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VARIABILITY AND AGRONOMIC PERFORMANCE OF WEST AFRICAN OKRA (*Abelmoschus caillei*) (A. Chev) Stevels, IN A DERIVED SAVANNA ECOLOGY OF NIGERIA

***C.O. ALAKE, M.A. AYO-VAUGHAN AND O.O. AJANI**

Department of Plant Breeding and Seed Technology, University of Agriculture, Abeokuta, Nigeria.
***Corresponding author:** alakeolusanya@yahoo.com

ABSTRACT

West African okra (*Abelmoschus caillei*), an important vegetable crop in Nigeria and other African countries, has hitherto been ignored in genetic improvement. Data obtained from evaluating eleven diverse genotypes of West African okra for two years in the Teaching and Research Farm of University of Agriculture, Abeokuta in the Nigerian Derived Savanna Ecological zone were used to study variability and agronomic performance of pod yield and yield related characters. Significant variations observed in the phenotypic variances were higher than the corresponding genotypic variances for the characters. These differences were observed in height at flowering, number of leaves at flowering, final plant height, seeds per pod and yield per plant indicating greater influence of environment for expression of these characters. Ridge per pod, pod breadth, pod length and 250 seed weight showed least difference between phenotypic and genotypic variances. Genotypes and year of planting interacted significantly ($p \leq 0.05$ and ≤ 0.01) for height at flowering, 250 seed weight and pod yield per plant. High genotypic coefficient of variation, high heritability and expected genetic advances were recorded for height at flowering, seed per pod, number of leaves at flowering and pod yield per plant. This indicates the prevalent role of additive genes involved in phenotypic expression of these characters.

Keywords: West African Okra, Variability, Additive genes, Genetic advance, Heritability

INTRODUCTION

West African okra (*Abelmoschus caillei* [A.Chev] Stevels) belongs to the family Malvaceae and the genus Abelmoschus. It is one of the vegetable crops grown in Southwestern Nigeria as well as other African countries. West African okra grows naturally in Nigeria. They are cultivated in backyard farms, along roads and on waste lands but rarely in undisturbed forest (Ariyo, 1993).

Most of the West African okra germplasms available in Nigeria are photoperiod sensitive (Ariyo, 1993). Flowering is prolonged as long as the day length remains short. They are grown during the dry season in the rainfed island ecosystem, thereby supplementing production of *Abelmoschus esculentus* (common okra) during the dry season.

West African okra is of economic importance because of its nutritive value. The tender pod of okra at edible stage contains 88ml water, 2.1g protein, 0.2 fat, 8g carbohydrate, 36 calories, 1.7 fibre, 175.2mg minerals and

232.72mg vitamin in 100g of edible portion (Berry *et al.*, 1988), which compares favourable with common okra.

Though the crop is nutritionally very important, information on its genetic improvement is meager, therefore limiting breeding effort to increase its pod yield potential. The quantitative measurement of individual character provides the basis for an interpretation of analysis of variance. Consideration of qualitative approach for exploiting the genetic variability in West African okra is also of paramount importance. Different researchers like Ariyo (1993), Adeniji (2003) and Aladele *et al.* (2008) in their studies have reported the presence of high genetic variability in different yield related attribute of West African okra. Genotypes employed in this study had not been fully characterized and little is known about their yield potential. Hence, the present investigation was undertaken to study the variability and agronomic performance of yield and yield related characters in West African okra.

MATERIALS AND METHODS

The experiments were conducted at the Teaching and Research farm of the University of Agriculture, Abeokuta (17°15'N, 3°2S), (forest-savanna transition zone) Ogun-State in Southwest Nigeria between July and December 2007 and 2008. The soil type was sandy loam. A total of 11 West African okra genotypes (Table 1) were evaluated for their yield and yield related characteristics. These genotypes were sourced from the National centre for Genetic Resource and Biotechnology (NACGRAB) Ibadan, Oyo State, Nigeria.

In these trials, land was mechanically prepared by ploughing and disc-harrowed at two week intervals. The experiments were laid out in a randomized complete block design replicated three times. A two row plot was adopted for each genotype in this study. The spacing used was 1 meter between rows and 60cm within row. A minimum of 13 plants and maximum of 15 plants were maintained per row. Pod insects were controlled by spraying with pyrethoid insecticide (karate EC) at the rate of 40mls in 10 litres of water. All other cultural practices were carried out during the cropping season according to recommended local practices. Harvesting was done when visual observations showed that 90% of the pod colour changed to black. Sundried samples were threashed manually.

Observations were made on eight quantitative characters on 10 randomly selected plants per plot. The data were taken for each genotype in the three replications. Data was measured as follows:

Plant height, main stem (cm) at flowering: height of the main stem at 50% flowering measured from the ground level to the highest point of the plant with a meter rule.

Number of leaves at 50% flowering: Number of leaves on the branches and main stem were counted at 50% flowering.

Final plant height (cm): height of the main stem at physiological maturity measured from the ground level with a meter rule.
Pod length (cm): Randomly selected ten pods per plant were used for the estimation of pod length.

Pod breadth (cm): The same randomly selected ten pods per plant as in pod length were used for the estimation of pod breadth.

Number of ridges per pod: This was estimated by counting the actual number of ridges on 10 randomly selected pods per plant.

Number of seeds per pod: Average number of seeds per pod harvested from 10 plants.

250 seed weight (g): a sample of 250 seeds was weighed using Mettler balance 2000.

Dried pod yield per plant (g): average pod weight of 10 plants.

Statistical Analysis

Data collected were averaged over the seasons and subjected to analysis of variance and covariance using the plot yield, with the equation:

$$Yijk = \mu+yi+rij+gk+gyik+gyrijk$$

where: μ, yi, rij, gk, gyik and gyrijk represent the population mean and the effects of years, replication within year, genotype, genotype by year interaction and the experimental error, respectively. Treatment means were compared statistically using Duncan Multiple Range test at 5% level of probability (Duncan,1955).

Estimates of variance components were observed from the mean square in the analysis of variance. Phenotypic variance of the means for genotypes over seasons and replication, (σ^2p) was estimated according to the formular:

$$\sigma^2p = \sigma^2g + \sigma^2gy/ Y+ \sigma^2gyr/RY$$

σ^2p = Phenotypic variance

σ^2g = genotypic variance

σ^2gy = genotype by year interact tion

σ^2gyr = experimental error

R = number of replications

Y = number of seasons

The genotypic (GCV) and phenotypic (PCV) coefficient of variation were estimated according to the procedure outlined by Johnson *et al.* (1955).

$$PCV = \frac{\sigma^2p \times 100}{x}$$

$$GCV = \frac{\sigma^2g \times 100}{x}$$

where, x = grand mean across seasons

Heritability in broad sense (H_B) was estimated on genotypic mean basis as described by Hill *et al.* (1988) and Allard (1999) as:

$$H_B = \sigma^2g / \sigma^2p$$

The genetic advance expected under selection assuming the selection intensity of 5% was calculated according to Johnson *et al.* (1955) as

$$GA = K(\sigma p)\, H_B$$

GA = Expected genetic advance

K = Selection differential (2.06 at 5% selection intensity)

σp = Phenotypic standard deviation

Genetic advance as percent of mean (GAM) was calculated using the formula:

$$GAM = \frac{GA \times 100}{x}$$

x = mean of the character

RESULTS AND DISCUSSION

Descriptive statistics for the nine morphological traits of the *Abelmoschus caillei* genotypes including the minimum, maximum mean and their standard error for data in Table 2. In general, all the traits exhibited wide range of variation. For instance, final plant height varied from 6.50cm to 27.50cm, seed per pod from 36.50 to 101.50. There was more or less no variation in the two years of experiment for all traits that were evaluated except for number of seeds per pod.

In Table 3, genotypes varied significantly with respect to height at flowering, number of leaves at 50% flowering, pod length 250 seed weight, number of seed per pod, ridge per pod and yield per plant, which suggested that there was a great variability existing in the populations. The existence of high variability for different characters among West African okra varieties had been earlier reported by Ariyo (1993) and Adeniji (2003). However, genotypes responded differently to changes in the environmental conditions of the two years, as mean squares genotype x year interaction were significant ($p \leq 0.05$) for some of the characters such as plant height at flowering, 250 seed weight and yield per plant. Owode-2 showed highest pod yield per plant (30.25g) and significantly out yielded other genotypes. It also exhibited highest mean performance for number of ridges per pod (8.65) and 250 seed weight (15.44g) (Table 4). Equally, it showed high value of mean performance for pod breadth and number of leaves at flowering. Besides pod yield, Akure-2-9 showed highest number of ridges per pod (8.82) a value that was not significantly different from those of NCRI (8.27), OWODE-2 (8.65) and NGAE-96-012-1 (8.55). Akure-2-9 showed highest mean value for number of seeds per pod (88.28). Genotype OAA/96/175-5326 showed highest mean value for pod length (10.69cm) while the highest mean value for plant height at 50% flowering, number of leaves at 50% flowering and final plant height was recorded for NCRI-05 (40.59, 64.55 and 117.72cm, respectively).

The four genotypes mentioned above may serve as promising materials for selection of good plant type with increased yield potential. Similarly, some other genotypes showing very high mean performance for other characters can be used as donor parents for improving those characters in a future breeding programme.

Estimates of different genotypic and phenotypic variations, genotypic and phenotypic coefficients of variability, heritability and genetic advance as percentage of mean for different characters are given in Table 5. For most traits, the genotype x year interactions (σ^2gy) were either similar or larger than the genetic variance (σ^2g). Largest genotypic variation was found for final plant height followed by number of seeds per pod. Phenotypic variation was also largest for final plant height and minimum for pod breadth. Phenotypic coefficient of variability (PCV) ranged from 5.95 to 21.16%. Pod breadth, 250 seed weight and pod length had the lowest PCV whereas yield per plant, number of leaves at flowering and height at flowering had the highest PCV. The genotypic coefficient of variation (GCV) showed similar trend as PCV and ranged between 4.38% for pod breadth and 18.97% for number of leaves at flowering. The observed estimates of GCV and PCV were lower than 20.0% for each of the traits under investigation suggested that improvement in these traits through selection may be achieved up to a reasonable extent. However, observed very low estimates of GCV and PCV particularly for pod length, pod breadth and 250 seed weight implies that chances of getting substantial gain through selection are likely to be less for these characters. Moderate genotypic coefficient of variability was also observed by Adeniji (2003).

Heritability (H_B) estimate ranged from 54.21% for pod breadth to 94.88% for ridge per pod. Suggesting that estimates of heritability may differ widely in the same crop and same trait (Rasmusen, 2002), because heritability always refers to a defined population and specific experimental set-up (Holland *et al.,* 2002)

High heritability does not necessarily mean high genetic gain. The utility of heritability estimate is, therefore, increased when they are used to estimate genetic advance (GA) (Johnson *et al.,* 1955). Genetic advance indicates the degree of gain in a character obtained under a particular selection pressure. In the current study, genetic advance as percent of mean varied from 6.6% for pod breadth to 35.27% for number of leaves of flowering. Due to the large differences in the phenotypic variation between different traits, the GA is not directly related to heritability. Pod breadth combined low GA and moderate heritability, whereas high heritability and relatively low GA were observed for 250 seed weight and pod length. The remaining characters showed high heritability and relatively high GA values. The GA values suggest that population mean for most of the characters evaluated may be improved substantially by selecting the superior 5% of the materials studied.

As stated by Panse (1957), high heritability associated with high genetic advance is mainly due to additive gene effect, but if the heritability is mainly due to dominance and epitasis, the genetic gain would be low. Hence, selection for yield per plant and number of leaves at flowering in the current study can be quite effective since the characters seemed to be governed by additive genes action.

Other characters such as seed per pod, final plant height, seed per pod and plant height at flowering exhibited equal contribution of additive and non-additive gene effects (Shelby, 2000). Characters such as 250 seed weight, pod length and pod breadth with low genetic gain but high H_B suggested that the heritability of these characters were mainly due to dominance and epistatis.

High GCV along with high heritability and genetic advance will provide better information than a single parameter alone (Sahao *et al.,* 1990). Hence in this study, yield per plant, number of leaves at flowering, plant height at flowering and seed per pod exhibited high GCV, and heritability together with relatively high GA indicate that these characters would be very useful as selection indices in West African okra for yield and agronomic performances.

From the above study, it may be concluded that significant enhancement in pod yield and yield related characters can be achieved through rigorous selection for important traits like number of leaves at flowering, plant height at flowering, ridge per pod and seed per pod. Okra genotypes Owode-2, NCRI-05 and Akure-2-9 that were outstanding for above traits hold promise for future breeding programmes.

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Table 1: West African okra varieties and their source/origin

NUMBER	VARIETY	SOURCE	ORIGIN
1.	OWODE-3	NACGRAB	OWODE
2.	NGAE-96-0069	NACGRAB	IBADAN
3.	OJA-OBA-2	NACGRAB	AKURE
4.	NGAE-96-012-1	NACGRAB	IBADAN
5.	NCRI-05	NACGRAB	IBADAN
6.	AKURE-2-9	NACGRAB	AKURE
7	OWODE-5	NACGRAB	OWODE
8.	OWODE-2	NACGRAB	OWODE
9.	00A/9/175-5326	NACGRAB	IBADAN
10.	CEN-005	NACGRAB	CENRAD, Ibadan
11.	CEN-007	NACGRAB	CENRAD, Ibadan

NACRAB-National Centre for Genetic Resource and Agric Biotechnology
CENRAD- Centre for Genetic Resource and Development

Table 2: Ranges, Means and Standard errors (SE±) for the West African okra traits over two years

Traits	Minimum value	Maximum value	Mean	SE(+)
Height of flowering	19.90	45.38	33.35	0.84
Number of leaves at 50% flowering	23.80	75.30	47.34	1.65
Final plant height	27.50	161.50	91.82	2.99
Pod breadth	7.00	10.90	8.95	0.13
Pod length	6.97	11.96	9.33	0.16
250-Seed weight	11.64	16.05	13.83	0.13
Seed per pod	36.50	101.50	72.78	2.04
Ridge per pod	5.40	9.40	7.56	0.14
Yield per plant	10.88	36.92	22.45	0.70

Table 3: Combined analysis of variance (ANOVA) for pod yield and yield related characters in the West African okra genotypes over two years

Source of Variance	DF	Height of flowering	Number of leaves at 50% flowering	Final Plant height	Pod breadth	Pod length	250 seed weight	No of Seed per pod	Ridge per pod	Yield per plant
Replication	2									
Year (Y)	1	93.94	168.64	909.32	0.78	0.42	0.26	954.56*	2.64	162.93
Genotypes (G)	10	146.32**	593.79**	897.43	1.70	4.21**	4.59**	641.48**	4.99*	135.77**
G x Y	10	33.60*	109.96	236.52	0.78	1.39	0.89*	145.64	0.26	30.03**
Error	44	24.24	99.93	373.39	0.84	1.05	0.35	204.44	0.64	9.70
Total	66									

*, ** Significant at $\leq$ 0.05 and 0.01 respectively

Table 4: Mean values of pod yield and yield related characters in the West African okra genotypes over two years

Cultivars	Height at flowering	Number of leaves at 50% flowering	Final plant height	Pod breadth	Pod length	250 Seed weight	Seed per pod	Ridge per pod	Yield per plant
Owode-3	30.78cde	53.55ab	103.82ab	8.93ab	10.34Ab	14.17bc	58.76d	6.60cd	17.93de
NGAE-96-0069	33.04bc	51.51bc	91.62bc	8.35ab	8.05f	14.84ab	80.76Ab	6.20d	18.29dc
OJA-OBA-1	25.64de	58.08ab	78.95bc	8.29ab	8.24ef	13.34d	58.30d	7.28bc	27.09ab
NGAE-96-012-1	31.48dc	39.73cd	86.27bc	9.44ab	10.13abc	14.58b	77.60abc	8.55a	18.97dc
OAA/96/175-5326	36.46abc	48.76bc	93.35abc	9.51a	10.69a	13.76cd	79.80abc	7.17bcd	23.38bc
NCRI-05	40.59a	64.55a	117.72a	8.22b	8.75edf	13.54cd	78.93abc	8.27a	26.32ab
Akure-2-9	25.18e	38.81cd	95.35abc	9.22ab	9.54abcde	13.55d	88.28a	8.82a	21.15cd
Owode-5	35.78abc	33.90d	73.85c	8.39ab	9.66abcd	13.55cd	61.26cd	7.02bcd	15.07e
Owode-2	36.79abc	50.56bcc	88.68bc	9.17ab	8.97cdef	15.44A	66.48bcd	8.65a	30.25a
CEN-005	32.52bc	47.96bc	81.55bc	9.41ab	9.09bcdef	13.08de	80.86ab	6.72cd	27.04ab
CEN-007	38.55ab	33.27d	97.88abc	9.49a	9.18bcdef	12.40e	69.47abcd	7.83ab	21.45cd

Values within a column with a letter superscript in common are not significantly different from each other at $p \leq 0.05$

Table 5: Estimates of variance components (σ^2p, σ^2g, σ^2gy), phenotypic (PCV) and genotypic (GCV) coefficients of variation, broad sense heritability (h^2_B) and genetic advance (GA) and GA as percent of the mean over two years

Trait	σ2p	σ2g	σ2gy	PCV (%)	GCV (%)	HB (%)	GA	GA (% of mean)
Height of flowering	24.39	18.79	33.60	14.81	13.00	77.04	783.67	23.50
Number of leaves at 50% flowering	98.97	80.64	109.96	21.02	18.97	81.48	1669.81	35.27
Final plant height	149.57	110.15	236.52	13.32	11.43	73.64	1855.38	20.21
Pod breadth	0.28	0.15	0.78	5.92	4.38	54.21	59.42	6.64
Pod length	0.70	0.47	1. 37	8.98	7.35	67.06	115.73	12.40
250 seed weight	0.76	0.61	0.89	6.29	5.64	80.45	144.01	10.42
Seed per pod	10.91	82.64	145.64	14.21	12.49	77.30	1646.42	22.62
Ridge per pod	0.83	0.79	0.26	12.08	11.77	94.88	178.38	23.61
Yield per plant	22.57	17.13	33.00	21.16	18.44	75.89	742.71	33.08

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