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Full Length Research Paper

Genotype × environment interaction in $NH_{47\text{-}4}$ variety of okra – *Abelmoschus esculentus* (Linn.) Moench

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Sixty lines of $NH_{47\text{-}4}$ variety of okra (*Abelmoschus esculentus*), obtained from the National Institute of Horticultural Research and Training (NIHORT), Ibadan, Nigeria, were grown in two different locations (Akure and Ilara-Mokin, Ondo State, Nigeria) under rain-fed conditions using the Randomised Complete Block Design (RCBD) with four replicates. The plants' genotypic coefficients of variation and correlations were analysed for eleven quantitative traits, namely 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, weight of 100 seeds and seed yield. The number of branches per plant, number of pods per plant and seed yield showed high genotypic coefficient of variation. Plant height at flowering, final plant height and number of seeds per pod showed positive direct genotypic effect on the number of branches per plant. Number of pods per plant and number of seeds per pod showed very high direct genotypic effect on seed yield. For a reliable selection index, number of pods per plant was a prime character. This was closely followed by height at flowering and then number of seeds per pod. Therefore, greater attention should be given to these traits in variety development.

Key words: Genotype, environment, interaction, correlation coefficient, variation, okra, selection.

INTRODUCTION

$NH_{47\text{-}4}$ variety of okra- *Abelmoschus esculentus* (Linn.) Moench- is an okra hybrid developed and produced by the National Institute of Horticultural Research and Training (NIHORT), Ibadan, Oyo State, Nigeria. Okra is a fast growing annual crop belonging to the family Malvaceae (Alege et al, 2009). It is an important vegetable crop throughout the tropics and sub-tropics (Kocchar, 1986; Hamon and Van Sloten, 1989; Akinyele and Osekita, 2006). The immature pods serve as ingredients of soup and stew (Ariyo, 1993; Osekita et al., 2000). Okra is recommended for people that suffer from renal colic, leucorrhoea and general weakness (Rai and Yadav, 2005).

According to Odeleye et al. (2007), the inability of okra to transplant well makes its cultivation to start from the seed. Being a chasmogamous plant, its breeding is verytactical because it produces much of its progeny through selfing (Akinyele and Temikotan, 2007). Hence, cross fertilization in the crop often requires careful observation before blooming in order that the breeder's aim might be achieved.

The plant's traits which interact with the environment principally are the quantitative traits. These traits are easily discernible by mere looking at the plants in the breeding nursery. The variability that is observed shows the interaction of the gene component (qualitative and quantitative) with the prevailing environmental factors during the cropping season (Akinyele and Osekita, 2006; Akinwale et al., 2010a).

Genotype and environment may interact in a variety of ways. According to Mather and Jinks (1971), the environment may affect the genetic constitution of a population by the pressure of selection it exercises on the population which in the longer term, may lead to evolutionary changes. The environment may also affect the genotype by stimulating permanent changes in the genetic materials themselves. These changes in the genetic make-up, though not common, are familiar mutagenic effects of radiations and various chemical substances which, ordinarily, are seldom encountered unless they are

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Table 1. Estimate of the genetic and environmental components of the generation means for eleven quantitative traits of $NH_{47\text{-}4}$ variety of okra.

Trait	Mean and standard error	h^2	e^2
Days to flowering	31.0667 ± 0.5178	0.57	1.85
Days to maturity	54.0500 ± 0.9008	0.91	8.14
Number of branches/plant	1.7000 ± 0.0283	0.28	0.42
Number of pods/plant	3.3000 ± 0.055	0.55	1.21
Height of flowering (cm)	40.8683 ± 0.6812	0.68	19.35
Final height (cm)	49.4450 ± 0.8241	0.86	45.71
Pod length (cm)	9.1117 ± 0.1519	0.59	0.58
Pod width (cm)	3.0500 ± 0.0508	0.50	0.08
Number of seeds/pod	91.2000 ± 1.5204	0.98	44.38
Weight of 100 seeds (g)	6.0132 ± 0.1002	0.48	0.06
Seed yield (g)	18.9948 ± 0.3166	0.66	43.58

deliberately introduced as part of experimentation (Watson et al., 2008). Certain varieties of flax (plant grown for its seeds and fibre), when grown in soil carrying a combination of nitrogenous, phosphotic and potassic fertilizers, according to Durrant (1958), not merely reflect the effects of the mutagenes in their own growth but also transmit them to their offspring in the next and later generations through the pollen grains and the ova (Brink, 1960). It should be noted, however, that genotype and environment may interact in the production of differences among individuals and families under direct observation by virtue of their interplay in development to produce non-transmissible effects. Such effects normally fade away under different environmental conditions (Akinyele and Odiyi, 2007). The effect of summer cover crops and soil amendments on the growth and nutrient uptake of okra as observed by Wang et al. (2006) is worth mentioning here. The phenotypic diversity observed by Duzyaman (2005) within a collection of district okra cultivars derived from Turkish landraces is another example.

Correlated responses of yield attributes need special attention as a basis for selection (Singh and Singh, 1977). As the number of independent variables influencing a particular dependent variable increases, there is bound to be a certain amount of interdependence. Under such a complex situation, correlations are insufficient to explain the true association for an effective manipulation of characters (Fakorede and Opeke, 1985; Akinyele and Osekita, 2006). The objective of this work, therefore, is to determine the yield status brought about by the contribution of genotype × environment interaction arising in response to micro-environmental differences within and between families raised in the same macro-environment and to the variation within generations.

MATERIALS AND METHODS

Lines of $NH_{47\text{-}4}$ variety of okra obtained from NIHORT, Ibadan, Nigeria were grown in different locations under rain-fed conditions using the randomized complete block design (RCBD) with four replicates. The two locations used were Akure and Ilara-Mokin in Ondo State, Nigeria. The plot size in each replicate was 3 m × 2 m. Plots were separated by 1 m between replicates and 0.5 m between plots for easy movement during cultural and field operations. Three seeds were sowed per hole and later thinned to one plant per stand three weeks after sowing. Data were collected on the following metrical traits: 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 pods, weight of 100 seeds and seed yield. In each of the plots, representative samples from which the metrical traits were measured were tagged. Data collected were subjected to analysis of variance (ANOVA). Genotypic correlation coefficients and environmental correlations were estimated according to the method of Akinyele and Osekita (2006). Coefficients of variation and mean values of the traits were also calculated according to the method of Akinwale et al. (2010b).

RESULTS AND DISCUSSION

The pod length and width had appreciable mean values of 9.1117 cm and 3.0500 cm, respectively. The mean values of the number of seeds per pod and the weight of 100 seeds were 91.2000 seeds and 6.0132 g respectively. Heritability estimate was highest in the number of seeds per pod while the least was recorded for the number of branches per plant (Table 1). In spite of the marked differences in the absolute values, the relative values of the heritability estimates are consistent and in conformity with the genetic make-up of the crop. The genotypic coefficient of variation for the different locations and seasons was very high in the number of branches per plant (46.3304), number of pods per plant (41.1126) and seed yield (40.9014g) whereas it was very low in the weight of hundred seeds (5.3126 g) and days to flowering (5.3622). These are shown in Table 2.

The number of branches per plant had significant positive direct genotypic correlation with plant height at flowering, final height and number of seeds per pod. The association of the weight of 100-seeds with days to flower-

Table 2. Mean values and genotypic coefficients of variation for eleven quantitative traits of NH_{47-4} variety of okra.

Trait	Mean value	Genotypic coefficients of variation (GCV)
Days of flowering	31.0667	5.3622
Days to maturity	54.0500	7.5282
Number of branches/plant	1.7000	46.3304
Number of pods/plant	3.3000	41.1126
Height at flowering (cm)	40.8683	14.6365
Final height (cm)	49.4450	17.1505
Pod length (cm)	9.1117	10.4433
Pod width (cm)	3.0500	12.2007
Number of seeds/pod	91.2000	17.5157
Weight of 100 seeds (g)	6.0132	5.3126
Seed yield (g)	18.9948	40.9014

Table 3. Genotypic correlations showing direct and indirect effects of some characters on seed yield.

Character	Days to flowering	Days to maturity	No. of branches per plant	No. of pods per plant	Plant height at flowering (cm)	Final Plant Height (cm)	Pod length (cm)	Pod width (cm)	No. of seeds per pod	Weight of 100 seeds (g)	Seed yield (g)
Days of flowering		-0.1789	0.1739	0.2158	-0.0063	-0.0192	0.1615	-0.0680	0.0929	-0.2767*	-0.0365
	-	0.1753	0.1876	0.1007	0.9621**	0.8852**	0.2217	0.6087	0.4840**	0.0339	0.7839**
Days to maturity			0.1166	-0.1132	0.2070	0.2331	0.0512	0.1303	-0.0673	0.0669	-0.0219
		-	0.3790*	0.3931	0.1156	0.0756	0.7004**	0.3252	0.6125**	0.6148**	0.8687**
No. of branches per plant			-	-0.0262	0.3318*	0.3727*	0.0998	-0.1228	0.3330*	0.1258	0.1161
				0.8437**	0.0102	0.0036	0.4521**	0.3542	0.0100	0.3424*	0.3814*
No. of pods per plant				-	0.1463	0.0804	-0.1798	-0.2259	0.1211	-0.2494*	0.8923**
					0.2689	0.5448**	0.1731	0.0853	0.3610*	0.0568	<0.0001
Plant height at flowering (cm)						0.9006**	-0.0000	-0.0775	0.1622	0.1579	0.4496*
					-	<0.0001	0.9998**	0.5594**	0.2198	0.2322	0.0004
Final plant height (cm)							0.0411	-0.0015	0.2086	0.2083	0.3615*
						-	0.7572**	0.9910**	0.1129	0.1133	0.0049

Table 3 Cont.

Pod length (cm)		0.2684	0.1540	-0.0482	0.0694
	-	0.0398	0.2443	0.7170**	0.6013**
Pod width (cm)			-0.0663	-0.1824*	0.1755*
		-	0.6177**	0.1667	0.1836*
No. of seeds per pod				0.1870*	0.9162**
			-	0.1561	<0.0001
Weight of 100 seeds (g)					0.2894*
				-	0.0262
Seed yield					-

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

flowering, number of pods per plant and pod width was negative and significant. Number of pods per plant showed a positive but negligible direct genotypic correlation with final plant height. Final plant height had higher positive direct genotypic effect (0.9006) with plant height at flowering. It was also recorded that the number of pods per plant and the number of seeds per pod had the highest positive genotypic correlation coefficients of 0.8923 and 0.9162, respectively. The negative direct genotypic effect of plant height at flowering with pod length may be due to the highest genotypic indirect effect of 0.9998 which has masked the expression of the genotype. The same explanation is advanced for pod width and final plant height.

The variability that is seen in each of the quantitative traits shows the extent of genotype × environment interaction within families and plots. The environmental effect is the sum total of all the components of the environment to which an organism is exposed e.g radiation duration and intensity, the nutrients available, moisture condition, diseases, insects etc. As shown in Table 1, it is clear that heritability for all the traits ranges from moderate to high with the highest environmental variances in the seed yield, number of seeds per pod and final height.

Table 2 shows that the number of branches per plant is the most variable trait followed by number of pods per plant and seed yield. This indicates that the traits can be selected for in breeding programmes. It follows, therefore, that improvement could be directed at these traits. This is in line with the findings of Osekita and Akinyele (2008) and Salameh and Kasrawi (2007). However, the finding is at variance with that of Ariyo (1990). Genotypic correlation in most cases is low when compared to other correlation coefficients. Therefore, it would be a good index for selection of desirable traits in any environment. Correlation measures the degree of closeness between dependent and independent variables. The association of number of pods per plant with final plant height, though negligible, must have been accounted for by the highly significant indirect genotypic effects. The negative but non-significant correlation of days to maturity, plant height at flowering, final plant height, pod width and seed yield with days to flowering recorded in this work (Table 3) is in line with the findings of Ariyo et al. (1987), Henry and Krishna (1990) and Newall and Eberhart (1961). Accordingly, such association should be disregarded in selection for the crop and/or its variety improvement.

Conclusion

The association of final plant height with plant height at flowering and that of number of pods per plant with seed yield show very high direct genotypic effects, indicating a clear evidence of interaction between the traits. They should, therefore, be given prior attention in variety development because because of their great influence on yield.

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