African Journal of Biotechnology Vol. 5 (14), pp. 1330-1336, 16 July 2006
Available online at http://www.academicjournals.org/AJB
ISSN 1684–5315 © 2006 Academic Journals

Full Length Research Paper

Correlation and path coefficient analyses of seed yield attributes in okra (*Abelmoschus esculentus* (L.) Moench)

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Accepted 9 June, 2006

NH47-4 variety of okra, *Abelmoschus esculentus* (L.) Moench, was grown in two locations for two years from seeds collected from the National Institute of Horticultural Research and Training (NIHORT), Ibadan, Nigeria. Experimental design adopted for the study was the randomised complete block design (RCBD). Correlation and path coefficients were calculated for seed yield per plant and its components from data amassed over two years. The components of seed yield considered are days to flowering, days to maturity, number of branches per plant, number of pods per plant, height at flowering, final height, pod length, pod width, number of seeds per pod and weight of hundred seeds. Seed yield per plant showed significant positive correlation with number of pods per plant, height at flowering, pod width and weight of hundred seeds. Path coefficient analysis revealed that number of pods per plant and height at flowering had the highest direct effect on seed yield. This suggests that the two attributes have a strong influence on seed yield. Hence, number of pods per plant and height at flowering are the main determiners of seed yield per plant in the studied variety.

Key words: Correlation coefficient, path coefficient, seed yield, okra.

INTRODUCTION

Abelmoschus esculentus (L.) Moench, commonly called okra, is believed to be native to tropical Africa. It is an important vegetable crop throughout the tropics and sub tropics (Kochhar, 1986; Hammon and Van Sloten, 1989). There are 2,283 accessions out of which 2,029 were collected from the African continent of which 1,769 are from West Africa. Okra, therefore, is far more heavily represented in West Africa than what obtains in any other parts of the world (Hammon and Van Sloten, 1989). The seeds of okra are round, grayish and quite large. Leaves are 3-7 lobed, more or less divided, 20-40 cm long, on a petiole. Owing to its floral structure and absence of self-incompatibility, okra produces much of its progeny through selfing. However, cross-pollination is frequently mentioned in the literature.

Progress in crop production depends to a great extent on the ability of the breeders to select high yielding varieties. Considerable effort is currently being made in a number of okra breeding programmes to improve yield attributes such as seed yield, number of pods per plant, pod length and pod width. These traits are particularly important in the breeding of okra programmes. The vegetative traits are also a measure of yield and should be considered, just as pod characteristics, during selection in breeding programmes to improve yield (Ariyo, 1992). The weight of the pod and the number of pods per plant have been consistently identified as very important components of pod yield (Kaul et al., 1978; Ariyo, 1989). Number of pods per plant, days to flowering and plant height are some of the most variable quantitative characters of okra (Singh and Singh, 1977). Variation is a necessary condition for selection programme aimed at improving some desirable traits.

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Table 1. Mean squares of the eleven characters studied in okra.

Source of variation	Degree of freedom	Days to flowering	Days to maturity	No. of branches/ plant	Seed yield (g)	Height at flowering (cm)	Final heigth (m)	No. of seeds/pod	Pod length (cm)	Pod width (cm)	No. of pods/plant	Weight of 100 seeds (g)
Treatment	2	27.53**	261.92**	6.64	569.59**	389.87**	646.54**	2616.8**	8.03	1.61	20.65**	1.26
Block	2	3.47	2.60	0.05	12.5	139.73**	189.77**	90.65*	2.84	0.20	0.45	0.025
Error	55	1.85	8.14	0.42	43.58	19.35	45.71	44.38	0.58	0.08	1.21	0.05

*, **Significant at 5% and 1% levels of probability, respectively.

Table 2. Pearson correlation coefficients of the eleven characters studied in okra.

Characters	Days to flowering	Days to maturity	No. of branches/plant	Height at flowering (cm)	Final height (cm)	Seed yield (g)	Pod length (cm)	Pod width (cm)	No. of pods/plant	No. of seeds/pod	Weight of 100 seeds (g)
Days to flowering											
Days to maturity	0.9650**										
No. of branches/plant	0.143	0.155									
Height at flowering	0.733**	0.725**	-0.007								
Final height (cm)	0.756**	0.776**	0.151	0.718**							
Seed yield (g)	-0.638**	-0.645**	-0.100	-0.376**	-0.437**						
Pod length (cm)	-0.721**	-0.715**	-0.084	-0.511**	-0.489**	-0.427**					
Pod width (cm)	-0.756**	-0.748**	-0.185*	-0.488**	-0.524**	0.528**	0.706**				
No. of pods/plant	0.089	0.088	0.000	0.221*	0.177	0.612**	-0.047	-0.042			
No. of seeds/pod	-0.529**	-0.555**	-0.162	-0.277**	-0.370**	0.291**	0.467**	0.417**	-0.175		
Weight of 100 seeds	0-0.932**	-0.931**	-0.089	-0.680**	-0.723**	0.646**	0.707**	0.732**	-0.039	0.561**	

*, ** significant at 5% and 1% levels of probability, respectively.

Table 3. Environmental correlation coefficients of the eleven characters studied in okra.

Characters	Days to flowering	Days to maturity	No. of branches/ plant	Height at flowering (cm)	Final height (cm)	Seed yield (g)	Pod length (cm)	Pod width (cm)	No. of pods/ plant	No. of seeds/pod	Weight of 100 seeds (g)
Days to flowering		-0.1788*	0.1705	-0.0282	-0.0354	-0.0523	0.1588	-0.0766	0.0510	0.1001	-0.2804*
Days to maturity			0.1158	0.1822*	0.2164*	-0.0110	0.0506	0.1259	-0.611	-0.0646	0.0617
No. of branches/plant				0.3232**	0.3698**	0.0560	0.1020	-1098	0.0381	0.3187**	0.1359
Height at flowering					0.9094**	0.4302**	0.0189	0.0122	0.4433**	0.0735	0.2498*
Final height (cm)						0.3301*	0.0533	0.0607	0.3287**	0.1398	0.2759*
Seed yield (g)							0.0440	0.1880*	-0.8915	-1647	0.2606*
Pod length (cm)								0.2716*	-0.0421	0.1445	-0.0350
Pod width (cm)									-0.0671	-0.0952	-0.1240
No. of pods/plant										-0.0928	0.1233
No. of seeds/pod											0.1352
Weight of 100 seeds(g)											

*, **Significant at 5% and 1% levels of probability, respectively.

Table 4. Genotypic correlation coefficients of seed yield on yield components in okra.

Character	Days to flowering	Days to maturity	No. of branches/ plant	No. of pods/ plant	Height at flowering (cm)	Final height (cm)	Pod length (cm)	Pod width (cm)	No. of seeds/pod	Weight of 100 seeds (g)
Days to flowering		-1630*	0.2198*	-0.0839	0.0776	0.1265	0.1940	-0.0480	0.1563*	-0.1809
Days to maturity			0.2329*	-0.0780	0.2393*	0.1196	0.0157	0.1553*	-0.0770	0.0495
No. of branches/plant				0.5907**	0.2425*	0.0148	-0.0863	-0.1979	0.1242	0.2143*
No. of pods/plant					0.4497**	-0.1322	-0.0131	0.0988	-0.0928	0.1306
Height at flowering (cm)						0.0321	0.0909	0.0663	0.0630	0.2086*
Final height (cm)							0.1214	-0.0331	0.0573	-0.0559
Pod length (cm)								0.1689*	0.0962	-0.0362
Pod width (cm)									0.0003	0.8032**
No. of seeds/pod										0.0004
Weight of 100 seeds										

*, ** Significant at 5% and 1% levels of probability respectively.
All the listed characters are seed yield dependent. Hence the eleventh character does not appear on the table.

Singh et al. (1974) investigated variation in okra species and found out that a large number of okra characters such as pigment colour and spines on the fruit surfaces are inherited in a simple fashion, suggesting that these characters are controlled by relatively few genes. Mishra and Chhonkar (1979) reported considerable variation in okra vegetative and fruit characters. They noticed variation in number of branches per plant, pod yield per plant, number of seeds per pod, pod length, plant height at flowering, final plant height, pod growth, pod weight, days to 50% flowering and total number of leaves per plant. Ariyo (1993) indicated that the pattern of genetic variation observed in each of the characters studied in West African okra suggests a lot of out crossing among the taxon.

Correlation measures the mutual association between two variables while path coefficient analysis identifies the causes and measures the relative importance of the association. Correlation coefficient measures the mutual association between a pair of variables independent of other variables to be considered. Therefore, when more than two variables are involved, the correlations per se do not give the complete picture of their inter-relationships (Fakorede and Opeke, 1985). To evaluate relationships, correlation analyses are used such that the values of two characters are analyzed on a paired basis, results of which may be either positive or negative. The result of correlation is of great value in the determination of the most effective procedures for selection of superior genotypes. When there is positive association of major yield characters, component breeding would be very effective but when these characters are negatively associated, it would be difficult to exercise simultaneous selection for them in developing a variety.

Multiple regression and path coefficient analyses are particularly useful for the study of cause-and-effect relationships because they simultaneously consider several variables in the data set to obtain the coefficients (Fakorede and Opeke, 1985). The establishment of a positive or negative relationship does not lead to a direct cause-and-effect interpretation, but a path coefficient analysis measures the direct influence of one variable upon another and permits the separation of the correlation into components of direct and indirect effects. Kaul et al. (1978) observed that seed yield per plant followed by number of primary branches per plant had maximum direct effect on pod yield per plant. In the same study, days to first harvest had a negative direct effect on pod yield. Kumar and Reddy (1982) observed that number of pods per plant had the highest direct effect on seed yield followed by plant height, number of primary branches and days to flowering. Ariyo et al. (1987) reported that edible pod weight had the highest positive direct effect on pod yield with its largest indirect effect through reduction in edible pod width.

Waldia et al. (1979) observed in their study that path analysis may or may not give results identical to correlation studies and in case of disparities, reliance must be placed on path analysis because it provides a better understanding of the course-and-effect relationship between pairs of characters. So far, none of the works carried out on yield attributes of okra has been directed at identifying the characters that have influence on its seed yield. The aim of this work, therefore, is to investigate the inter-relationship of yield attributes of okra with a view to identifying the traits that contribute significantly to its seed yield.

MATERIALS AND METHODS

NH47-4 lines of *Abelmoschus esculentus* obtained from NIHORT, Ibadan, Nigeria were grown in July 2002 and July 2003 under rain fed conditions using randomized complete block design (RCBD) with three replicates. The plot size in each replicate was 3 m x 2 m. Plots were separated by 1 m between replicates and 0.5 m between plots to facilitate easy movement during field operations. Three seeds were sowed per hole and later thinned to one plant hill per stand at three weeks after sowing, giving a plant density of 55, 555 plants per hectare.

Biometric observations commenced when the plants began to bloom. Data were collected on days to flowering, days to maturity, number of pods per plant, pod length, pod width, weight of hundred seeds, number of seeds per pod, plant height at flowering, final plant height, seed yield and number of branches per plant. In each plot, five plants were randomly selected, tagged and used as a representative sample. The data collected were subjected to standard analysis of variance. Genotypic correlation coefficients of the biometric observations were estimated according to the method suggested by Aljibouri et al. (1958) and phenotypic correlation coefficients according to the method of Steel and Torrie (1960). Path coefficient analysis was carried out using the method of Wright (1921) as modified by Dewey and Lu (1959). Summaries of basic features of the method and its applications are given by Li (1948, 1956).

RESULTS AND DISCUSSION

Mean squares of the eleven characters studied are presented in Table 1. Pearson and environmental correlation coefficients of the eleven characters of okra are presented in Tables 2 and 3, respectively. There are marked differences between the Pearson and environmental correlation coefficients as shown in the tables. The genotypic and phenotypic correlation coefficients of seed yield on yield components are presented in Tables 4 and 5, respectively. The direct and indirect effects of some characters on seed yield as well as residual factors are given in Table 6. In spite of the large number of characters used in the path coefficient analysis, the value of the residual factor was found to be –0.7431 which may be due to rounding off errors.

Variation is a necessary condition for selection in breeding programmes. In plant breeding, selection is aimed at improving some desirable traits. The analysis of variance in this work revealed highly significant differences in days to flowering, days to maturity, seed

Table 5. Phenotypic correlation coefficients of seed yield on yield components in okra.

Characters	Days to flowering	Days to maturity	No. of branches/plant	No. of pods/plant	Height at flowering (cm)	Final height (cm)	Pod length (cm)	Pod width (cm)	No. of seeds/ pod	Weight of 100 seeds
Days to flowering		-0.179*	0.174*	0.216*	-0.006	-0.019	0.162	-0.068	0.093	-0.277**
Days to maturity			0.0117	-0.113	0.207*	0.2338	0.051	0.130	-0.067	0.067
No. of branches/plant				-0.026	0.332**	0.372**	0.099	-0.123	0.333**	0.126
No. of pods/plant					0.146	0.0804	-0.180*	-0.226*	0.121	-0.250
Height at flowering (cm)						0.901**	0.000	-0.078	0.162	0.158
Final height (cm)							0.041	-0.002	0.209*	0.208*
Pod length (cm)								0.268*	0.154	-0.048
Pod width (cm)									-0.066	0.182*
No. of seeds/pod										0.187*
Weight of 100 seeds (g)										

*, **Significant at 5% and 1% levels of probability, respectively.
All the listed characters are seed yield dependent. Hence the eleventh character does not appear on the table.

Table 6. Direct and indirect effects of some characters on seed yield in okra.

Characters	Direct effect on seed yield	Days to flowering	Days to maturity	No. of branches /plant	No. of pods/ plant	Height at flowering (cm)	Final height (cm)	Pod length (cm)	Pod width (cm)	No. of seeds/ pod	Weight of 100 seeds	Genotypic correlation coefficient
Days to flowering	0.0396		0.0235	0.0052	-0.0753	0.0331	-0.0146	0.0103	-0.0105	-0.0257	-0.0410	-0.1346
Days to maturity	-0.1439	0.0065		0.0055	-0.0700	0.1019	0.0138	0.0008	0.0338	0.0127	0.0112	-0.0277
No. of branches/ Plant	0.0238	-0.0087	-0.0335		0.5305	0.1033	-0.0017	-0.0046	-0.0431	-0.0205	0.0481	-0.4674**
No. of pods/plant	0.8980	0.0033	0.0112	-0.0141		0.1916	0.0152	-0.0007	0.0215	0.0153	0.0296	1.1709**
Height at flowering (cm)	0.4260	-0.0031	-0.0344	0.0058	0.4038		-0.0037	0.0048	0.0144	-0.0104	0.0472	0.8504**
Final height (cm)	-0.1151	-0.0050	-0.0172	0.0004	-0.1187	0.0137		0.0064	-0.0072	-0.0094	-0.0127	0.0070
Pod length (cm)	0.0530	-0.0070	-0.0023	-0.0021	-0.0118	0.0387	-0.0140		0.0368	-0.0158	-0.0240	0.0508
Pod width (cm)	0.2177	0.0090	-0.0205	-0.0047	0.0887	0.0282	0.0038	0.0090		0.0000	0.1819	0.5060**
No. of seeds/ plant	-0.1647	-0.0062	0.0049	0.0030	-0.0833	0.0268	-0.0016	0.0051	-0.0001		0.0001	-0.2210*
Weight of 100 seeds (g)	0.2264	0.0071	0.0071	0.0051	0.1173	0.0889	0.0064	-0.0019	0.1749	-0.0001		0.6171**

*, **Significant at 5% and 1% levels of probability respectively.
Residual factors = -0.7431.

yield, height at flowering, final height, number of seeds per pod and number of pods per plant at 1% level of probability. The significant differences revealed by the above listed attributes of yield may be due to environmental influences on the parental genetic constitution. The non-significant differences observed in the number of branches per plant, pod length, pod width and weight of hundred seeds indicate that the genetic components of the parental material are intact. It follows, therefore, that any improvement sort must be directed at days to flowering, days to maturity and number of pods per plant, which is similar to the findings of Singh and Singh (1977), Ariyo (1989, 1992a) and Kaul et al. (1978). Heights at flowering and final height are vegetative traits that are important for yield determination. Their facilitatory role contributes significantly to final yield and should be considered, just as reproductive characteristics, during selection to improve yield in breeding programmes. The mutual association of characters is often expressed by the phenotypic, genotypic and environmental correlations. It was observed in this study that genotypic correlation coefficients were not significantly different from their corresponding phenotypic and environmental correlations. However, since environmenttal correlation coefficients were low in most cases, phenotypic correlations which incorporate the genotypic and environmental correlations would be good indices of genotypic correlation coefficients.

The association of days to flowering with days to maturity, height at flowering and final height showed that there is strong relationship between days to flowering and days to maturity and hence, indicative of a strong relationship between the stage of plant growth at which flowering is initiated and final height at which the entire crop life cycle is completed. The negative but highly significant correlation of days to flowering with characters like seed yield, pod length, pod width, number of seeds per pod and weight of hundred seeds shows that varieties with shorter days to flowering tend to produce more yield – having considerable pod length, pod width, number of seeds per pod and weight of seeds. Although some of these characters that exercise negative correlation with one another will be difficult to select for in characterization of desirable traits, those with negative association but non significant correlation will be disregarded in selection for crop or variety improvement (Ariyo et al., 1987; Henry and Krishna, 1990; Newall and Eberhart, 1961). Pod width, number of seeds per pod and weight of hundred seeds significantly correlated positively with pod length. This shows that there is a strong relationship between seed yield and length of pod, the width of the pod as well as the weight of seeds in each of the pods.

The negative significant association of final height with seed yield, pod length, pod width and weight of hundred seeds indicates that the performance of the crop plant in terms of final yield will be reduced because considerable height at flowering favours production of more fruits/pods than shorter heights. The number of pods per plant exhibited positive significant environmental correlation with height at flowering, final height and seed yield. This means that the environmental factors favour the performance of the okra plant in terms of seed yield and should be selected for as a component of yield. Number of seeds per pod had negative significant environmental correlation with number of pods per plant suggesting that effects of the environment did not favour production of more pods and consequently number of seeds will be reduced. Therefore, selection based upon this condition will not be effective. The significant genotypic and phenotypic correlation between days to flowering and number of days to maturity, though negative, indicates that number of days to flowering can be used as a criterion for selecting lines that have a few number of days to maturity, so that production can occur twice in a cropping season. This finding is similar with the report of Ariyo et al. (1987). The significant environmental and phenotypic correlations of number of branches per plant with height at flowering, final height and days to maturity indicates that selection for seed yield based upon the phenotypic performance of these characters will not be effective. Non-significant genotypic correlation between weight of hundred seeds and number of seeds per pod indicates that the two characters are independent on one another and that they could be selected for separately as they are components of seed yield. Since there is a significant association between number of pods per plant and number of branches per plant, the more the number of branches per plant the more the number of pods produced and this will simultaneously increase seed yield.

The high positive direct effects of number of pods per plant and height at flowering on seed yield indicates that, with other variables held constant, an increase in number of pods per plant and height at flowering might increase seed yield per plant. Although number of branches per plant had the least direct effect on seed yield, its indirect effects via number of pods per plant and height at flowering were high thereby counterbalancing the very low direct effect of number of branches per plant. Pod width had appreciable direct effect on seed yield with high indirect effect via weight of hundred seeds. This shows that increase in pod width will result in increase in weight of seeds without necessarily increasing the number of seeds. Data analysis reveals that number of pods per plant had the highest genotypic correlation coefficient and direct effect on seed yield and the corresponding indirect effect through height at flowering and pod width. Hence, number of pods per plant should be given prior attention in okra improvement programme because of its major influence on yield.

In conclusion, days to flowering, days to maturity, seed yield, height at flowering, final height, number of pods per plant and number of seeds per pod show highly significant differences from the variance analysis. This suggests that the characters should be considered in okra improvement programme. The significant genotypic and phenotypic correlation between days to flowering and days to maturity, though negative, can be used as a criterion for selecting lines with short life span. Number of pods per plant had the highest genotypic correlation coefficient and direct effect on seed yield and its indirect effect through height at flowering and pod width. Hence number of pods per plant should be seen as a major determiner of final yield.

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