

Genetic Variability, Heritability and Genetic Advance for Yield and Yield Contributing Traits in Okra (*Abelmoschus esculentus* (Linnaeus) Moench)

Olusesan Olawale Oguntolu*^{1,4}, Dickson Junior Nwosu², Christian Okechukwu Anyaoha³, Uterdzua Orkpeh⁴, Joseph Temidayo Olofintoye⁵, Aderibigbe Helen Adeniyi⁷, Bukola Deborah Omololu⁴, Aderonke Opeyemi Abesin⁴, Hafsat Abubakar Ahmad⁴, Ibrahim Abioye Olaleye⁴, Oluwafemi Emmanuel Oladokun⁸ Samuel Adelowo Olakojo⁶ And Olubukunola Oyesiku¹

¹Department of Plant Science, Olabisi Onabanjo University, Ago-Iwoye, Ogun State, Nigeria.

²National Centre for Genetic Resources and Biotechnology, Ibadan, Oyo State, Nigeria. ³Spices Programme, National Horticultural Research Institute, Ibadan, Oyo State, Nigeria. ⁴Genetic Resources Unit, National Horticultural Research Institute, Ibadan, Oyo State, Nigeria. ⁵Fruit Programme, National Horticultural Research Institute, Ibadan, Oyo State, Nigeria. ⁶Institute of Agricultural Research & Training, Obafemi Awolowo University, Ibadan.

⁷Farming system Programme, National Horticultural Research Institute, Ibadan, Oyo State, Nigeria

⁸Seed Technology Unit, National Horticultural Research Institute, Ibadan, Oyo State, Nigeria

Corresponding author email: sesanoguntolu@gmail.com +2348033021307

*Permanent address: Genetic Resources Unit, National Horticultural Research Institute, Ibadan, Oyo State, Nigeria.

Abstract

The study investigated genetic variability in terms of genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), broad sense heritability, genetic advance (GA), genetic advance by mean (GAM), and relationship among traits. Thirty accessions of okra, collected from six agro-ecological zones of Nigeria were planted out in a Randomized Complete Block Design (RCBD) in three replications and for two cropping seasons at the experimental field of Plant Science Department, Olabisi Onabanjo University, Ago-Iwoye, Nigeria. Planting was done on a 2 m² plot having 0.6 m and 0.5 m between and within row distances respectively. Data was recorded for each genotype on some growth and yield traits. Analysis of variance revealed significant differences among the accessions for all traits studied. Values for PCV were greater than GCV for all traits. High (>20 %) GCV and PCV were observed for all traits except for days to flowering, days to 50 % flowering, stem girth (medium 10-20 %) and canopy spread with low (< 10 %). High heritability (> 70 %) and high genetic advance (> 20 %) were observed for most of the traits studied. The high heritability and genetic advance exhibited among the accessions for number of branches, number of fruits per plant and yield per plot suggest that yield of okra can be greatly improved by selection.

Keywords: Accession, Crop improvement, Genetic variability, Okra

Introduction

Okra, *Abelmoschus esculentus* (Linnaeus) Moench, is an annual, erect growing crop with numerous cultivars that differs in plant height, degree of branching, period of maturity, pod shape, pod size and degree of pigmentation of various parts (Teman *et al.*, 2020). It is a self-pollinated plant which belongs to the family of *Malvaceae* (Oppong-Sekyere *et al.*, 2011) and is grown throughout the tropics and warmer temperate regions of the World (Patil *et al.*, 2015). Planting of okra in Nigeria occurs in two seasons of early rainy season of April to July and late rainy season of September to November. Okra fruit in its tender form is a good source of nutrients of carbohydrate, protein, fibre, Calcium, Potassium, Phosphorous, Magnesium and vitamins (A, B and C) which makes it an important component of diet especially in a resource-constrained families (Oguntolu, 2023).

Despite enormous economic benefits and the outstanding nutritional qualities of okra, the production of okra barely reaches its maximum potential due to several constraints such as the use of locally unimproved varieties, high incidence of pests and diseases burden and a narrow genetic base of existing varieties (Ibitoye and Kolawole, 2022). Lack of improved varieties and complex interactions of biotic and abiotic stresses are implicated in the decrease in fruit yield over the years. The low yield may also be attributed to poor yielding genotypes that are used by farmers (Manyong, *et al.*, 2002) and possibly the seasonal variation as a result of climatic change.

Genetic improvement depends on the genetic variation inherent in the population of any crop. Determination of this variability is a great tool used by breeders in selection of genotypes from diverse population for development of hybrids (Ullangula, 2017). Checking for existence of genetic variability in a crop is important before embarking on any breeding programme that is geared towards crop improvement hence, thorough knowledge of the nature and magnitude of genetic variability, trait heritability and association among various characters including yield is important. The magnitude of phenotypic and genotypic variability that exist among genotypes is important in selecting and developing superior varieties in breeding program. For a given population, variabilities are always measured by phenotypic and genotypic coefficient of variation. Heritability is the proportion of variation in a trait that is due to genetic factors. Analysis of both genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) helps in understanding the proportion of genetic variability in a population. Genotypic coefficient of variation together with estimates of broad sense heritability, genetic advance (GA), genetic advance as per cent of mean (GAM) indicate the nature of gene action governing a trait and it forms the basis of effective genotype selection in breeding for an improved variety (Zaki and Radwan, 2022). Johnson *et al.*, (1955) opined that heritability only indicates the effectiveness with which selection of a genotype can be based on phenotypic performance, and that heritable variation can be effectively used with greater degree of accuracy when heritability is studied in conjunction with genetic advance. The improvement in the mean genotypic values of selected families over base population helps the breeder to select progenies in the earlier generation. Effective way of crop improvement begins with selection of desirable genotypes from the variation observed and the use of better genotype in the breeding programme. Early maturing and high yielding traits are polygenic and their expression are influenced by the environmental fluctuations. (Olayiwola *et al.*, 2020). Developing early flowering and high yielding okra varieties is paramount to farmers and this study was therefore conducted to investigate genetic variability, genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), heritability, genetic advance (GA) and genetic advance by mean (GAM) together with correlations from data collected for yield and yield traits among 30 okra accessions for two seasons.

Materials and Methods

The study was carried out on the experimental field of Plant Science, Department of Olabisi Onabanjo University, Ago-Iwoye, Ogun State, Nigeria during the early and late season of 2019. The experimental materials for the study consisted of 30 genotypes collected from the genebank of National Horticultural Research Institute (NIHORT), Ibadan. The materials were earlier sourced from different agro-ecological zones of Nigeria (Table 1). Seeds were sown on a 2 m² plot of 0.6 m between rows and 0.5 m within rows to accommodate ten plants per plot in triplicates using randomized complete block design (RCBD). Good agricultural practice of raising healthy crops was carried out and observations were recorded according to International Plant Genetic Resources Institute (IPGRI) descriptor from five competitive plants from each replication. Data were recorded on days to first flower, days to fifty per cent flower, plant height, number of branches, stem girth, canopy spread, number of fruits per plant and yield per plot.

Data collected were subjected to analysis of variance (ANOVA) to test for significance of genotypic and seasonable effects. Correlation was also carried out to assess relationship among traits using Statistical Tool for Agricultural Research (STAR). Genotypic and phenotypic coefficient of variation were calculated (Prakash *et al.*, 2017), broad sense heritability was calculated and genetic advance was estimated by the method of Johnson *et al.*, 1955 and Zaki and Radwan, (2022).

$$\text{Heritability} = \frac{\text{Genotypic variance}}{\text{Phenotypic variance}} \times 100$$

$$\text{Phenotypic variance}$$

Zaki and Radwan, (2022)

Table 1: Accessions, collection places, regions and co-ordinates

Accession	Place of collection	Region	Latitude	Longitude
30S	Gboko	North Central	7°20'N	9°0'E
ALAROIGBO	Auchi	South South	6°33'N	7°33'E
ET1	Auchi	South South	6°33'N	7°33'E
GAANDO	Makurdi	North Central	7°37'N	8°52'E
IKENNE	Ikenne	South West	6°52'N	3°51'E

JOKOSO	Eleyele, Ibadan	South West	7o25'N	3o50'E
KANOLOCAL	Kano	North West	12o1'N	8o42'E
KOOMI	Igbogila	South West	7o2'N	2o59'E
LD88KANO	Bagauda	North West	12o43'N	8o28'E
LD88NH	NIHORT, Ibadan	South West	7o24'N	3o50'E
NH47-4	NIHORT, Ibadan	South West	7o24'N	3o50'E
ODAN	Oja Odan	South West	6o53'N	2o50'E
OGT1	Igbogila	South West	8o5'N	2o48'E
OGT2	Ijoun	South West	7o8'E	2o51'E
OGT3	Ilara, Ogun	South West	7o26'N	2o48'E
OGT4	Oja Oba, Akure	South West	7o15'N	5o12'E
OKN	Okenne	North Central	7o33'N	6o14'E
OKUNOWA	Okun Owa	South West	6o51'N	3o49'E
ORITA	Sawonjo	South West	7o4'N	2o59'E
ORKP1	NIHORT, Ibadan	South West	7o24'N	3o50'E
ORKP2	NIHORT, Ibadan	South West	7o24'N	3o50'E
ORKP3	NIHORT, Ibadan	South West	7o24'N	3o50'E
ORKP4	NIHORT, Ibadan	South West	7o24'N	3o50'E
ORKP5	NIHORT, Ibadan	South West	7o24'N	3o50'E
ORLU	Orlu, Anambra	South East	10o5'N	11o10'E
PSID	Mbato, Imo	South East	5o37'N	7o27'E
PSIS	Mbato, Imo	South East	5o62'N	7o45'E
SAKI	Saki	South West	8o40'N	3o23'E
V35	Dadinkowa, Gombe	North East	10o42'N	8o38'E
YARBALE	Kano	North West	11o57'N	8o36'E

Results and Discussion

Analysis of variance (ANOVA) revealed that the okra genotypes evaluated were significantly different for all the characters measured which indicates the presence of enough genetic variability among the genotypes, a prerequisite for any crop improvement (Table 2). This diversity is in agreement with the result of Reddy *et al.*, (2013) and Kerure *et al.*, (2019) who also obtained significant difference in all the traits studied and with the studies of Sunil *et al.*, (2022), Ranga *et al.*, (2021) who reported genetic variability among okra genotypes. The significant differences revealed may be due to inherent genetic makeup of the studied accessions and it is an indication of genetic variability that could be explored for future improvement. Similar results were reported by Olayiwola *et al.*, (2020) for okra.

Table 2: Analysis of variance (ANOVA) for quantitative traits in 30 okra genotypes (Combined)

Source	Df	Dtf	D50f	Ph	Nob	Stg	Cnp	Nofp	Ypp
Rep/ Season	4	3.82	0.21	0.24	0.42	0.24	0.039	0.80	0.91
Season	1	0.0024	0.19	0.23	3.39	0.0015	1.97	60.00*	37.97*
Accession	29	101.12*	24.56*	10.48*	46.44*	3.27*	11.11*	48.40*	84.64*
Season x accession	29	0.56	0.68	0.08	0.68	0.050	0.29	1.81	1.70
Error	116	0.57	2.38	610.72	0.09	3.36	10.45	0.36	40.12
Total	179								
Mean		43.89	44.41	104.64	2.04	13.64	68.10	9.35	172.54
R ²		0.96	0.86	0.76	0.92	0.47	0.74	0.93	0.95
CV		1.72	3.47	23.62	14.28	13.44	4.75	6.44	8.72

Dtf = days to first flower, D50f = days to 50 % flowering, Phs = Plant height, Nob = Number of primary branches, Stg = stem girth, Cnp = Canopy size, Nofp = number of fruits per plant, ypp = yield per plot

Means of plant and yield related traits (Table 3) showed that accession Ogt3 is the earliest in terms of flowering (38 days after planting) among the thirty accessions while Psid was the latest to flower (54 days after planting). The wide variation observed in days to flower is a good indication of possible improvement in earliness to flower selection programme which is a good trait especially in drought prone areas. The result is similar to that of Mohammed, *et al.*, (2022) who obtained 42 days but earlier than what was obtained by Eshiet and Brisibe, (2015) who had between 72 days and 112 days for number of days to flowering in their collection. For plant height, which is an attribute of growth and yield, Okn was the tallest with 156.36 cm. For number of branches, another growth and yield attribute, the highest value was recorded for NH47-4 with 5 branches. The result is in agreement with what was obtained by Asare *et al.* (2016) who obtained 5, 3 and 2 as the leading three. Tall genotypes with big stem and wide canopy will be advantage for high biomass and dry matter content useful for livestock feed, especially in places where green pastures are hard to find during dry season. Highest number of fruits per plant of 15 and yield per plot of 298.46 g were observed in NH47-4. Kaur *et al.* (2013) also reported similar number of fruits per plant.

Table 3: Means of agronomic and yield related traits of the 30 accessions of okra

Accession	Dtf	D50f	Ph	Nob	Stg	Cnp	Nofp	Ypp
30S	42.42ijk	42.72ijk	68.14ef	1.14lm	12.76cde	64.08ghi	10.97bc	292.38a
Alaroigbo	43.86efg	44.94de	156.22a	1.31klm	15.27abc	64.58ghi	8.13ijk	142.06ij
Et1	42.34jk	43.17fgh	144.62ab	2.70cd	12.84cde	66.11efg	10.50cde	118.39kl
Gaando	44.83de	45.33d	48.78f	1.14lm	13.01cde	60.78l	7.10lm	119.80kl
Ikenne	43.72fgh	44.36fgh	99.42cde	2.03gf	15.07bcd	71.17bc	10.70bcd	237.53c
Jokoso	43.22fghi	44.14efg	61.50f	1.06lm	13.66cd	63.47ijk	8.73hi	158.16ghi
Kanolocal	43.94def	44.92de	124.28abc	1.39ijk	14.11cd	67.42def	6.83m	143.70ij
Koomi	41.97kl	43.08fgh	139.81ab	1.97fgh	12.25fgh	69.97cde	9.73fg	198.54de
Ld88kano	46.78c	48.06c	118.50bc	1.58hij	12.75cde	62.31kl	7.57klm	127.61jk
Ld88NH	44.17def	44.58efg	133.11abc	0.94n	12.39fgh	62.92jkl	7.27efg	77.02n
NH47-4	44.86d	44.92de	112.03bc	4.69a	16.03a	72.31bc	14.60a	298.46a

Odan	44.11def	45.20ef	59.00f	1.39ijk	12.55fgh	70.08cde	10.70bcd	241.14bc
Ogt1	39.81n	40.61ijk	120.97bc	2.14ef	13.16cd	66.44efg	7.43klm	131.62jk
Ogt2	41.11lm	41.53ij	114.17bc	1.78ghi	14.27cd	75.20b	9.97fg	94.55mn
Ogt3	38.00n	38.50l	131.89abc	1.72ghi	12.65cde	69.31def	7.50klm	203.29de
Ogt4	41.53ijk	42.89ghij	117.22bc	2.00fg	13.50cd	71.84bc	9.80fg	256.07b
Okn	46.70c	47.36cd	156.36a	1.81fgh	15.89ab	70.14cde	10.47cde	206.28de
Okunowa	47.00c	47.75cd	53.25f	2.06gf	15.15bc	67.17def	10.17def	203.08de
Orita	42.78hijk	43.61fgh	100.72cd	1.86fgh	13.10cde	70.03cde	8.60hij	190.38ef
Orkp1	40.97m	41.11ij	73.50def	3.39b	15.13bc	68.28cde	9.60fg	176.80fg
Orkp2	42.50ijk	42.72ghij	98.78cde	2.92c	11.74gh	68.50def	9.47fg	194.83ef
Orkp3	43.50fghi	43.64fghi	137.64ab	3.09bc	12.40fgh	67.25def	7.87jkl	131.90jk
Orkp4	42.92ghij	43.11fgh	101.30cd	2.47de	12.87cde	67.14def	10.20def	214.44d
Orkp5	39.64n	39.81kl	121.70bc	2.97c	15.86ab	63.72def	9.30gh	170.67gh
Orlu	42.92ghij	43.33fgh	100.64cd	1.58hij	12.87cde	68.11cde	7.50klm	170.72gh
Psid	53.72a	53.95a	128.92abc	2.75cd	14.52abc	82.28a	11.37b	106.23lm
Psis	51.67b	52.50b	131.36abc	2.89c	16.16a	66.56efg	11.37b	87.03n
Saki	42.50ijk	43.69fgh	71.72def	1.94fgh	13.47cd	75.20b	8.23ijk	167.69gh
V35	46.83c	46.81cd	58.22f	1.11lm	11.50h	64.86efg	8.17ijk	159.44ghi
Yarbale	44.14def	44.09fg	55.39f	1.33jkl	12.47fgh	65.86fgh	10.70bcd	156.49hi
Mean	43.82	44.41	104.64	2.04	13.65	68.10	9.35	175.54
S.E (0.05)	0.57	2.38	610.72	0.09	3.36	10.45	0.36	266.50

Means followed by the same letters in column are not significantly different ($p < 0.05$).

Dtf = days to first flower, D50f = days to 50 % flowering, Phs = Plant height, Nob = Number of primary branches, Stg = stem girth, Cnp = Canopy size, Nofp = number of fruits per plant, ypp = yield per plot

Combined seasons correlation coefficient among the eight traits as presented in Table 4 showed that a number of traits in the okra genotypes showed significant positive and negative correlation among the traits studied. For instance, while there is a significant positive relationship between number of fruits per plant and number of branches (0.521*) and yield per plot (0.442*). However, days to fifty percent flowering showed significant $p < 0.05$ negative correlation with yield per plot (-0.461*).

Phenotypic correlation coefficient among the eight traits revealed that several traits in the okra genotypes showed extremely significant positive and negative correlation among the traits studied and this implies that single character selection may increase the trait values of positively correlated characters and reduce the values for negatively correlated traits. This corroborates the findings of Ahiakpa *et al.* (2013) and this suggest that component breeding would be very effective in the event of strong positive associations of major yield characters (Hazra and Basu, 2000).

While there is a high significant positive correlation between number of fruits per plant and yield per plot (0.442*), there is a significant negative correlation between days to flowering and yield per plot (-0.461*). This is in accordance with the work of Anyaoha *et al.*, (2018). More attention should therefore be given to the traits with positive correlation when selecting for breeding purpose.

Table 4: Pearson's correlation coefficient of the quantitative traits for okra genotypes (Combined)

Traits	Dtf	D50f	Ph	Nob	Stg	Cnp	Nofp	Ypp
Dtf	-							
D50f	0.992*	-						
Ph	0.048	0.072	-					
Nob	-0.204	-0.229	0.265	-				
Stg	0.089	0.103	0.247	0.440*	-			
Cnp	0.156	0.161	0.173	0.359*	0.223	-		
Nofp	0.062	0.048	0.001	0.521*	0.374*	0.273	-	
Ypp	-0.461*	-0.459*	-0.308	0.113	-0.138	0.018	0.442	-

p < 0.05 is considered significant. *refers to strong correlation.

Dtf = days to first flower; d50f = days to fifty percent flowering; Nob = number of branches; Cnp = canopy spread; Ph = Plant height; Stg = stem girth; Nofp = Number of fruits per plant; Ypp = yield per plot.

A higher magnitude of phenotypic coefficient of variation (PCV) than genotypic coefficient of variation (GCV) was recorded for all the traits (Table 5). PCV ranged from 9.89 % for canopy spread to 59.72 % for number of branches while the range for GCV was 8.5 % for canopy spread to 57.94 % in number of branches. The findings are in consonance with what was obtained by Kumar *et al.*, 2019 who also obtained highest phenotypic variance for the number of primary branches.

All the characters exhibited high heritability and genetic advance except for stem girth and canopy spread. Similar observation has been reported by Agbowuro, *et al.*, (2019). It may be stated therefore that all the traits except for stem girth and canopy spread are likely to be operated by additive genes. Any improvement in these characters would give excellent result by selection on the basis on phenotypic observation.

Table 5: Estimates of Variability, heritability, genetic advance and genetic advance per cent of mean for different traits in 30 okra genotypes for Combined seasons

Traits	Means	Genotypic Variance	Phenotypic Variance	Environmental Variance	Heritability (%)	GCV (%)	PCV (%)	Genetic Advance	GAM (%)
Dtf	43.81	20.47	21.19	0.73	96	10.32	10.51	20.90	47.72
Dt50f	44.41	20.71	21.34	0.63	97	10.25	10.40	20.79	46.83
Phs	104.64	1994.74	2492.64	497.89	80	42.68	47.71	78.66	75.17
Nob	2.04	1.39	1.48	0.09	94	57.94	59.72	115.81	5676.96
Stg	13.65	2.80	5.52	2.71	51	13.23	18.57	19.53	153.59
Cnp	68.10	36.31	45.38	9.07	80	8.85	9.89	16.31	23.94
	9.35	5.69	6.26	0.57	91	25.51	26.75	50.12	535.99
Nofp									
Ypp	175.54	6295.59	6610.01	314.41	95	45.99	47.12	92.45	53.58

Dtf = days to first flower, D50f = days to 50 % flowering, Phs = Plant height, Nob = Number of primary branches, Stg = stem girth, Cnp = Canopy size, Nofp = number of fruits per plant, ypp = yield per plot

Conclusion and recommendation

There is wide variability in agronomic among the agronomic traits of the okra accessions studied accompanied with high heritability estimates, high genetic advance and genetic advance by percent of means. This is an indication of expression of additive gene action and therefore selection for improvement of these traits by plant breeders will be effective in the improvement of the okra crop for the benefits of farmers. Hybridization between Ogt3 and NH47-4 genotypes is highly recommended to develop a hybrid that combines early flowering with high yielding okra.

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