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Effect of NPK Fertilizer Rates and Method of Application on Growth and Yield of Okra (*Abelmoschus esculentus* (L.) Moench) at Ado-Ekiti Southwestern, Nigeria

S.O. Omotoso and O.S. Shittu
Department of Crop, Soil and Environmental Sciences, University of Ado-Ekiti, P.M.B. 5363, Ado-Ekiti, Nigeria

Abstract: This study was conducted to determine the effect of NPK fertilizer application rates and method of application on growth and yield of okra (*Abelmoschus esculentus* (L.) Moench) at the Teaching and Research Farm, University of Ado-Ekiti. Okra seed variety LD88 were treated to three levels of NPK fertilizer rates (0, 150 and 300 kg NPK ha^{-1}) and two methods of fertilizer application (ring and band method). Treatments were arranged in a split-plot design with fertilizer application method as main plot factor and NPK rates as sub-plot factor. The treatments were replicated three times to give a total of eighteen experimental field plots. The result indicated that the fertilizer NPK significantly increase growth parameters (plant height, leaf area, root length, number of leaves), yield and yield components with optimum yield of okra obtained at 150 NPK kg ha^{-1} and ring method of application seems appropriate for okra production.

Key words: Placement, NPK fertilizer, application methods, plant nutrition, okra

INTRODUCTION

Abelmoschus esculentus (L.) okra is a widely cultivated vegetable and can be found in almost every market all over Africa (Schippers, 2000). The nutritional constituents of okra include calcium, protein, oil and carbohydrates; others are iron, magnesium and phosphorus. Most okra is eaten in cooked or processed form. Young fruits may be eaten raw. The oil in the seed could be as high as in poultry eggs and soybean (Akinfasoye and Nwanguma, 2005).

Nitrogen as well as Phosphorus plays an important role in fruit, seed and quality development of okra (Nihort, 1985). NPK fertilizer has been reported to give a yield increase in okra (Babatola, 2006). Different methods of fertilizer application have been known to influence plant yields. Sweeney *et al*. (1996) reported that greater yields of early-grazing samples and higher P and K concentration was obtained by broadcasting fertilizer than was obtained for knifing (subsurface banding).

Crop response to N fertilization varies with rate, timing and methods of N application in relation to plant development. Cochran *et al*. (1978) reported increased biomass build-ups of soft white winter wheat due to accumulation of fall-applied fertilizer in the lower layers of the root profile, which can be available to the crop late in the growing season. Mahler *et al*. (1994) reported better use of banded fertilizer by spring wheat and attributed this to the fact that the banded fertilizer is positionally more available to the crop than germinating weeds.

In broadcasting, the fertilizer is uniformly applied over the soil surface and may be incorporated in the soil or left on the soil surface and may reach the root zone by percolating rainfall or irrigation water. Application of NPK fertilizer by broadcasting method encourages vigorous and wider root

Corresponding Author: S.O. Omotoso, Department of Crop, Soil and Environmental Sciences, University of Ado-Ekiti, P.M.B. 5363, Ado-Ekiti, Nigeria

network for absorption of available plant nutrients from the soil solution (Toews and Soper, 1998). N fertilizer placement by broadcasting method does not optimize the use of limited fertilizer resources, which may just be as available to the weeds as it is to the crop (Tisdale *et al*., 1985).

The effect of NPK fertilizer application rates on growth and yield of okra has been studied by many researchers in Nigeria, but there seem to be a dearth of information on the effect of NPK fertilizer application rates and methods of application. This study was therefore carried out with the objective of examining the effect of NPK fertilizer rates and the appropriate method of application on growth and yield of okra.

MATERIALS AND METHODS

Trial Sites

The study was conducted at the Teaching and Research Farm, University of Ado-Ekiti between May and July 2006. Ado Ekiti is located on latitude 7°30 N and longitude 7°48' E. The area has a bimodal rainfall with mean annual rainfall of 1367 mm and a daily temperature of 27°C. The area falls within the high forest zone where the rich tropical forests once thrived. The region has a tropical humid climate with distinct wet and dry seasons. The wet season is from late March to October with little dry season in July and August.

Soil Preparation and Analysis

Prior to planting, soil samples were collected air-dried in the Laboratory, ground and sieved through a 2 mm sieve. Particle-size distribution was determined by the hydrometer method (Bouyoucos, 1951). Soil pH was measured using the pH meter at 1:1 soil to water ratio. The percentage organic carbon was determined by the Walkey Black wet oxidation method (Walkley and Black, 1934) while percent total Nitrogen (N) was determined by the micro-kjeldahl technique (Jackson, 1962). The present organic matter was estimated by multiplying the percent organic carbon with a factor of 1.724. Available P was extracted by the Bray/method and determined colorimetrically (Bray and Kurtz, 1945). Exchangeable bases were displaced by NH_4 + from neutral/NH_4OAC solution as described by Jackson (1958). Calcium (Ca) and magnesium (Mg) were determined by the Atomic Absorption Spectrophotometer (AAS) and potassium (K) and sodium (Na) were determined by flame emission photometry. Cation Exchange Capacity (CEC) was determined by the neutral/NH_4OAC saturation method. Base saturation was calculated with reference to the NH_4OAC-CEC. Exchangeable acidity was extracted with IM KCL and determined by titration with NaOH solution.

Field Trials

Field trial was conducted between July and October, 2005 and May to August 2006 at the Teaching and Research Farm, University of Ado-Ekiti. The size of the plot used was 12×8 m. This was divided into three blocks (replicates) each measuring 4×2.5 m. The trial was a 2×3 factorial experiment in randomized complete block design.

Three seeds of okra variety LD 88 (Nihort) were planted on the field at spacing of 50×30 cm which were latter thin to one per stand. Before sowing, the seeds were soaked in water to determine its viability through floating method. NPK 15:15:15 fertilizer was applied at 0, 150 and 300 NPK kg ha^{-1} and two method of fertilizer application (ring and band methods) were adopted.

Treatments were arranged in split-plot design with application method as main plot factor and NPK 15:15:15 fertilizer rates as sub-plot factor. The six treatments were randomized completely within each block separately using the random digit of number and were replicated three times to give a total of eighteen experimental field plots.

Weeding commenced at two weeks after sowing of okra seed and subsequent weeding was carried out as at when due. Thinning was done two weeks after sowing of okra seed. Chemical spraying with

hypermetricin was carried out to control some insect pests that affect the leaves of okra plant. Eight plants were selected per plot for determination of growth and yield parameters. Successive harvesting was done thrice as fruits reached marketable size. Number of fruits was counted on each occasion and fresh weight obtained to determine yield. The vegetative parameters assessed included plant height, number of branches, root length, leaves area. At final harvest, the okra plants were uprooted partitioned into leaves, stem and roots and were measured Each of these part were oven-dried in brown envelope for 48 h at 60°C. Measurements of dry weight were taken of stem, leaves and roots.

RESULTS AND DISCUSSION

Characteristics of the Soil Used

The result of the analysis of soil used for the experiment were presented in Table 1, which gave particle size as sand 720 g kg^{-1}, silt as 229 g kg^{-1} and clay as 51 g kg^{-1}. The pH of the soil was 6.3 which is slightly acidic, organic carbon content was 6.15% which is high for this soil, Nye (1950) who worked on the relationship between Nitrogen responses on previous soil treatment and C/N ratio in soil of Gold coast savanna area reported that derived savanna soils have lower N status and wider C/N ratio than forest soils which greatly affect N availability. ECEC was 1.03 cmol kg^{-1} while total N and available P were 0.07% and 6.20 mg kg^{-1}, respectively. The soil was sandy loam, Total N and available P content were very low compared with critical levels of 0.1% for N (Adeoye, 1986) and a range of 10-12 mg kg^{-1} for available P (Adeoye and Agboola, 1985) obtained for soils in southwestern Nigeria (FMANR, 1990). Using the critical levels of 0.16-0.20 cmol kg^{-1}, exchangeable K was low (Agboola and Obigbesan, 1974).

Effect of NPK Fertilizer Rates on Growth Characters of Okra

The height of plant is an important growth character directly linked with the productive potential of plant in terms of fodder, grains and fruit yield. An optimum plant height is claimed to be positively correlated with productivity of plant (Saeed *et al*., 2001). The results showed significant ($p<0.05$) response to different rates of NPK fertilizer application (Table 2). Okra plants were taller in those plants that received 300 NPK kg ha^{-1} than those that received lower rates of application due to higher nitrogen content which induced higher plant height, number of leaves, leaf area, root length and number of branches. This is in agreement with the findings of Babatola *et al*. (2002) who reported that increasing level of NPK 20:10:10 was observed to increase growth and yield of okra in an okra/sweetcorn intercrop. There was however no significant difference in plant height, number of leaves

Table 1: Physico-chemical properties of surface soil used

Soil properties	Values
pH (H_2O)	6.3
Organic C (%)	6.15
Total N (%)	0.07
Available P (mg kg^{-1})	6.20
Exch. bases (cmol kg^{-1})	
K	0.17
Ca	0.40
Mg	0.06
Na	0.14
Exch. acidity	0.26
CEC (cmol kg^{-1})	1.03
Base saturation (%)	72.1
Sand (g kg^{-1})	720
Silt (g kg^{-1})	229
Clay (g kg^{-1})	51
Textural class	Sandy loam

Table 2: Effect of NPK fertilizer rates and application method on growth characters of okra

NPK (kg ha^{-1})	Plant height (cm)	No. of leaves	Leaf area (cm^2)	Root length (cm)	No. of branches
0	17.36b	8.26a	162.90c	10.42b	1.03b
150	25.02a	8.05a	184.21b	12.16b	1.88b
300	26.32a	9.76a	192.3a	18.91a	2.51a
Method of application					
Band	21.71a	8.32a	172.61b	11.21b	2.00a
Ring	23.84a	8.21a	183.50a	13.68a	2.31a

Mean with the same letter in each column for each factor are not significantly different ($p<0.05$) by DMRT

Table 3: Effect of NPK fertilizer rates and application method on fresh weight and dry matter accumulation of okra

Treatments	Fresh weight g plant^{-1}			Dry weight g plant^{-1}			
NPK (kg ha^{-1})	Leaf	Root	Stem	Leaf	Root	Stem	Fruit
0	60.50a	14.69a	31.94a	8.63a	2.23b	5.39b	23.21
150	63.18a	12.07a	25.02a	11.03a	3.28a	6.72b	24.11
300	66.93a	15.29a	33.59a	12.31a	4.43a	10.75a	25.63
Method of application							
Band	59.32b	15.82b	35.47	12.03b	3.01b	9.62b	21.56b
Ring	67.47a	16.21a	32.20	14.15a	4.32a	10.12a	24.10a

Mean with the same letter in each column for each factor are not significantly different ($p<0.05$) by DMRT

and number of branches irrespective of the method of fertilizer application although, those plants that received ring method of application gave the highest value in plant height, number of leaves, number of branches while there was significant ($p<0.05$) increase in leaf area and root length.

Effect of NPK Fertilizer Rates on Fresh Weight and Dry Matter Yield of Okra

Fresh leaf, root and stem weight was higher in treatments that received 300 NPK kg ha^{-1} than those that received 0 and 150 NPK kg ha^{-1} (Table 3). At higher fertilizer rate. Also, dry weight shows that only root and stem weight were significantly higher (4.43 and 10.75 g plant^{-1}). There was no significant difference in dry fruit weight. These findings are in accordance with previous reports of Obi *et al*. (2005) who reported no significant increase in both fresh and dry weight of okra plant with increasing NPK fertilizer treatment rates. Treatments having ring method of application gave significant difference ($p<0.05$) at leaf fresh and dry weight. There was also significant increase in fruit dry weight in treatment that received ring method of fertilizer application. This trend has been reported by Olufolaji *et al*. (2002) in a comparative evaluation study on soil and foliar applied fertilizer on growth and yield of celosia argentea reported increase in leaf area and fruit yield.

Effect of NPK Fertilizer Rates on Yield and Yield Components of Okra

The number of fruit per plant, fruit length, fruit girth and fresh fruit weight per plant (Table 4) were significantly ($p<0.05$) increased when 150 NPK kg ha^{-1} was applied. Trends in the data of yield and yield components was such that 150 NPK kg ha^{-1}>300 NPK kg ha^{-1}>0 NPK kg ha^{-1}. The ring method of fertilizer application gave a significant ($p<0.05$) increase in fruit length and fresh fruit weight per plant while there was no significant difference in fruit girth and number of fruit per plant. Okra yield and yield components were least without application of N, P and K nutrients. This confirms findings from earlier studies in Nigeria which showed that application of these nutrients are important for enhanced yield of okra (Adediran and Banjoko, 2003; Adepoju, 1995; Akintunde *et al*., 2000). Uyovbisere *et al*. (2000) noted that there was substantial depletion of nutrients when no NPK fertilizer was applied and that nitrates and available phosphorus were substantially reduced with cropping in humid zone of southwestern Nigeria.

Effect of NPK Fertilizer on Marketable Yield

Seed sown in 150 kg NPK ha^{-1} rate produced plants with the highest number of fruits. The lowest was produced at zero and 300 kg NPK ha^{-1}. Okra plant that received fertilizer by ring method

Table 4: Effect of NPK fertilizer rates and application method on yield and yield components of okra

Treatments NPK (kg ha^{-1})	Fruit length plant^{-1} (cm)	Fruit girth plant^{-1} (cm)	No. of fruit plant^{-1}	Fresh fruit weight plant^{-1} (g)
0	5.53c	6.88c	1.12b	40.96c
150	7.76a	10.00a	2.15a	48.96a
300	6.63b	8.60b	1.36b	46.83b
Method of application				
Band	5.96b	7.96a	1.52a	41.04b
Ring	7.34a	8.66a	1.76a	47.78a
Interactions effect				
Band method				
0	4.23c	6.35d	0.38c	17.38c
150	7.92a	9.71a	2.23a	19.32b
300	7.01a	9.69a	2.01b	11.40e
Ring method				
0	7.00a	6.01d	0.88c	18.20b
150	7.89a	8.23b	2.88a	22.16a
300	6.93b	7.06c	2.13b	16.92d

Mean with the same letter in each column for each factor are not significantly different ($p<0.05$) by DMRT, All the tables present results of two growing season, late season of 2005 and early season of 2006

of application produced the highest number of fruits. The interaction showed that Band-150 kg NPK ha^{-1} and Ring 150 kg NPK ha^{-1} produced the highest number of fruits which were not significantly different from each other. However, ring method gave the highest value. Also, there were significant interactions in fresh fruit weight between the two methods of application. Ring method significantly ($p<0.05$) gave the highest fruit weight per plant.

CONCLUSIONS

The result showed that NPK fertilizer rates and methods of application have a profound effect on the overall performance of okra. Application of NPK fertilizer at the different levels used in this study had significant effect on the growth characters except number of leaves. Similarly, NPK fertilizer at different levels had significant effect on the yield and yield components of okra. Methods of application had significant effect only on fruit length and fruit fresh weight. Fertilizer application rate of 150 kg NPK ha^{-1} and ring method of fertilizer application are effective for the growth and yield of okra.

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