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Genetic Diversity, Heritability, Genetic Advance of Growth and Yield Traits of Some Okra (*Abelmoschus Esculentus* L. Moench) Accessions

Justina KR*[1], Florence AO[1], Aderoju DO[1], Olusegun OA[1] and Stephen FL[2]

[1]Department of Plant Science and Biotechnology, Federal University Oye-Ekiti, Nigeria
[2]Department of Pest, Crop and Soil Science, Federal University of Technology, Nigeria

***Corresponding author:** Komolafe Ronke Justina, Federal University Oye-Ekiti, Department of Plant Science and Biotechnology, Nigeria, Email: ronke.komolafe@fuoye.edu.ng

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Abstract

Genetic improvement of okra for yield is significant to overcome the low genetic potential of the existing varieties and environmental factors which are the major constraints to okra yield. This study was carried out to understand the genetic nature of yield and its components on which selection can be made. The seed of each accession was sown in a plot laid out in randomised complete block design with three replications. Data were collected on fifteen agronomic characters and analysed. The magnitude of phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) were highest for number of pods and lowest for number of days to germination respectively. The PCV was moderately higher than GCV in most of the traits studied, which indicated that environment played a little role in the expression of these traits. Low heritability was recorded for number of leaves and number of branches which indicated more influence of environmental effect, which may be due to the presence of non-additive gene action in the expression of the traits. High heritability and high genetic advance as percent of mean were recorded for plant height at flowering, days to 50% flowering, plant height at maturity, internode length, number of pods and days to maturity, indicating that these traits were less influenced by environment and presence of additive gene action. NGB00378A, NGB00299, NGB00304 and NGB00302 had higher fruit yields; flowered earlier, had longer harvesting period. Therefore, selection can be made on these for further improvement of this crop.

Keywords: Additive Gene; Germplasm; Genetic Advance; Heritability; Variability

Abbreviations: NACGRAB: National Centre for Genetic Resources and Biotechnology; RCBD: Randomized Complete Block Design; GCV: Genotypic Coefficient of Variation; GMS: Genotypic Mean Square; EMS: Error Mean Square; VP: Phenotypic Variance; VG: Genotypic Variance; VE: Environmental Variance; PCV: Phenotypic Coefficient of Variation; ECV: Environmental Coefficient Of Variation; H_2BS: Broad Sense Heritability; GA: Genetic Advance; GAM: Genetic Advance as Percent of Mean.

Introduction

Okra (Abelmoschus esculentus L. Moench) is one of the most important and widely grown vegetable crops. It is primarily grown for its soft green fruits and leaves, which are generally eaten as fresh vegetables [1]. It is a nourishing vegetable comprising 86.1% water, 2.2% protein, 0.2% fat, 9.7% carbohydrate, 1.0% fibre and 0.8% ash [2]. Okra is also made up of other valuable nutrients. Compared to

other fleshy fruit vegetables like Solanum melongena and Lycopersicon esculentum, okra is a better source of calcium and ascorbic acid [3]. It is also a good source of fibre and proteins [4], has extensive culinary [5], therapeutic [6] and industrial [4] properties.

Genetic improvement of okra for yield is significant because of the nutritional and health benefits inherent in it and to overcome the low genetic potential of the existing varieties and environmental factors which are the major constraints to okra yield. Genetic diversity study is done so as to select parents for further breeding work. Breeders often calculate heritability estimate, a value that predicts to what extent their selection effort will be successful. Heritability is defined as the proportion of phenotypic variance that is attributable to an overall genetic variance for the genotype [7]. Adequate knowledge of components of variances and their effects, heritability, and genetic advance of the traits under consideration help to the breeders in deciding the appropriate breeding method to improve the genetic makeup [8]. Johnson HW, et al. [9] reported that the value of heritability estimate is enhanced when used together with the genetic advance. Combined high heritability estimates and high genetic advance shows that variation is attributable to high degree of additive gene effect and selection will be rewardable [10]. Kumar S, et al. [11] reported that before undertaken crop improvement process in any species, a thorough knowledge of the degree of genetic variability existing in the crop for various characters is essential. The nature and magnitude of genotypic and phenotypic variability in any species of crop play an important role in devising successful breeding strategy for developing superior cultivars.

Materials and Methods

Seven accessions of okra collected from the germplasm of National Centre for Genetic Resources and Biotechnology (NACGRAB), Ibadan, Nigeria were grown during rainy season of 2019. The trial was conducted in a randomized complete block design (RCBD) with three replications at the research field of the Department of Plant Science and Biotechnology, Federal University Oye-Ekiti, Ekiti State, Nigeria. The site of experiment is located at 25.570 N latitude, 81.51o E longitude. The average annual rainfall was 1013.4 mm. Each replication consisted of single row for each accession. Each row plot consists of 10 stands per accession planted at 30cm apart. Two seeds were planted into each hole of 2cm deep and later thinned to one after emergence.

Data Collection

Data were collected on various quantitative characters from five randomly selected plants of each accession in each plot on fifteen characters of okra.

Statistical Analysis

The mean values of data were subjected to analysis of variance using the SAS (2000) package and used to estimate the following genetic parameters.

Genotypic variance: The genotypic variance was estimated using the formula suggested by Lush JL [12].

$$\sigma_g^2 = \frac{GMS - EMS}{r}$$

Where,
= Genotypic variance, GMS= Genotypic mean square and EMS = Error mean square.

Phenotypic variance: It was calculated as follows:

$$\sigma_p^2 = \sigma_g^2 + \sigma_e^2$$

Where,
= Phenotypic variance, = Genotypic variance, and = Error variance

Genotypic coefficient of variation (GCV): It was calculated using the following formula as suggested by Mehta DR, et al. [13].

$$GCV = \frac{\sqrt{\sigma_g^2}}{\bar{X}} X100$$

Phenotypic coefficient of variation (PCV): It was calculated using the following formula as suggested by Mehta DR, et al. [13].

$$PCV = \frac{\sqrt{\sigma_p^2}}{\bar{X}} X100$$

Heritability (h2): It was estimated in broad sense by using following formula as suggested by Oppong-Sekyere D, et al. [14].

$$h^2 = \frac{\sigma_g^2}{\sigma_p^2} X100$$

Genetic advance: The expected genetic advance for different characters under selection was estimated using the formula suggested by Oppong-Sekyere D, et al. [14] and Saifullah M, et al. [15].

$$GA = K \frac{\sigma_g^2}{\sqrt{\sigma_p^2}}$$

Where K is the selection differential, which equal 2.06

Genetic gain: It is percent expected genetic advance over the population mean. It was computed as follows using the formula of Saifullah M, et al. [15].

$$GG = \frac{GA}{\bar{X}} X100$$

Results

Mean Performance and Genetic Variability in Accessions of Okra

The analysis of variance for different traits is presented in Table 1. The variation due to treatments was significant (P<0.05) for days to germination, petiole length, internode length, peduncle length, number of pods and fruit weight. There were highly significant (P < 0.001) differences among the accessions for plant height at flowering, plant height at maturity, days to 50% flowering, days to maturity and fruit length.

The mean performance of all the accessions for days to 50% flowering showed that NGB00299 flowered earlier (67.00) while NGB00298 had late flowering (131.33). Minimum fruit weight was observed in NGB00350 (20.12g) while the maximum fruit weight was observed in NGB00302 (41.40g). NGB00378a recorded maximum number of pods per plant (61.67) while NGB00350 recorded minimum number of fruits per plant (16.00). NGB00378a recorded the lowest days to maturity (84.00) whereas NGB00350 recorded the highest days to maturity (135.33) (Table 2).

Coefficients of Variation

The highest phenotypic and genotypic variances in all the characters considered (Table 3) were recorded in plant height at 50% flowering (3104.28 and 2887.50), followed by plant height at maturity (2086.50 and 1815.34), days to 50% flowering (713.05 and 707.53), days to maturity (587.55 and 581.20) and number of pods (263.92 and 200.16) respectively.

Phenotypic coefficient of variation varied from 9.21 for days to germination to 47.92 for number of pods, whereas, genotypic coefficients of variation ranged from 4.97 for number of seeds to 43.54 for plant height at flowering. The phenotypic coefficients of variation were

Sources of variation	df	Germination	Plant height at flowering	Plant height at maturity	Days to 50% flowering	Number of leaves	Petiole length	Inter node length	Number of branches	Days to maturity	Peduncle length	Fruit length	Number of locules	Number of pods	Number of seeds	Fruit weight
Block	2	1.04	11.45	305.65	98.44*	465.37	62.47**	12.58	44.31	193.84**	0.37	0.68	1.02	723.05*	172.87	12.61
Geno type	6	1.19*	9312.85**	6259.50**	2139.16**	180	23.26*	69.83*	24.09	1762.66**	0.82*	6.64**	1.35	791.75*	247.93	127.54*
Error	12	0.41	650.34	813.48	16.58	204.89	6.64	18.54	19.79	19.07	0.22	0.78	0.5	191.27	181.96	38.49

Table 1: Mean squares from ANOVA for various characters of okra accessions.

Genotype	Days to 50% Flowering	Inter node Length (Cm)	Plant Height At Maturity	Fruit Length (Cm)	Fruit Weight (G)	Peduncle Length (Cm)	Number of Pods Per Plant	Number of Seeds Per Pods	Plant Height at Flowering	Days to Germination	Number of Leaves	Petiole Length	Number Of Branches	Number Of Locules	Days To Maturity
NGB00378A	72.33^{de}	11.18^{b}	126.13^{cd}	10.40^{a}	32.92^{ab}	2.34^{cab}	61.67^{a}	93.97^{a}	79.03^{c}	6.00^{b}	25.73^{a}	22.09^{ab}	5.73^{b}	8.87^{cab}	84.00^{d}
NGB00299	67.00^{e}	19.88^{a}	95.15^{d}	11.04^{a}	33.09^{ab}	2.93^{ab}	42.00^{ab}	87.75^{a}	45.70^{c}	7.25^{a}	33.88^{a}	16.25^{c}	7.63^{ab}	8.00^{cab}	76.00^{e}
NGB00302	93.53^{c}	12.15^{b}	192.04^{ab}	10.10^{a}	41.40^{a}	2.16^{bc}	37.00^{cb}	104.67^{a}	160.47^{ab}	6.00^{b}	29.53^{a}	24.30^{a}	9.80^{ab}	8.88^{cab}	96.53^{c}
NGB00298	131.33^{a}	6.33^{b}	218.88^{a}	7.17^{b}	28.27^{bc}	1.70^{c}	17.00^{c}	85.50^{a}	199.21^{a}	6.90^{ab}	30.63^{a}	18.31^{bc}	10.28^{ab}	8.56^{cab}	134.33^{a}
NGB00350	130.67^{a}	6.23^{b}	177.46^{ab}	8.51^{b}	20.12^{c}	1.73^{c}	16.00^{c}	109.00^{a}	156.46^{ab}	7.13^{ab}	42.53^{a}	20.93^{ab}	14.02^{a}	9.84^{cab}	135.33^{a}
NGB00304	78.33^{d}	10.20^{b}	108.87^{d}	10.68^{a}	27.45^{bc}	3.03^{a}	39.67^{cab}	87.67^{a}	78.93^{c}	7.63^{a}	17.13^{a}	19.09^{bc}	6.27^{ab}	8.00^{cab}	86.00^{d}
NGB00346	106.37^{b}	6.91^{b}	159.93^{bc}	11.20^{a}	31.97^{ab}	1.73^{c}	16.00^{c}	109.00^{a}	156.46^{ab}	7.13^{ab}	27.87^{a}	17.70^{bc}	9.87^{ab}	9.33^{cab}	111.87^{b}

*Mean with the same superscript across the same column are not significantly different from each other at p<0.05

Table 2: Mean performance of seven accessions of okra in terms of growth, yield and its related characters of okra.

Character	Min	Max	Mean	Vp	Vg	Ve	PCV (%)	GCV (%)	ECV (%)	H^2bs	GA	GAM
Germination	6	8	6.84	0.4	0.26	0.14	9.21	7.45	5.4	65.55	0.85	12.43
Plant height at flowering	45.7	199.2	123.41	3104.28	2887.5	216.78	45.15	43.54	11.93	93.02	106.76	86.51
Plant height at maturity	95	219	154.07	2086.5	1815.34	271.16	29.65	27.65	10.69	87	81.87	53.14
Days to 50% flowering	67	131	97.15	713.05	707.53	5.53	27.49	27.38	2.42	99.22	54.58	56.18
Number of leaves	17.1	42.5	29.62	68.3	8.3	60	27.9	9.73	26.15	12.15	2.07	6.98
Petiole length	16.3	24.3	19.81	7.75	5.54	2.21	14.01	11.88	7.51	71.45	4.1	20.69
Internode length	6.2	19.9	10.41	23.28	17.1	6.18	46.35	39.72	23.88	73.45	7.3	70.13
Number of branches	5.7	14	9.09	8.03	1.44	6.6	31.17	13.18	28.25	17.87	1.04	11.48
Days to maturity	76	135	103.44	587.55	581.2	6.36	23.43	23.3	2.44	98.92	49.39	47.75
Peduncle length	1.7	3	2.32	0.27	0.2	0.07	22.53	19.34	11.57	73.65	0.79	34.19
Fruit length	7.2	11.2	9.87	2.21	1.95	0.26	15.07	14.15	5.16	88.24	2.7	27.4
Number of locules	8	9.8	8.78	0.45	0.28	0.17	7.64	6.05	4.66	62.74	0.87	9.87
Number of pods	16	62	33.9	263.92	200.16	63.76	47.92	41.73	23.55	75.84	25.38	74.87
Number of seeds	85.5	109	94.29	82.64	21.99	60.65	9.64	4.97	8.25	26.61	4.98	5.29
Fruit weight	20.1	41.4	30.75	42.51	29.69	12.83	21.2	17.72	11.65	69.83	9.38	30.5

Table 3: Estimates of range, grand mean, phenotypic and genotypic coefficients of variation, heritability in broad sense ($h_2$bs) and genetic advance in per cent of mean (GA) for 15 characters in okra.

Vp= Phenotypic variance, Vg= Genotypic variance, Ve= Environmental variance PCV= Phenotypic coefficient of variation, GCV= Genotypic coefficient of variation, ECV= Environmental coefficient of variation, H_2bs= Broad sense heritability, GA= Genetic advance and GAM= Genetic advance as percent of mean recorded high for number of pods (47.92), internode length (46.34), plant height at flowering (45.15), number of branches (31.17) and plant height at maturity (29.65), while moderate for traits like number of leaves (27.9), days to 50% flowering (27.49), days to maturity (23.43), peduncle length (22.53) and fruit weight (21.20). Low phenotypic coefficients of variability were recorded for fruit length (0.15), petiole length (15.07), number of seeds (9.64), days to germination (9.20) and number of locules (7.64).

The genotypic coefficient of variation was also recorded high for plant height at flowering (43.54), number of pods (41.73), internode length (39.72), while moderate for traits like plant height at maturity (27.65), days to 50% flowering (27.38) and days to maturity (23.30). Low genotypic coefficients of variability were recorded for peduncle length (19.34), fruit weight (17.72), fruit length (14.16), number of branches (13.18), petiole length (11.88), number of leaves (9.73), germination (7.45), number of locules (6.05) and number of seeds (4.97).

Heritability in Broad Sense and Genetic Advance

High heritability together with high genetic advance in percent of mean were found for characters like days to 50% flowering (99.22, 56.18), days to maturity (98.92, 47.75), plant height at flowering (93.02, 86.51), plant height at maturity (87.00, 53.14), number of pods (75.84, 74.87) and internode length (73.45, 70.13). High heritability with moderate genetic advance was recorded for fruit length (88.24, 27.40), peduncle length (73.66, 34.19), and fruit weight (69.83, 30.50), while moderate heritability coupled with low genetic advance as percent of mean was recorded for days to germination (65.55, 12.43) and number of locules (62.74, 9.87). The low heritability and low genetic advance were recorded for number of seeds (26.61, 5.29), number of branches (17.87, 11.48) and number of leaves (12.15, 6.98).

Discussion

This may be due to differences in the genetic component of the various accessions. This also corroborates with the findings of Schmidt PJ, et al. [16] and Sharma VR, et al. [17] who stated the role of differences in the genetic components of different varieties in yield determination of okra. The variability can be used to improve the crop for the desired character through selection. This is in accordance with

Siemonsma JS, et al. [18] who also recorded variability in different characters of okra genotypes they studied.

The genetic composition of a plant, the environment and the interaction of genotype with environment are pre-requisites for determining the phenotype of a plant. The identification and selection of plants that have genotypes conferring desirable phenotypes, rather than plants with favorable phenotypes due to environmental effects is paramount to successful plant breeding. In crop improvement programme, it is only the genetic component of variation (GCV) that is of significant value because it explains the proportion of the variation that is heritable but phenotypic variation is a function of both genotypic and environmental components. The observed variations in the various quantitative traits among the accessions are due to the effect of genotype and environment.

Phenotypic coefficients of variation were higher in magnitude than genotypic coefficient of variation for all the characters studied which indicates that these traits are influenced by environmental factors. Similar observations were also reported by Yadav M, et al. [19].

Phenotypic coefficient of variation varied from 9.21 for days to germination to 47.92 for number of pods, whereas, genotypic coefficients of variation ranged from 4.97 for number of seeds to 43.54 for plant height at flowering, this indicates considerable diversity in the germplasm studied for various agronomic traits.

Heritability of a character is very important to breeder because it helps him or her to predict the extent to which selection effort will be successful in the next generation. According to Ibrahim MM, et al. [8], heritability is used to establish the extent to which a character may be passed unto the offspring by the parent. Heritability could be regarded as low if it is within the range of 0-30%, 31-60% as average while > 60% is grouped as high [19]. Heritability in the broad sense separates genotypic variance from environmental variance, expresses the extent to which the phenotype is determined by the genotype, which is known as the degree of genetic determination, and very useful in the selection of superior lines from homozygous lines. this signifies that these traits were less influenced by the environmental factor, hence, the presence of additive gene effect is suspected, hence selection for improvement of such characters may be reliable. Similar result was reported by Yadav M, et al. [19] for plant height. The low heritability associated with low genetic advance for number of seeds (26.61, 5.29), number of branches (17.87, 11.48) and number of leaves (12.15, 6.98) revealed that environment or non-additive gene action may be prevailing for these characters and so heterosis breeding will be beneficial.

Conclusion

This study concluded that accessions NGB00378a, NGB00299, NGB00304 and NGB00302 gave higher fruit yields; they flowered earlier, had longer harvesting period and also performed better by producing more fruit yield. NGB00346, NGB00298 and NGB00350 had shorter internode length and their productivity is comparatively low due to low number of fruits per plant. Therefore, these accessions with higher fruit yields have potential for improvement in further okra breeding. Also, a wide range of variability and heritability with high genetic advance was observed for the characters like internode length, days to 50% flowering, number of pods, plant height at maturity and plant height at flowering. Therefore, selection of superior genetic materials based on these performances could be very effective.

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