ACTA UNIVERSITATIS SAPIENTIAE
AGRICULTURE AND ENVIRONMENT, **8** (2016) 112–125

DOI: 10.1515/ausae-2016-0010

Varietal performance and correlation of okra pod yield and yield components

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Manuscript received Oct. 19, 2016; revised Oct. 25; accepted Oct. 30

Abstract: Field irrigation experiments were conducted to assess the varietal performance and correlation of pod yield and yield attributes under irrigation at the Teaching and Research Farm, University of Maiduguri, Nigeria, during the 2015 and 2016 dry seasons. The results revealed that the most outstanding for fresh pod yield per plant were okra cultivar Kwadag Y'ar gagure Salkade, and Kwadam, in descending order, with yield ranging from 580.38 to 622.67 g, while the Composite cultivar had the lowest value of pod yield of 428.62 g over the two years. The greatest average values for the number of pods per plant and the number of primary branches per plant were observed for Salkade and Y'ar gagure, respectively. Highest fresh pod length and fresh pod diameter were also exhibited for Salkade and Kwadag. The genotypic coefficient of variation was higher than the phenotypic variation for the entire yield-contributing characters. Days to 50% flowering were positive and highly significant differences associated with plant height, number of pods per plant, and fresh weight per pod could be observed. Path coefficient analysis showed that the number of pods per plant exhibited positive and direct influence on the pod yield across the studied years. Indirect influence of other yield components through this character also contributed mainly towards pod yield. Therefore, days to 50% flowering, plant height, pod length, number of pods per plant, pod diameter, number of primary branches per plant, and fresh weight per pod could be taken into consideration for the selection and development of high pod-yielding varieties in okra.

Keywords: phenotypic, genotypic, correlation coefficient, path analysis, okra pod yield

1. Introduction

Okra (*Abelmoschus esculentus* L. Moench) is a member of the hibiscus family Malvaceae and is a popular vegetable in the world, originating from Africa [1]. It ranks above other vegetable crops including cabbage, amaranths, and lettuce [2]. Okra is an annual, hardy, erect, and high-yielding plant, which varies in size, pod shape, pigmentation, degree of branching, period of maturity, and plant height [3]. Okra is usually grown in Nigeria during the rainy season; it is limited to irrigation in the dry season, especially in the Fadama vegetation [4]. Fresh okra fruit, leaves, buds, and flowers are consumed as vegetables. According to [6], okra fresh fruits contain nutrients including water (88%), protein (1.52 grams), dietary fibre (2 grams), carbohydrates (5.76 grams), vitamin C (13.04 mg), vitamin A (460 IU), calcium (0.4 mg), folic acid (36.5 micrograms), magnesium (46 mg), and potassium (256.6 mg) [7]. Based on [8], okra pod, containing vitamin B_6, calcium, and folic acid, could help in good vision, bone formation, growth, proper circulation of blood, and digestion. The okra pod protein assists in building muscle tissues and enzymes, which control the hormones of the organs. Its soluble fibre also helps in lowering serum cholesterol, reducing heart disease and cancer, especially colorectal cancer.

Information on the genetic variability of crop is essential for the identification and breeding of unique accessions vital for curators of gene banks for germplasm conservation [9–14]. Diversity of crops and morpho-agronomical characters are the first step highly recommended to be taken before in-depth molecular and biochemical studies [15]. Knowledge of correlation between pod yield and its related characters could also improve the efficiency of selection in okra breeding. Progress and gain from selection in any breeding programme depend upon the magnitude of useful variability present in the population and the degree to which the desired traits are heritable. Yield is a complex quantitative character and controlled by several genes that interacting with the environment. Yield is also the product of various factors known as yield components. The efficiency of selection in any breeding programme mainly depends upon the knowledge of association of the characters. The suitable knowledge of such associations between yield and its related characters could appreciably enhance the efficiency of the crop improvement through the utilization of the appropriate selection indices [16]. The correlation coefficient that indicates an association between two characters is useful as a basis for indirect selection for further crop improvement. It does not only assist in the formation of selection indices but it also permits the prediction of correlated response. Selection of parents based on yield alone could be misleading. Correlation analyses are mainly used where values of two traits are analysed based on paired bases. Such results might be positive or negative. The findings of correlation are of immense benefit in determining the most effective methods for choosing cultivars. If there is a positive relationship among the main yield traits, component breeding could be very efficient; on the other hand, when these traits are negatively related, applying simultaneous selection could be challenging in improving the genotypes.

In order to formulate selection indices for the genetic improvement of yield, the cause and effect relationship of the trait is very essential, and this can be achieved through path analysis. Path coefficient analysis provides information on the effect of each character contributing to yield indirectly and directly [17]. The analysis allows breeders to rank genetic components according to their influence. This is also essential in the indirect selection of elite cultivars from diverse genetic populations. Availability of good information of these genetic components existing in various yield-contributing traits and the relative proportion of genetic information in different quantitative attributes are pre-requisites for efficient crop breeding. As okra plays an important role among other annual crops in the economy of nations, further consideration should be given to choosing varieties of higher yield for edible and seed pods. This study was conducted to assess the varietal performance and correlation of pod yield and other related characters of okra cultivars under irrigation with a view to devising a breeding stratagem for development, selection, and conservation.

2. Materials and methods

Field irrigation experiments were carried out at the Teaching and Research Farm, University of Maiduguri (11^0 53′N, 16′E) in the Sudan savannah of Nigeria, during the 2015 and 2016 dry seasons. Of the ten okra cultivars, four (Kwalpuku, Kwadag, Mola kwadag, and Composite) were obtained from the Borno State Agricultural Programme, Maiduguri, Nigeria, and six cultivars (Yar'duwi, Salkade, Yar'gagure, Y'ar kwami, Kwadam, and Lai-lai) originated from the Gagure Gulani Local Government Area of Yobe State, Nigeria. The pictures of the okra grown on the field are presented in plates 1 and 2.

Figure 1. The Okra plant

Figure 2. Okra evaluation on the field

The field experiment was arranged in a Randomized Complete Block Design along with three replications. The plot was 216 m^2, divided into 33 plots of 2 m x 2 m with 1 m spacing between replications, and 0.5 m between treatments. Weeding was carried out manually at 3, 6, and 9 weeks after sowing (WAS). N.P.K. 15:15:15 fertilizer was spread at a proportion of 60 kg N/ha in two doses, first at three weeks after planting and then at flowering. Two millilitres of Ultracide 40EC insecticide in 15 litres was applied fortnightly to control insect pests. Light watering was applied using a watering can every morning and afternoon. This was continued for a week for the rapid and good establishment of the germinated seedlings.

Six plants were randomly chosen from each plot to evaluate the okra quantitative characters. Data were recorded on a number of primary branches per plant, days to 50% flowering, number of pods per plant, fresh pod length, fresh pod diameter (cm), plant height, fresh weight per pod (g), and fresh pod yield per plant (g). Statistical analysis of the data was computed on all measured traits using the Statistical Analysis System (SAS) software for Windows Version 9.2 [18]. Data collected regarding each character were first determined with analysis of variance (ANOVA) distinctly prior to a combined ANOVA in the two years. The variability of each agronomic character was estimated by simple measures such as ranges, means, and values of 'F' (variance ratio) test. The SAS GLM procedure employed for the ANOVA was mixed model. Replication was regarded as a random effect, while cultivars as fixed effects. The degree of variation was assessed utilizing % coefficient of variation at $P< 0.05$. Treatment means were separated with the help of Duncan's Multiple Range Test (DMRT) at 0.05 percent probability suggested by [19].

Genotypic and phenotypic variances were estimated as suggested by [20]. The correlation coefficients were classified into indirect and direct effects utilizing the path coefficient analysis as suggested by [21]. Path coefficient analysis was also determined based on the approach suggested by [21].

3. Results and discussion

In the two years, the varietal mean performances of irrigation for okra crop phenology and fruit characters indicated significant differences in the cultivars for all the agronomic traits (*Table 1*). The most outstanding for fresh pod yield per plant were okra cultivar Kwadag, Y'ar gagure, Salkade, and Kwadam, in descending order, with yield ranging from 580.38 to 622.67g, while the Composite cultivar had the lowest value of pod yield of 428.62 g over the two years. [22] reported that pod yield varied significantly among okra genotypes. The number of pods the flower buds produced is a measure of fruit yield potential, but this potential could not be realized in the two dry seasons because of flower bud abscission. It is, however, interesting to note that once the flower buds have developed into flowers they have equal chances of developing into pods. Breeding for drought tolerance using the number of flower buds could produce a desirable cultivar for the dry season. Plant height at harvest varied from 1.11 to 1.49 m with a mean of 1.25 m (tables 1 and 2) with Kwadag having the highest. The range observed for days to 50% flowering was 33.00–50.33 days with the overall mean of 46.82 days. This revealed that dissimilar okra cultivars take a significantly different number of days to flowering and that cultivars were morphologically different from one another in flower-bearing habits. Several researchers have found that days to flowering varied significantly among the okra genotypes [22, 23]. The greatest average values for the number of pods per plant and the number of primary branches per plant were noted for Salkade and Y'ar gagure, while the highest fresh pod length and fresh pod diameter were exhibited by Salkade and Kwadag. [24, 25] earlier observed significant differences among the okra accessions for the number of primary branches per plant, which implied that the collected cultivars were phenotypically different. The mean fresh pod length and fresh pod diameter ranged between 11.49 and 14.88 cm and between 1.22 and 1.84 cm respectively. The highest fresh weight per pod (16.88 g) was recorded for Y'ar gagure, while Kwalpuku had the lowest (13.14 g). The error of variance of the mean was small for all the characters (*Table 2*). This might be the result of an optimum number of replications (three) and data used in estimating the components of variance for the characters in the two dry seasons. The wide variability recorded for pod yield among the genotypes shows that there is copious opportunity for selection and improvement. This variability is possibly heritable and could be used in the selection processes during improvement programmes.

Significant positive interrelationships among yield and yield-contributing traits that would increase yield are suitable in crop improvement programmes, as they do not only simplify the selection process but it also gain from the selection [17]. The progress from selection does not only depend on the knowledge of interrelationships of yield and yield-contributing characters but it is also useful in the efficient selection of characters. In this study, the phenotypic and genotypic correlation coefficients calculated in the examined okra morpho-agronomic characters are presented in *Table 2*. The phenotypic correlation coefficients of the okra traits showed a highly significant and positive correlation of the number of pods yield per plant with plant height (r = 0.61), days to 50% flowering (r = 0.72), fresh weight per pod (r = 0.44), and pod length (0.43) (*Table 2*). This indicated that increasing these attributes could invariably increase pod yield. These findings also conformed to previous studies [24] in which pod yield per plant was positively associated with the number of branches per plant, number of pods per plant, and pod length. The authors further stressed that traits that are phenotypically associated but not genotypically correlated will be relevant for selection because selection is sometimes due to the phenotypical performance of traits. The significant relationship between plant height and pod yield in flowering also revealed that yield could be improved via the direct selection of plant height during flowering, as a single trait could be practicable during crop improvement. Days to 50% flowering were positive and highly significantly associated with plant height (r = 0.99) and the number of pods per plant with r = 0.45, and fresh weight per pod (r = 0.55). The days to 50% flowering that positively correlated with plant height morphologically indicated that when the internodes' formation ceases at floral initiation the early maturing okra cultivars usually have short status. Similar findings of fruit yield, which was positively and significantly associated with plant height, number of pods per plant, number of branches per plant, and weight per pod, have been observed by many researchers [26–28]. This also conformed to the report of [29]. These studies, therefore, showed the prospect of improving early-, short-, and higher-yielding okra cultivars by employing the aforesaid associations.

It is of interest to note that genotypic correlation coefficients (*Table 3*) were comparable in magnitude with phenotypic coefficients, except the number of pods per plant with negative and non-significant correlation with fresh pod yield per plant. A high genotypic correlation implied that the selection of one character directly affected the other character. Conversely, low or non-significant correlation suggested independence of association that would be possible to select for the two characters in question for diverse directions. There were positive significant phenotypic and genotypic correlations of fresh weight per pod with days to 50% flowering, pod length, and pod diameter, similar to the findings of [24]. This has also revealed that genetic factors were responsible for these associations. The significant positive association between plant height and number of pods per plant was not surprising because pods in okra are usually borne in the leaf axil at the nodes; number of pods per plant was also found to be strongly correlated positively with the number of nodes on the main stem [30]. Delay in fruiting could be a result of prolonged vegetative growth induced by certain factors of the environment such as photoperiod.

Even though both phenotypic and genotypic correlations were comparable in magnitude, genotypic correlations were higher than phenotypic correlations for entire pairs of traits, indicating that these characters were genetically controlled and that their expression is lessened under the influence of environment. Several works [11, 31] found that phenotypic correlation is an aggregate of environmental and genotypic correlations. However, it has been noted that genotypic correlations have always been stronger than phenotypic correlation coefficients in many crops. The relationship of days to 50% flowering and fresh pod yield per plant was negative and significant at both phenotypic and genotypic levels in this study. This connoted that exceedingly early maturity might enhance decline in the pod yield of okra [16, 24, 32. 33]. Since the pod yield did not correlate phenotypically and genotypically with days to 50% flowering, deviations from anthesis to physiological maturity could influence pod yield as compared with plant emergence to anthesis period. Association between pod yield per plant and pod diameter was low at the phenotypic and genotypic levels across the two years, indicating that there is ample opportunity of receiving plum pods with the least leeway in improving fresh pod yield per plant.

The significant phenotypic and genotypic relationship between pod yield per plant and plant height and number of branches per plant might be related to appropriate light interception provided by greater height. This could also provide higher photosynthetic capacity acquired by other leaves that were on the branches [34]. It is from the leaves that the plants manufacture their food through photosynthesis. The higher the number of leaves, the higher the yield in crops. This is based on higher photosynthetic capacity and photosynthetically active radiation (PAR) via enhanced leaf area index, higher intercepted and fraction of intercepted radiation (FI) as well as its utilization efficiency. Also, in okra, more branches produced increased fruit-bearing nodes.

Table 1. Combined mean performance of ten okra genotypes for fresh pod yield per plant and other related characters under irrigation between the 2015 and 2016 dry seasons in Maiduguri (Nigeria)

Genotypes	**Days to 50% flowering**	**Plant height at harvest (m)**	**Number of primary branches per plant (no)**	**Number of pods per plant (no)**	**Fresh pod length (cm)**	**Fresh pod diameter (cm)**	**Fresh weight per pod (g)**	**Fresh pod yield per plant (g)**
Y'ar duwi	43.11	1.14	2.84	25.34	12.34	1.56	15.96	479.38
Salkade	50.33	1.44	4.23	33.75	14.88	1.22	16.23	598.65
Y'ar gagure	50.75	1.39	3.51	34.45	14.73	1.83	16.56	616.97
Composite	44.23	1.11	1.89	22.54	12.52	1.48	14.73	428.62
Kwalpuku	43.00	1.18	3.18	23.92	11.49	1.51	13.14	488.38
Kwadag	49.31	1.49	3.75	34.35	14.37	1.84	16.83	622.67
Mola kwadag	49.11	1.21	2.66	24.88	12.84	1.48	14.64	457.92
Y'ar kwami	45.34	1.18	3.33	25.18	13.37	1.52	14.34	431.63
Kwadam	45.11	1.22	1.67	28.23	13.64	1.44	15.11	580.38
Lai–lai	47.93	1.16	2.12	28.64	11.59	1.52	14.98	532.85
Mean	46.82	1.25	2.92	28.03	13.08	1.54	15.25	523.75
Range	7.33	0.38	2.56	11.91	3.39	0.62	3.68	194.05
SE±	11.849	6.111	2.759	6.654	6.149	11.234	10.171	11.73
LSD α 0.05	2.23*	1.11*	1.45*	4.62**	2.14*	1.01*	1.43*	3.57
CV%	4.36	7.82	6.39	4.92	10.52	7.45	7.18	6.83

Table 2. Ranges, means, and values of 'F' from estimates for fresh pod yield per plant and other related characters of okra cultivars under irrigation between the 2015 and 2016 dry seasons in Maiduguri (Nigeria)

Characters	**Range of variation**	**Means**	**S.E.**	**Standard deviation**	**Error variance**	**F value**
Days to 50% flowering	33.00–50.33	46.82	0.91	3.45	0.54	45.28
Plant height at harvest (m)	1.11–1.49	1.25	0.84	0.33	7.25	26.72
Number of primary branches per plant	1.67–4.23	2.92	1.25	0.34	3.52	35.98
Number of pods per plant	22.54–34.45	28.03	1.12	1.48	2.35	10.63
Fresh pod length (cm)	11.49–14.88	13.08	1.38	1.32	7.75	40.73
Fresh pod diameter (cm)	1.22–1.84	1.54	1.52	0.87	0.53	22.53
Fresh weight per pod (g)	13.14–16.88	15.25	1.58	0.12	3.78	33.54
Fresh pod yield per plant (g)	428.62–622.67	523.75	0.47	0.83	1.52	67.93

PHT: plant height (cm), DF: Days to 50% flowering, NBP: Number of primary branches per plant, NPP: Number of pods per plant, PL: Pod length (cm), PD: Pod diameter (cm), FPW: Fresh weight per pod (g), and FPY: Fresh pod yield per plant (g)

Table 3. Genotypic and phenotypic correlations for okra pod yield and yield attributes combined across the years under irrigation in Maiduguri, Nigeria

S/N		PHT	DF	NBP	NPP	PL	PD	FPW	FPY
PHT	rg	1.00							
	rp	1.00							
DF	rg	–0.55**	1.00						
	rp	–0.53**	1.00						
NBP	rg	0.21	0.26	1.00					
	rp	0.22	0.27	1.00					
NPP	rg	0.52**	0.47**	0.19	1.00				
	rp	0.48**	0.46**	0.20	1.00				
PL	rg	0.60*	0.14	–0.50**	0.18	1.00			
	rp	0.59*	0.11	–0.47**	0.19	1.00			
PD	rg	0.18	0.11	–0.13	–0.30	–0.22	1.00		
	rp	0.17	0.13	–0.10	–0.27	–0.19	1.00		
FWP	rg	0.29	0.52**	0.18	0.10	0.53**	0.85**	1.00	
	rp	0.25	0.48**	0.10	0.07	0.51**	0.78**	1.00	
FPY	rg	0.61**	–0.51**	0.32*	0.79**	0.72**	0.25	0.75**	1.00
	rp	0.50**	–0.43**	0.29*	0.65**	0.63**	0.20	0.61**	1.00

*,**, significant at $P< 0.05$ and $P< 0.01$ respectively.

PHT: plant height (cm), DF: days to 50% flowering, NBP: number of primary branches per plant, NPP: number of pods per plant, PL: pod length (cm), PD: pod diameter (cm), FPW: fresh weight per pod (g), and FPY: fresh pod yield per plant (g)

The pod yield of okra is governed by several agronomic traits with either indirect or direct contribution to the yield. The path coefficient analyses employed to acquire more information on the associations between morpho-agronomic characters and their influences on okra fresh pod yield per plant are described in *Table 4*. The number of pods per plant had the greatest direct influence on pod yield (p = 6.63), followed by fresh weight per pod (p = 6.13), which had positive genotypic association with pod yield. Previous literature on path coefficient analysis showed that the number of pods per plant and fruit weight had positive and high direct effects on fruit yield, indicating their importance as reliable selection criteria for the improvement of yield in okra [22, 35].

Table 4. Path coefficient of okra fresh pod yield and other related attributes combined across the years under irrigation in Maiduguri, Nigeria

Character	**Genotypic correlation**	**Indirect effects**						
		PHT	**DF**	**NBP**	**NPP**	**PL**	**PD**	**FPW**
PHT	0.58**	**–3.56**	1.67	0.47	–0.56	1.31	–0.76	0.17
DF	–0.48**	0.41	–0.87	0.18	0.12	1.29	0.64	0.41
NBP	0.27*	–0.55	0.59	–1.67	0.13	0.45	0.83	0.73
NPP	0.77**	0.80	2.83	–2.05	6.63	1.23	–1.71	0.34
PL	0.74**	0.92	1.45	–1.72	0.49	–3.57	3. 11	0.59
PD	0.21	–0.30	–5.33	2.11	–0.73	1.33	3.76	–0.42
FPW	0.62**	–0.63	–7.76	–0.79	0.81	–4.81	1.22	**6.13**

*,**, significant at P< 0.05 and P< 0.01 respectively. Direct effect and indirect values are provided in diagonal and off-diagonal, respectively.
Residual effect (h = 0.30). PHT: plant height (cm), DF: days to 50% flowering, NBP: number of primary branches per plant, NPP: number of pod per plant, PL: pod length (cm), PD: pod diameter (cm), FPW: fresh pod weight (g)

It is of the opinion that by enhancing ear weight because of the increased absorption of photoassimilates, the best segment of assimilates remobilize to grains, and consistently enhance grain weight. However, as direct and indirect influences of the number of pods per plant were prominent, these had a positive impact on pod length and pod diameter, which could have resulted the high correlation coefficient that existed between pod yield and the number of pods per plant (rg = 0.77). The direct response of this character could be attributed to the indirect positive influence of plant height, days to 50% flowering, pod length, and fresh weight per pod. Some researchers reported that plant height exhibited positive direct influence on okra pod yield per plant [7, 36]. This, therefore, suggests the vital and successful achievement in choosing these characters once high yield is the main objective. Pod length had the highest negative direct influence on pod yield despite its positive genotypic interrelation with pod yield per plant. This showed

the flaw of selection based on inter-character association only. Therefore, the selection of this character may not produce the desired results. While direct influence of plant height on fruit yield resulted a negative value (p = –3.56), its correlation coefficient also had a negative value (rg = –0.58), whereas it had a high positive indirect influence on pod length and number of pods per plant.
Regardless of the importance of pod-yield-contributing traits used in path coefficient analysis computation, the residual effect (h = 0.10) is relatively low, denoting that the characters considered in this analysis have sufficiently accounted for the variability in okra yield as supported by many researchers [37–39]. It is projected that 78.93% difference in pod yield at a genotypic level is determined. This further portrayed the occurrence of some factors that contributed to okra pod yield that were not considered in this study. It could also be due to that correlation coefficients were ordinary estimates and were constantly used for rounding-off errors. Pod length, days to 50% flowering, number of pods per plant, and weight per pod are favourable characters that could be utilized in choosing high pod yield in okra due to their highly significant genotypic and phenotypic associations with fresh pod yield per plant in this study. It was also observed by [40] that a significant increase in each of these parameters tested could lead to an increase in the total okra pod yield. These evaluated traits also had the greatest indirect and direct influences via the majority of other traits. It is apparent that these prominent agronomic parameters could be given attention as essential condition in advancing okra varieties for high pod yield.

Acknowledgments

The authors would like to thank the Farm Manager and the team of Teaching and Research Farm, University of Maiduguri, Maiduguri, Nigeria for providing all necessary facilities to carry out the research.

References

[1] National Research Council (2006), *Lost Crops of Africa:* Volume II*:* Vegetables. Washington, D.C., 286–301.

[2] Babatunde, R. O., Omotesho, O. A., Sholoton, S. O. (2007), Socio-economic characteristics and food security status of farming household in Kwara State, North Central Nigeria. *Pak. J. Nutr.* 6(1), 16–22.

[3] Purquerio, L. F. V., Lago, A. A., Passos, F. A. (2010), Germination and hard seedness of seeds in okra elite lines. *Hort. Brasil Brasília* 28(2), 23–32.

[4] Aladele, S. E., Ariyo O. J., de Lapena, R. (2008), Genetic relationship among West African okra (*Abelmoschus caillei*) and Asian genotypes (*Abelmoschus esculentus*) using RAPD. *Afr. J. Biotechnol*. 7, 1426 –1431.

[5] Farinde, A. O., Owalarefe, L. B. (2007). Nigeria fertilizer sector, present situation and future prospects. IFDC. *Technical Bulletin* 12(1), 18–25.

[6] Wolford, R., Banks, D. (2006). Okra (*http://www.urbanext.uivc/veggies/okra 1.htm*).

[7] Saifullah, M., Rabbani, M. G. (2009), Evaluation and characterization of okra (*Abelmoschus esculentus* (L.) Moench.) genotypes. *SAARC J. Agric*. 7(1), 92–99.

[8] FAO. (2004), An ecological guide: Training resource text on crop development, major economic practices, disease and insect ecology, insect pests, natural enemies and diseases of okra. The National Academies Press, http://www.vegetableipmasia.org/docs/Ecological%20Guide/ OKRA%20ECO%20GUIDE.pdf.

[9] Olaoye, G., Bello, O. B., Olayiwola, L. S., Abubakar, A. Y. (2009), Analyses of moisture deficit grain yield loss in drought tolerant maize (*Zea mays* L.) germplasm accessions and its relationship with field performance. *Afr. J. Biotechn*. 8(14), 3229–3238.

[10] Bello, O. B., Afolabi, M. S., Ige, S. A., Abdulmaliq, S. Y., Azeez, M. A., Mahmood J.(2011), Yield response of diallelic crossed maize (*Zea mays* L.) genotypes to varying nitrogen regimes in Nigeria. *J. Bio-Sci*. 19, 43–52.

[11] Bello, O. B., Abdulmaliq, S. Y., Ige, S. A., Mahmood, J., Oluleye, F., Azeez, M. A., Afolabi, M. S. (2012), Evaluation of early and late/intermediate maize varieties for grain yield potential and adaptation to a southern guinea savanna agro-ecology of Nigeria. *Intern. J. Plant Res*. 2(2), 14–21.

[12] Bello, O. B., Afolabi, M. S., Ige, S. A., Abdulmaliq, S. Y., Azeez, M. A., Mahmood J. (2012), Nitrogen use efficiency and grain yield in a diallelic cross of maize populations. *Inter. J. Plant Res*. 2(3), 94–102.

[13] Bello, O. B., Olawuyi, O. J., Ige S. A., Mahamood, J., Afolabi, M. S., Azeez, M. A., Abdulmaliq, S. Y. (2014). Agro-nutritional variations of quality protein maize (*Zea mays* L.) in Nigeria. *J. Agric. Sci.* 59(2), 101–116.

[14] Bello, O. B., Olawuyi, O. J., Abdulmaliq, S. Y., Ige, S. A., Mahamood, J., Azeez. M. A. Afolabi, M. S. (2014), Yield performance and adaptation of early and intermediate drought-tolerant maize genotypes in Guinea savanna of Nigeria. *Sarhad J. Agric*. 30(1), 53–66.

[15] Bello, O. B., Olawuyi, O. J. (2015). Gene action, heterosis, correlation and regression estimates in developing hybrid cultivars in maize. *Trop. Agric*. 92(2), 102–117.

[16] Adekoya, M. A., Ariyo, O. J., Kehinde, O. B., Adegbite, A. E. (2014), Correlation and path analyses of seed yield in okra (*Abelmoschus esculentus* (L.) Moench) grown under different cropping seasons. *Pertan. J. Trop. Agric. Sci.* 37(1), 39–49.

[17] AdeOluwa, O. O., Kehinde, O. B. (2011), Genetic variability studies in West African Okra (*Abelmoschus caillei*). *Agric. Biol. J. North Ame*. 2(10), 1326–1335.

[18] SAS. (2011), *Statistical analysis system (SAS) software for windows version 9.2. Vol. 1*. SAS Institute. Cary, N.C. USA.

[19] Gomez, K. A. Gomez, A. A. (1984). *Statistical procedure for agricultural research (2nd ed.)*. International Rice Research Institute, A Willey Institute of Science. 28–192.

[20] Johnson, H. W., Robinson, H. F. Comstock, R. E. (1955), Estimation of genetic and environmental variability in soybeans. *Agron. J.* 47, 314–318.

[21] Dewey, D. R., Lu, K. H. (1959), A correlation and path coefficient analysis of components of crested wheat grass seed production. *Agron. J. Hort.* 57(4), 342–346.

[22] Subrata, S., Hazra, P., Chattopadhyay, A. (2004), Genetic variability, correlation and path analysis in okra (*Abelmoschus esculentus* (L.) Moench). *Hort. J.* 17(1), 59–66.

[23] Medagam, T. R., Mutyala, H. B., Konda, C. R., Hameedunnisa, B., Reddivenkatagari, S. K. R., Jampala, D. B. (2013), Correlation and path coefficient analysis of quantitative characters in okra (*Abelmoschus esculentus* (L.) Moench). *Songklanakarin J. Sci. Technol*. 35(3), 243–250.

[24] Rashwan, A. M. A. (2011), Study of genotypic and phenotypic correlation for some agro-economic traits in okra (*Abelmoschus esculentus*). *Asian Crop Sci*. 3, 85–91.

[25] Singh, B., Aakansha, G. (2014), Correlation and path coefficient analysis in okra (*Abelmoschus esculentus*). *Indian J. Agric. Sci*. 84(10), 1262–1266.

[26] Simon, S. Y., Gashua, I. B. Musa, I. (2013), Genetic variability and trait correlation studies in okra [*Abelmoschus esculentus* (L.) Moench]. *Agric. Bio. J. North Ame*. 10, 532–538.

[27] Mihretu, Y., Weyessa, G., Adugna, D. (2014), Variability and association of quantitative characters among okra (*Abelmoschus esculentus* (L.) Moench) collection in South Western *Ethiopia. J. Bio. Sci*. 14, 336–342.

[28] Kishor, D. S., Arya, K. Yogeesh, K. J. Vinod, K. Y. Hee–Jong, K. (2016). Genotypic variation among okra (*Abelmoschus esculentus* (L.) Moench) germplasms in South *Ind. Plant Breed. Biotechnol*. 4(2), 234–241.

[29] Anand, C., Kartikeya, S. A., Vishal, S. Santosh, K. (2016), Elucidation of variability, interrelationships and path–coefficient in maize (*Zea mays* L.). *Nat. Env. Pollut. Technol*. 15(2), 653–656.

[30] Bhalekar, S. G., Nimbalkar, C. A. Desai, U. T. (2005), Correlation and path analysis studies in okra. *J. Maharashtra Agric. Univ*. 30(1), 109–112.

[31] Ahiakpa, P. D., Kaledzi, E. B., Adi, S., Peprah, H. K., Dapaah, A. M. A. Rashwan, A. (2011), Study of genotypic and phenotypic correlation for some agro-economic traits in okra (*Abelmoschus esculentus* (L.) Moench). *Asian J. Crop Sci*. 3, 85–91.

[32] Ahamed, K. Akter, U., B., Ara, N., Hossain, M. F., Moniruzzaman, M. (2015), Heritability, correlation and path coefficient analysis in fifty seven okra genotypes. *Int. J. Appl. Sci. Biotechnol*. 3(1), 127–133.

[33] Tesfa, B., Yosef, A. (2016), Characterization of okra (*Abelmoschus esculentus* (L.) Moench) germplasms collected from Western Ethiopia. *Int. J. Res. Agric. For*. 3(2), 11–17.

[34] Stevels, C. O. A., Ariyo, O. J. Ayo–Vaughan, M. A. (2012), Genotypic performance, character correlations and path analysis of pod yield in *Abelmoschus caillei* (A. Chev.). *Italian J. Agron*. 7(E44), 337–345.

[35] Adeniji, O. T., Kehinde, O. B., Ajala, M. O. Adebisi, M. A. (2007), Genetic studies on seed yield of West African okra (*Abelmoschus caillei*) (A chev.) Stevels). *J. Trop. Agric.* 45(1–2), 36–41.

[36] Solankey, S. S., Singh, A. K. (2010), Correlation studies in okra (*Abelmoschus esculentus* L. Moench). *Asian J. Hort.* 5(1), 70–75.

[37] Akanbi, W. B., Togun, A. O., Adediran, J. A. Ilupeju, E. A. O. (2010), Growth, dry matter and fruit yield components of okra under organic and inorganic sources of nutrients. *American–Eurasian J. Sustain. Agric*. 4(1), 1–13.

[38] Mishra, A., Mishra, H. N., Senapati, N., Tripathy, P. (2015), Genetic variability and correlation studies in okra (*Abelmoschus esculentus* (L.) Monech). *Electron. J. Plant Breed*. 6(3), 866–869.

[39] Demelie, M., Mohamed, W., Gebre, E. (2016). Variability, heritability and genetic advance in Ethiopian okra [*Abelmoschus esculentus* (L.) Monech] collections for tender fruit yield and other agro-morphological traits. *J. Appl. Life Sci. Inter*. 4(1), 1–12.

[40] Jagan, K., Ravinder, R. K., Sujatha, M., Madhusudhan, R., Sravanthi, V. (2013), Correlation and path coefficient analysis for certain metric traits in okra (*Abelmoschus esculentus* (L.) Moench) using line x tester analysis. *Inter. J. Innov. Res. Dev*. 2(8), 287–293.