024 Cropping Season in Mubi

Treatments	No. of Seeds / Fruit	Average Fruit Weight, (g)	Hundred Seed Weight (g)	Fresh fruit yield/ hectare (ton ha^{-1})
$S_1 N_1$	251.00[d]	14.87[c]	7.67[bc]	0.87[e]
$S_1 N_2$	256.67[cd]	17.83[cb]	7.00[c]	0.98[d]
$S_1 N_3$	261.33[cd]	19.33[bc]	8.33[bc]	1.17[c]
$S_1 N_4$	275.67[bcd]	19.67[bc]	8.33[bc]	1.19[c]
$S_2 N_1$	275.00[bcd]	20.00[cb]	8.67[bc]	1.03[d]
$S_2 N_2$	284.00[abc]	20.67[abc]	8.67[bc]	1.24[cd]
$S_2 N_3$	324.67[ab]	25.53[ab]	12.67[ab]	1.73[a]
$S_2 N_4$	295.67[bc]	24.74[ab]	10.67[bc]	1.46[abcd]
$S_3 N_1$	262.00[cd]	20.33[cb]	8.33[bc]	1.44[abcd]
$S_3 N_2$	293.00[bc]	20.66[cb]	8.67[bc]	1.58[bcd]
$S_3 N_3$	356.33[a]	29.80[a]	15.67[a]	1.87[a]
$S_3 N_4$	278.67[bcd]	19.33[bc]	9.33[bc]	1.31[cd]
$S_4 N_1$	256.67[cd]	20.41[bc]	11.00[bc]	1.60[abc]
$S_4 N_2$	289.67[bc]	23.40[abc]	10.00[bc]	1.56[bcd]
$S_4 N_3$	301.33[bc]	23.800[ab]	10.67[bc]	1.56[bcd]
$S_4 N_4$	314.33[abc]	25.00[ab]	10.00[bc]	1.60[abc]
SE±	5.66	3.544	1.85	0.04
LOS	*	*	*	*

Keys: [a,b,c, - d] Mean within the same column bearing different superscript (s) is significantly ($P < 0.05$) S_{1-4} = means (Plant spaced at: 30 × 60, 40 × 60, 50 × 60 and 60 × 60), N_{1-4} = Means (0, 50, 100 and 150 kg Nitrogen hectare $^{-1}$. WAS = Weeks after Sowing, SE = Standard Error, LOS = Level of significant, *, = P<0.05, NS = not significant

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