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Full Length Research Paper

Soil status and yield response of different varieties of okra (*Abelmoschus esculentus* (L.) Moench) grown at Mubi floodplain, North Eastern, Nigeria

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The performance of three okra *Abelmoschus esculentus* L. Moench varieties were evaluated under irrigation on the floodplain soils of Mubi, north eastern Nigeria. The treatments consisted of three okra varieties: V_1 (improved), V_2 (serial) and V_3 (local okra) laid out in a randomized complete block design and replicated three times. The land was cleared, ploughed, harrowed, leveled and marked into blocks and plots with 1 m between replication and 0.5 m between plots. Okra seeds were sown by dibbling 3 seeds per hole at 50 cm × 50 cm spacing. The seedlings were later thinned to two plants per stand two weeks after emergence. Phosphorus fertilizer was applied in split doses at the rate of 45 kg P_2O_5 ha^{-1} as single super phosphate. Nitrogen was also applied 2 to 4 weeks after emergence as urea at the rate of 40 kg ha^{-1}. The plots were irrigated on weekly bases. The results obtained were subjected to analysis of variance and means separated using Duncan's multiple range test. Significant ($p<0.05$) differences were observed for all the parameters measured. V_1 (improved) recorded the highest fresh fruit yield of 10.7 tons/ha as compared to V_3 (local) that recorded the lowest fresh fruit yield of 4.9 tons/ha. It was observed that V_1 (improved okra) responded well at this floodplain and performed better in terms of yield output in this region.

Key words: *Abelmoschus esculentus,* flood plain, soil status, varieties.

INTRODUCTION

Okra *Abelmoschus esculentus* (L.) Moench, is an annual crop, requiring warm growing condition and found in almost every market all over Africa (Schippers, 2000). Okra contains carbohydrates, proteins and vitamin C in large quantities and also essential and non essential amino acids which are comparable to that of soybean (Adeboye and Oputa, 1996). It is grown mainly for its leaves and young pods which are frequently eaten green as vegetable. Therefore, the consumption of okra plays an important role in human nutrition. Worldwide production of okra as fruit vegetable was estimated at 6,000000 tons per year. In West Africa, it was estimated at 500,000 to 600,000 tons per year (Burkill, 1997).

Schippers (2000) observed a great diversification of okra with the most important production regions localized in Ghana, Burkina Faso and Nigeria. Two main varieties, the dwarf and the tall type were also observed in okra cultivated areas. Vegetable crops such as tomatoes, sorrel, amarantus, cabbage, sesame okra, pepper, onions, etc, are largely cultivated under irrigation on the floodplain soils in Nigeria. The floodplain soils potential is highest in Adamawa State (625,000 ha.), based on available area for irrigation and free of forest cover and requires no drainage (Ramalan et al., 1998). These areas have potential for irrigation, using underground and surface water; they remain still under-developed limiting significant commercial activities. FAO (1986) indicated that knowledge of the soil within a potential irrigation area is essential for economic and technical reasons. The design of the irrigation scheme itself is dependent on detail knowledge of soils lying within the irrigable floodplain

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areas. Ojanuga et al. (1996) states that wetland soils are grossly underutilized in Nigeria for any kind of purpose, especially in the drier Guinea, Sudan and Sahel savannas where wetland are loci for permanent agriculture. This important vegetable like any other crop requires increased productivity through the use of appropriate variety. The use of local varieties has attracted less attention by farmers due to low yield. Problems of pest and disease were observed affecting the performance of the crop. In a previous study conducted by Alfredo and Arturo (1999) they pointed out that changes in weather have been recorded to affect the growth pattern and consequently, the productivity of okra. Okra is sensitive to low temperatures and develop poorly below 15℃ (Marsh, 1992). Reports of MacGillvray (1953) also indicate that okra requires high temperatures of about 70℃ and long-day length for optimum growth and development. Studies on the optimum weather requirement for high yield okra in the tropics show that okra does best when the minimum and maximum temperatures are 18^o and 35℃, respectively (Ezeakunne, 1984). Grubben (1997) observed temperatures of between 25 to 40℃ for optimum growth and yield of okra, while Oyolu (1977) recorded a critical day length of 12½ h for flower initiation and fruit yield. Welby and McGregor (1997) observed an improvement in the performance of okra when rainfall was about 750 mm, evenly distributed and relative humidity was between 90 to 95%. However, low temperatures of 28.9 to 29.2℃ (maximum) and 17.9 to 19.8℃ (minimum) and short day-lengths of 5.2 to 5.7 h resulted in a higher number of flowers (Thamburaj, 1972). Adeniji (2003) in previous study on performance of different varieties of West African okra, observed that improved and serial varieties produce high yield. Researches on okra has been conducted at National Horticultural Research Institutions (NIHORT) Ibadan and Institute for Agricultural Research (IAR), Ahmadu Bello University ABU, Samaru Zaria, where much emphasis on agronomy and physiology performance improvement programme has made little progress due to the fact that okra continues to be regarded as a marginal crop. In tropical Africa, a wide variety of cultivations are adopted to various environments and selected for various uses (Ado et al., 1987). Okra plant is largely cultivated under irrigation on the floodplain soils during dry season in Nigeria. The production and economic importance of okra as a vegetable in Nigeria has rapidly increased in recent years. Different varieties were used by farmers in order to meet the demand of okra by consumers. These varieties have different response on a given soil and season. The seasonal supply of this vegetable to a large extent affects how much of it is consumed by majority of the people. Information on soil status and yield response of these varieties of okra grown on the floodplain soil was not document in literatures though other studies were conducted. Therefore, this research was carried out to assess the soil status and yield response of different varieties of okra mostly grown on the floodplain soils of Mubi north eastern Nigeria.

MATERIALS AND METHODS

The experiment was conducted during 2010 dry season at Mubi flood plain Adamawa State, north eastern Nigeria, located at latitude 10° 11' North of the equator and longitude 13° and 13' East of Greenwich Meridian. The area is sparsely populated, with an estimated population density of 19 to 22 people/km^2. Agriculture is the most important economic activity in the area, employing more than 90% of the labour force. Most of the farmers are subsistence oriented.

The area received an annual rainfall of 700 to 1600 mm. Rainfall distribution is unimodal, with much of the rain falling between May and October. The wettest months are August and September (Adebayo, 1997). The rainy season is followed by a long dry season. During this period, the area comes under the strong influence of the harmattans (winds that originate in the Sahara and blow across the Sahel region). The harmattans are very dry, and, as a result, humidity may be as low as 10 to 20% during the dry season. Dry land farming usually begins in November and run through May.

The temperature characteristics are typical of the West African savannah climate. Temperature in this climate region is high throughout the year because of high radiation income, which is relatively evenly distributed throughout the year (Adebayo and Tukur, 1999). Maximum temperature can reach 40℃ particularly in April while minimum temperature can be as low as 18℃ between December and January. The mean monthly temperature ranges from 26.7℃ in the south to 27.8℃ in the northeastern part (Kowal and Knabe, 1972).

Humidity follows the simple relationship with the change of the seasons. It is generally lowest in the dry season about 20% and is very high in the wet season about 80% in August. An increase in the humidity always precedes the onset of the rains in May.

With the southerly movement of the inter-tropical convergence zone from October to April, the wing blows consistently from the north or more often the northeast. During this period the area is exposed to very dry winds blowing from the Sahara, the hamattan, often carrying a thick haz of wind borne, conspicuously diatomaceous dust (Carroll and Hope, 1970). From May throughout the summer it rains until September, the direction is reversed and the wind blows mainly across the area from the southeast.

This area is richly supplied with a network of river and streams. River Yedsarem form the major river and joined by numerous tributaries. The topography is generally flat, becoming undulating and hilly toward the northeast. Altitudes range from 820 to 850 m above sea level.

The soils are generally young and do not show horizon differentiation. The soils are fairly good, belonging to capability classes II and III, and are somewhat uniform across the study area. One distinct soil class can be identified as "Typic Topaqualf "(United States Department of Agriculture [USDA] classification), or "Gleyic Cambisol "(FAO).

Experimental design

The land was cleared, ploughed, harrowed and leveled manually using hand hoe. The field was marked into blocks and plots in a randomized complete block design (RCBD). There were three replications and three treatments. Each block had three treatments making a total of nine plots.

Experimental design consists of three okra varieties viz: local dwarf, improved and serial varieties obtained from local market. The treatments were laid out in a randomized complete block design (RCBD) replicated three times. The total land area of the experiment was 77 m^2. Each plot was 2 m × 3 m (6 m^2), with 1 m between replication and 0.5 m between each plot. Prior to sowing, the seeds were soaked in water to determine its viability through floating method. Three seeds per hole were sown at the depth of 3 to 5 cm and spacing of 50 × 50 cm. The seedlings were later thinned to two plants per stand two weeks after emergence making a total of 16 plants per plot. Weeding commenced at two weeks after sowing and subsequent weeding was carried out at 7 and 12 weeks after sowing to minimize weed interference. Hypermethricin at the rate of 4 L ha^{-1} was sprayed 4 weeks after sowing to control aphis and other insects associated with okra plant. Subsequent spraying was done at the interval of three weeks to the completion of harvest.

Phosphorus fertilizer was applied in split doses at the rate of 45 kg P_2O_5 ha^{-1} as single super phosphate. Nitrogen was also applied 2 to 4 weeks after emergence as urea at the rate of 40 kg ha^{-1}. The plots were irrigated on weekly bases.

Eight plants each per plot were randomly selected for determination of growth and yield parameters. Successive harvesting was done at three days interval as fruits reach market size. Number of fruits was counted on each occasion and fresh pod weight obtained to determine yield. The harvesting of the okra fruits were done at the proper early stage which indeed enhanced the blooming of the plants. The parameters assessed included, plant height at 2, 4 and 12 weeks after sowing (WAS), number of branches per plant at 12 WAS, days to 50% flowering, number of fruit at 1, 2 and 3rd week of harvest, fruit length (cm), harvested fruit weight (g) and yield of fresh fruit (kg/ha).

Soil analysis

Prior to sowing, soil samples from the study area were collected air-dried for two days at 28°C, crushed in wooden mortar and sieved with a mesh of 2 mm diameter. All soil samples were analyzed for pH (1:2.5) soil to water ratio using glass electrode pH meter as described by Bates (1954). Particle size was determined using hydrometer method as described by Bouyoucos (1951), electrical conductivity, soil organic carbon using chromic acid oxidation procedure (Walkley and Black, 1934). Available phosphorus was extracted with 1 N NH_4F and 0.5 N HCl (Bray and Kurtz, 1945) at the wavelength of 660 nm, the titrimetric method for the determination of calcium and magnesium in the soil as described by Black (1965), the regular Macro-Kjeldahl method as described by Black (1965) was used for the determination of soil total nitrogen, potassium and sodium was determined in 1 N neutral NH_4OAc soil extract using flame photometry and exchangeable acidity (The Titration Method) as described by Mclean (1965). The effective cation exchange capacity (ECEC), and CEC were determined by summation method. The exchangeable sodium percentage was obtained by expression the exchangeable sodium as percentage. The percentage base saturation was obtained by expression of the CEC as a weight percentage of ECEC. The sodium adsorption ration was obtained by dividing the ion concentration of the sodium with the square root of the sum of ½ the ion concentration of calcium and magnesium.

The data obtained were subjected to analysis of variance and means separated using Duncan's multiple range test (SAS, 1993).

RESULTS AND DISCUSSION

Soil status

The soil from the study area was loamy in texture (Table1). The soil pH measured in water was neutral indicating that the pH range is optimum for the irrigation of most crops, but proper management should be maintained in order to reduce the chances of alkalinity hazards. The value of the organic carbon content was of high class (1.86%) indicating that the soil was high in organic matter content. The nitrogen content of the soil was very low (<0.05%) and far below 0.15% critical level recommended (Solulo and Osiname, 1981; Agboola et al., 1982). The phosphorus content was below the recommended critical level 8.51 $mgkg^{-1}$ soil (Agboola et al., 1982) indicating serious deficiency problem of phosphorus. The exchangeable potassium value (1.46) cmol (+) kg^{-1} soil is rated very high (Sobulo and Osiname, 1981).

The value of exchangeable calcium (7.6) cmol (+) kg^{-1} soil indicates moderate calcium status in the soil. Exchangeable Mg was high (3.6) cmol (+) kg^{-1} soil. Thus, Mg is likely to constitute constraints to agricultural productivity in this soil. The exchangeable sodium percentage (ESP) of the soil does not exceed 15%. This indicates that salinity problem is not anticipated in this area for now. Effective cation exchange capacity was low (12.86) cmol (+) kg^{-1} soil. This could be attributed to the low clay content of the soil, and this agreed with the findings of (Lombin and Knabe, 1981). The floodplain soils of Mubi in its present status have low to moderate nutrient with moderate buffering capacity. Therefore, the application of either organic or inorganic fertilizer is required to enhance crop growth and performance. Regular soil evaluation becomes imperative in order to check nutrient imbalance.

Vegetative parameters

The influence of variety on the height of okra and the number of branches is presented in Table 2. The Serial okra variety (V_2) recorded the highest mean of 10.3 at 2 WAS and 22.1 at 4 WAS whereas the highest mean of 32.2 at 12 WAS was recorded by improved (V_1) okra variety. Significant ($p<0.05$) differences were observed among all the means. The local (V_3) okra variety was shorter in height as compared to improved and serial varieties. It was also noticed that, the improved and serial varieties performed better during the dry season irrigation with high temperature. These findings agreed with that of Thamburaj (1972), who reported that taller okra plants were obtained at maximum temperature of 25 to 35°C. High maximum temperature was experienced during the vegetative growth and consequently more assimilates production which probably induced better yield in the dry season. This result supports similar work on okra by Randhawa (1967) who reported that growth and development of okra can be influenced by season.

The number of branches at 12 WAS for all the 3 varieties recorded a significant ($p<0.05$) difference (Table 2). V_1 produced the highest number of branches (7.7) than that of V_2 and V_3. The higher number of branches

Table 1. Characteristics of Mubi floodplain soils, north eastern Nigeria.

Textural class	pH (1:2.5) in H_2O	O/C	% N	P mg/kg-1	K Cmol(+)kg-1	Na Cmol(+)kg^{-1}	Ca Cmol(+)kg^{-1}	Mg Cmol(+)kg^{-1}	EC (ms/cm)	ECEC Cmol(+)kg^{-1}	ESP	PBS	SAR
Loam	7.3	1.87	0.03	6.6	1.46	0.12	7.6	3.6	0.08	12.86	12	99.3	0.051

Table 2. The effect of varietal difference on the height of okra at 2, 4 and 12 weeks after sowing (WAS) and number of branches per plant at 12 WAS.

Okra variety	Plant height at 2 weeks (cm)		Plant height at 4weeks (cm)		Plant height at 12weeks (cm)		No. of Branches/plant	
	Mean	S.E	Mean	S.E	Mean	S.E	Mean	S.E
V_1	11.7_a	±1.28	21.0_a	±1.65	34.2_a	±1.01	7.7_a	±0.33
V_2	10.8_a	±0.47	22.1_a	±0.81	32.7_a	±0.75	6.3_b	±0.33
V_3	7.1_b	±0.61	14.1_b	±1.43	25.2_b	±1.05	5.0_c	±0.00
Significance	*		*		*		*	

Means with the same letter are not significantly different (Duncan's multiple range test at $p< 0.05$).*: Significant; SE: standard error; V_1 :improved okra; V_2: serial okra; V_3: local okra.

could in turn lead to higher fruit production. The three okra varieties differed in the number of branches.

Fruit parameters

Number of fruits at 1st, 2nd and 3rd harvest is summarized in Table 3. Significantly ($p<0.05$) high number of fruits were produced with V_1 in all the three harvesting periods as compared to other treatments. Lower numbers of fruits were recorded with V_3. This performance may not be unconnected with the more favourable environmental conditions provided during the dry season irrigation. This result corroborates the findings of Katung (2007) who reported that changes in environmental conditions influence the growth and performance of okra. Abdul and Aarf (1986) also observed that the number of fruits of okra per plant increases under optimum environmental conditions and performs well.

The effect of varietal difference on fruit length (cm), days to 50% flowering, harvested fruit weight (g) and yield of fresh fruit (kg/ha) is presented in Table 4. The results showed that the response of fruit length, was significant ($p<0.05$) with V_1 recording the highest fruit length of 7.23 cm and V_3 the lowest with 4.87 cm. Significant difference was also observed with days to 50% flowering V_2 recorded the lowest days (58) to flowering as compared to V_1 (66) and V_3 (71), respectively. This result therefore implies that V_2 (serial variety) matures earlier than other varieties and stands a better chance of return. This, however, may be due to the fact that the floodplain soil, prevailing climate and environmental condition and dry season irrigation may have been more conducive to allow for better expression of the genetic potentials of the varieties thereby eliciting their differential performance. Also, the most important factor of production solar radiation might have been utilized differently by the varieties. Several researchers have noted that the yield advantage of one variety over other variety varies by environment (Foley et al., 1986; Wilcox, 1998). This is in agreement with these findings because the environment may not be favourable in same manner to all the varieties.

Conclusion

The optimum productivity of Okra grown on floodplain soil in Mubi during the dry season irrigation is considered more appropriate. V_1 (improved) and V_2 (serial) varieties performed better than the V_3 (local okra) variety during the dry season irrigation period. V_3 recorded the harvest fresh fruit yield of 4.9 tons/ha as compared

Table 3. The effect of varietal difference on the number of fruit at 1, 2 and 3rd week of harvest.

Okra variety	No. of fruit at 1st wk of harvest		No. of fruit at 2nd wk of harvest		No. of fruit at 3rd wk of harvest	
	Mean	S.E.	Mean	S.E.	Mean	S.E.
V_1	12.33_a	±0.33	13.67_a	±0.33	16.67_a	±0.33
V_2	11.00_a	±0.58	13.00_a	±0.00	15.67_a	±0.33
V_3	9.00_b	±0.58	10.00_b	±0.58	12.33_b	±0.33
Significance	*		*		*	

Means with the same letter are not significantly different (Duncan's multiple range test at p< 0.05). *: Significant; SE: standard error; V_1:improved okra; V_2: serial okra; V_3; local okra.

Table 4. The effect of varietal difference on fruit length (cm), days to 50% flowering, harvested fruit weight (g) and yield of fresh fruit (kg/ha).

Okra varieties	Fruit length (cm) at harvest		50% Days to flowering		Harvested fruit weight (g)		Yield of fresh fruit (tons ha^{-1})	
	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.
V_1	7.23_a	±0.49	66_b	±0.33	802.68_a	±49.43	10.7_a	±0.66
V_2	7.10_a	±0.31	58_c	±0.33	727.17_a	±9.44	9.7_a	±0.12
V_3	4.87_b	±0.58	71_a	±0.58	370.99_b	±40.49	4.9_b	±0.54
Significance	*		*		*		*	

Means with the same letter are not significantly different (Duncan's multiple range test at p< 0.05). *: Significant; SE: standard error; V_1: improved okra; V2: serial okra; V_3: local okra.

to V_1 that recorded the highest fresh fruit yield of 10.7 tons/ha.

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