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Effect of Nitrogen Fertilizer and Fruit Positions on Fruit and Seed Yields of Okro (*Abelmoschus Esculentus* L. Moench)

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Abstract

Study was conducted in 2006 and 2007 cropping seasons at the experimental field of Federal University of Technology, Minna (9o 401N and 6o 301E), in the Southern Guinea Savanna of Nigeria to determine the effects of N fertilizer and the fruit positions on fruit and seed yield of okro. The treatment comprised factorial combination of five nitrogen levels (0, 30, 60, 90 and 120 kg/ha) and five fruit positions on a mother-plant (3, 5, 7, 9 and 10) which were replicated three times and laid in a Randomized Complete Block Design (RCBD). The results indicated that significant taller plants were recorded in the plots that received 120 kg N/ha while shorter plants were recorded in plots that received 0 N/ha in both years of the study. The higher N level of 120 kg/ha and lower fruit position of 3 significantly gave higher number of fruit yield while the yield decreased with decrease in N level and increase in fruit position on the mother-plant. Similarly, heavier fruits were recorded in lower fruit positions and higher N levels. The fruits formed at the lower position 3 and 5 produced more seeds with higher seed weight than those formed at the higher positions. The results also showed that significantly higher seed yield was recorded at N level of 120 kg/ha ?.

Keywords: Nitrogen fertilizer, fruit position, yield and okro

1. Introduction

Okra or okro (*Abelmoschus esculentus* (L.) Moench) known in many English-speaking countries as ladies fingers, bhindi, bamila, ochro or gumbo, is a flowering plant in the malvaceae family and it is valued for its edible green seed pods. It is widely cultivated in the tropics and sub- tropics and warm temperate regions around the world. It is a chief vegetable crop grown for its immature pod that can be used as a boiled or fried vegetable, or may be added to salad or soup (Kashif *et al* 2010). Okra plays an immense role in the human diet, providing carbohydrates, fats, proteins, vitamins and minerals (Abd El-Kader *et al*., 2010). Okra is rich in unsaturated fatty acids, linoliec acid, that are generally deficient in the other human diet (Savello *et al*., 1980). It is an important pan-tropical vegetable, particularly in West Africa, India, Brazil and Southern USA (Gruben, 1989).

Nitrogen, phosphorus and potassium are among the common major nutrients, which are essential for the growth and development of all plant species. Nitrogen is an essential element and important determinant in the growth and development of crop plants (Firoz 2009). It plays an important role in chlorophyll, protein, nucleic acid, hormone and vitamin synthesis and also helps in cell division and elongation. Several works have reported linear increase in green pod yield of okra with the application of N from 56 to 150 kg/ha (Hooda *et al.*, 1980; Mani and Ramanathan, 1980; Majanbu *et al*., 1985 and Singh, 1995)

Tropical soils are generally low in organic matter and total nitrogen due to high temperature and low rainfall leading to sparse vegetation and high rate of mineralization, leaching and erosion (Okafor 1989; Rasyad 1990). Deficiency symptoms of nitrogen in soils where okra is grown has been reported to result in poor growth, thin shoot, yellowing and bristle leaves (Chonker and Sign, 1963). Olasantan (1998) reported that phosphorus and potassium if lacking would drastically reduce the yield due to their synergic interaction with nitrogen. According to Liu (2004) attainment of optimum yield where? is hardly possible without the use of fertilizer. Fertilizer recommendation for okra? varies from place to place due to environmental conditions including soil factors. Majanbu *et al*. (1986) stated in their work that 112 kg N/ha, is recommended in Trinidad while 80 kg N is the recommendation in Brazil. The South Eastern American soils have a recommendation of 120 kgN/ha. For Northern Nigeria Majanbu *et al.*, (1986), Ahmed and Tullock-Reid (1980) and FAO (1992) recommended 100 kg N/ha.

Thomas *et al.* (1979) stated that the position at which a carrot or celery seed is produced on the plant can markedly affect its size, germination characteristics and size of the ensuing seedling. In both species the lowest percentage seed germination and seedling emergence were obtained from seeds produced on primary umbels A similar result was also recorded in tomato by Dias *et al*. (2006). Fruit size is also known to vary with position on mother-plant. Ho and Hewit (1986) reported that during rapid growth in tomato, both the rates of maximum growth and of starch accumulation of proximal fruits are higher than those of distal fruits. However, when the assimilate supply is abundant, the proximal fruit could gain more weight than the distal ones.

There is dearth of information in respect of N requirement for okro seed production as; researchers appear to be more concerned with fruit production of okro for table consumption. Sajid, et al., (2012) observed that there are various ways of improving yield and seed production of okra and the best way is to provide appropriate amount of N fertilizers () and ensuring the use of appropriate fruit position on the mother-plant (Ibrahim and Oladiran, 2011) to select high yielding cultivars. In this connection, present study was conducted to study the effect of various levels of N fertilizer and fruit position on the mother-plant with the view to finding out the most suitable N level and appropriate fruit position for high seed and fruit yields of okra.

2. Materials and Methods

The study was conducted at the Teaching and Research Farm of the Federal University of Technology, Minna (Minna (latitude 6^o 33^{1}N and longitude 9^o 45^{1}E)), Niger State, Nigeria. Field and laboratory studies were conducted in in the Southern Guinea Savanna zone of Nigeria. Rainfall was 155.33mm in 2006 and 240.66mm in 2007. Wet and dry season temperatures were about 27^{o}C and 39^{o}C respectively /). Seeds of okra (*A. esculentus* L. Moench) variety NHAe 47-4 were sown on the flat at 75 cm inter row and 40 cm intra row spacing. Soil samples were collected at random from the entire field ? at the depth of 0-15cm, using an auger and the composite samples were subjected to physico-chemical analysis as described by Page *et a*l. (1982).

The experiment consisted of fruit position on mother-plant (position 3, 5, 7, 9 and 10 the odd numbering suddenly changed to whole number 10 thus distorting the sequence for position, which should be 11? numbering from ground level) and nitrogen fertilizer levels (0, 30, 60, 90, and 120 kg/ha) with five treatments each giving a 25 treatment combination and planted on six 2 m x ? m ridges giving a plot size of 7.5 m^2 laid out in a Randomized Complete Block Design (RCBD) with three replications. Three seeds were sown per hole and following emergence seedlings were thinned to one per stand at two weeks after planting. Hoe weeding was carried out at 3, 6 and 9 weeks after planting (WAP).

Data were collected on plant height at 50% flowering, dry fruit weight, number of fruit harvested per plot, number of seeds per fruits, seed weight/fruit and seed yield/plot and converted to tha^{-1} Data collected were subjected to analysis of variance (ANOVA) using the ?. Means were separated where significant differences between treatments were obtained using which statistic? Least significant difference (LSD)? The amount of treatments would not be adequately separated with LSD, the Duncan's Multiple Range Test could suffice.

3. Results

Table 1 indicates some physico-chemical properties of the soil from the experimental site before each cropping season. The soil was sandy loam and near neutral in pH in 2006 and neutral in 2007. The organic carbon, total N, and exchangeable bases were low in 2006 and slightly higher in 2007. The effective cation exchange capacity for both years was low.

Plant height recorded at 50% flowering was observed to be highly significant influenced by different levels of nitrogen. (Table 1). Plants grown with minimum dose of N (120 kg N/ha) were found to be significantly taller (70.8 and 70.5cm in 2006 and 2007 respectively) than the plants grown with inadequate amount of N fertilizer. Plant height increased with the increasing rate of N up to 120 kg/ha. The shorter plants were recorded in the plots that received no N application in both years. The fruit position on the mother-plant did not have significant effect on the plant height in both years of study.

In 2006, the dry fruit weight was significantly influenced by only fruit position on the mother-plant and heaviest fruits were from position 3 while the lightest were from 10th position. In 2007, fruit weights were affected by fruit position, fertilizer levels and position by fertilizer interaction. The significant interaction of fruit position by fertilizer is an indication that responses to N level varied with fruit position. In 2007, significant higher fruit was recorded at position 3 when 90 kg/ha of N was applied while lower fruit weight was recorded at position 10 at the same N level.

Consistently, significantly higher numbers of fruits were recorded at lower position 3 in both years of study while position 10 gave significantly lower number of fruits. The application of different N levels had decisive effect on number of fruits and 120 kgN/ha gave significantly higher fruit numbers than the other N levels evaluated in this study though similar with 90 kg/ha at position 3 in 2006 and positions 3, 5 and 7 in 2007(Table 4). The interaction of fruit position by N levels had significant effect on number of fruits.

On seed yield, it was found that fruits at the lower positions contained significantly more seeds than those at higher positions in both years (Table 5). The different N levels were found to have insignificant effect on number of seed in both years of study. Also, a significant interaction of fruit position by fertilizer level was recorded in 2007. The fruit position on the mother-plant had no significant effect on seed weight per fruit in both years of study and the 120 and 90 kg N/ha gave significantly higher seed weight in both years while no N application gave lower seed weight per fruit. The interaction of fruit position by N levels had no significant effect on seed weight (Table 6).

Fruits closest to the base of the plant yielded more seeds than those closest to the plant tip. Fruit positions and fertilizer levels had significant effects on the seed yield per plot in both years of study (Table 7). Fruits from the lower positions significantly yielded more seeds than those at higher positions. Application of 90 and 120 kgN/ha resulted in significantly higher seed yield production compared to less? yields obtained at lower N levels.

4. Discussion

The higher dose of N might have enhanced cell division and formation of more tissues resulting in luxuriant vegetative growth giving rise to to the observed tall plants recorded in the present study (Firoz, 2009). Minimum plant height (66.2 and 62.6 cm) in zero N plots might be due to the poor nutritional status which resulted in retarded growth resulting in 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. The results are also similar to that obtained by Sarnaik *et al*., (1986) who recorded maximum plant height with application of 120 kg N + 60 kg P ha^{-1}. Similar results were also obtained by Gondane and Bhatia (1995) who reported that NPK fertilizer significantly increased plant height. Majanbu *et al*., (1985) also observed that plant height was enhanced by N fertilizer upto 100 kg N /ha. The significant progressive increase in plant height as fertilizer rate was increased in this study agrees with observations reported by Gupta (1981), Majambu et al. (1985) and Katung et al. (1996).

In both 2006 and 2007 trials the heaviest fruits were from position 3 (position closest to the plant base) while the lightest were from position 10. 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. The absence of significant increase in fruit weight in response to increasing addition of N in this study indicates that okro fruits at high positions are poor physiological sinks. Guillaspy, *et al.* (1993) reported that tomato fruits located on late trusses were smaller and lighter due to their low capacity to compete for photo-assimilates. Bertin, *et al.* (1998) also reported that tomato fruit size was affected by position on mother-plant under competition for assimilates. The above explanations may also hold for why significantly fewer fruits were produced at position 10 than at other lower positions 3, 5, and 7 irrespective of the fertilizer rates applied Both fruit position and the N level received generally influenced the number and seed weight per pod in this trial, following the trend reported for fruit weight by other workers. Khan and Passam (1992) reported a positive correlation between fruit size and seed number in pepper. *Cucurbita pepo* fruit size was also reported to correlate positively with seed number (Stephenson *et al.*, 1988). The significant increase in seed yields at high fertilizer rates as recorded in this study is in agreement with the work of Malhi *et al.* (2000) which showed that the highest okra seed yield was obtained when fertilizer which type of fertilizer? Was it NP, NK or NPK? was increased from 100 to 120kg/ha though Saimhi and Padda (1990) had earlier recorded the best yield at 100 kg N/ha. Almeida (2002) stated that yield and quality became significantly superior when fertilizer level was raised from 0 to $100kgNha^{-1}$. Similarly, Chandler (1999) recorded significant okra seed quality improvement when N level was increased up to 120kg/ha. In a similar study, Sawan *et al.* (1998) reported that the increase in seed weight and better storability of cotton seeds due to high N rate might be due to the increased accumulation of metabolites which had direct impact on seed weight. A better fertilizer strategy would have to be worked out so as not only to obtaineseeds of better vigour at higher positions on mother-plants but also to improve overall yield. Nolan *et al.* (1999) stressed that higher yield and better seed quality will always be obtained at lower positions compared to higher positions unless a good strategy is devised to get greater N fertilization to upper positions in preference to lower ones. I disagree with this statement as the ability to produce seeds with higher weights and seed number is a genetic function and not phenotypic one to be influenced by N fertilization.

5. Conclusion

It is clearly established from this study that application of 90 – 120 kg N/ha gave better fruit and seed yield of okra. Seed and fruit yield of okra plant is better at a lower position on the mother-plant than higher position. With the result of this study, we therefore advise okra farmer in the zone to apply 90 kg N/ha and use the seed obtained from the lower position as the planting material.

Table 1. Selected physico-chemical properties of soil at the experimental site during the 2006 and 2007 cropping seasons.

Soil Properties	Values	
	2006	2007
Particle size analysis (gkg-1)		
Sand	800	800
Silt	57.0	57.0
Clay	46.0	46.0
Textural Class	Sandy loam	Sandy loam
PH (1:2 H2O)	6.90	7.00
Total N (%)	0.14	0.20
Organic Carbon (gkg-1)	10.1	12.4
Available P (mg kg-1)	1.99	2.01
Exchangeable bases (cmol.kg-1)		
K	0.22	0.30
Mg	0.12	0.14
Ca	0.30	0.33
Na	0.31	0.35
CEC	1.28	1.30
Exchangeable Acidity (cmol.kg-1)	0.5	0.7

Table 2. Effect of N fertilizer levels on plant height at 50% flowering in 2006 and 2007 cropping season

Plant height (cm)		
N fertilizer rate (kg/ha)	2006	2007
0	66.2	62.6
30	69.7	66.2
60	70.3	70.0
90	73.1	73.0
120	74.5	79.7
Mean	70.8	70.5
LSD (0.05)	0.9	1.9

Table 3. Effect of fruit positions and N fertilizer levels on dry fruit weight in 2006 and 2007

N fertilizer (kg/ha)	Fruit Position 2006						Fruit Position 2007					
	3	5	7	9	10	Mean	3	5	7	9	10	Mean
0	8.58	7.63	5.91	4.97	4.92	6.40	8.77	7.77	6.49	4.85	4.42	6.46
30	9.12	7.59	7.33	5.80	4.50	6.95	9.20	7.59	7.47	5.81	4.76	6.97
60	8.25	8.04	7.25	7.35	5.29	7.23	8.38	8.32	7.72	7.53	5.48	7.49
90	11.00	8.47	7.80	5.43	4.97	7.53	11.00	8.85	7.91	6.66	4.37	7.76
120	10.18	10.09	6.97	5.44	5.46	7.63	10.41	9.69	6.97	5.67	5.26	7.60
Mean	9.43	8.37	7.13	5.80	5.03		9.55	8.44	7.31	6.11	4.86	

LSD (0.05) Fruit position = 1.40 = 1.00

LSD (0.5) Fertilizer levels = NS = 1.10

LSD (0.05) Fruit position x N fertilizer levels = NS =1.20

Table 4. Effect of fruit positions and N fertilizer levels on the number of fruits harvested per lot in 2006 and 2007

N fertilizer	Fruit Position 2006						Fruit Position 2007					
(kg/ha)	3	5	7	9	10	Mean	3	5	7	9	10	Mean
0	11.38	9.00	6.34	8.33	6.00	8.20	12.00	10.00	9.00	7.00	6.00	8.80
30	11.00	8.00	7.33	7.66	6.33	8.27	11.00	10.66	9.00	7.67	7.00	9.06
60	10.67	10.33	9.00	6.67	6.00	8.41	10.67	10.33	9.00	8.00	7.00	9.00
90	12.00	10.66	8.00	6.66	6.33	9.23	12.00	11.33	10.00	9.33	7.33	10.00
120	12.00	11.00	10.00	9.00	6.60	9.73	12.00	11.00	10.00	8.00	7.67	9.73
Mean	11.40	9.80	8.13	8.07	6.26		11.53	10.67	9.40	8.00	7.00	

LSD (0.05) Fruit position = 1.51 =1.20

LSD (0.5) Fertilizer levels = 0.20 =1.20

LSD (0.05) Fruit position x N fertilizer levels = NS =1.40

Table 5. Effect of fruit positions and N fertilizer levels on number of seed per fruit in 2006 and 2007

N fertilizer	Fruit Position 2006						Fruit Position 2007					
(kg/ha)	3	5	7	9	10	Mean	3	5	7	9	10	Mean
0	87.67	76.83	58.34	54.33	53.33	66.10	82.00	77.00	74.00	66.33	66.33	72.53
30	77.33	61.67	80.33	58.00	54.66	66.40	89.00	83.67	77.33	68.00	63.67	76.33
60	83.33	79.66	64.67	67.67	64.33	71.93	94.67	91.00	85.00	71.33	64.67	81.33
90	90.00	72.00	57.67	54.67	54.67	69.27	97.00	96.00	90.00	81.67	70.33	87.00
120	78.33	72.00	65.95	56.60	57.57	63.47	101.3	99.00	95.67	80.00	67.33	88.67
Mean	83.33	73.70	65.95	56.60	57.53		92.80	89.33	84.40	73.47	65.86	

Table 6. Effect of fruit positions and N fertilizer levels on seed weight (g) per fruit in 2006 and 2007

N fertilizer	Fruit Position 2006						Fruit Position 2007					
(kg/ha)	3	5	7	9	10	Mean	3	5	7	9	10	Mean
0	6.16	6.57	7.09	3.73	5.14	5.74	4.46	3.79	3.49	3.18	2.74	5.53
30	7.25	6.25	5.34	6.02	5.22	6.02	5.77	4.88	4.63	4.19	3.72	4.64
60	6.54	5.74	4.47	5.62	5.27	5.53	6.31	5.86	4.93	4.49	3.70	5.05
90	8.98	8.16	9.51	4.02	6.02	7.33	6.75	6.31	5.81	4.60	4.11	5.05
120	8.04	8.87	6.56	7.95	6.32	7.54	7.21	6.73	6.29	5.81	4.98	6.21
Mean	7.39	7.12	6.59	5.46	5.59		6.10	5.52	5.03	4.45	3.85	

LSD (0.05) Fruit position = NS =1.12

LSD (0.5) Fertilizer levels =1.30 =1.10

LSD (0.05) Fruit position x N fertilizer levels = NS =NS

Table 7. Effect of fruit positions and N fertilizer levels on seed yield (g) per plot in 2006 and 2007

N fertilizer	Fruit Position 2006						Fruit Position 2007					
(kg/ha)	3	5	7	9	10	Mean	3	5	7	9	10	Mean
0	66.85	53.00	39.25	25.28	29.80	43.45	67.85	54.00	40.25	29.29	30.80	44.45
30	68.01	43.67	44.04	41.82	29.66	45.43	69.01	44.67	45.04	42.82	30.66	45.43
60	59.81	55.93	37.76	37.84	32.17	44.51	60.81	55.93	38.76	38.84	33.17	45.51
90	106.84	67.63	58.21	32.46	31.93	59.43	107.8	68.63	59.21	33.56	32.93	60.43
120	92.75	80.34	58.94	46.70	39.62	63.67	93.75	81.34	59.94	47.70	40.62	64.67
Mean	78.85	59.92	47.65	34.00	32.63		79.85	73.92	48.50	38.42	35.00	

LSD (0.05) Fruit position = 1.20 =2.21

LSD (0.5) Fertilizer levels = 2.21 =3.20

LSD (0.05) Fruit position x N fertilizer levels = NS = NS

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