Evaluation of stability in sweetpotato using different methods

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ABSTRACT

Naskar S.K. and Mukherjee A. 2001. Evaluation of stability in sweetpotato using different methods. *Ann. Trop. Res.* 23[1]:11-20.

The stability in sweetpotato (*Ipomoea batatas* L.) was evaluated using the methods of Eberhart and Russel (1966), Shukla (1972) and Francis and Kannenberg (1978). Eight sweetpotato lines along with a check local cultivar were grown for three years in eight environments across Orissa, India. Variances due to genotypes, environments, and genotype x envoriment interaction were highly significant. Both linear and nonlinear components were also significant. The three stability methods differed in identifying stable cultivars. Eberhart and Russel's S^2d and Shukla's S^2 parameters were highly correlated ($r^2 = 0.78**$). Only one genotype (90/606) was found stable under the three methods evaluated. The Francis and Kannenberg technique was most convenient in grouping the cultivars.

Keywords: coefficient of variation. G x E interaction. rank correlation. stability. sweetpotato.

INTRODUCTION

Stability is of interest to crop breeders because it determines the consistency of performance of a cultivar in different environments which is essential for the selection of superior cultivars. In India, stability analysis has been extensively used for most crops including sweetpotato following the

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method of Eberhart and Russel (1966). Although this method is extensively used by crop breeders in determining cultivar stability, its validity has been questioned (Freeman and Perkins,1971; Shukla, 1972; Freeman, 1973;). Several parameters are currently available for the evaluation of stability. In sweetpotato, Bacusmo *et al.* (1988) used the stability methods of Eberhart and Russel (1966), Tai (1971), Sukarso and Engle (1983) and Shukla (1972) to determine the stability and adaptation of sweetpotato. They observed that Shukla's method was more effective than the others but the calculation to obtain stability variance was cumbersome. They also found that the methods of Eberhart and Russel (1966) and Tai (1971) were equally effective. Kang and Miller (1984) evaluated the stability of sugarcane and found that the method of Plaisted (1960) was cumbersome while the methods of Shukla (1972) and Wrickle (1962) were more effective. In cassava, Ngeve (1991) observed that the genotype grouping technique of Francis and Kannenberg (1978) was useful in classifying genotype into degrees of desirable rather than suitable and unsuitable type. He also suggested that Shukla's method could be used along with the techniques of Francis and Kannenberg and that of Eberhart and Russel.

Francis and Kannenberg (1978) used phenotypic coefficient of variation (CV) while the other methods are based on the partitioning of G x E interaction into variance components. For yield stability studies in short season maize, Francis and Kannenberg (1978) pointed out that the responsive one is not always undesirable.

In this study, attempt has been made to study the parameters of Eberhart and Russel (1966), Shukla (1972) and Francis and Kannenberg (1978) to determine the stability of sweetpotato clones.

MATERIALS AND METHODS

Eight sweetpotato (*Ipomoea batatas* L.) clones along with a check cultivar were planted in randomized block design with three replications in 1994, 1995 and 1996 in eight environments across Orissa, India. The plot size was 5 x 2.4 m. Fertilization was according to recommended practices (Ravindran and Nair, 1994). Harvesting was done at 120 days after planting. Vines were cut and storage roots were uprooted manually. Observations on

fresh total storage roots, marketable root and weevil-infested root yield were recorded. Only total storage root yield is reported in this study.

Analysis of variance was carried out for the total root yield for each trial. Stability parameters were then computed using the methods of Eberhart and Russel (1966) and Shukla (1972). Grouping technique in classifying the genotypes was carried out based on Francis and Kannenberg (1978). The methods used for the estimation of stability are briefly discussed below.

Method I.

Eberhart and Russel (1966) used the following model:

$$Y_{ij} = \mu_i + B_i I_j + d_{ij}$$

where:

Y_{ij} = mean of the ith variety in jth environment

μ_i = ith variety mean over all enviroments

B_i = regression coefficient of the ith variety regressed on the enviromental index

I_j = environmental index

d_{ij} = deviation for the regression coefficient

They summed the squared deviation from linear regression to provide another estimate of stability, Sd^2:

$$S^2 d_j = [\Sigma d^2_{ij}/(n-2) - S^2 e/r]$$

where:

$S^2 e/r$ = estimate of the pooled error.

According to Eberhart and Russel, a stable cultivar is one with high mean yield, b = 1.0 and $Sd^2 = 0$

Method II:

Shukla (1972) suggested an unbiased estimator of stability variance as:

$$\sigma_i = [1/(s-1)(t-1)(t-2)] \times [t(t-1)\Sigma(\mu_{ij}-\mu_i)-\Sigma\Sigma(\mu_{ij}-\mu_{ij}^{-2})]$$

where:

μ_{ij} = y_{ij}-y.j.μ_i = $\acute{O}y\mu_{ij}$/s.s = number of locations
t = number of cultivars
y_{ij} = trait value of the ith cultivar in jth location
y_j = mean of all cultivars in the jth location

Method III:

Francis and Kannenberg's (1978) descriptive method for grouping genotypes is based on yield and consistency of performance where mean yield is plotted against coefficient of variation (CV). It classifies genotypes on group basis rather than individually. The desirable variety is one which provides high and consistent performance. Spearman's (1904) correlation coefficients were calculated between all pairs of stability parameters and mean yield to find out relationships among them. Significance of rank correlation coefficient difference were tested following Steel and Torrie (1980).

RESULTS AND DISCUSSION

Joint regression analysis of the data showed that the mean square of the genotypes was highly significant indicating that the genotypes were genetically diverse (Table 1). Variances due to environment and genotype x environment interaction were significant, but the magnitude of G x E interaction was smaller compared to genotypes and environmental variances (Bacusmo *et al.*, 1988; Naskar and Singh, 1992). The G x E interaction component was again further partitioned into linear (heterogeneity between regressions) and nonlinear components. Both linear and nonlinear components were significant indicating that both predictable and unpredictable components shared G x E interaction. Total storage root yield ranged from 8.94 to 19.57 t/ha. The highest yield was

Table 1. Joint regression analysis of variance for storage root yield

Source	df	MS
Genotypes	8	92.70**
Environments	7	104.70**
(Joint Regression)		
G x E	56	5.78**
Heterogenecity	8	11.28**
Regression		
Remainder	48	4.86**
Pooled error	128	2.99

observed in 90/704 followed by 90/774 and 90/660. The local check gave the lowest yield. Differences in yield between the highest yielding genotypes were not significant (Table 2).

Estimates of stability parameters along with the yield are presented in Table 2. In Eberhart and Russsel's method, a variety is called stable if it has average mean yield, unit regression ($b=1$) and non-significant least deviation from regression ($S^2d=0$). As per definition, only the line 90/606 can be considered stable. The highest yielding line viz. 90/704 had non-significant S^2d, but it has high regression value ($b \geq 1$). Based on the definition of Eberhart and Russel (1966), this line is unstable but responsive to the environment.

Shukla's (1972) parameter revealed that four lines gave significant estimates of stability variance. Five lines were found to be stable since their stability variance was not significant. Among the lines, 90/606 was considered to be the most stable because it obtained the smallest stability variance. The highest yielding line 90/704 had also small stability variance, but the value was higher than in line 90/606. According to Shukla's definition, lines 90/606 and 90/704 are stable, although the former is more stable.

When the second highest yielding line 90/774 was compared with the other two parameters, it was observed that the regression coefficient had a high value ($b \geq 1$) and the deviation value from regression was also not significant. According to Eberhart and Russel (1966), this line can be suitable for better growing environment. Under Shukla's stability variance parameter, these lines are unstable as indicated by its significant stability variance.

Table 2. Yield adaptability parameters of nine sweetpotato genotypes evaluated in multilocational trials in Orissa (1993-1995)

SP clones	Mean root yield/ (rank)	Eberhart & Russel				Shukla's stability		Francis & Kannenberg groups
		b_i	rank	sd^2	rank	s^2	rank	
90/566	14.93 (4)	0.7	(2)	2.95	(7)	7.18	(8)	I
90/606	16.53 (3)	1.06	(6)	-0.14	(2)	2.28	(1)	I
90/774	17.10 (2)	1.39	(8)	1.84	(6)	7.09*	(7)	II
90/101	12.88 (6)	0.78	(3)	0.09	(3)	3.48	(2)	III
90/757	10.10 (8)	0.96	(4)	3.01	(8)	6.01*	(6)	IV
90/704	19.57 (1)	1.52	(9)	-1.55	(1)	5.01	(5)	I
90/235	14.52 (5)	1.20	(7)	0.30	(4)	3.65	(3)	II
90/701	12.41 (7)	1.04	(5)	1.48	(5)	4.34	(4)	IV
Local	8.94 (9)	0.29	(1)	4.53	(9)	15.09**	(9)	IV

* significant at 5% level;   ** significant at 1% level; SP = sweetpotato

Using the grouping method of Francis and Kannenberg (1978), wherein the mean yield is plotted against CV, the lines can be grouped into four as follows (Fig. 1):

Group I – high yield, small variation
Group II – high yield, large variation
Group III – low yield, small variation
Group IV – low yield, large variation

Figure 1 reveals that three lines appeared in Group I and Group IV, two lines in Group II and only one line appeared in Group III. Group I lines viz. 90/704, 90/606 and 90/566 would be most desirable. According to Francis and Kannenberg (1978), a stable genotype is one that provides high and consistent performance. Only Group I fits the definition. Comparison of the classification of these lines using other methods was done. Among Group I lines, 90/606 was considered stable under the methods of Shukla (1972) and Eberhart and Russel (1966), line 90/704 was also considered stable under Shukla's method. Lines 90/566 obtained a regression value of less than unity ($b \leq 1$) as well as a non-significant S^2d_i value indicating that it can be grown under a poor environment although it is unstable. Under Shukla's stability variance parameter, this line is considered as unstable.
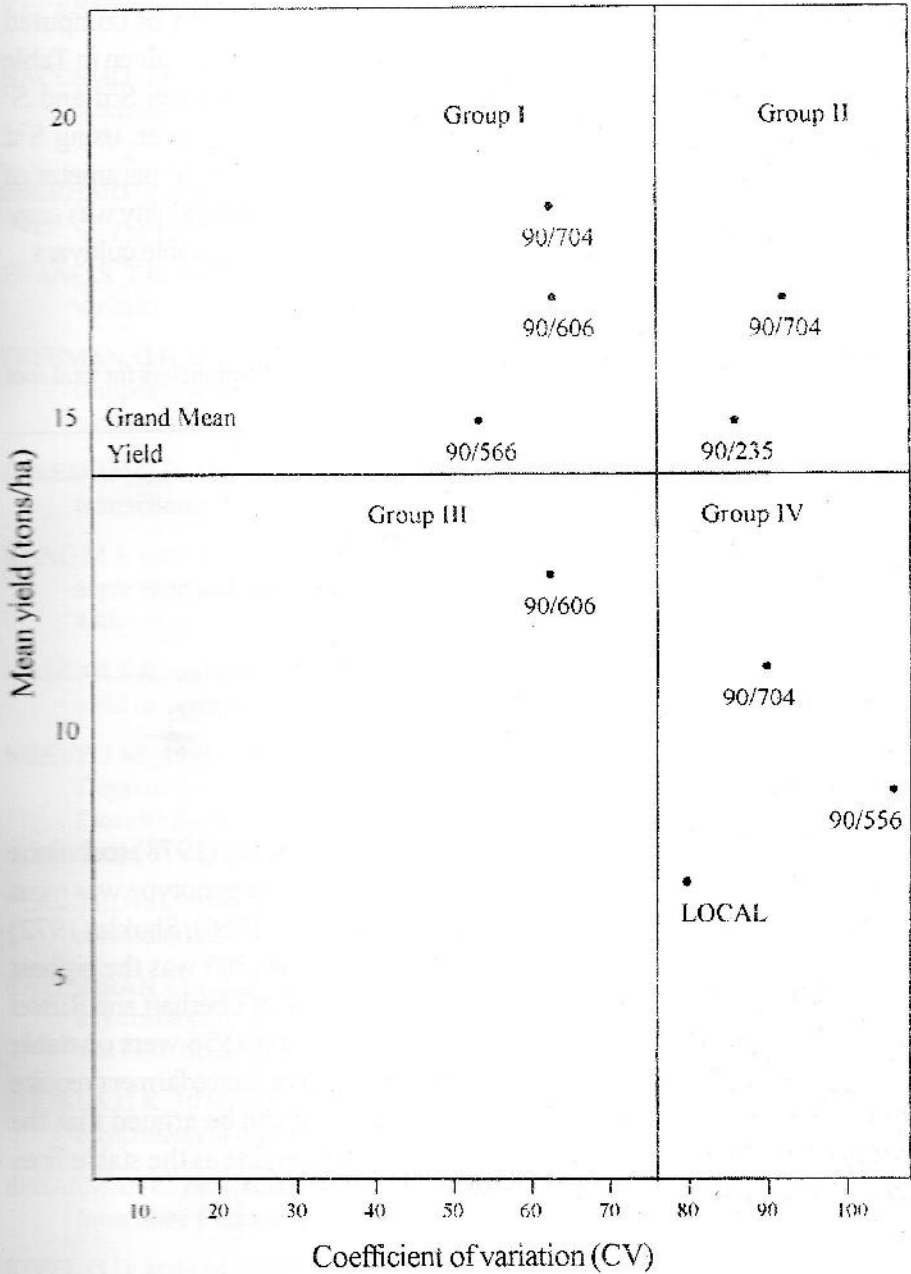
Figure 1. Mean yield plotted against CV from data collected on 9 genotypes in 8 environments

Rank correlation coefficients calculated between pairs of computed stability parameters (b, sd^2 and S^2) and mean of root yield are given in Table 3. A strong correlation (r^2 = 0.78**) was observed between S^{2}d and S^2 confirming the high correlation of methods I and II. However, using S^{2}d parameter, more varieties were rated as unstable than using S^2 parameter of method III since grouping of the cultivars into classes of desirability was easy. Nevertheless, all the three methods are useful in identifying stable cultivars.

Table 3. Rank correlation (r^2) between the mean and stability parameters for total root yield of the nine genotypes

Pairs of parameters	Root yield
b-S^{2}d	-0.65
b-S^2	-0.36
b-mean	-0.75*
S^{2}d-S^2	0.78**
S^{2}d-mean	-1.00**
S^2-mean	0.87**

CONCLUSION

Of the three methods used, Francis and Kannenberg (1978) technique was most convenient in grouping the cultivars. Only one genotype was most stable using the three methods of Eberhart and Russel (1966), Shukla (1972) and Francis and Kannenberg (1978). Although line 90/705 was the highest yielding variety, it was quite unstable under the method of Eberhart and Russel but stable under Shukla's method. Lines 90/774 and 90/556 were unstable based on the stability variance and regression coefficient. Since farmers require high yield and quality harvest as well as stability, it can be argued that the unstable lines like 90/774 and 90/556 are also as desirable as the stable lines like 90/606 and 90/704 for cultivation.

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