

PERFORMANCE OF OKRA (*ABELMOSCHUS ESCULENTUS* (L.) MOENCH) AS AFFECTED BY NITROGEN FERTILIZER APPLICATION RATES IN MUBI NORTH, ADAMAWA STATE, NIGERIA

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ABSTRACT

The 2 years experiments were conducted to examine the performance of okra (*Abelmoschus esculentus* (L.) Moench) as affected by nitrogen fertilizer application rates in Mubi North, Adamawa State Nigeria, during the 2018 and 2019 rainy seasons. The experiments were laid out in Complete Randomized Blocked Design (CRBD) with four (4) treatment levels of nitrogen: 0 kg N ha⁻¹, 50 kg N ha⁻¹, 100 kg N ha⁻¹ and 150 kg N ha⁻¹ replicated 3 times. Data collected on plant height, number of leaves, stem diameter, days to first fruit setting, fruit length, fruit diameter, number of seeds / fruit, fresh and dried fruit yield / hectare. All the data collected were subjected to analysis of variance ANOVA using Statistical Analysis System (SAS, 2010) and means that showed significant differences separated by F-test using Duncan Multiple Range Test. Results for the combined analysis revealed that nitrogen fertilizer significantly applied at 150 kg N ha⁻¹ had significantly ($P \geq 0.001$) influenced plant height with the greatest mean values of 9.724, 21.010, 38.563 cm; number of leaves/plant 7.404, 11.915, 19.738 and stem diameter 2.807, 6.201, 14.660 mm (3, 6 and 9 WAS). Equally, significant reduction in days to first fruit setting (59.083 days) recorded at 150 kg N ha⁻¹. Furthermore, significant increase in fruit length (8.836 cm); fruit diameter (9.799 cm); number of seeds per fruit (102.258); fresh fruit yield (1.265 kg ha⁻¹) and dried fruit yield (0.633 kg ha⁻¹) for the combined analysis all observed at 150 kg N ha⁻¹ accordingly. It was concluded that, okra grown from the plots that received 150 kg N ha⁻¹ performed significantly higher than the rest of the treatments. The study therefore recommends the application of 100 kg N ha⁻¹ or 150 kg N ha⁻¹ at 3, 6 and 9 WAS as suitable dose to okra farmers in Mubi and its environs for optimum fruit yield and profit maximization.

Keywords: Fertilizer, Nitrogen Okra, Performance and Rates.

INTRODUCTION Okra (*Abelmoschus esculentus* (L.) Moench), originated from Ethiopia in Africa, but nowadays widely cultivated throughout the tropics, sub-tropics and warmer parts of the temperate regions of the world (Echo, 2003; Khalid *et al.*, 2005; Farinde, *et al.*, 2007). It is a flowering plant and a member in *malvaceae* family, a polyploidy crop with chromosome number as: $2n = 130$, as reported by National Research Council (NRC. 2006). Distribution of West African okra is restricted to humid and per humid climates in Africa, between 12° N and 12° S. It is grown from Guinea to Nigeria in West Africa, Cameroon, Gabon and DR Congo in Central Africa and Uganda, in East Africa (Dhaliwal, 2017). It is one of the priority vegetable crops in Nigeria and ranks above other vegetable crops including cabbage, Amaranthus, and Lettuce (Babatunde *et al.*, 2007). The fruits are consumed immature and can be used in salads, soups and stews fresh or dried, fried or cooked (Gemedede *et al.*, 2013). Fresh okra fruits are the most important vegetable source of viscous fiber, an important dietary component to lower cholesterol (Arapirtsas, 2008). Seed protein of okra is rich in tryptophan (94 mg/g N) and also contains adequate amounts of sulfur-containing amino acid (189 mg/1 g N) (Chadha, 2002). Okra fruit contain carbohydrate, protein, vitamin A, B, C and K, sodium, calcium as well as magnesium. The vitamin A, Vitamin B₆, calcium and folic acid presence in okra could help in good vision, bone formation, growth and proper circulation of blood, and digestion (FAO, 2004). Although, okra is a very important vegetable crop with outstanding qualities, but yields obtained from farmers' fields are often very low. Average yield per hectare in Nigeria is 2.10 t / ha, which is less than half of those in other countries like India (10.12 t / ha) and world average (7.65 t / ha). Research identified low soil fertility,

weed infestation and the use of low yielding varieties as the major production constraints attributed to low yields of okra in Nigeria (Adeyemi *et al.*, 2008; Iyagba *et al.*, 2012). Unfortunately, crops and weeds have the same basic nutrient requirements (Foster, 1996) because the same nutrients applied to crops are generally available to weeds as reported by O'Donovan *et al.* (2001). The rate and time of nutrient application therefore, determines the relative competitiveness between crops and weeds. Hence strategies to increase productivity of okra in less fertile soils in order to meet the increasing demands of okra in Nigeria will have to focus on the supply of adequate nutrients for vigorous okra growth and yield (Adeigun *et al.*, 2018). It is worthy to note that, empirical data and information on nitrogen fertilizer application rates is still inadequate in the study area. This study therefore, was carried out to examine the performance of okra as affected by nitrogen fertilizer application rates in Mubi North, Adamawa State, Nigeria.

MATERIALS AND METHODS

The Study Area

The experiments were conducted at the Teaching and Research Farm of Food and Agricultural Organization / Tree Crop Plantation (FAO / TCP), Faculty of Agriculture Department of Crop Science, Adamawa State University Mubi, situated between Latitude 9° 26' and 10° 10' N and Longitude 13° 10' and 13° 44' E at an altitude of 696 m above sea level. The soil is largely of sandy clay loam, sandy loam or loam textured. The annual mean rainfall in Mubi was 900 mm and the minimum temperature of 18 °C during the harmattan period and 40 °C maximum in April (Adebayo *et al.* (2020). Muhammad, *et al.*, (2017) identified 2 types of seasons, viz; the wet season which lasted from April – October and dry season covered November – March characterized by cold dry dust laden wind especially in January and February.

Soil Analysis: Physico-chemical properties of soil of the experimental site before cropping

Prior to sowing in both years, 5 core soil samples were randomly collected from 0 – 30 cm depth using soil auger and were properly mixed to form a composite sample. The composite soil samples were air – dried, grounded, and passed through a 2 mm sieve mesh and subsequently subjected for analysis to determine the soil textural classes, chemical properties and exchangeable bases of soil using standard laboratory procedures. The soil pH was determined by glass electrode pH meter, total nitrogen content was obtained by micro-kjedahl method designed by (Bremner and Mulvaney, 1982), and total Phosphorus was by Bray 1 method (Bray and Kurtz, 1945), while calcium and magnesium were determined by the Atomic Absorption Spectrophotometer (Perkin-Elmer Corp, 1969). Sodium determined using flame emission photometry profound by Doll and Lucas (1973). Determination of organic carbon content was achieved according to Walker- Black wet oxidation method (Walkey and Black, 1934) as shown in Table 1.

Land Preparation and Experimental Design

The experiments were laid out in a Complete Randomized Block Design (CRBD) with four (4) treatment levels of nitrogen: 0 kg N ha⁻¹, 50 kg N ha⁻¹, 100 kg N ha⁻¹ and 150 kg N ha⁻¹ replicated 3 times. The experimental site was cleared and then ploughed with the aid of tractor mounted implement, larger soil clods were further broken down to create fine soil tilth conditions. Then, plots were manually constructed using hand hoe, shovel, rake and other simple farm tools. Total land area of the experimental plots was 32.7 x 13.5 (441.45 m²) with gross plot size of 3 x 2.1 (6.3 m²) and the net plot size of 2.25 x 1.8 m (4.05 m²). The experimental field was divided into 3 blocks and each consisted of 16 plots given a total of 48 plots. A path way of 0.5 m between plots and 1 m between blocks to allow easy passage for regular data collection was created. Nitrogen fertilizer was applied to the field in 2 split doses (during plot construction and at 5 weeks after seedling emergence) in accordance with the experimental design as follows: 50 kg N ha⁻¹, 100 kg N ha⁻¹ and 150 kg N ha⁻¹ and the control (0 kg N ha⁻¹).

Seed Treatment and Sowing

The okra seed (variety Yar-kwadam) was used for the experiments which was obtained from a certified local seed vendor in Mubi main market. The seeds were treated with Apron Star WS (*Thia-methoxan + difenocanazole*) at 1 sachet (10 g) per 3 kg okra seeds 5 hour prior to planting on the field. Healthy seeds were sown in 10th July, 2018 manually by placing the seeds in a moist soil after rainfall at the rate of 2 – 3 seeds / hole using 2 - 3 cm depth and later thinned down to 1 seedling / stand at 2 weeks after sowing. Seeds were sown at the spacing distance of 75 cm x 30 cm inter and intra raw spacing.

Post-Harvest Management

Weeds were kept free during the study period using hand hoeing. Karate lambda insecticide (Lambda cyhalothrim) mixed with water was applied 4 times at 5 days' intervals to guard against insect pest and also during flowering stage. Fresh okra fruits were harvested at an interval of 3 days and mean values recorded.

Data collection

Growth and yield parameters determined includes: plant height, number of leaves / plant, stem diameter, days to first fruit settings, fruit length, fruit diameter, number of seeds / fruit, fresh and dried fruit yield / hectare.

Data Analysis

The data collected were subjected to analysis of variance (ANOVA) using Statistical Analysis System (SAS, 2010) and means that showed significant differences were separated using Duncan Multiple Range Test (DMRT).

RESULTS AND DISCUSSION

Soil analysis:

Results for the Physico-chemical properties of soil of the experimental site before cropping are presented in Table 1. The data indicated that, the texture of the soil of the study sites was sandy-loam, with the pH of 6.41 (2018) and 6.62 (2019) which were slightly acidic in nature. The organic carbon content 3.70 % and 3.93 % 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 soil of the experimental site are considered as medium total nitrogen (0.73 % and 0.19 %) 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. Available phosphorus of 6.67 ppm and 6.83 ppm (2018 / 2019) were fairly low soil according to the classification of Bray and Kurtz (1945), they also classified available P < 5 ppm as: very high, high, medium, low and very low accordingly. The experimental site has Carbon exchange capacity (CEC) of 3.25 and 3.44 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.

Growth characters

Results for the combined analysis of the performance okra as affected by nitrogen fertilizer application rates on the growth parameters were significant ($P \geq 0.001$) Table 2. The data indicated that, 150 kg N ha⁻¹ produced plants with the tallest height of 9.724, 21.010 and 38.563 cm while the lowest mean values of 9.024, 17.003 and 31.434 cm obtained from the control treatment (0 kg N ha⁻¹). Similarly, 150 kg N ha⁻¹ significantly recorded plant with the highest number of 7.404, 11.915 and 19.738 leaves whereas, the lowest numbers: 6.533, 9.603 and 14.956 leaves being the least observed from the control too. Furthermore, plants with the thickest and thinnest stems measured as: 2.807, 6.201 and

14.660 mm / 2.337, 5.201, 12.063 mm equally recognized from the plots that received 150 kg N ha⁻¹ and the control all at 3, 6 and 9 WAS accordingly. The sequence of response shown by these growth parameters in this study under varying rates of nitrogen fertilizer was in accordance with the earlier findings of Sultana, (2002) who reported that Nitrogen fertilizer level at the rate of 150 kg N ha⁻¹ significantly improved growth and yield of okra. Significant increase in okra stem girth with the application of 100 kg N ha⁻¹ nitrogen was earlier observed by (Singh *et al.*, 2007). Uddin *et al.* (2014) have earlier reported significantly higher number of leaves of okra plant and other related growth characters at the nitrogen application rates of 120 kg N ha⁻¹.

Table 1: Physico-chemical properties of soil of the experimental site before cropping

S/No.	Parameters	2018	2019
Physical properties			
a.	Particle size distribution (%)		
.	Clay	14.2	14.3
	Silt	31.6	33.0
	Sand	54.2	53.7
b.	Textural Class	Sandy-loam	Sandy-loam
c.	Cation exchange capacity		
	pH (1 – 2 soil: water solution)	6.41	6.62
	Organic carbon (kg ⁻¹)	3.70	3.93
	Cation exchange capacity (c mol (+) kg ⁻¹)	3.25	3.44
	Available nitrogen (g N kg ⁻¹)	0.73	0.19
	Available phosphorus (mg P kg ⁻¹)	6.67	6.83
	Available potassium (c mol (+) kg ⁻¹)	0.45	0.46
	Available magnesium (c mol (+) kg ⁻¹)	0.47	0.48
	Available sodium (c mol (+) kg ⁻¹)	0.38	0.36
	Available calcium (c mol (+) kg ⁻¹)	1.93	1.95

Source: laboratory experiment, 2018 and 2019

Table 2: Mean Performance of okra as affected by nitrogen fertilizer application rates on plant height in 2018 and 2019 cropping season

Treatments	3 WAS			6 WAS			9 WAS		
	2018	2019	Combined	2018	2019	Combined	2018	2019	Combined
0 kg N ha ⁻¹	8.128 _c	9.920 _c	9.024 _d	15.47 _{8^c}	18.52 _{9^d}	17.003 _d	28.385 _d	34.483 _c	31.434 _d
50 kg N ha ⁻¹	8.478 _b	10.089 _b	9.283 _c	17.21 _{6^b}	19.61 _{8^c}	18.417 _c	30.942 _c	37.718 _b	34.330 _c
100 kg N ha ⁻¹	8.751 _a	10.417 _a	9.584 _b	18.01 _{3^b}	20.62 _{5^b}	19.319 _b	32.955 _b	38.803 _b	35.879 _b
150 kg N ha ⁻¹	8.907 _a	10.542 _a	9.724 _a	19.61 _{3^a}	22.40 _{8^a}	21.010 _a	34.960 _a	42.165 _a	38.563 _a
SE ±	0.074	0.055	0.046	0.332	0.249	0.208	0.393	0.678	0.392
Level of Sig.	***	***	***	***	***	***	***	***	***

Means with the same letter (s) in each treatment column are not significantly different at 5 % level of probability **Key:** WAS = Week after Sowing, SE = Standard Error, *** = Significant at 0.001 %

Table 3: Mean Performance of okra as affect by nitrogen fertilizer application rates on the number of leaves/ plant in 2018 and 2019 cropping season

Treatments Nitrogen	3 WAS			6 WAS			9 WAS		
	2018	2019	Combined	2018	2019	Combined	2018	2019	Combined
0 kg N ha ⁻¹	5.417 ^c	7.650 ^c	6.533 ^d	7.958 ^c	11.247 ^c	9.603 ^c	14.345 ^c	15.569 ^c	14.956 ^d
50 kg N ha ⁻¹	5.783 ^b	8.017 ^b	6.900 ^c	8.208 ^c	13.041 ^b	10.625 ^b	16.335 ^b	16.447 ^c	16.391 ^c
100 kg N ha ⁻¹	6.067 ^a	8.158 ^b	7.113 ^b	8.567 ^b	14.733 ^a	11.650 ^a	17.818 ^b	18.267 ^b	18.042 ^b
150 kg N ha ⁻¹	6.267 ^a	8.542 ^a	7.404 ^a	8.883 ^a	14.948 ^a	11.915 ^a	19.796 ^a	19.680 ^a	19.738 ^a
SE ±	0.091	0.103	0.069	0.092	0.549	0.278	0.551	0.482	0.366
Level of Sig.	***	***	***	***	***	***	***	***	***

Table 4: Mean Performance of okra as affect nitrogen fertilizer application rates on stem girth in 2018 and 2019 cropping season

Treatment Nitrogen	3 WAS			6 WAS			9 WAS		
	2018	2019	combined	2018	2019	Combined	2018	2019	Combined
0 kg N ha ⁻¹	2.238 ^c	2.437 ^b	2.337 ^c	5.098 ^c	5.304 ^c	5.201 ^d	12.408 ^c	11.718 ^c	12.063 ^d
50 kg N ha ⁻¹	2.460 ^b	2.583 ^b	2.521 ^b	5.662 ^b	5.556 ^b	5.609 ^c	13.309 ^b	12.454 ^{bc}	12.882 ^c
100 kg N ha ⁻¹	2.543 ^b	2.602 ^b	2.573 ^b	5.937 ^b	5.709 ^b	5.823 ^b	14.028 ^b	13.123 ^b	13.575 ^b
150 kg N ha ⁻¹	2.753 ^a	2.860 ^a	2.807 ^a	6.413 ^a	5.988 ^a	6.201 ^a	15.244 ^a	14.076 ^a	14.660 ^a
SE ±	0.046	0.082	0.047	0.095	0.065	0.058	0.273	0.303	0.204
Level of Sig.	***	*	***	***	***	***	***	***	***

Key * = Significant at 0.05 %

Phenological charactes

Data for the combined analysis of the performance of okra in respect to the rates of nitrogen fertilizer significantly ($P \geq 0.001$) affected days to first fruit setting, fruit length and diameter in 2018, 2019 cropping seasons Table 5. The results showed that, plots that received 150 kg N ha⁻¹ commenced fruiting as the shortest (59.083 days) compared to 60.042 days recorded from the control plot. Meanwhile, okra fruit reached the maximum length and diameter of: 9.088 and 9.799 mm at the highest application rates of 150 kg N ha⁻¹ while their minimum values: 7.881 and 8.778 mm recorded from the control treatment accordingly. The observed pattern of significantly progressive increased in fruit length and diameter at the varying rates of nitrogen fertilizer recorded in this study was relatively similar to the previous findings of Mani and Ramanathan (1980); Mjambu *et al.* (1985), and Singh *et al.* (1998) recorded linear increase in fruit length and diameter of okra with the application rates of 125 kg N ha⁻¹ and 145 kg N ha⁻¹. Sultana (2002) equally reported significant improvement of okra fruit length with at the rates of 100 kg N ha⁻¹. In their previous findings Dwivedi *et al.* (1994) and Ambare *et al.* (2005) recorded maximum number of days to first

fruit setting in okra plants at the rates of 100 and 150 kg N ha⁻¹. Amanga (2014) in his investigation reported that application of nitrogen as low as 46 and 69 kg N ha⁻¹ led to the longest days to first fruit setting.

Table 5: Mean Performance of okra as affect by nitrogen fertilizer application rates on some phonological characters in 2018 and 2019 cropping season

Treatment Nitrogen	Days to first fruit setting			Fruit Length (mm)			Fruit Diameter (mm)		
	2018	2019	Combined	2018	2019	combined	2018	2019	Combined
0 kg N ha ⁻¹	61.333 _b	58.750 _a	60.042 ^a	7.633 _d	8.129 _d	7.881 ^d	8.560 ^d	8.996 ^c	8.778 ^d
50 kg N ha ⁻¹	61.083 _{ab}	61.083 _{ab}	59.958 ^a	8.003 _c	8.418 _c	8.210 ^c	9.041 ^c	9.318 ^b	9.179 ^c
100 kg N ha ⁻¹	60.500 _{ab}	57.667 _b	59.167 ^b	8.298 _b	8.655 _b	8.477 ^b	9.392 ^b	9.614 ^a	9.503 ^b
150 kg N ha ⁻¹	60.333 _b	58.00 ^b	59.083 ^b	8.584 _a	9.088 _a	8.836 ^a	9.731 ^a	9.867 ^a	9.799 ^a
SE ±	0.306	0.008	0.194	0.091	0.007	0.056	0.089	0.010	0.066
Level of Sig.	*	**	***	***	***	***	***	***	***

Key: ** = Significant at 0.01 %,

Yield traits

The same results pattern of significance were observed in relation to the performance of okra to the rates of nitrogen fertilizer with regard to yield characters (Table 6). The greatest number of: 102.258 seeds/fruit; highest 1.265 kg ha⁻¹ fresh fruit yield and 0.633 kg ha⁻¹ dried fruit yield obtained at 150 kg N ha⁻¹. However, the lowest yield for all these parameters recorded from the control (0 kg ha⁻¹) and hence the least performing treatment as no fertilizer applied. These results were similar to the earlier findings of Gates (1998) and Chandler (1999) who recorded linear significant improvement in okra seeds numbers at 150 kg N ha⁻¹. Our results equally corroborated with earlier investigation of Navdeep and Daljeet (2016) how reported significantly higher number of seeds/fruit and yield kg ha⁻¹ when nitrogen was applied at the rate of 125 kg N ha⁻¹. Olasatan (2001); Babatola *et al.* (2002) revealed that, growth and yield of okra fruits depends on available soil nitrogen and also amount of nitrogen applied.

Table 6: Mean Performance of okra as affect by nitrogen application rates on some yield and yield attributed characters in 2018 and 2019 cropping seasons

Treatment Weeding	Number of seeds per fruit			Fresh Fruit Yield Per Hectare (kg ha ⁻¹)			Dried Fruit Yield Per Hectare (kg ha ⁻¹)		
	2018	2019	Combined	2018	2019	Combined	2018	2019	Combined
0 kg N ha ⁻¹	88.932 ^c	92.333 ^c	90.632 ^c	1.032 ^c	1.109 ^c	1.071 ^d	0.464 ^c	0.493 ^d	0.478 ^d
50 kg N ha ⁻¹	94.364 ^b	97.038 ^b	95.701 ^b	1.084 ^c	1.163 ^c	1.124 ^c	0.518 ^c	0.535 ^c	0.527 ^c
100 kg N ha ⁻¹	97.291 ^b	98.733 ^b	98.012 ^b	1.162 ^b	1.234 ^b	1.198 ^b	0.576 ^b	0.591 ^b	0.583 ^b
150 kg N ha ⁻¹	102.02 _{3^a}	102.48 _{4^a}	102.258 ^a	1.238 ^a	1.293 ^a	1.265 ^a	0.615 ^a	0.652 ^a	0.633 ^a
SE ±	1.271	1.094	0.839	23.933	20.000	15.598	14.333	11.117	9.070
Level of Sig.	***	***	***	***	***	***	***	***	***

Mean with the same letter (s) in each treatment group are not significantly different at 5 % level of probability using Duncan's Multiple Range Test (DMRT). **Key:** SE = Standard Error, *** = Significant at 0.001 %

CONCLUSION

The results of this study showed that, nitrogen fertilizer application rates significantly promoted the growth, phenological yield and yield attributing characters during the period of investigation. It was observed that, nitrogen applied at the highest rate of 150 kg N ha⁻¹ performed better than the rest of the treatments in terms plant height, number of leaves/plant, stem girth, days to first fruit setting, fruit length and diameter. Other traits are; number of seeds/fruit, dried and fresh fruit yield per ha⁻¹. Therefore, farmers who engage in the cultivation of okra in Mubi and its surroundings environment are advised to apply 150 kg N ha⁻¹ in 3 split doses (3, 6. And 9 WAS) to encourage early growth and yield performance.

REFERENCES

- Adebayo, A.A. Tukur, A.L and Zemba, A. A. (2020). '*Adamawa State in Maps*', (2nd Ed) Paraclete, Publishers, Yola, Nigeria, 31 – 35 pp,
- Adigun, O. S. Daramola, O. R. Adeyemi, A. O. Ogungbesan, P. M. Olorunmaiye, and O. A. Osipitan (2018). 'Impact of Nitrogen Levels and Weed Control Methods on Growth and Yield of Okra (*Abelmoschus esculentus* (L.) Moench) in the Nigerian Forest-Savanna Transition Zone', *Journal of Experimental Agriculture International*, 20 (2): 1 - 11,
- Adeyemi, O.E., Smith, M.A.K. and Ojeniyi, S.O. (2008). 'Effect of Land Preparation Techniques on Weed Control Effectiveness in Okra (*Abelmoschus esculentus* (L.) Moench)' *Nigerian Journal of weed science*, 21: 72 - 83,
- Amanga O. (2014). 'Effects of Plant Population and Nitrogen Rates on Growth and Yield of Okra (*Abelmoschus esculentus* (L.) Moench) in Gambella Region, Western Ethiopia. M.Sc. Thesis at Haramaya University, 34 – 65 pp,
- Ambare, T. P., Gonge, V. S., Deshmukh, D. T. Warade, A. D. and Hameed, B. (2005). 'Effect of Nitrogen on Growth and Yield of Okra (*Abelmoschus esculentus* (L.) Varieties', *Journal of Maharashtra agricultural University*, 30 (2): 217 - 218,
- Arapirtsas, P. (2008). 'Identification and Quantification of Polyphenolics Compounds from Okra Seeds', *Food Chemistry* 110: 1041 - 1045,
- Babatunde, R.O., Omotesho, O.A. and Sholaton, S.O. (2007). 'Socio-economic Characteristics and Food Security Status of Farming Household in Kwara State, North Central Nigeria' *Pack. Journal of Nutrition*,. 6 (1): 16 – 22.
- Babatola, L.A.; Ojo, D.O.; Adewoyin, O.B. (2002). 'Effect of NPK 20:10:10 Fertilizer Levels on the Yield of Okra Sweet-com Intercrop and Post-harvest Quality of Okra', *Proceedings for Horticultural Society of Nigeria, Conference*. Pp.: 74 – 78,
- Bello, D., Sajo, D., Chubado, E. and Jellason, J.J. (2006). 'Variability and Correlation Studies in Okra (*Abelmoschus esculentus* (L.) Moench)', *Journal of Sustainable Development and Agricultural Environments*, 2 (1): 120 - 126,

- Bray, R.H. and Kurtz, L.T. (1945) Determination of Total Organic Carbon and Available Phosphorus in Soil, *Soil Science*, 59: 39 – 45.
- Bremner, L.M. and Mulvaney, C.S. (1982). 'Nitrogen Total in Method of Soil Analysis Page'AL (Ed), *Agronomy*, 9 (2): Pp.: 595 - 624,
- Chadha, K.L. (2002). '*Hand Book of Horticulture*', Indian Council of Agricultural Research on Okra, India: 422 – 427 pp.
- Chandler, E.K. (1999). Comparison of Uniform and Variable Rate of Fertilizer in Okra (*Abelmoschus esculentus* (L.) Moench) Yield Precision Agriculture', Proceedings International Conference. St. Paul, M.N. Pp.: 675 - 686,
- Dhaliwal, S. (2017). 'Okra (*Abelmoschus esculentus* (L.) Moench', Research-gate, Punja Agricultural University, <http://www.researchgate.net/publicatio/313572725>
- Doll, E.C and Lucas, R.E. (1973). 'Testing Soils for Potassium, Calcium and Magnesium', Pp.: 133 – 152,
- Dwivedi, Y.C., Sengupta, S. K. and Sharma, R.S. (1994). 'Effect of Sowing Dates and Nitrogen Fertilization on Seed Crop of Okra', *Journal of Vegetative Science*, 21 2: 122 - 125,
- Echo, (2003). 'Plant Information Sheet'. ECHO, North Fort Myers. Florida, USA, 12 – 18 pp.
- FAO, (2004). 'An Ecological Guide: Training Resources' Text on Crop Development Major Economic Practice, Disease and Insect Ecology, Insect Pests, Natural Enemies and Diseases of Okra. The National Academic Press,
- <http://www.begetableipmasia.org/does/Ecological%2Guide/OKRA%20Eco%20GUIDE.pf>
- Farinde, A.J., Owolarafe, O.K. and Ogungbeni, O.I. (2007). 'An Overview of Production, Processing, Marketing and Utilization of Okra in Egbedore Local Government Area of Ogun State'. Nigeria, *Agricultural Engineering International, the (CIGRE) Journal*, 9: 1 – 17.
- Foster K. (1996). 'Organic crop production': Weed management, sustainable production. Farm Facts, Saskatchewan Agriculture and Food Bulletin,
- Gates, R.N. (1998). 'Seed Yield and Seed Quality Response of Pensacola and Improved Balia Grasses to Fertilization', *Agronomy Journal*, 90: 607 - 611,
- Gemedo, H.F., Ratta, N., Haki, G.D., Ashagrie, Z., Woldegiorgis and Beyene F. (2013). 'Nutritional Quality and Health Benefits of Okra (*Abelmoschus esculentus* (L.) Moench): A Review, *International. Journal of Nutrition and Food Science*, 4: 208 - 215,
- Iyagba, A.G., Onuegbu, B.A. and Ibe, A.E., (2012). 'Growth and Yield Response of Okra (*Abelmoschus esculentus* (L.) Moench) Varieties to Weed Interference in South Eastern Nigeria', *International Research Journal Agricultural Science and Soil Science*, 3 (9): 328 – 335,

- Khalid, U., E. Ahmad, U.K. Muhammad, (2005). 'Integrated Weed Management in Okra' *Pakistan Weed Science Journal*, 11 (1 - 2): 55 - 60.
- London, J.R. (1991). 'Booker Tropical Soil Manual. A Handbook for Soil Survey and Agricultural Land Evaluation in the Tropics and Subtropics'. Co. Published. The United State with John Wiley and Sons, Inc, New York 474 PP.
- Mahmoud, B.A, Hamma, I.L., Abdullah, S. and Adamu, Y. (2013). 'Growth and Yield of Okra As Influenced by Weeding Regimes in Samaru – Zaria, Nigeria'. *International Journal of Agronomy and Agricultural Research (IJAAR)*, 3 (9): 19 – 25.
- Mjambu, I. S., Ogunlela, V. B, Ahmed, M. K. and Olarewaju, J. D. (1985). 'Response of Two Okra Varieties to Fertilizers, Yield and Yield Components as Influenced by Nitrogen and Phosphorus Application', *Fertilizer Research* 6 (3): 257 – 267.
- Mani, S. and Ramanathan K.M. (1980) Effect of Nitrogen and Phosphorus on the Yield of Bhindi Fruits', *South Indian Horticulture* 20: 136 – 138.
- Mohammad, M.K., Fadhilah-Nor, M., Tahir, D., Mohammad, H. and Sajili, N. M. (2017). 'Effect of Different Rates of Inorganic Fertilizer on Physiology, Growth and Yield of Okra Cultivated on BRIS Soil of Terengganu, Malleyasia, *Australian Journal of crop science*, (AJCS) 11: (7): 880 – 887.
- National Research Council (NRC) (2006). '*Lost Crops of Africa, Volume 2: Vegetables*. The National Academies Press, Washington D.C, USA, 134 pp.
- Navdeep, S.B and Daljeet, S. (2016). 'Impact of Nitrogen and Spacing on the growth and Yield of Okra (*Abelmoschus esculentus* (L.) Moench). Department of Vegetable Science, University College of Agriculture, Guru Kashi, University, Tlwandi Sabo (Bathinda, 52 (1): 1 – 7.
- O'Donovan JT, Harker KN, Claytron GW, Robinson D, Blackshaw RE, Hall LM (2001). 'Implementing integrate weed management' in baley (L.), pp 136. In: Blackshaw, RE and LM Hall (Eds.). *Integrated Weed Management: Explore the Potential*. Expert Committee on Weeds, Sainte-Anne-deBellevue, QC Publishers, London. PP. 133-175
- Olasatan, F.O. (2001). 'Optimum Population Density for Okra (*Abelmoschus esculentus* (L.) Moench) in a Mixture with Cassava (*Manihot esculentus*) and its Relevance to Rainy Season-based Cropping System in South-Western Nigeria', *Journal of Agricultural Science*, 136: 207 – 214.
- Perkin-Elmer C (1969). 'A Recalibration of the Hydrometer for Mechanical Analysis of Soils', *Aronomy Journal*, 42: 434 – 435,
- SAS (2010). 'Proprietary Software Release 9.1.3 (TSIMO) SAS Institute Inc., North Carolina State University – Campus-wide – T/R, Site 0027585003.Cary, NC, USA.
- Singh, K.V., Singh, M.K. and Singh, B (2007). 'Response of Macro and Micro-Nutrients on Growth and Yield of Okra (*Abelmoschus esculentus* (L.) Moench) cv Pusa Sawani', *Prog. Agric.* 7 (1-2): 63 – 65.

- Smith, M.A. K. and Ojo, I. K. (2007). 'Influence of Intra-row Spacing and Weed Management System on Gap Colonization of Weeds, Pod Yield and Quality in Okra (*Abelmoschus esculentus* (L.) Moench)', African Crop Science, Conference Proceeding, 8: Pp.: 313 – 317.
- Sultana, S. (2002). 'Effect of Nitrogen, Phosphorus, Potassium, Sulphur and Boron on Okra' M.Sc. Thesis. Department of Soil Science, Banghabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur, pp: 38 – 45.
- Uddin, J.U., Hossain, M.I., Islam. S., Mehraj, H and Jamal, U (2014). 'Growth and Yield of Okra as Influenced by Different Level of Nitrogen', *International Journal of Business, Social and Scientific Research*, 2 (2): 101 – 108.
- Walkley, A.J. and Black, I.A. (1934). "Estimation of Soil Organic Carbon by the Chronic Acid titration Method' *Soil Science*, 37: 29 – 38,