EVALUATION OF FOUR OKRA (*ABELMOSCHUS ESCULENTUS* L. MOENCH) CULTIVARS FOR GROWTH AND YIELD UNDER THE SOUTHERN GUINEA SAVANNAH AGRO-ECOLOGICAL ZONE

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Abstract
Poor planting genotype is one of the leading causes of low productivity of okra in Nigeria. The existing varieties either are not adapted to the local conditions or have become mixed probably due to exchanges at border communities. To improve productivity of okra, new cultivars with excellent growth and yield attributes must be identified and incorporated into the farming systems. A field experiment was conducted at the Teaching and Research Farm of the University of Agriculture, Makurdi during the 2012 cropping season to evaluate the yielding potentials of four okra cultivars and the nature of association between yield and yield components. The experimental design used was a randomized complete block design with four replications while the four okra cultivars (47-1, LD88, NGO-07 and local) constituted the treatments. Data was collected on ten agronomic characters namely plant height, number of leaves per plant, fruit girth, fruit length, fruit weight, leaf area, number of fruits per plant, days to first flowering, days to 50% flowering and fruit yield. Data were subjected to analysis of variance using the GenStat Software 2011 Edition and correlation analysis was done using the SPSS statistics version 20. Results of the analysis of variance showed significant varietal effect for all the characters except for fruit girth, fruit length, and days to 50% flowering, indicating that the cultivars are genetically diverse. The high values obtained for yield, fruit weight and number of fruits per plant observed among the cultivars is evident that they are promising at Makurdi. NGO-07 gave fruit yield that was 143.97, 88.28 and 38.89% higher than the yield obtained from local, LD88, and 47-1 cultivars, respectively. Thus, NGO-07 is a promising genotype for Makurdi and other places with similar conditions. The results of the correlation analysis showed that the number of fruits per plant (0.954**), number of leaves per plant (0.508*) and plant height (0.556*) had positive significant correlation with fruit yield. This result indicated that selection of cultivars based on these characters would substantially increase fruit yield.
Keywords: Okra, cultivars, correlation, variation, fruit pods

Introduction

Okra (*Abelmoschus esculentus* L. Moench) belongs to the family *Malvaceae*. Although a native of tropical Africa, okra is presently cultivated in many parts of the world including the subtropical and warmer parts of the temperate regions (Varmudy, 2011). Nigeria is the second largest producer of okra in the world accounting for about 15.4% of the world production (Varmudy, 2011). The immature fruits attract premium prices in Nigerian markets probably due to its drawing property which is used in thickening soups (Schipper, 2000, Farinde *et al*., 2006). They are cherished as important sources of dietary minerals and vitamins and its consumption has extended to countries in Europe and North America. Okra seeds contain 18-20 percent oil and 20-23 percent crude protein while the leaves serve as feeds for animals (Varmudy, 2011). It has also been reported that okra fruits have medicinal, health and industrial applications (Markose and Peter, 1990; Lengsfelf *et al*., 2004; Barrett, 2013).

To date, the yield of okra in Nigeria is low (2.7 t/ha) compared to other countries such as India (10.50 t/ha), Sudan (10.2 t/ha), Egypt (15.7 t/ha), Pakistan (7.6 t/ha), Saudi-Arabia (11.5 t/ha) and Ghana (5.5 t/ha) (Varmudy *et al*., 2011) and it is regarded as a minor vegetable crop. Most of the okra produced and consumed in Nigeria is grown in intercrop systems as a measure to augment its low productivity and production is predominantly in the hands of peasant farmers. (Ibeawuchi, 2007, Ijoyah and Jimba, 2012, Ijoyah and Anyam, 2013; Ehirim *et al*., 2014). This low yield may be attributable to the poor yielding genotypes that are used by the farmers (Manyong, 2002).

Fruit yield in okra is a complex trait that is governed by several yield components that are interrelated. The significance of number of pods per plant, early flowering and fruit weight in determining fruit yield in okra cultivars has been widely investigated by several workers (Demrany and Faraq, 1994; Khan *et al*., 2002; Chaudhary *et al*., 2006; Rahman *et al*., 2012). Jamala *et al*. (2011) compared the yield performance of a local variety and an improved cultivar in Mubi and found that the improved cultivar was superior to the local in terms of pod yield. To date, there is paucity of data on the yield potentials of some new okra cultivars that are cultivated in makurdi. Thus, this study was designed to investigate the yield potentials of new cultivars that can replace the existing ones for increased productivity.

Materials And Methods

Field study was conducted at the Teaching and Research Farm of the University of Agriculture, Makurdi during 2012 cropping season to evaluate the breeding potentials of four okra cultivars popularly cultivated in Makurdi. Makurdi is

located on latitude $7^0 41'$ and Longitude $8^0 35'$ and it is a location within the Southern Guinea Savannah Agro-ecological Zone.

Three improved okra varieties were obtained from the Vegetable Unit of the University of Agriculture, Makurdi and a local cultivar sourced from the local farmers comprised the experimental materials. The experimental design used for the study was a randomized complete block design, replicated four times. A piece of land measuring 156.60 m^2 was cleared and divided into sixteen equal plots in which beds were raised. Each plot measured 1.8m x 3.75m (6.75m^2) consisted of 25 plants spaced 0.3m within row and 0.75 cm between rows. Plots were detached by path distance of 0.5m within and 1m between replications. Standard cultural practices were maintained throughout the experimental period to give the cultivars a favorable environment to fully express their genetic potentials. Five plants were randomly chosen and tagged for data collection. Data were taken on plant height, number of leaves per plant, fruit girth, fruit length, fruit weight, leaf area index, number of fruits per plant, days to flowering, days to 50% flowering and fruit yield. Data collected were subjected to analysis of variance to partition the variance into the various causes and principal components analysis was performed on the traits to identify the most important traits contributing to genetic diversity in okra species using GenStat Release 7.22 DE (2009). Correlation analysis was also done to investigate the nature of association that existed between yield and its components using SPSS version 20. Significant means were separated using the Least Significant Difference as described by Steel and Torrie (1980).

Results and Discussion

Results of analysis of variance on some okra characters

The result of the analysis of variance showed that highly significant ($P<0.01$) cultivar effect was observed for plant height, number of leaves per plant, fruit weight and leaf area index (Table 1). Number of fruits per plant, days to first flowering and fruit yield were also significantly ($P<0.05$) different among the cultivars. Non-significant ($P>0.05$) cultivar effect was noticed in fruit girth, fruit length and days to 50% flowering. The result suggests the presence of tremendous variation among the four cultivars studied except for those characters that were not significant. The presence of wide genetic variability provides an indication of a better scope for genetic improvement. Similar results were reported by other workers (Akortkar *et al*., 2010; Ade-Oluwa and Kehinde, 2011; Simon *et al*., 2013) who also investigated genetic variability in okra and found significant cultivar effect in all the studied traits.

Plant height (cm): Significant cultivar effect was observed for plant height. Maximum height (42.60 cm) was recorded in NGO-07 whereas the local (24.60 cm) gave the minimum, but NGO-07 and LD88 were statistically at par. In the same vein, LD88 and 47-7 had heights that were statistically at par but significantly higher than the local. Khan *et al*. (2002) and Rahman *et al.* (2012) also reported significant differences for plant height among the five okra varieties evaluated in Pakistan.

Number of leaves per plant: Number of leaves per plant is considered a crucial component for yield in okra because of its usefulness as the facility for photosynthesis. The four okra cultivars varied significantly among themselves with respect to number of leaves per plant. The highest number of leaves was obtained from plots that were sown with NGO-07 (16.75), followed by 47-7 (15.50) and LD88 (14.00), but all these three cultivars were at par except the local cultivar (6.50) which had the least number of leaves per plant. Previous workers also found significant cultivar effect on number of leaves per plant (Falusi *et al*., 2012).

Fruit girth (cm): No significant cultivar effect was noted with respect to fruit girth. It showed that the cultivars did not differ with respect to fruit girth. However, the cultivar 47-7 recorded the largest girth of 1.90 cm whereas the least was observed in the local (1.70cm). Khan *et al*. (2002) also observed a non-significant cultivar effect on fruit size in their study.

Fruit length (cm): Significant cultivar effect was observed in the fruit length. The cultivar 47-7 had maximum fruit length of 10.42 cm while the minimum occurred in the local (8.57 cm). However, the fruit length for plots sown with 47-7, NGO-07 and LD88 were not statistically different indicating that they did not differ in terms of fruit length.

Fruit weight (g): The result of the fruit weight indicated that the four okra cultivars were significantly different. The cultivar 47-7 produced significantly heaviest (31.90 g) fruits compared to the other cultivars, suggesting that fruit weight is governed by fruit girth and length. NGO-07, LD88 and Local were not significantly different with regard to fruit weight, though noticeable differences existed among them, but such differences were not significant. Khan *et al*. (2002) and Rahman *et al*. (2012) also recorded significant effect of cultivar on single fruit weight.

Leaf area (cm^2): The cultivars differed significantly with respect to leaf area. The cultivar 47-7 (326.0 cm^2) and local (84.0 cm^2) had the highest and least leaf area observed in the present study. The result indicated that LD88 (279.0 cm^2) and NGO-07 (228.0 cm^2) had leaf area that were statistically at par but significantly higher than the local (84.0 cm^2). Okonmah (2011) had reported a significant effect of leaf area at 6, 8 and 10 weeks after planting on the three cultivars of okra evaluated in Asaba, Nigeria.

Number of fruits per plant: Number of pods per plant showed significant effect among the okra cultivars. The cultivar NGO-07 produced 12.50 fruits which were significantly higher among the cultivars evaluated. The number of fruits per plant produced by 47-7, LD88 and local was 7.88, 7.38 and 5.50, respectively and all these three cultivars were statistically at par to one another. This result appears to suggest that the three cultivars possessed similar fruiting potentials. This result corroborates the earlier reports of several authors (Choudhary *et al*., 2006; Hussain *et al*., 2006; Sachan, 2006; Bello *et al*., 2006; Rahman *et al*., 2012) who also had significant effect of number of pods per plant in different okra cultivars. However, our finding contradicts the findings of Khan *et al*. (2002) who had noted a non-significant effect of cultivar on number of pods per plant in Pakistan.

Days to first flowering: The result of the analysis pertaining to days to first flowering revealed a significant behavior. Statistically similar result was obtained in LD88, 47-7 and local that took 59.50, 57.50, 57.00 days to commence flowering, whereas NGO-07 (54.25) took significantly the lowest number of days to flower. The differential performance of the cultivars to flowering may have been influenced by their unique genetic characteristics. Our results are supported by previous works (Khan *et al*., 2002; Ashraful and Hossain, 2006; katung, 2007; Rahman *et al*., 2012).

Days to 50% flowering: The variation due to days to 50 % followed a similar pattern as noticed in days to flowering. The plots that were sown with NgO-07 had half of their plants population flowered earliest with 58.75 days after planting, which is significantly different from the other cultivars. Maximum days to 50% flowering occurred in LD88 (64.75), closely followed by local (60.75) and 47-7 (60.50) in that order, but all these cultivar were statistically at par with one another. Rahman *et al*. (2012) had observed a range of 52.67-58.67 days to fruit setting in their study.

Fruit yield per plot (kg/ha): The maximum fruit yield of 932.0 kg/ha was recorded in NGO-07 which was significantly higher than the yield produced by LD88 and local but statistically similar to 47-7. The local (382.0 kg/ha) had the minimum fruit yield, making it inferior to the rest of the cultivars. The result also showed that 47-7 (671.0 kg/ha), LD88 (495.0 kg/ha) had intermediate performance, but altogether were statistically not different from the local. This result proved the superiority of the improved cultivars over the local. Jamala *et al*. (2011) had reported a similar observation. NGO-07 gave the highest fruit yield, the local produced the least, while 47-7 and LD88 showed intermediate performance. This result appears to support the hypothesis that early flowering may have conferred NGO-07 a better opportunity for early and longer fruit setting period which consequently influenced its yielding advantage over the others. This observation is in line with the reports of other researchers (Khan *et al*., 2002; Rahman *et al*. (2012) who also found highest pod yield in plots that flowered earliest and also had the highest pods per plant.

Genetic diversity studies on okra characters using principal component analysis

The result of the principal component analysis (PCA) is presented in Table 3. The result of the PCA, indicated that PC1 accounted for 57.50 % of the total variation and was affected by plant height, number of leaves per plant, fruit length, number of fruits per plant, and fruit yield. The PC2 and PC3 contributed 33.70 and 8.80 %, respectively. PC2 was associated with fruit girth, leaf area and days to first flowering while variation at PC3 was attributable to fruit weight and days to 50% flowering. This result implied that traits such as plant height, number of leaves per plant, fruits per plant, fruit length, fruit yield, fruit girth, leaf area and days to first flowering which associated with PC1 and PC2 are implicated for being responsible for the phenotypic divergence observed in the cultivars and can be used for cultivar discrimination.

Correlation studies on ten okra characters evaluated in Makurdi

The result of analysis of correlation of okra characters revealed that fruit yield correlated positively and highly significantly with number of fruits per plant (0.954**) but negatively with days to first flowering (- 0.404) as shown in Table 3. This result showed that early flowering cultivars have advantage over late flowering ones as it allows for a longer duration of fruiting which ultimately influences fruit yield. Simon *et al*. (2013) also reported a negative relationship between days to flowering and fruit yield. Fruit yield also associated significantly with plant height (0.556*) and number of leaves per plant (0.508*), indicating that cultivars with these characteristics may be selected for increased okra fruit yield. Although Simon *et al*. (2013) observed a significant correlation between fruit weight and fruit yield, the present study showed a non-significant association between the two characters.

Conclusion

Knowledge of the extent of variation among okra cultivars and the nature of the association between characters provide useful information for selecting appropriate procedure for crop improvement. The present study demonstrates the superiority of NGO-07 over 47-7, LD88, and local cultivars in terms of having better growth and yield potentials under Makurdi climatic and soil condition. It also revealed the relationship between fruit yield and its components as they affect fruit yield.

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Table 1. Mean square estimates from ANOVA of yield and yield components of Okra evaluated at Makurdi during 2012 cropping season

Source of variation	Df	Plant height (cm)	No. of leaves/ plant	Fruit girth (cm)	Fruit length (cm)	Fruit weight (g)	Leaf area (cm^2)	No. of fruits/ plant	Days to first flowering	Days to 50% flowering	Fruit yield (Kg/plot)
Rep	3	91.04	6.729	0.03667	0.866	22.788	2487.0	3.354	1.729	13.562	45350.0
Variety	3	241.33**	84.56**	0.042^{NS}	4.43^{NS}	29.12**	43944**	35.35*	18.73*	25.73^{NS}	229614*
Error	9	21.24	8.729	0.03167	1.402	3.285	3974	6.312	2.840	8.507	46027

NS=Not significant, *=Significant at 5% probability level, **=Significant at 1% probability level

Table 2. Performance of four okra cultivars evaluated at Makurdi during 2012 cropping season.

Trait	Plant height (cm)	Number of leaves/ plant	Fruit girth (cm)	Fruit length (cm)	Fruit weight (g)	Leaf area (cm^2)	Number of fruits/ plant	Days to first flowering	Days to 50% flowering	Fruit yield (kg/plot)
47-1	37.60	15.50	1.90	10.85	31.90	326.0	7.88	57.50	60.50	671.00
LD88	31.60	14.00	1.88	10.42	26.42	279.00	7.38	59.50	64.75	495.00
NGO-07	42.60	16.75	1.73	10.67	27.75	228.00	12.50	54.25	58.75	932.00
LOCAL	24.60	6.50	1.70	8.57	25.97	84.00	5.50	57.00	60.75	382.00
MEAN	34.10	13.19	1.80	10.13	28.01	230.00	8.31	57.06	61.19	620.00
LSD(0.05)	7.37	4.73	0.28	1.89	2.90	100.80	4.02	2.70	4.67	343.20
CV (%)	13.50	22.40	9.90	11.70	6.50	30.20	27.50	3.0	4.80	34.60

CV=coefficient of variation

Table 3. Principal component analysis showing the percentage contribution of okra characters to total variation.

Variable	**PC1**	**PC2**	**PC3**
Plant height	0.412	0.076	-0.071
Number of leaves per plant	0.400	-0.112	-0.206
Fruit girth	0.147	-0.506	0.118
Fruit length	0.384	-0.205	-0.120
Fruit weight	0.271	-0.163	0.744
Leaf area index	0.313	-0.360	0.022
Number of fruits per plant	0.350	0.236	-0.350
Days to first flowering	-0.183	-0.488	-0.088
Days to 50% flowering	-0.165	-0.437	-0.478
Fruit yield	0.383	0.208	-0.106
Proportion (%)	**57.50**	**33.70**	**8.80**
Cumulative (%)	**57.50**	**91.2**	**100.00**

Table 4. Correlation coefficients of some characters of okra cultivars evaluated at Makurdi.

TRAITS	No.of leaves per plant	Fruit girth (cm)	Fruit length (cm)	Fruit weight (g)	Leaf area $(cm)^2$	No. of fruits per plant	Days to first flowering	Days to 50% flowering	Fruit yield (Kg/plot)
Plant height	0.850**	0.117	0.510*	0.556*	0.528*	0.447	-0.319	-0.176	0.556*
NOL/P		0.281	0.653**	0.413	0.795**	0.442	-0.092	0.055	0.508*
FG			0.400	0.173	0.414	-0.016	0.521*	0.636**	0.19
FL				0.138	0.432	0.320	0.162	0.343	0.035
FW					0.516*	0.155	-0.540	-0.339	0.418
LA						0.341	0.166	0.095	0.443
NOF/P							-0.443	-0.360	0.954**
DFF								0.845**	-0.404
D50%F									-0.418

*, **, significant at 0.05 and 0.01, respectively.