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Stability of performance of okra as influenced by planting date

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Summary. Fifteen selected okra genotypes, consisting of six from a pedigree breeding programme and nine established varieties as checks, were evaluated in five different environments for stability of performance. Performance was measured by pod yield per plant, number of days to flowering, final plant height, number of branches per plant, number of pods per plant and edible pod weight. A regression method and a genotype grouping technique were employed in the evaluation. The results showed significant genotype × environment interaction only with respect to number of days to flowering and number of branches per plant. Additive environmental effect was significant for all characters. Line UI 313 was considered stable with respect to pod yield per plant and edible pod weight. One line resulting from the pedigree breeding programme was also considered stable by the genotype-grouping technique.

Key words: Okra – Planting date – Stability – Sensitivity – Environments

Introduction

Phenotypic variation is a composite of three variables, viz. genetic, environmental, and genotype × environment interaction. It is a common practice in trials involving varieties and breeding lines to grow a series of genotypes in a range of different environments. If all the genotypes respond similarly to all the environments tested, their relative performance in other environments may be predicted with some confidence. A genotype × environment (g × e) interaction exists where the relative performance of varieties changes from environment to environment. The presence of g × e interaction is a major problem in getting a reliable estimate of heritability and it makes it difficult to predict with greater accuracy the rate of genetic progress under selection for a given character.

Various techniques have been used to assist in the analysis of g × e variation. The regression technique has been widely used by various workers (Yates and Cochran 1938; Finlay and Wilkinson 1963; Eberhart and Russell 1966; Perkins and Jinks 1968; Breese 1969; Shukla 1972; Langer et al. 1979). The genotype-grouping technique has also been utilised by Francis and Kannenberg (1978) and Ntare and Aken'Ova (1985). Apart from determining the stability of varieties, these techniques also provide additional parameters which measure the ability of varieties to respond to improving environmental conditions.

The purpose of this study was to determine (1) the stability of performance of six new lines arising from a pedigree breeding programme as well as of nine established varieties, and (2) the relative discriminatory ability of regression and genotype-grouping techniques.

Materials and methods

Six newly developed lines of okra – 'UI 1-1', 'UI 4-30', 'UI 22-77', 'UI 53-139', 'UI 204-2-3' and 'UI C-6-2', from the University of Ibadan pedigree breeding programme together with nine established varieties were grown in three-row plots measuring 1.8 × 1.8 m at the University of Ibadan Teaching and Research Farm and at the National Horticultural Research Institute (NIHORT) also at Ibadan.

Plantings were carried out during the early (April), mid (July) and late (September) rainy seasons of 1983 at the University of Ibadan while only early and late season plantings were conducted at NIHORT. These plantings thus provided five different environments (Table 1) under which the varieties were evaluated. Rows were spaced 90 cm apart while plants were 45 cm apart within each row.

Two methods were employed to investigate the response of the lines to different environments as measured by number of days to flowering, pod yield, final plant height, number of pods per plant, edible pod weight and number of branches per plant. In the first method, the data were subjected to combined analysis of variance and regression analysis following procedures outlined by Eberhart and Russell (1966). In this method, a genotype with average sensitivity will have a unit regression coefficient (b = 1.0) while a stable genotype will have minimum deviation from regression ($S^2di = 0$).

The second method was that proposed by Francis and Kannenberg (1978) in which the mean yield of each entry averaged over environments is plotted against its coefficient of variation (c.v.) over environments. This method groups genotypes into the following four classes.

Group I. Genotypes with high or above average mean yields but small c.v., i.e. smaller than the mean c.v.

Group II. Genotypes with high or above average yields and above average c.v.

Group III. Genotypes with low or below average yield and below average c.v.

Group IV: Genotypes with below average yields but above average c.v.

A comparison of the two procedures was made with respect to which genotypes were considered stable using either procedure.

Results

The analysis of variance for stability of performance as measured by days to flowering, final plant height, number of pods per plant and number of branches per plant using Eberhart and Russell's (1966) procedures showed significant differences among the okra genotypes. Additive environmental effects were significant for all characters evaluated, and genotype × environment (linear mean squares (MS) were not significant with respect to pod yield, number of pods per plant, edible pod weight and final plant height (Table 2). The pooled deviations for all the characters were significant indicating a non-linear response to environments.

The average pod yield per plant, regression coefficient, and deviation from regression (S^2d) of each genotype are presented in Table 3. Since regression coefficients measure response of genotypes to an increment in an improving environment, genotypes 'UI 313' and 'UI 104' with regression coefficients significantly greater than 1 had above average responses and were consistently high yielders in all above average environments. Furthermore, except for line 'UI 313', all lines had deviation MS significantly greater than zero. Only 'UI 313' could therefore be considered to be stable with respect to pod yield by this regression technique. The regression coefficients and MS of other characters

Table 1. Locations, seasons, and planting dates in the okra stability analyses

Location	Season	Planting date	Rainfall (mm)	Sunshine (h)
University of Ibadan	Early	April	523.2	617.6
	Mid	July	348.7	542.1
	Late	September	263.2	701.8
NIHORT (Ibadan)	Early	April	535.1	598.6
	Late	September	494.5	670.8

Table 3. Mean pod yield per plant, regression coefficient, b, and deviation mean square for 15 okra genotypes

Genotypes	Mean pod yield/plant (g)	Regression Co-efficient (b ± sd)	Deviation mean square (S^2 di)
'UI 1-1'	148.2	1.16 ± 0.61	2,023.35[b]
'UI 4-30'	176.6	1.69 ± 0.57	1,766.76[b]
'UI 22-77'	168.0	1.08 ± 0.68	2,585.67[b]
'UI 53-139'	146.0	0.42 ± 0.80	3,553.84[b]
'UI 72-11'	135.9	0.63 ± 0.63	2,185.18[b]
'UI 72-204'	131.8	0.94 ± 0.55	1,637.55[b]
'NHAe 81'	159.3	1.41 ± 0.80	3,566.37[b]
'UI 92'	145.2	0.89 ± 0.52	1,513.26[b]
'UI 104'	176.3	1.52 ± 0.21[a]	241.22[b]
'UI-143'	90.4	0.36 ± 0.31	525.65[b]
'UI 204-2-3'	146.9	0.24 ± 1.10	6,614.41[b]
'UI 208'	148.0	0.79 ± 0.52	1,502.48[b]
'NHAe 301'	168.3	1.38 ± 1.34	9,854.56[b]
'UI 313'	176.3	1.64 ± 0.16[a]	129.30
'UI C-6-2'	133.3	0.85 ± 0.45	1,123.36[b]

[a] Regression co-efficient, (b), significantly greater or less than 1.0

[b] Deviation mean square, (S^2di), significantly greater than 0

Table 2. Mean squares from the stability analyses of variance of okra lines (Eberhart and Russell 1966)

Sources of variation	d.f.	Pod yield/ plant (g)	Days to flowering	No. of pods/plant	Edible pod weight (g)	Final plant height (cm)	No. of branches/plant
Genotypes	14	2,593.30^{NS}	167.27**	13.82**	26.82**	1,362.46**	2.08**
Environment (linear)	1	249,024.51**	2,240.81**	689.00**	342.42**	22,707.44**	158.23**
Genotype × environment (linear)	14	3,592.07^{NS}	71.23**	8.09^{NS}	5.05^{NS}	237.71^{NS}	0.77**
Pooled deviation	45	2,575.56**	13.65**	5.45**	3.74**	225.96**	0.36**
Pooled error	140	77.40	0.20	0.04	0.6	0.6	0.04

** Significant at $P = 0.01$

Table 4. Regression coefficient, b, for 5 characters in 15 okra genotypes across 5 environments

Genotypes	Days to flowering	No. of pods/plant	Edible pod weight (g)	Final plant height (cm)	No. of branches/plant
'UI 1-1'	0.20±0.24[a]	1.08±0.39	0.77±0.63	0.76±0.98	0.79±0.30
'UI 4-30'	0.50±0.31	1.54±0.41	1.27±0.63	1.14±0.78	0.95±0.04
'UI 22-77'	0.16±0.32[a]	1.15±0.52	0.49±0.32	0.56±0.49	0.61±0.23
'UI 53-139'	1.69±0.78	0.69±0.62	1.97±0.13[a]	0.83±0.10	1.25±0.32
'UI 72-11'	0.01±0.84	1.46±0.89	0.58±0.45	1.10±0.47	0.71±0.06[a]
'UI 72-204'	0.92±0.33	1.25±0.56	1.10±0.83	0.66±0.42	0.93±0.36
'NHAe 81'	0.97±0.64	1.07±0.38	0.55±0.81	0.90±0.48	0.83±0.34
'UI 92'	2.41±0.84	0.54±0.54	1.61±0.80	1.48±0.66	1.19±0.23
'UI 104'	1.23±0.36	1.26±0.45	1.08±0.80	0.79±0.47	1.48±0.31
'UI 143'	0.75±0.45	0.23±0.32[a]	0.97±0.49	1.41±0.25	1.15±0.26
'UI 204-2-3'	0.86±0.21	0.38±0.80	1.12±1.15	0.69±0.88	1.01±0.37
'UI 208'	1.78±0.69	0.58±0.56	1.11±0.83	1.81±0.81	0.90±0.31
'NHAe 301'	1.71±0.51	1.29±0.96	1.40±1.45	1.24±0.62	1.53±0.45
'UI 313'	1.33±0.37	1.26±0.50	1.07±0.00[a]	1.33±0.72	1.0 ±0.51
'UI C-6-2'	0.54±0.46	1.11±0.50	0.90±0.53	0.31±1.10	0.74±0.22

[a] Regression coefficient; (b), significantly greater or less than 1.0

Table 5. Deviation mean square (S^2di) of 5 characters in 15 okra genotypes

Genotypes	Days to flowering	No. of pods/plant	Edible pod weight (g)	Final plant height (cm)	No. of branches/plant
'UI 1-1'	2.85[b]	2.34[a]	2.86[a]	484.17[a]	0.31[a]
'UI 4-30'	4.57[a]	2.63[a]	2.88[a]	303.14[a]	0.41[a]
'UI 22-77'	4.90[a]	4.32[a]	1.55[a]	117.90[a]	0.18[a]
'UI 53-139'	29.82[a]	5.97[a]	1.16[a]	114.66[a]	0.35[a]
'UI 72-11'	34.91[a]	12.55[a]	1.41[a]	111.56[a]	0.20[a]
'UI 72-204'	5.25[a]	5.06[a]	5.0[a]	102.49[a]	0.45[a]
'NHAe 81'	20.23[a]	2.27[a]	4.77[a]	116.52[a]	0.41[a]
'UI 92'	34.94[a]	4.65[a]	4.67[a]	216.92[a]	0.18[a]
'UI 104'	6.33[a]	3.15[a]	4.67[a]	111.31[a]	0.34[a]
'UI 143'	9.92[a]	1.58[a]	1.69[a]	230.77[a]	0.23[a]
'UI 204-2-3'	2.17[a]	10.01[a]	9.68[a]	392.9[a]	0.47[a]
'UI 208'	23.54[a]	5.00[a]	5.01[a]	330.43[a]	0.33[a]
'NHAe 301'	12.92[a]	10.67[a]	10.67[a]	195.84[a]	0.71[a]
'UI 313'	9.96[a]	3.98[a]	0.07	203.36[a]	0.89[a]
'UI C-6-2'	10.55[a]	3.87[a]	2.03[a]	607.41[a]	0.17[a]

[a] Deviation mean square (S^2di), significantly greater than 0

evaluated are presented in Tables 4 and 5. It is noteworthy that most characters did not respond to environmental changes. Genotypes 'UI 53-139' and 'UI 313' produced bigger pods under more favourable environments. Only these two genotypes were stable with respect to pod weight by having non-significant deviation MS.

The genotype-grouping technique suggested by Francis and Kannenberg (1978) classified the genotypes into four groups according to their means and CV's as shown in Fig. 1. By this method, only genotype 'UI 22-77' could be regarded as showing consistent above average performance. Although genotypes 'UI 208', 'UI 53-139', 'UI 204-2-3', 'UI 92', 'UI 72-11' and 'UI C-6-2' were stable by having below average CV, their yields were also below average. Genotypes 'UI 104', 'UI 313', 'UI 4-30', 'NHAe 301', and 'NHAe 81', however, had above average yields with large CV, an indication of sensitivity to environmental changes. Genotypes 'UI 1-1' and 'UI 72-204' in group IV are the least desirable as they combine above average CV with below average pod yield.

Discussion

Although it is not necessary to breed a variety that is adapted to all ecological conditions, breeding methods

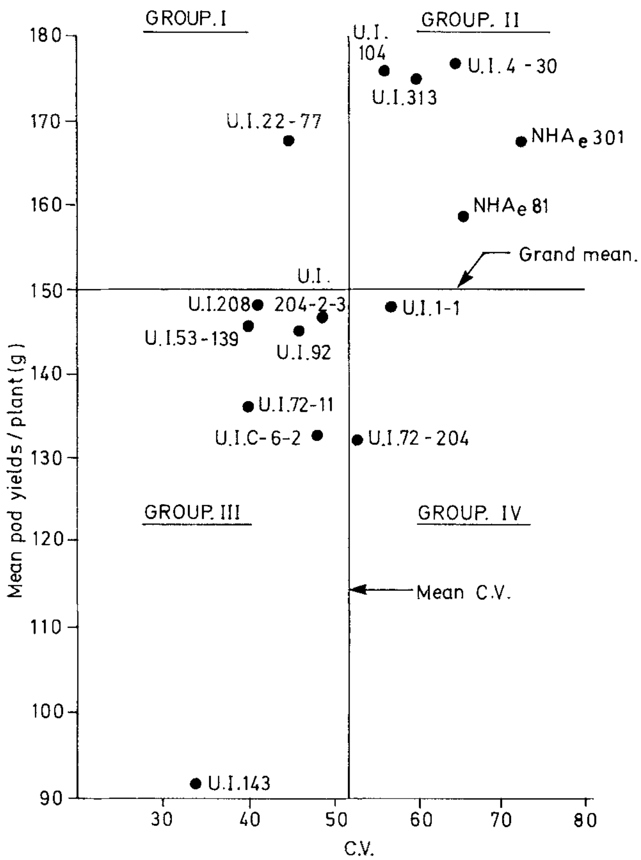

Fig. 1. Mean pod yields/plant (g) plotted against coefficients of variation c.v. from five environments

can be designed towards producing a high yielding variety with a considerable degree of general adaptability. In this study, the regression of mean yields on environmental indices indicated that a significant portion of the total variation was accounted for by linear regression although a portion of this remained non-linear. The most often used parameters in selecting genotypes for high yield and stability of performance are mean yield, regression co-efficient and minimum deviation from linear regression (Eberhart and Russell 1966; Breese 1969). Varieties with above average performance were those that had regression coefficients significantly greater than unity (Perkins and Jinks 1968; Breese 1969). This is the case with genotypes 'UI 104' and 'UI 313' which performed best only in the above average environments. Only genotype 'UI 313' could therefore be considered to be stable in respect of pod yield by the regression technique. According to Francis and Kannenberg's (1978) genotype-grouping technique, only line 'UI 22-77' was desirable as it combined above average yield with below average CV.

Most other characters had average sensitivity to environmental changes, a condition which probably culminated into average sensitivity of most genotypes with respect to pod yield. The stability of performance exhibited by genotype of 'UI 313' with respect to pod weight, a major component of pod yield, was probably responsible for the stability of performance of 'UI 313' regarding pod yield by the regression technique.

None of the lines arising from the pedigree breeding programme significantly outyielded 'UI 104', the top yielding established variety, when averaged over environments. However, that some lines significantly surpassed 'UI 104' in certain environments suggested the possibility of developing certain lines for specific environments. There is, in any case, a need to test these lines in a more diverse and wider range of locations to assure more reliable recommendations. The two methods of determining stability of performance produced similar results by classifying the majority of genotypes as unstable. They were, however, contradictory in identifying the stable genotype.

Although genotype-grouping technique has no predictive value, it will be valuable in early generations where a large number of entries are usually handled.

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References

Breese EL (1969) The measurement and significance of genotype×environment interactions in grasses. Heredity 24:27–44

Eberhart SA, Russell WA (1966) Stability parameters for comparing varieties. Crop Sci 6:36–40

Finlay KW, Wilkinson GN (1963) The analysis of adaptation in plant breeding programme. Aust J Agric Res 14:742–754

Francis TR, Kannenberg LW (1978) Yield stability studies in short-season maize I: a descriptive method of grouping genotypes. Can J Plant Sci 58:1029–1034

Langer I, Frey KJ, Bailey TB (1979) Association among productivity, production response and stability indexes in oat varieties. Euphytica 28:17–24

Ntare BR, Aken'Ova M (1985) Yield stability in segregating populations of cowpea. Crop Sci 25:208–211

Perkins JM, Jinks JL (1968) Environmental and genotype-environmental components of variability. III: Multiple lines and crosses. Heredity 23:339–356

Pfahler PL, Linskens HL (1979) Yield stability and population diversity in oats (*Avena* sp.). Theor Appl Genet 54:1–5

Shukla GK (1972) Some statistical aspects of partitioning genotype-environment components of variability. Heredity 29:237–245

Yates F, Cochran WG (1938) The analysis of groups of experiments. J Agric Sci 28:556–580