Journal of Biology, Agriculture and Healthcare
ISSN 2224-3208 (Paper) ISSN 2225-093X (Online)
Vol.4, No.13, 2014

Ontogenesis of West African Okra (*Abelmoschus. Caillei* (A.Chev) and Conventional Okra (*Abelmoschus. esculentus* (L. Moench) V*a*rieties and its Effects on Fresh Pod Yield in Umudike in Southeastern Nigeria in 2009 and 2010 Cropping Seasons

Lawrence Chinatu*, Peter Okocha and Mathias EKA
Department of Agronomy, College of Crop and Soil Sciences, Michael Okpara University of Agriculture, Umudike.P.M.B. 7267, Abia State, Nigeria
*Email: lawrencechinatu@yahoo.com

Abstract
Ten elite varieties of *A. caillei* and *A. esculentus* were evaluated to understand their developmental phases and their impact on fresh pod yield in 2009 and 2010 cropping seasons at Michael Okpara University of Agriculture, Umudike, research farm. The field experiments were carried out in randomized complete block design with three replications. The seeds were planted in May, data collected from germination to end of life cycle were subjected to analysis of variance (ANOVA). The ANOVA showed that the species were the same ($P>0.05$) with respect to number of days from seed planting to germination, flowering to podding and hours from flower bud maturity to anthesis. The other stages in vegetative and reproductive phases were highly significantly different ($P<0.01$). Hence, *A.caillei* was completely different from *A.esculentus*. The vegetative phase of *A.caillei* lasted longer than the entire life cycle of *A.esculentus*, that by the time *A.esculentus* started flowering, *A. caillei* had been harvested. The reproductive phase of *A.caillei* also lasted longer than the life cycle of *A.esculentus*. These influenced the significantly ($P<0.05$) higher and heavier number of pods/ plant produced by *A.caillei*, such that NGAE-96-012-1 and NGAE-96-0067 (*A. caillei* varieties) fresh pod yields / hectare were two times the fresh pod yield of NGB/06/080 (*A.esculentus* with highest fresh pod yield/hectare) in 2009 and 2010. NGAE-96-012-1 and NGAE-96-0067 could be released to farmers in Umudike to boost fresh pod production and improve their well-being, NGB/06/080 could also replace the commonly planted *Clemson spineless* (*A. esculentus* variety). *A.esculentus* could be planted in August to synchronize flowering in both species for effective hybridization to improve okra yield by plant breeders.
Keywords: Ontogenesis, okra species, vegetative and reproductive phases, yield, humid tropics.

Introduction

West African okra (*Abelmoschus caillei* (A) Chev) belongs to the family *Malvacease* and is an important vegetable crop of tropical and subtropical world (Kehinde 1999). It is a short day plant with green stem, (Ariyo, 1993 and Adeniji *et al.* 2007), with slight traces of red colour (pigmentation) in some accessions (Adeniji, 2003). It is cultivated for fresh pods, leaves, stem and seeds. West African okra contained 194 diploid chromosomes as against 130 of the conventional okra (*A.esculentus*) thereby indicating that *A.caillei* constitutes a new okra species (Kehinde, 2001 and Adeniji, 2003). Due to its high yield and hardiness, it has become a major source of okra pods in Nigeria and its cultivation is progressively replacing the conventional type (Kehinde, 1999; Adeniji and Aremu2007). It takes 8 to 12 months and 3 to 4.5 months for *A. caillei* and *A. esculentus* to complete their life cycle respectively (Kehinde, 1999; Siemonsma and. Kouame, 2004; Okocha and Chinatu, 2008). It has also been reported that *A.caillei* is photoperiod sensitive (Ariyo, 1993; Adeniji *et al*. 2007) while *A. esculentus* is not (Kehinde 1999 ; Chinatu and Okocha, 2006). This has made synchronization of flowering in the species a subject of interest, which could be resolved after proper understanding of the developmental stages of each species (Kehinde, 1999).

Table 1.Potential of okra for research and contribution to enhance livelihood.

Criterion	Potential
Indigenous and general adaptation.	Early domestication took place in Africa because of its wider adaptaion in the region.
Specific adaptation (breeding)	Fast maturing types would be well-suited to tropical heat, humidity and also to dry (rain-fed) and hot (Sudano-Sahelian) conditions
Food and nutritional Security	Pods contain high amount of dietary fiber and they are often dried, stored and consumed as soup/ souse much like a staple food. Half a cup of cooked Pods (fresh) provides about 10% of the recommended levels of vitamin B6, folic acid and vitamins A and C. The seed (usually consumed with pods) protein is distinct from both cereals and legumes.
Market/ Income security	Because it can easily be dried, moulded (powder) and stored for long periods (unlike perishable vegetables), producers, and processors are better able to add value and take advantage of seasonal fluctuations in price.
Biomass for fuel	Besides pod yield, the foliage and stems can weigh up to 27t/ha. This biomass is likely to become useful with fuel prices increasing worldwide and new technologies promising efficient conversion to liquid fuels. It is worth mentioning that okra stems generate considerable heat without sparks, excessive smoke or bad odours.
Other industrial uses	The potential for non-vegetable use are: paper pulp, like its close relative kenaf, oil seed, mucilage, sacks and ropes, bioabsorbent, medicine.

National Acedemic Press (2006).

Table 2: Agronomic potentials of *A. esculentus*and*A.caillei*.

Species	Cytogenetics	Contrasting traits
A.esculentus		
(common okra) 95% cultivated Area	Amphidiploid (2n = 130-140)	Poor adaptation to humid zone More susceptible to biotic stresses Less vigorous, short life cycle usually day neutral, cultivated in both rainy (rain fed) and dry (irrigated) seasons.
A. caillei		
(West African okra) 5% cultivated	Amphidiploid (2n = 190-200)	Better adaptation in humid zone Tolerant/ resistant to biotic stress more vigorous, longer life cycle, photoperiod sensitive cultivated across the entire season.

Kumar *et al*., 2010

A.caillei has the potential for industrial, nutritional and biomedical purposes in the developing countries, but is under-utilized in the sub-saharan Africa (Adeniji *et al.* 2007; Kumar *et al*. 2010, Adelekun *et al*.2008) Kehinde (1999), Adeniji and Kehinde (2004) reported that West African okra is photoperiodic, which stands as one of the most striking differences between *A. caillai* and *A. esculentus*. Okra contains moderate levels of some essential mineral and vitamins which are important for body metabolic processes that utilize carbohydrates, proteins and fats (FAO, 2008).The immature fruits are eaten in soup either fresh or prepared by boiling or frying, and used in soup and stews, (Okocha and Chinatu, 2008). Pods and seeds are rich in phenolic compounds with derivatives, catechin oligomers and hydroxycinnamic derivatives (Arapitsas, 2008).The nutrient content of okra seed showed that okra seed contains 21% protein,14% lipids and 5% ash. Removal of the seed hulls by grinding and sifting produced a meal with 35% protain,25% lipids and 6% ash, (Savello*et al*.,1980). Dietary portfolio studies to maximize reduction of low-density lipoprotein cholesterol have indicated that plant based diets (rich in viscous fibers) may be an effective strategy for the prevention of hyperlipidemia. Fortunately, okra along with eggplant is considered by medical experts as the most important vegetable sources of viscous fiber (Kendall and Jenkins, 2004). Since indigenous okra varieties are predominantly cultivated by the local farmer in Umudike and according to Kehinde (1999), that due to high yield and hardiness of the indigenous varieties, they have become the major source of okra pods in Nigeria and their cultivation is progressively replacing the conventional type(*A. esculentus* (L) Moench). Identification and selection of high yielding varieties and subsequent introduction to the existing local types will lead to increase in okra fresh pod production in Southeastern Nigeria. Proper understanding of their ontogenesis would enable breeders to synchronize flowering in *A. caillei* and *A. esculentus* for successful hybridization. Understanding of the period each species takes to complete vegetative and flowering phase will enable the agronomist in the application of best agronomic practices to boost okra fresh

pod and seed yield.

Materials and Methods.

Study Site

The field experiments were conducted in early and late cropping seasons of 2009 and 2010 at Research Farm of Michael Okpara University of Agriculture, Umudike which lies within longitude $07^0$34'and latitude $05^0$29'N, and is 122m above sea level (National Root Crop Research Institute Meteorological Station, Umudike). Umudike had two peaks of rainfall. First peak occurred in May in both years, while second peak was in September and October in 2009 and 2010 respectively, Table 3. Information on temperature, relative humidity and solar radiation have also been given on Table 3.

The top soil of the experimental site was sandy-loam. Soil samples collected from the study site before planting were analyzed at Soil Science laboratory, National Root Crop Research Institute, Umudike, Abia State, Nigeria, to determine the nutrient level of the soil. Nitrogen, Phosphorus, Potassium, Calcium and Magnesium were obtained using the Kjeldahl (,flame photometric, oxidation and atomic absorption spectrophometer) methods (Kjeldahl,1983), respectively, while organic matter was obtained using Walkley method (Walkley 1947), % sand, % silt, % clay and pH in water were obtained using the Bouyoucos hydrometer (Jackson,1962) and pH meter methods, respectively.

Table 3: Meteorological information for Umudike, Nigeria (May – November) 2009 and 2010

Months	Average monthly Rainfall (mm)	Average Temperature	Monthly (^{0}C)	Average Relative Humidity (%)	Solar Radiation (hr)
2009		Minimum	Maximum		
May	306.1	32.4	23.0	78.9	4.6
June	237.5	31.5	22.5	84.0	3.2
July	300.9	29.9	22.3	87.3	1.9
August	287.4	29.4	22.4	87.6	2.8
September	205.3	30.3	24.0	85.3	1.5
October	305.3	30.4	22.5	82.3	3.8
November	23.7	32.0	22.2	75.0	5.1
December	0.0	32.0	22.0	52.0	5.6
2010					
May	138.5	32.2	24.2	70.3	3.6
June	427.0	30.1	23.6	78.3	3.7
July	310.2	29.6	23.0	76.8	2.2
August	376.7	29.5	23.0	77.8	2.5
September	303.0	29.5	22.8	75.6	3.1
October	349.0	30.8	22.8	78.0	3.9
November	77.8	31.0	23.0	70.6	4.2
December	8.9	33.0	22.0	58.5	5.3

National Root Crop Research Institute Meteorological Station, Umudike

Table 4: Physico – chemical properties of soil at Umudike experimental site in 2009 and 2010 cropping seasons.

Parameter	2009	2010	Method of analysis
Organic matter (%)	1.9	2.90	Walkley Method (1947)
Total N (%)	0.05	0.06	Kjeldahl Method (1983)
Av. P (mg/Kg)	0.96	11.01	Flame photometric (Kjeldahl, 1983)
K %	0.12	0.13	Oxidation (Kjeldahl, 1983)
Ca (cmol/Kg)	3.10	2.95	A. A. S. (Kjeldahl, 1983)
Mg (cmol/Kg)	1.40	1.40	A. A. S
Sand (%)	81.80	80.11	Hydrometer (Jackson, 1962)
Silt (%)	6.80	7.60	Hydrometer
Clay (%)	12.20	12.40	Hydrometer
pH (H_20)	5.26	5.58	pH Meter

Type of soil: sandy-loam, ppm:part per million, A.A.S: Atomic absorption Spectrometer

Experimental set up**.**

The experiment was a randomized complete block design (RCBD) with three replications, five (5) varieties of *A.*

caillei and five (5) varieties of *A. esculentus*as treatments. The experiment comprised a total of 30 plots; 15 plots each measuring 2.25 by 1.40m with a distance of 1m separating the plots and the blocks and 15 plots each measuring 1.8 x 1.20m with a distance of 0.6m separating the plots and the blocks for *A. caillei* and *A. esculentus* respectively, with a total experimental area of 155.99m^2. In 2009 and 2010, the seeds of the okra varieties were sown 3(three) per hole, at a spacing of 0.70 x 0.70m and 0.60 x 0.60m with a distance of 1.00m separating the plots and blocks for *A. caillei* and *A. esculentus* respectively. Supplying of missing hills which brought germination count to100%, was done 10 days after planting. Plants were thinned down to 1 per stand, 3 weeks after seed emergence. Compound fertilizer, NPK (20:10:10) was applied at the rate of 500kg\ha, four weeks after seed emergence, using ring method of application. Weeding was done manually using hoe. Karate (*Lambda-cyhadrothrin*, containing 25g of *lambda-cyhadrothrin* per liter) brand of insecticide was applied to control insect pest (*Podagricaspp*) attack, (Agunloye, 1986).Data were collected on the following; Number of days from seed planting to germination, Number of days from germination to branching, Number of days from branching to budding, Number of days from budding to flowering, Number of days from flowering to podding , Number of days from 50% podding to first harvest of fresh pods, Number of days from first harvest of fresh pods to end of harvesting, Number of days from flower bud maturity to anthesis, Number of days from anthesis to fresh pod maturity, Length of flower bud at maturity (ready for blooming), Number of flower buds initiated/plant, Number of pods/ plant.

Data transformation and analysis.

When some data are less than 15 or when some data contain zero, it is recommended that 0.5 be added to each observation (Xy), before the square is taken $\sqrt{Xy + 0.5}$. The linear additive model applies to the transformed data, but not to the original data. Treatment means on the original scale of measurement are obtained by squaring treatment means of the transformed data (Obi, 2002). Plant attributes that their counts were less than 15 and they contained zero as their individual observation (Xy) included, Number of days from planting to germination, Number of days from flowering to 50% podding, Number of days from podding to 50% first harvest and Number of pods/plant. Square root transformation was used to transform the data recorded on these attributes. Analysis of variance for each of the data on agronomic traits was done following the procedure outlined by Obi, (2002) for a randomized complete block design. Comparison of treatment means and significant differences between treatment means were separated using Fisher's least significant difference (LSD) as outlined by Gomez and Gomez (1984). Genstat Discovery Edition 3 was used for the analyses of data.

Results and discussion.

The soil and climatic conditions within Umudike (Tables 3 and 4) are favourable for the production of okra,(Adelusi, *et al*.,2006; Okocha and Chinatu 2008; Anonymous 2010).The mean performances of the varieties stages of development, making up the life cycle of *A. caillei* and *A. esculentus* in 2009 and 2010 are presented on Tables 5 and 6 respectively. Seed planting to germination varied from 5 to 6 days and was not significant (P> 0.5) in each year. Number of days from Germination to Branching varied from 20 to 81 days and from 22 to 79 days in 2009 and 2010 respectively and was highly significantly (P<0.001) different. This implied that the varieties differed significantly among themselves with respect to days from seed germination to branching in each year. Least significant difference (LSD) was used to separate the means. After germination, it took NGAE-96-012-1 (*A. caillie*) about 81 and 79 days in 2009 and 2010 to start branching, while *Clemson spineless* (*A. esculentus*) branched after 20 and 22days in 2009 and 2010 respectively.NGAE-96-012-1 had the highest value while *Clemson spineless* had the lowest value in both years. Number of days from branching to budding varied from 6.0 to 52.0 and from 7.0 to 50.0 in 2009 and 2010 respectively. ANOVA showed that the varieties were highly significantly different (P<0.001) with respect to number

Table 5: Ontogenetic studies on A.caillei and A. esculentus under Umudike environment in 2009 cropping season.

Parameters	Genotypes										
	A. caillei					*A. esculentus*					
	NGAE-96-0067	NGAE-96-012-1	CEN-012	NGAE-96-0061	OWODE	NGB/06/080	NG/SA/07/0081	NG/SA/07/0528	NG/SA/07/0522	*Clemson spineless*	$LSD_{0.05}$
1.Seed planting to 50% germination (days)	6.00	6.00	6.00	5.00	6.00	5.00	5.00	5.00	5.00	5.00	ns
2.Germination to 50% branching (days)	74.00	81.00	69.00	72.00	72.00	31.00	30.00	28.00	29.00	20.00	1.76
3.Branching to 50% budding(days)	45.0	52.00	44.00	47.00	44.00	12.00	10.00	8.00	8.00	6.00	1.63
4.Budding to 50% flowering (days)	34.00	34.00	32.00	31.00	30.00	11.00	11.00	12.00	10.00	10.00	0.90
5.Flowering to 50% podding (days)	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	ns
6.Podding to 50% first harvest (days)	9.00	9.00	9.00	9.00	9.00	7.00	7.00	7.00	8.00	6.00	1.20
7. First harvest to end harvest(days)	66.0	67.00	65.00	66.00	60.00	19.00	18.00	18.00	18.00	22.00	1.96
8. Length of flower bud at maturity ((cm)	4.30	3.80	4.50	4.10	3.80	4.10	3.90	4.10	3.90	3.80	0.21
9. Flower bud maturity to anthesis(hours)	13.50	13.50	13.00	13.00	13.00	13.50	13.50	13.00	13.50	13.00	ns
10.Number of pod/plant	17.60	18.70	12.90	13.70	12.50	8.90	8.30	7.60	8.60	3.80	1.28
11. Weight of pod(g)	20.90	21.90	19.20	19.80	19.70	16.10	15.80	16.60	15.90	17.70	0.88
12.Fresh pod yield/ha (kg/ha)	7506.90	8357.80	5054.70	5535.90	5025.50	3980.30	3642.80	3504.40	3798.30	1868.30	506.90

Table 6:Ontogenetic studies on A.caillei and A. esculentus under Umudike environment in 2010 cropping season.

Parameters	Genotypes										
	A. caillei					*A. esculentus*					
	NGAE-96-0067	NGAE-96-012-1	CEN-012	NGAE-96-0061	OWODE	NGB/06/080	NG/SA/07/0081	NG/SA/07/0528	NG/SA/07/0522	*Clemson spineless*	$LSD_{0.05}$
1.Seed planting to 50% germination (days)	6.00	6.00	6.00	5.00	6.00	5.00	5.00	5.00	5.00	5.00	ns
2.Germination to 50% branching (days)	74.00	81.00	69.00	72.00	72.00	31.00	30.00	28.00	29.00	20.00	1.76
3.Branching to 50% budding(days)	45.0	52.00	44.00	47.00	44.00	12.00	10.00	8.00	8.00	6.00	1.63
4.Budding to 50% flowering (days)	34.00	34.00	32.00	31.00	30.00	11.00	11.00	12.00	10.00	10.00	0.90
5.Flowering to 50% podding (days)	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	ns
6.Podding to 50% first harvest (days)	9.00	9.00	9.00	9.00	9.00	7.00	7.00	7.00	8.00	6.00	1.20
7. First harvest to end harvest(days)	66.0	67.00	65.00	66.00	60.00	19.00	18.00	18.00	18.00	22.00	1.96
8. Length of flower bud at maturity ((cm)	4.30	3.80	4.50	4.10	3.80	4.10	3.90	4.10	3.90	3.80	0.21
9. Flower bud maturity to anthesis(hours)	13.50	13.50	13.00	13.00	13.00	13.50	13.50	13.00	13.50	13.00	ns
10.Number of pod/plant	17.60	18.70	12.90	13.70	12.50	8.90	8.30	7.60	8.60	3.80	1.28
11. Weight of pod(g)	20.90	21.90	19.20	19.80	19.70	16.10	15.80	16.60	15.90	17.70	0.88
12.Fresh pod yield/ha (kg/ha)	7506.90	8357.80	5054.70	5535.90	5025.50	3980.30	3642.80	3504.40	3798.30	1868.30	506.90

of days from branching to budding. LSD was used to separate the means. The variety NGAE-96-012-1 had the highest values while *Clemson spineless* had the least values in each year. From germination to start of budding delineate vegetative phase, (Kehinde, 1999). Hence, number of days from germination to branching and from branching to the start of flower bud production is the vegetative phase. For *A.caillei* it varied from 113 in CEN-012 to 133days in NGEA-96-012-1, while in *A. esculentus* it varied from 26 in *Clemson spineless* to 43 in NG/SA/06/080, Tables 5 and 6.The staggering significant difference in number of days associated with the vegetative phases of *A.caillei* and *A.esculentus*is a great difference between the two species, since it took *A caillei* more than the number of days associated with *A. esculentus* entire life cycle to complete its vegetative phase. Kehinde (1999), Adeniji and Peters (2005) and Adeniji and Aremu (2007) had reported that *A.caillei* (WAT) is photoperiod sensitive. They flower in late September or early October (Ariyo, 1993), while *A. esculentus* planted in May (same day with *A.caillei*) had completed its life cycle at the time *A. caillei* began to flower. Adeniji and Aremu, 2009 reported that reduction in length of vegetative phase resulted in reduction in number of pods/plant and reduction in weight of pods which led to reduction in fresh pod yield /

hectare.Vegetative character (plant height, number of leaves and number of lateral branches) according to Ajibade and Morakinyo (2000), Chinatu and Okocha, 2006,Okocha and Chinatu (2008) and Anonymous (2010),determine the amount of photosynthates available to plants for growth and fresh pod yield. Tenebe *et al*., (1995) had reported that growth parameters (plant height, number of leaves and number of lateral branches) are strong yield parameters. Adeniji and Aremu (2007) reported that the proportion of the assimilates (photosynthates) allocated to the reproductive parts during flowering and fruit set go a long way to determine the number of pods, weight of pods, number of seeds and weight of seeds of okra varieties. The findings from this work are that the varieties with longer vegetative phase growth produced higher fresh pod yield and vice versa. The *A. caillei* with longer vegetative phase were significantly different from *A. esculentus* in number of days associated with vegetative phase.

The reproductive phase started from budding and ended in pod maturity, (Kehinde, 1999). Days from budding to flowering varied from 10 to 34 and from 10 to 35 in 2009 and 2010 respectively. ANOVA showed that varieties were significantly different ($P<0.01$) with respect to days from budding to flowering. LSD was used to separate the varietal means. *A. esculentus* flowered much earlier in both years than *A. caillei* (Table 5 and 6) showing that proper understanding of developmental stages of *A.caillei* and *A.esculentus* is needed to synchronize flowering so as to ensure effective hybridization between the two species. Days from flowering to podding was not significantly different ($P>0.05$). Two days after flowering both *A. caillei* and *A. esculentus* varieties produced small pods in each year. Days from podding to first harvest varied from 6 to 9 days and 7 to 9 days in 2009 and 2010 respectively. ANOVA showed that from podding to first harvest was significant ($P<0.05$). LSD separated the means of *A. caillei* varieties from those of *A. esculentus* with the exception NG/SA/07/0522 in 2007. Generally, *A.caillei* and *A. esculentus* pods matured 9 and 7 days from start of podding respectively. First harvest to end of harvest varied from 18 to 22 days and from 17 to 21 days in *A.esculentus* and from 60 to 67 days and from 61 to 67 days in *A.caillei* in 2009 and 2010 respectively. ANOVA showed days from first harvest to end of harvest to be significantly different ($P<0.01$) in each year.LSD separated the means showing that *A. caillei* was different from *A. esculentus*. While *A. esculentus* completed its life cycle in 22days after first harvest of fresh pods, *A.caillei* took over two months to do so. Fresh pods were harvested 5 times in *A. esculentus* while in *A. caillei* harvest was done 11 times at the interval of 6 days after first harvest. Flower bud maturity to anthesis varied from 13 to 13.5 hours and was not significantly different ($P>0.05$) in each year. Length of flower bud at maturity varied from 3.8 to 4.5 cm and from 3.8 to 4.4 cm in 2009 and 2010 respectively and was significantly different ($P<0.01$). LSD separated the varietal means. Kehinde (1999) recorded pod length of 3.5 to 4.0 cm in *A. caillei.* Number of pods/plant varied from 3.8 to 18.7 and from 4.0 to 17.8 in 2009 and 2010 respectively. ANOVA showed varieties to be highly significantly different ($P<0.01$) with respect to fresh pod yield. LSD separation of the mean showed remarkable difference between *A.caillei* and *A. esculentus*, since some *A. caillei* fresh pod yield was twice the yield of some *A. esculentus* variety (Tables 5 and 6) in both years. Weight of fresh pod varied from 15.8 to 21.9g and from 15.7 to 22.1g in 2009 and 2010 respectively. ANOVA showed that the varieties were significantly different ($P<0.05$) with respect to fresh pod yield in each year. LSD separated the varietal means. Pods from *A. caillei* varieties were significantly heavier than pods from *A. esculentus* varieties in each year. Fresh pod yield/ hectare varied from 1868.3 to 8357.8kg and from 1944.4 to 8028.2kg in 2009 and 2010 respectively. ANOVA showed that the varieties were very highly significantly different ($P<0.001$) in each year. LSD separated the varietal means. With the exception of days from flowering to podding and hours from flower bud maturity to anthesis, the stages that made up the reproductive phase of *A. caillei* lasted significantly longer than the stages that made up reproductive phase in *A.esculentus*. The vegetative phase of *A.caillei* lasted longer than the entire life cycle of *A. esculentus* in each year (Tables 5 and 6). Kehinde (1999), Adeniji and Peters (2005) and Adeniji and Aremu (2007) had reported that *A.caillei* (WAT) is photoperiod sensitive. The production of *A. caillei* (WAT) is limited to the four months of September to December because of its photoperiod sensitivity (Ariyo, 1993 and Kehinde, 2001). Irrespective of time of planting it continued to grow and flowered towards ending of September or early October. It is the accumulation of enough thermal units that induce the flowering (Usman,2001 and Anonymous, 2010). This prolonged the vegetative phase of *A.caillei*, hence, they grew taller, had more leaves and more lateral branches. Higher performance of vegetative characters led to higher reproductive characters performance, due to higher accumulation of photosynthates (Chinatu and Okocha, 2006; Katung, 2007;Adeniji and Aremu, 2007; Okocha and Chinatu, 2008 and Anonymous, 2010).The reproductive phase of *A.caillei* also lasted longer than the entire life cycle of *A. esculentus*. In okra, higher performance of vegetative characters led to higher performance of reproductive characters which led to higher fresh pod yield (Ajibade and Morakinyo, 2000; Katung, 2007and Okocha and Chinatu 2008). Hence, *A. caillei* fresh pod yields were by far higher than those of *A. esculentus*.

Conclusion.

The vegetative and reproductive phases of *A. caillei* lasted longer than those of *A.esculentus. A. esculentus* should be planted ending of August or early September to synchronize flowering with *A. caillei* for effective

hybridization since *A. caillei* flowered towards ending of September or early October.NGAE-96-012-1 and NGAE-97-0067 (*A. caillei* varieties) fresh pod yields approximately were two times higher than the fresh pod yield of NGB/O6/080 (*A. esculentus* genotype with highest fresh pod yield in both years). This great variation in vegetative and reproductive phases as well as fresh pod yield between *A. caillei* and *A. esculentus* portends high prospects in okra fresh pod improvement through inter specific hybridization, since Ariyo (1993) Kehinde (2001) and Adeniji and Aremu (2007) had reported that crossability exists between the species.

References.

Abdelmageed, A. H.A., 2010. Mode of Inheritance of pod spines in okra, (*A. esculentus*.(L) Moench). Tropical and Sub-tropical Agroecosystem.12; 405-409.

Adelakun, O.E., Oyelade, O.J., Ade-Omowaye B.I.O, Adeyemi, I.A., Van de, M. 2008. Influence of pre-treatment on yield, chemical and antioxidant properties of Nigerian okra seed (*A. esculentus* Moench) flour: DOI: 10.1016/j.fct.2008.12.023

Adeniji, O.T. 2003. Inheritance studies in West African okra (*A. caillei*). M. Agric. Thesis. University of Agriculture. Abeokuta, Nigeria, 98p.

Adeniji, O.T and Aremu, C.O.2007. Interrelationships among characters and path analysis for pod yield components in
West African Okra (*Abelmoschus caillei*(A.Chev) Stev). J. Agron. 6(1) 162-166.
http//dx.doi.org/10.3923/ja.2007.162.166 .

Adeniji, O.T. and Kehinde, O.B. 2004. Diallel analysis of earliness in West African Okra. J. Gen. Belg. 58: 191-195.

Adeniji, O.T., Kehinde, O.B., Ajala, M.O. and Adebisi M.A.2007. Genetic studies on seed. Agric and Food Chem.28:1163-1166

Adeniji, O.T. and Peters, J.M.2005. Stepwise regression analysis of pod and seed yield characters in segregating F_2 population of West African okra (*A.caillei*). proc. 30th annual conf. Genet.Soc. Nigeria. pp 250- 258.

Agunloye, O.1986. Effects of Cypermetrin on the population of *Podagricauniforma* and *Podagricasjostedi* on the yield of okra. Tropical pest management 32(1): 55-56.

Ajibade, S.R. and Moraking, J.A.2000. Heritability and correlation studies in cowpea,(*Vignaunguiculata*(L) Walp. Nigeria J.Genet 15 (2000): 29-33.

Anonymons, 2010. Productivity of okra (*Abelmoschusesculentus* L. Moench) at varying sowing dates in Markurdi Nigerian J. of Appl.Biosci. 32:2015-2019.

Arapitsas, P. 2008. Identification and quantification of polyphenolic compounds from okra seeds and skins. Food Chem. 110:1041-1045

Ariyo, D. J. 1993. Genetic diversity in West African Okra (*A. caillei*), Multivariate analysis of morphological and agronomic characteristics.Genet. Res. and Crop Evolution, 40:25-32.

Chinatu, L.N.and Okocha, P. I. 2006. Prospects of increased fresh pod production in cowpea. V*igna unguiculata (*L) Walp. J. Agric. Research, 11:43-47.

FAOSTAT, 2008. Food and Agricultural Organization of the United Nations. On-line and Multilingual Database, http://faostat.fao.org/faostat/

Gomez, K.A and Gomez, A.A. 1984. Statistical Procedures for Agric. Reseaech 2nd edition. New York John Willey and Sons. 680p.

Jackson, M. L. (1962). Soil chemical and particle size analysis: Prentice Hall, Ince. Eagle wood Cliffs, 10p.

Katung,M.D. 2007. Productivity of okra varieties as influenced by seasonal changes in Northern Nigeria Not. Bot.Hort. Agrobat. 35(1):65-71.

Kendall, C.W.C, Jenkins, D.J.A. 2004. A dietary portfolio: maximal reduction of low-density lipoprotein cholesterol with diet. Current Atherosclerosis Reports 6:492-498.

Kjeldahl, J. (1983). The Kjeldahl determine of nitrogen: retrospect and prospect. Trends in analytical Chemistry, Vol.13, No. 4 ,138p

Kehinde, O.B.1999. Floral Biology of West African okra Nig. J. of Genetics.14:14-17.

Kehinde , O.B .2001. Crossability studies in the Genus *Abelmoschus*.Nig. Journal of Horticultural Sci.Vol.5: 37-42.

Kumar, S.; Sokona, D; Adamou, H; Alain, R; Dov, P and Christophe, K. 2010. Okra (*Abelmoschus spp.*) in West and Central Africa: potential and progress on its improvement. African Journal of Agricultural Research Vol.5 (25) :3590-3598, December 2010. http//www. academic journals. Org/AJAR.

Manach, C., Williamson, G., Morand, C., Scalbert, A., Remesy, C. 2005. Bioavailability and bioefficacy of polyphenols in humans. Review of bioavailability studies. Amer. J. Clinical Nutrit. 81:230-242.

Moniruzzaman, M., Uddin, M.Z., and Choudhury, A.K.2007. Response of okra seed crop to Morphological and Agronomic characteristics.Genet. Resource and crop Evolution 40: 25-32.

National Acedemic Press .2006. Lost Crops of Africa Volume II: Vegetables. www.nap.edu/

catalog/11763.html:pp.287- 301
Obi, I.U. 2002. Statistical Method of detecting differences between treatment means and research methodology issues in Laboratory and field experiments. Nsukka . AP Express Publishers Limited Nigeria, 69p.
Okocha, P.I.andChinatu, L.N. 2008. Evaluation of okra cultivars and breeding lines for Agronomic traits South-eastern Nigeria. Global J. of Agric. Sciences,Vol 7.No1: 11-16
Oyelu ,C. 2002. Variability in photoperiodic response of okra (*Hibiscus esculentus* L.) Acta Horticulture 52: 207-215.
Savello, P.A., Martin, F.W. and Hill.J.M. 1980. Nutritional composition of okra seed meal. J. Agric and Food Chem.28:1163-1166
Siemonsma, J.S., Kouame, C 2004. *Abelmoschus esculentus* (L) Moench. Internet record from protabase. Grubben G.J.H, Denton, O.A. (eds), PROTA (Plant Resources of Tropical Africa, Wageningen, Netherlands. http://database.prota.org/search.htm.
Usman, S.D. 2001. Seed production and quality of okra affected by sowing time. Seed Research 29 (1): 47-51.
Walkley, A 1947. An Examination of Degtjareff method for determining soil organic matter and a proposed modification of the Chronic Acid Titration method. Soil Sci. 63:251-257

The IISTE is a pioneer in the Open-Access hosting service and academic event management. The aim of the firm is Accelerating Global Knowledge Sharing.

More information about the firm can be found on the homepage:
http://www.iiste.org

CALL FOR JOURNAL PAPERS

There are more than 30 peer-reviewed academic journals hosted under the hosting platform.

Prospective authors of journals can find the submission instruction on the following page: http://www.iiste.org/journals/ All the journals articles are available online to the readers all over the world without financial, legal, or technical barriers other than those inseparable from gaining access to the internet itself. Paper version of the journals is also available upon request of readers and authors.

MORE RESOURCES

Book publication information: http://www.iiste.org/book/

IISTE Knowledge Sharing Partners

EBSCO, Index Copernicus, Ulrich's Periodicals Directory, JournalTOCS, PKP Open Archives Harvester, Bielefeld Academic Search Engine, Elektronische Zeitschriftenbibliothek EZB, Open J-Gate, OCLC WorldCat, Universe Digtial Library , NewJour, Google Scholar