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Effects of nitrogen rates on growth, fruit position and seed yield of two okra (*Abelmoschus esculentus* L. Moench) varieties

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Abstract
A preliminary field trial was conducted at the Teaching and Research Farm of the Federal University of Technology, Minna (Southern Guinea Savanna ecological zone of Nigeria) during the 2019 cropping seasons. The experiment was laid out in a Randomized Complete Block Design and replicated three times. The treatments consisted of two okra varieties (NHAe47-4 and LD 88), five rates of nitrogen fertilizer (0, 30, 60, 90 and 120 kg N ha^{-1}) and six fruit positions on the mother-plant (1, 2, 3, 4, 5 and 6th). Each plot measures 2×5.25 m (10.5m^2) comprising of eight ridges. Parameters measured included days to first flower bud initiation and opening, days to 50% flowering, plant height and leaf area. Number of productive branches and flower abortion incidence were also determined among others. Data collected were subjected to analysis of variance (ANOVA). Means separation was caried out using Student- Newman Keuls (SNK) Test at 5% level of probability. Application of 90 - 120 kg N ha^{-1} gave better fruit size and seed yield of okra. Number of seeds of okra plant is better at a lower position on the mother-plant than higher position. With the result of this study; okra growth, fruit and seed yield can be enhanced by application of 90 kg N/ha.

Key words: Okra, Nitrogen ,Yield

Introduction

Okra (*Abelmoschus esculentus* L. Moench) also known as ladies' finger originated from Ethiopia (Sathish and Eswar, 2013) and was then propagated in North Africa, in the Mediterranean, Arabia and India by the 12th century BC (Tripathi *et al*., 2011). Itis one of the most widely known and utilized species of the family Malvaceae (Iyagba *et al*., 2013) and an economically important vegetable crop grown in tropical and sub-tropical parts of the world. It can be cultivated as a garden crop as well as on large commercial farms (Tripathi *et al*., 2011). The nutritional compositions of okra include calcium, protein, oil, carbohydrates, iron, magnesium and phosphorus (Duvauchelle and Joshua, 2011).

Fertilizer affects the quality and productivity of soils and crops (Watts *et al*., 2010). Weak vegetative growth, poor fruit setting, low fruit and seed yield resulting from inadequate levels of the primary soil nutrients (namely Nitrogen (N), Phosphorus (P) and Potassium (K)) have been reported by Liu *et al*, (2010). Nitrogen is the second most absorbed nutrient by vegetables and plays a fundamental role in their yield (Souza *et al*., 2017). In addition, N considerably influences the utilization of P and K and other plant nutrients in all plants (Watts *et al*., 2010). It also mobilizes the process of flower opening, fruit setting and fruit development. Seed development and seed position are two intrinsic factors which influence the seed performance (Bita and Maryam 2011). Number of fruits on the mother-plant and position of the ovules within the fruit determine the quality of seed. Seeds continue to develop and mature in the fleshy fruits until they got extracted from fruits (Nitsch, 2012). Sbirciog (2015) found out that there were significant differences between the values of the main physiological indices of the seeds' quality, both for the germinative faculty of the seeds and for their germinative energy. Considering the influence of the fruit position on the plant over the seed germination, he concluded that there are big variations between the germinative faculty of the seeds from the first fruit that developed on the plant and the germination capacity of the seeds from the fruits which have been formed in the 6th or 7th position on the plant. Positive effect of nitrogen fertilizer on mother-plant can be attribute of its role in delaying ageing cycle and providing enough time to obtain photosynthetic matters which translate to more weigh and higher quality (Bita and Maryam, 2011). The objectives of the study were to determine the effect of nitrogen rates on growth, fruit and seed yield of two okra varieties. Also, the seed quality in relation to position of fruit on the mother-plant were evaluated in two okra varieties

Materials and Methods

Field experiment was conducted at the Teaching and Research Farm of the Federal University of Technology, Minna (latitude 9° 51 'N and longitude 6° 44 'E) during the 2019 cropping seasons (May-Sept). Soils in Minna originated from basement complex rocks and generally are classified as Alfisols (Lawal *et al.*, 2012). Before land preparation, Soil samples were collected from 0-15cm depth with an auger from 10 points along four diagonal transects. The samples were bulked into four composite samples, air dried and sieved through 2mm and 0.5mm screen. The samples were analyzed for particle size distribution, pH 1:2 (H_2O and $CaCl_2$), Organic carbon, total nitrogen, available phosphorus, exchangeable bases (Ca^{2+}, Mg^{2+}, K^+,Na^+), exchangeable acidity (Al^{3+} + H^+) and effective cation exchange capacity following the procedures described by Agbenin (1995). Seeds of two okra varieties (NHAe 47-4 and LD 88 were sourced from the National Horticultural Research Institute (NIHORT) Ibadan, Oyo State Nigeria.

The land was manually cleared followed by ploughing with a tractor. Ridges of 2m length at 75 cm apart were made in each plot. The plots size was 2m × 5.25 m (10.5m^2) comprising of 8 ridges. The experiment was a factorial combination of two okra varieties (NHAe47-4 and LD 88), Five N levels (0, 30, 60, 90 and 120 kg ha^{-1}) and six fruit positions on the mother-plant (1, 2, 3, 4, 5 and 6) laid out in Randomized Complete Block Design (RCBD) with three replications. Three seeds were manually sown per hole at 0.5m apart and later thinned to one seedling per stand at two weeks after sowing (2WAS). Phosphorus and potassium fertilizers at 50 kg ha^{-1} each was applied in all the plots at 2WAS as basal application using single super phosphate and muriate of potash respectively. Urea was applied in two split doses (at 2 and 4WAS) to supply Nitrogen at different rates (0 kg N ha^{-1}, 30 kg N ha^{-1}, 60 kg N ha^{-1}, 90 kg N ha^{-1} and 120 kg N ha^{-1}). Weeding was carried out at two weeks intervals manually. Incidence of insect pests was kept down with the application of Zap® a.i (Lambda Cyhalothrin 25g/L), at 0.005kg a.i/ha. The insecticide was applied as from 2WAS till harvesting stage.

The parameters measured includes:

Days to first flower bud initiation – This was recorded bycounting the number of days from sowing to the sight of first flower bud.

Days to first flower opening – This was recorded by counting the number of days from sowing to the first flower opening.

Days to 50% flowering – This was recorded by counting the number of days from sowing to when half of the plant population flowered.

Plant height (cm) was measured from the base of the plant to the tip of the last leaf, using a meter rule. It was taken at first flower bud initiation, first flower opening, 50% flowering and at maturity.

Leaf area was calculated after measuring the leaf length and width using a meter rule at first flower bud initiation, first flower opening, 50% flowering and at maturity.

Number of productive branches at maturitywas recorded by counting the number of branches that produced fruit from the plant at maturity.

Flower abortion incidence at maturitywas recorded by counting the number of flowers that fall after formation (opening).

Fruit diameter was determined by measuring the fruit with the use of a caliper.

Fruit length was determined by using a meter rule at harvest.

Number of seeds and weight of seed were also determined.

Seed moisture content per each fruit position after harvest.

The data collected were subjected to analysis of variance (ANOVA) using SAS Statistical package 9.2. Means were separated using Student- Newman Keuls (SNK) Test at 5% level of probability.

Results

The results of some physical and chemical properties before land preparation for the trial showed that the soil of the site is sandy loam in texture with a moderate pH indicating the soil is slightly acidic. Soil organic carbon (SOC) was low with moderate contents of total soil nitrogen and available phosphorus. The ECEC of the soil was also found to be low (Table 1).

Table 1. Physiochemical properties of the soil sample of the experimental field.

Soil Properties	Values
Particle Size distribution (g kg^{-1})	
Sand	815.5
Silt	109
Clay	78
Textural class	SL
pH (1:2)	
H2O	6.7
Kcl or Cacl	5.5
Total N (g kg^{-1})	1.21
Organic C (g kg^{-1})	4.5
Available P (mg kg^{-1})	8.25
Exchangeable bases (C mol kg^{-1})	
Ca2+	3.75
Mg2+	3
k+	0.07
Na+	0.17
Exchangeable acidity (C mol kg^{-1})	
Al3+ H+	0.8
ECEC	8.2

SL: Sandy loam

There was no significant variation in terms of plant height between the two okra varieties at 4 WAP, flower bud opening and 50% flowering. Similarly, was observed not to be significantly different among different levels of nitrogen applied at 4 WAP, 50% flowering and maturity period. However, significant and higher plant height were recorded in LD 88 over NHAe 47-4 at flower bud initiation (FLBS) and maturity. Similarly, application of 120kgN/ha produced significantly highest plant height at flower bud initiation (FLBS) while application of 30kgN/ha produced the tallest plant at flower opening. No fertilizer application 0kgN/ha produced the shortest plant in all the treatments (Fig. 1).

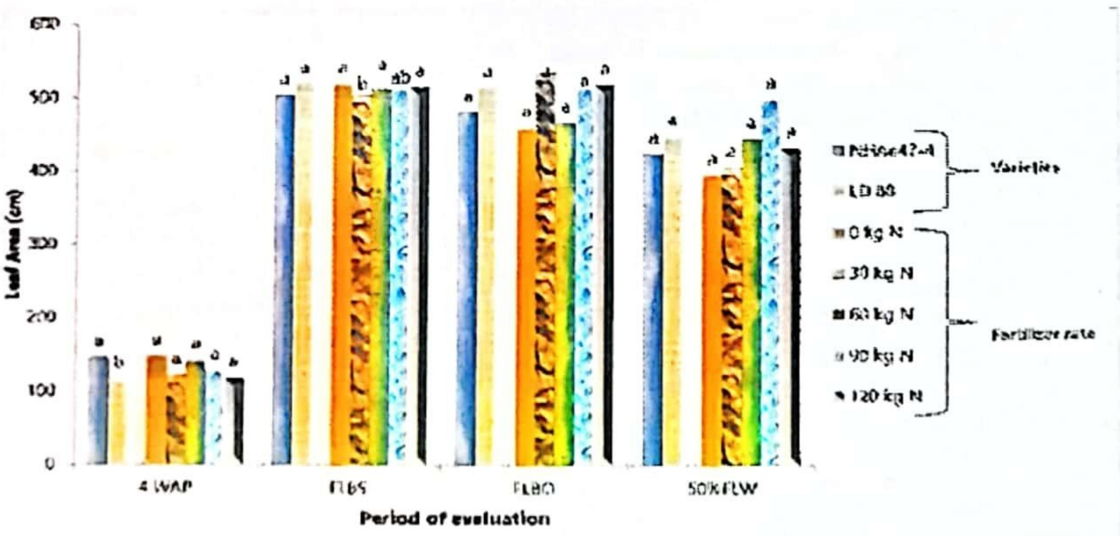

Fig 1. Plant height of two okra varieties evaluated under different nitrogen fertilizer levels application

With respect to leaf area, higher and significant leaf area was recorded in NHAe 47-4 over LD 88 at 4WAP. Leaf area was not significantly different between the two varieties at other periods of evaluation (Fig. 2). Similarly, leaf area was significantly influenced by N fertilization at flower bud initiation stage as highest leaf area was recorded in the control (0 Kg N) but this was not significantly different from leaf area recorded at 60 and 120 kg N (Fig. 2)

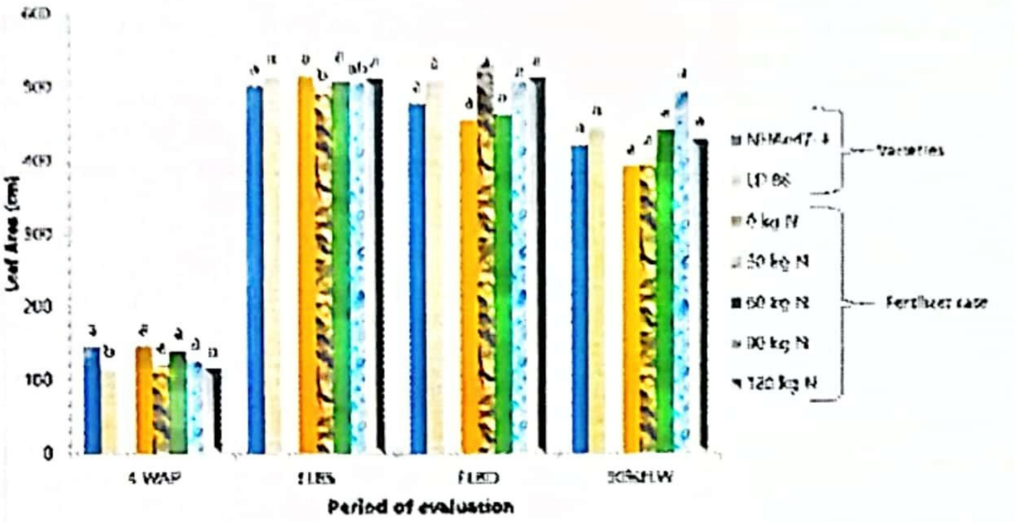

Fig 2. Plant height of two okra varieties evaluated under different nitrogen fertilizer levels

Furthermore, the number of productive branches was higher in NHAe 47-4 but not significantly different from LD 88 (Fig. 3 series 1). On the other hand, application of 120kgN/ha recorded higher incidence of flower but this was not significantly different from application of 90kgN/ha. Significant and lower flower abortion were observed in the control and 30kgN/ha application (Fig. 3 series 2).

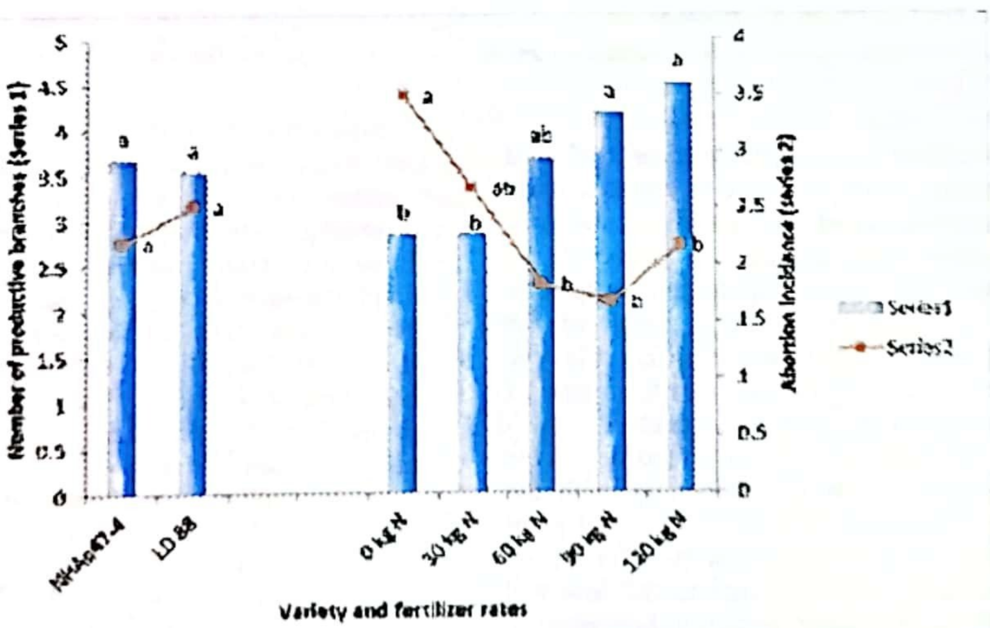

Fig 3. Number of productive branches and incidence of flower abortion in two okra varieties under different N-fertilizer application rates

The fruit diameter, fruit length, number of seeds per fruit and weight of seeds per fruit were significantly higher in LD 88 while seed moisture content was higher in NHAe 47-4. At fertilizer level, fruit and seed characters increased with increasing fertilizer application rate while with increasing fruit position fruit and seed characters increased. Significant interaction was recorded by interaction of fruit position by variety, fertilizer levels by fruit position, variety by fertilizer level, and fruit position by variety by fertilizer level (Table 2)

Table 2. Effects of variety and nitrogen application on fruit and seed pararmeters in two varieties of okra evaluated in the study.

Variety	Fruit diameter (cm)	Fruit length (cm)	Number of seeds	Weight of seeds per fruit (g)	Seed Moisture content (g)
NHAe47-4	10.31^{b}	9.14^{b}	52^{a}	3.77^{b}	13.77^{a}
LD 88	10.92^{a}	10.04^{a}	54^{a}	4.00^{a}	13.29^{b}
Fertilizer Level					
0	9.44^{d}	8.54^{c}	38^{d}	3.08^{d}	16.56^{a}
30	10.15^{c}	8.99^{c}	46^{c}	3.53^{c}	15.10^{b}
60	10.45^{c}	9.50^{b}	55^{b}	3.98^{b}	13.18^{c}
90	11.23^{b}	10.24^{a}	62^{a}	4.33^{a}	11.41^{d}
120	11.81^{a}	10.68^{a}	64^{a}	4.51^{a}	11.40^{d}
Position					
1	12.46^{a}	10.56^{a}	70^{a}	5.00^{a}	10.47^{d}
2	11.45^{b}	10.46^{a}	60^{b}	4.38^{b}	12.58^{c}
3	11.35^{bc}	10.18^{ab}	58^{b}	4.17^{b}	12.00^{c}
4	10.89^{c}	9.69^{b}	51^{c}	3.74^{c}	14.72^{b}
5	8.94^{d}	8.38^{c}	40^{d}	3.11^{d}	15.20^{ab}
6	8.61^{d}	8.31^{c}	39^{d}	2.91^{d}	16.21^{a}
--	*	*	*	*	*
Pos × F. level	*	*	*	*	*
Variety x F. level	*	*	*	*	*
Pos × Var × F. level	*	*	*	*	*

Pos - Position, Var -Variety, F – fertilizer

Means with the same alphabet in the same column are not significantly different at ($p \leq 0.05$) level of probability

Discussion

Fertilizer application is an important aspect of field crop management which is needed to enhance plant growth, fruit and seed yield. The variations observed between the two okra varieties in terms of the evaluated parameters may be due to genetic quality. The increase in plant height, as a result of the application of inorganic fertilizer at different levels, might have enhanced cell division and formation of more tissues resulting in luxuriant vegetative growth giving rise to the observed tall plants recorded in the present study. and this is in conformity with the observation of Zubairu *et al.* (2017). The least plant height recorded in in the control plots with no fertilizer application might be due to the low soil nutrients resulting in stunted growth (short plants). Muhammed *et al.* (2013) recorded similar result in their experiment conducted to evaluate the influence of nitrogen and phosphorous fertilizer on the phenology of okra. Similar trend was also obtained by Oladiran *et al.* (2016) who recorded maximum plant height with application of 120 kg N.

Leaf area of the plant increases with the increase in nitrogen application up to the highest level at different growth stages but became reduced at 50% flowering stage. Although, application of 90kgN/ha seems to be the most consistent across the different stages of the crop. Mohammed and Miko (2009) observed similar patterns of response, indicating that nitrogen promotes general crop vigour through its influence on cell division, cell elongation and expansion, synthesis of essential amino acid and chlorophyll formation.

The longest fruits size was from position 1 (position closest to the plant base) while the shortest were from position 6. This result agrees with the trend reported by Alan and Eser (2007) for pepper in which fruit weight gradually declined from positions closest to the plant base to those at upper layers. Also, the result was similar with that of Zubairu *et al.* (2017). The significant increase in fruit diameter, fruits length, number of seeds, seeds weight and moisture content in response to increasing application of N in this study indicates that okra fruits at high positions have poor physiological sinks. Oladiran *et al*., (2016) reported that okra fruits located on higher position were smaller and lighter due to their low capacity to compete for photo-assimilates. Bertin, *et al*. (1998) also observed that tomato fruit size was affected by position on mother-plant under competition for assimilates. Seeds from the peduncular fruit segments were delayed in reaching maximum quality compared with seeds from other positions in cucumber (Hu *et al*., 2019).

The above explanations may also hold for why significantly fewer number of seeds were produced at position 6 than at other lower positions 1, 2, 3, and 4 regardless of the fertilizer rates applied. Also, both fruit position and the N rates applied generally influenced the abortion rates, number of productive branches, number of seeds and seed weight per pod in this trial.

Conclusion

The application of 90 –120 kg N/ha gave better fruit size and seed yield of okra. Number of seeds of okra plant is better at a lower position on the mother-plant than higher position. Application of 90kg N/ha to okra is therefore suggested for good growth, improved fruit and seed yield in the studied zone.

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