PHENOTYPIC STABILITY ANALYSIS IN BHINDI
(*Abelmoschus esculentus* (L.) Moench.)

By
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THESIS
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1981

DECLARATION

I hereby declare that this thesis entitled "Phenotypic stability analysis in bhindi (Abelmoschus esculentus (L) Moench.)" is a bonafide record of research work done by me during the course of research and that the thesis has not been previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title of any other University or Society.

Vellanikkara,
9----6--1981.

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CERTIFICATE

Certified that this thesis, entitled "Phenotypic stability analysis in bhindi (Abelmoschus esculentus (L.) Moench.)" is a record of research work done independently by Shri. K.V. SURESH BABU, under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship, or associateship to him.

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INTRODUCTION

INTRODUCTION

'Phenotypic stability parameters' are useful to measure adaptability and stability of crop cultivars. The information is used to identify genotype (s) suitable for low, marginal, average and high yielding environments. The information is more vital in a large 'single variety based' seed production programme where the variety is expected to yield uniformly throughout its growing tracts in all the crop seasons. A number of statistics are available to estimate stability parameters with varying degree of efficiency and limitations.

Bhindi (Abelmoschus esculentus (L) Moench.) is an important warm season pod vegetable grown throughout Kerala in all the seasons. There is need to identify a variety suitable for all the growing tracts and for all types of farmers - poor, marginal and rich - with no substantial reduction in performance under adverse conditions. Attempts to identify bhindi genotypes (s) suitable for the above conditions are rather limited. The present investigation has been formulated with the following objectives.

(i) To classify the 25 popularly grown genotypes into groups suitod for low, marginal, average and high yielding environments.

(ii) To attribute reasons for the stability of genotype(s), if any, and to identify stable genotype(s) with desirable pod characteristics.

(iii) To estimate components of variability in the 25 genotypes which could be made use of in crop improvement programme.

(iv) To study the relative efficiency and easyness in the estimation of stability parameters suggested by different workers and to arrive at useful inferences from the overall information collected.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Genotype x environment interaction parameters are useful in measuring adaptability and stability. Information on stability of performance is vital in production as well as resistance breeding programme. A number of attempts have been made to assess the extent of genotype x environment interaction in many crops. (Horner and Frey (1957) in oats; Sprague and Federer (1951), Adams and Shank (1959), Robinson and Moll (1959), Allard (1961), Rowe and Andrew (1964), Utkhede and Rai (1974), Dhillon and Singh (1977), Gardner and Mrech (1977), Rutz (1978), Pollmer et al. (1978) and Utz and Alber (1978) in maize; Rao (1969), Reich and Atkins (1970), Rao and Rao (1978) in sorghum; Dhagat et al. (1976) in ragi; Singh and Gupta (1978) in pearl millet; Aldrich (1978) in grasses; Pathak and Upadhyay (1975) in rice; Kaltsikes and Larter (1970) in wheat; Joshi (1972) in pulses; Verma et al. (1972) in soybean; Joshi et al. (1972) in groundnut; Gupta and Katiyar (1979) in cotton; Makhija and Chandra (1978) in linseed; Basak (1968) in jute; Tegge et al. (1976) in potato; Li (1975) in sweet potato; Freeman and Dowker (1973) in carrot and Peter and Rai (1976) in tomato).

Most of the earlier workers who assessed the extent of genotype x environment interaction took into consideration the overall interaction between varieties and environments - the method suggested by Panse and Sukhatme (1967). This does not provide necessary information on the interaction of the individual varieties with individual environment which is now frequently needed in the recommendation of varieties for commercial cultivation in various agroclimatic zones. Finlay and Wilkinson (1963) reported an eloborate biometrical technique for measuring adaptability in varying environments. They studied the adaptation of barley varieties by the use of mean grain yield of a randomly chosen group of 277 varieties from a world collection, grown in replicated trials for several seasons at three sites in South Australia. For each variety a linear regression of yield on the mean yield of all varieties for each site and season was computed to measure variety adaptation. The mean performance of each variety over all the sites and seasons was also estimated to act as one of the two parameters of phenotypic stability. Eberhart and Russell (1966) improved upon the model reported by

Finlay and Wilkinson (1963). They took into consideration the deviation of each variety from the expected regression line (S^2d_i) along with the mean performance (μ) and the regression coefficient (b_i). The environmental index of a location was estimated as the difference between mean performance of all the varieties in a location and mean performance of all the varieties in all the locations. Perkins and Jinks (1968) proposed that a regression of genotype x environment interaction on environmental index should be obtained rather than mean performance on the environmental index. Ram et al. (1970) proposed phenotypic index as a parameter to estimate stability. Chaudhury et al. (1972) proposed adaptability index as a better and easy estimate of phenotypic stability.

Bhindi (Abelmoschus esculentus (L.)Monech.) is one of the most important warm season fruit vegetables grown for its tender pods. Many varieties have been evolved in this crop known for their higher yield and local adaptability. There is need to identify phenotypically stable variety (s) in bhindi which could be recommended for cultivation in marginal lands, fertile lands and also in areas of stress.

Korla and Rostogi (1979) conducted experiment with 6 varieties of bhindi, Vaishalivadhu, Long Green, Pusa Sawani, Pusa Selection 1-1, Pusa Selection 6-2 and Pusa Selection 2-2. The experiment was conducted in a randomised block design with four replications repeated for four years. The stability analysis for fruit yield indicated that the variety Pusa Sawani as most stable in yield. Pusa Selection 6-1 and Pusa Selection 2-2 showed below average stability but had greater adaptability for favourable conditions, Vaishalivadhu and Long Green exhibited poor yield stability, Pusa Selection 1-1 showed average stability with specific adaptation to unfavourable environments.

The present study was formulated to select out stable variety (s) among 25 genotypes of bhindi. The effectiveness, usefullness and easyness in computation of various stability parameters proposed by many workers were also evaluated.

MATERIALS AND METHODS

MATERIALS AND METHODS

The present studies were conducted during two crop seasons (May-August 1980 and September-January 1980-81) in the Instructional Farm of Kerala Agricultural University, Vellanikkara. This station is located at an altitude of 23 metres above mean sea level and is situated between 10° 32" N lattitude and 76° 16"E longitude. Geographically it falls in the warm humid tropic climatic zone.

A. Experimental materials

The material comprised of a total of 25 genotypes of bhindi selected from a bhindi germplasm maintained at department of olericulture of this University. Care was taken to include all the available, released and promising genotypes of bhindi. The origin and morphological discriptions are given in Table 1.

B. Experimental design

The 25 genotypes were grown in a randomised block design with two replications. The two contrasting environments - high fertile and low fertile - were created in each season by manurial and fertilizer dose variations. The high fertile environment was created through use of farm yard manure at the rate of 12 tons/ha and a fertilizer

Table 1. Origin and morphological description of 25 genotypes of bhindi

Sl. No.	Genotypes	Source	Plant stature	Branching habit	Plant colour	Fruit length	Immature pod colour
1.	Pusa Sawani	IARI, New Delhi	Tall	Non branched	Green	Medium	Green
2.	Lam Selection	ARS, Lam	Tall	Non branched	Green	Medium	Green
3.	IC 24908	NBPGR, New Delhi	Medium	Non branched	Dark green	Medium	Green
4.	Selection 2-2	IARI, New Delhi	Tall	Non branched	Green	Medium	Light green
5.	IC 7194	NBGR, New Delhi	Medium	Branched	Green	Medium	Green
6.	Vaishalivadhu	Bihar	Tall	Non branched	Green	Medium	Green
7.	IC 23592	NBPGR, New Delhi	Tall	Non branched	Dark green	Medium	Green
8.	Selection 1-1	IARI, New Delhi	Tall	Non branched	Green	Medium	Green
9.	AC 95	KAU, Vellanikkara	Medium	Branched	Green	Long	Light green
10.	IC 15055	NBPGR, New Delhi	Tall	Non branched	Green	Medium	Green
11.	IC 13999	NBPGR, New Delhi	Tall	Non branched	Green	Medium	Green
12.	IC 18974	NBPGR, New Delhi	Tall	Non branched	Green	Medium	Green
13.	Cochin Local	Cochin	Dwarf	Branched	Yellow	Medium	Light green
14.	Selection 1	IARI, New Delhi	Tall	Non branched	Green	Medium	Green
15.	Selection 2	IARI, New Delhi	Tall	Non branched	Green	Long	Green
16.	IC 1542	IARI, New Delhi	Tall	Non branched	Green	Medium	Green
17.	Selection 27-1	Pant Nagar	Tall	Non branched	Green	Medium	Green

(Contd.......)

(Contd. Table 1)

Sl. No.	Genotypes	Source	Plant stature	Branching habit	Plant colour	Fruit length	Immature pod colour
18.	Belts Five	Japan	Tall	Non branched	Green	Medium	Green
19.	Pusa Makhmali	IARI, New Delhi	Tall	Non branched	Green	Medium	Green
20.	Hybrid Selection 1	ARS, Lam	Tall	Non branched	Green	Medium	Green
21.	IC 15593	NBPGR, New Delhi	Tall	Branched	Dark green	Medium	Green
22.	Selection 27-2	Pant Nagar	Tall	Non branched	Green	Medium	Light green
23.	Co 1	TNAU, Coimbatore	Tall	Non branched	Dark red	Medium	Purple
24.	IC 12933	NBPGR, New Delhi	Medium	Non branched	Green	Short	Light green
25.	Pusa Sawani x 4203	Denmark	Tall	Non branched	Green	Medium	Green

dose of NPK at the rate of 120:60:60 kg/ha. The low fertile environment was developed with no application of farm yard manure and a reduced fertilizer dose of NPK at the rate of 40:20:20 kg/ha. There was two rows of length 6 metres for each genotype per replication. Spacing was 60 x 30 cm,10 competative plants were randomly labelled and observations were recorded on these plants. The quantitative characters observed were days to first fruit set, plant height, internodal length, leaves/plant, fruit length, fruit weight, fruits/10 plants and fruit yield/10 plants.

C. Statistical analysis

(a) Analysis of variance

Before proceeding with the detailed statistical analysis for the estimation of stability parameters, all the characters observed in each environment and in each season were analysed for the analysis of variance as described by Ostle (1966).

$$Y_{ij} = \mu + b_i + t_j + e_{ij} \qquad i = 1, -- 4$$
$$j = 1, -- 25$$

Where Y_{ij} = Performance of jth variety in ith block;
μ = General mean;
b_i = true effect of ith block;
t_j = true effect of jth variety
and e_{ij} = random error. Restrictions are

$$\sum_{i=1}^{2} b_i = 0 \quad \text{and} \quad \sum_{j=1}^{25} t_j = 0$$

Table 2. Analysis of variance of the design

Source	df	Mean squares	
		Observed	Expected
Total	49		
Between replications	1	M_1	
Between genotypes	24	M_2	Error variance + replication x genotypic variance
Error	24	M_3	Error variance

The actual break up of the total variance into variance due to replications, varieties and error and their expectations has been given in Table 2.

(b) Estimation of variability

Variability existing in the 25 genotypes for yield and its components were estimated as suggested by Burton (1952). The formulae used in the estimation of variability of the genotypic, phenotypic and environmental levels are as follows.

(i) Genotypic coefficient of variation (gcv) =

$$\frac{\text{Genotypic standard deviation}}{\text{Mean}} \times 100$$

(ii) Phenotypic coefficient of variation (pcv) =

$$\frac{\text{Phenotypic standard deviation}}{\text{Mean}} \times 100$$

(iii) Environmental coefficient of variation (ecv) =

$$\frac{\text{Environmental standard deviation}}{\text{Mean}} \times 100$$

(iv) Standard error of mean =

$$\frac{\text{Environmental standard deviation}}{(\text{No. of replications})^{\frac{1}{2}}}$$

The above estimates genotypic, phenotypic and environmental standard deviations were obtained by solving the following equations from the respective analysis of variance table for different characters.

M_3 = Error variance

M_2 = Error variance + replication x Genotypic variance

$$\text{Genotypic variance} = \frac{M_2 - M_3}{\text{replications}}$$

Phenotypic variance = Genotypic variance + Error variance

(c) Estimation of stability parameters and genotype x environment interactions

The pooled analysis of variance was done as proposed by Panse and Sukhatme (1967). The statistical techniques as proposed by Finlay and Wilkinson (1963), Eberhart and Russell (1966), Perkins and Jinks (1968), Ram et al. (1970) and Chaudhury et al. (1972) were utilized to estimate stability parameters and genotype x environment interactions for 25 genotypes.

1. Finlay and Wilkinson's model

$$Y_{ij} = \mu_i + b_i I_j + e_{ij} \qquad i = 1, \text{--}\ 25 \quad j = 1, \text{--}\ 4$$

Where Y_{ij} = Mean performance of ith genotype in jth environment; b_i = regression coefficient of ith individual mean performance on environmental index I_j; I_j = mean performance of all the genotypes at the jth environment and e_{ij} = random error. A regression coefficient of unit slope ($b_i = 1$) indicated that the genotypic mean performance was directly proportional to the environmental index. Finlay and Wilkinson (1963) defined such a genotype as having average stability. A completely stable genotype ($b_i \rightarrow 0$) would perform uniformly in all the environments.

2. Eberhart and Russell's model

Eberhart and Russell (1966) suggested three parameters to measure phenotypic stability of cultivars. They are (i) mean (ii) regression of individual mean performance on environmental index and (iii) deviation from regression.

$$Y_{ij} = m + B_i I_j + \delta_{ij} \qquad i = 1, \text{--} 25$$
$$j = 1, \text{--} 4$$

Where Y_{ij} = mean performance of ith genotype in the jth environment; m = mean of all the genotypes over all the environments.

B_i = the regression coefficient of ith genotype on the environmental index which measures the response of the genotype to different environments; I_j = the environmental index which is defined as the deviation of the mean of all the genotypes at a given location from the overall mean; δ_{ij} = the deviation from regression of the ith genotype at jth environment.

The environmental index I_j can be expressed as

$$I_j = (\sum_i Y_{ij}/25) - (\sum_i \sum_j Y_{ij}/100), \text{ with} \sum_j I_j = 0$$

The first stability parameter (b_i) was estimated using the formula

$$b_i = \sum_j Y_{ij} I_j / \sum_j I_j^2$$

The second stability parameter ($S^2 d_i$) was estimated using the formula

$$S^2 d_i = (\sum_j \delta_{ij}^2/2) - S_e^2 /r$$

where S_e^2 /r is the estimate of the pooled error and

$$\sum_j \delta_{ij}^2 = (\sum_j Y_{ij}^2 - Y_i^2/4) - (\sum_j Y_{ij} I_j)^2 / \sum_j I_j^2$$

The average of error mean squares over all the environment was taken as the estimate of pooled error. The detailed analysis of variance for the estimation of stability parameters and their tests of significance are given in Table 3.

(i) The significance of the difference among genotype means was tested using the F test

$$F \approx \frac{MS_1}{MS_4}$$

(ii) Genotype x environment interaction was tested using the F test

$$F \approx \frac{MS_2}{MS_5}$$

(iii) The genetic differences among genotypes for their regression on the environmental index were tested using F test

$$F \approx \frac{MS_3}{MS_4}$$

(iv) Deviation from regression for each genotype was tested using F test

$$F \approx \frac{(\sum_j \delta_{ij}^2)/2}{MS_5}$$

Table 3. Analysis of variance (Eberhart and Russell's model).

Source	df	S.S.	M.S.
Total	99	$\sum_i \sum_j Y^2_{ij}$ -- C.F. = T.S.S.	
Genotypes	24	$\sum_i Y^2_{i.}/4$ -- C.F. = G.S.S.	MS_1
Environments	3	$\sum_j Y^2_{.j}/25$ -- C.F. = E.S.S.	
G x Env	72	T.S.S. -- G.S.S. -- E.S.S.	MS_2
Env + (G x Env)	75	$\sum_i \sum_j Y^2_{ij} - \sum_i Y^2_{i.}/4$	
Env (linear)	1	$1/25 \left(\sum_j Y_{.j} I_j\right)^2 / \sum_j I_j^2$ = S.S.E. (linear)	
Genotypes x Env (linear)	24	$\sum_i \left[\left(\sum_j Y_{ij} I_j\right)^2 / \sum_j I_j^2\right]$ -- S.S.E. (linear)	MS_3
Pooled deviation	50	$\sum_i \left(\sum_j \delta^2_{ij}\right)$	MS_4
Genotype 1	2	$\left[\sum_j Y^2_{ij} - \frac{(Y_{i.})^2}{4}\right] - \left(\sum_j Y_{ij} I_j\right)^2 / \sum_j I_j^2$	
⋮	⋮	⋮	
Genotype 25	2	$\left[\sum_j Y^2_{25j} - \frac{Y^2_{25.}}{4}\right] - \left(\sum_j Y_{25j} I_j\right)^2 / \sum_j I_j^2$	
Pooled error	100		MS_5

3. Perkins and Jinks' model

From the stability point of view, the variance due to genotype x environmental interaction being the most important, Perkins and Jinks (1968) proposed that a regression of genotype x environment interaction on environmental index should be obtained rather than regression of mean performance (Y_{ij}) on the environmental index as done in the Eberhart and Russell's model. For describing Y_{ij}, the mean performance of ith variety in jth location, they proposed the following model.

$$Y_{ij} = m + d_i + e_j + g_{ij} + e_{ij} \qquad i = 1, -- 25$$
$$j = 1, -- 4$$

Where m = the general mean; d_i = the additive genetic effect; e_j = the additive environmental effect; g_{ij} = the genotype x environmental interaction effect and e_{ij} = the error associated with each observation.

These effects were estimated as follows:

$$m = Y....../100$$
$$d_i = (Y_{i.}/4) - m$$
$$e_j = (Y_{.j}/25) - m$$
$$g_{ij} = Y_{ij} - m - d_i - e_j$$

Further they defined

$$g_{ij} = \beta_i e_j + \delta_{ij}$$

Putting the values of g_{ij} in above model:

$$Y_{ij} = m + d_i + e_j + \beta_i e_j + \delta_{ij} + e_{ij}$$
$$= m + d_i + e_j (1 + \beta_i) + \delta_{ij} + e_{ij}$$

In this approach also the same two parameters regression coefficient and the deviation from regression were used as the parameters of stability. In comparison to Eberhart and Russell's model, the regression coefficient in this model is different in the sense that Perkins and Jinks (1968) proposed to calculate the regression of genotype x environment interaction value on the environmental index. In terms of this model, the earlier model of Eberhart and Russell (1966) is modified as regression of $(e_j + g_{ij})$ on e_j. The regression of e_j on e_j being one, and regression of g_{ij} on e_j being β_i, the b_i value of the Eberhart and Russell's model is thus

$$b_i = 1 + \beta_i$$

$$\beta_i = b_i - 1$$

Check $\sum_i \beta_i = 0.000$

S^2d_i remained same as in Eberhart and Russell's model, obviously the relative ranking of different genotypes in this model was no way different from that of Eberhart and Russell's model.

The analysis of variance for the estimation of stability parameters is given in Table 4.

Table 4. Analysis of variance (Perkins and Jinks' model).

Source	df	S.S.	M.S.
Lines (difference between genotypes)	24	$(\sum_i Y^2_{i.} /4) - Y^2 \ldots /100)$	MS_1
Environment (joint regression)	3	$(\sum_i Y^2_{.j} /25) - Y^2 \ldots /100) = S.S.E.$	
Line x environment	72	$\sum_i\sum_j Y^2_{ij} - (1/4)(\sum_j Y^2_{i.}) - (1/25)(\sum_j Y^2_{.j}) + 1/100 (Y^2 \ldots) = S.S.L \times E$	MS_2
Hetorogenity between regression	24	$\frac{\sum_i \left[\sum_j Y_{ij} \{(Y_{.j} /25) - (Y \ldots /100)\}\right]^2}{\sum_j I_j^2} - S.S.E$	MS_3
Remainder	48	S.S.L x E – S.S. duo to heterogoneity	MS_4
Error	100		MS_5

(i) The significance of the differences among genotypes was tested using F test

$$F = \frac{MS_1}{MS_4}$$

(ii) Line x environment was tested using the F test

$$F = \frac{MS_2}{MS_5}$$

(iii) The significance of the heterogeneity between regression was tested using F test

$$F = \frac{MS_3}{MS_4}$$

4. <u>Estimation of phenotypic index</u> (P_i)

Ram *et al.* (1970) proposed phenotypic index as a better and the easiest estimate of phenotypic stability.

$$P_i = \sum P_{ij}/4$$

Where P_{ij} = the difference between individual mean performance of ith genotype in jth environment and overall mean performance of 25 genotypes in jth environment.

5. <u>Estimation of adaptability index</u> (A_i)

Chaudhury *et al.* (1972) proposed adaptability index (A_i) for each genotype across all the environments.

The statistical procedure for its estimation was

$$A_{ij} = \frac{\hat{\hat{Y}}_{ij}}{Y_{.j}} \times 100 - 100$$

$$\hat{\hat{Y}}_{ij} = Y_{.j} + b_i I_j$$

$$A_i = \sum_{j=1}^{4} A_{ij} / 4$$

The estimations of regression coefficient (b_i) and environmental index I_j are same as in Eberhart and Russell's model.

RESULTS

RESULTS

The experimental data recorded in the study are presented under the following heads.

A. Analysis of variance and estimation of variability

B. Phenotypic stability analysis

A. Analysis of variance and estimation of variability

1. Analysis of variance

Before proceeding with the detailed statistical analysis, a general analysis of variance was conducted with respect to all the characters in each environment to test the significance of differences among 25 bhindi genotypes.

The 25 genotypes exhibited highly significant differences for all the characters studied. The differences were significant at 1 per cent level of significance (Table 5.). This was observed for all the four environments in which the experiments were done. This indicated that there were inherent genetic differences among genotypes studied.

2. Estimation of variability

The extent of variability present with respect to yield and yield components were measured in terms of range, mean and coefficient of variation.

Table 5. General analysis of variance for yield and its components in bhindi.

Sources of variation	df		Mean squares							
			Days to fruit set	Plant height (m)	Internodal length (cm)	Leaves/ plant	Fruit length (cm)	Fruit weight (g)	Fruits/ 10 plants	Fruit yield/ 10 plants (kg)
Replications	1	E_1	0.18	0.02	0.10	4.63	0.40	4.06	180.50	0.01
		E_2	4.58	0.47	1.05	1.28	2.32	0.29	6013.78	3.33
		E_3	6.58	0.05	10.16	30.79	0.27	2.79	180.50	0.01
		E_4	0.82	0.12	6.85	16.47	0.47	1.88	873.62	0.16
Genotypes	24	E_1	12.33**	0.20**	10.07**	27.52*	8.39**	7.90**	3687.62**	1.74**
		E_2	21.85**	0.21**	15.87**	10.55*	9.15**	6.78**	1599.16*	0.48**
		E_3	10.25**	0.64**	10.83*	42.59*	9.30**	9.35**	1097.88*	0.87*
		E_4	8.22**	0.67**	3.87*	18.78*	10.20**	6.79**	675.79**	0.25**
Error	24	E_1	0.93	0.02	1.32	10.52	1.03	1.91	754.89	0.44
		E_2	2.75	0.03	3.26	4.01	0.85	1.39	621.24	0.14
		E_3	1.66	0.03	4.37	18.08	0.91	0.84	509.50	0.35
		E_4	0.32	0.05	1.44	8.21	0.43	0.76	207.05	0.05

E_1 = High yielding environment in the first crop season
E_2 = Low " " " "
E_3 = High " " second crop season
E_4 = Low " " " "

*P = 0.05
**P = 0.01

Table 6. Range; mean; genotypic coefficient of variation (gcv), phenotypic coefficient of variation (pcv) and environmental coefficient of variation (ecv) with respect to yield and its contributing characters.

Components of variation		Days to first fruit set	Plant height (m)	Inter-nodal length (cm)	Leaves/ plant	Fruit length (cm)	Fruit weight (g)	Fruits/ 10 plants	Fruit yield/ 10 plants (kg)
Range	E_1	39.0-51.0	1.2 -2.7	8.5-18.6	17.8-26.0	14.0-23.9	14.7-26.5	65.0-303.0	1.2-5.7
	E_2	40.0-52.0	0.52-2.1	6.5-19.5	14.5-25.5	12.2-23.4	13.0-25.2	46.0-189.0	0.7-2.6
	E_3	35.0-43.0	1.2 -1.8	8.1-19.9	17.1-30.6	12.2-24.3	14.7-22.8	85.0-181.0	2.0-5.3
	E_4	36.0-47.0	0.5- 1.4	5.0-22.5	21.0-32.6	12.2-23.8	13.4-19.0	33.0-113.0	0.9-2.6
Mean	E_1	41.5± 0.5	2.3 ±0.1	13.8± 0.8	22.5± 2.2	16.3± 0.7	18.7± 1.0	207.5±19.4	4.3±0.5
	E_2	45.2± 1.2	1.7 ±0.1	14.4± 1.3	18.9± 1.4	15.7± 0.7	17.5± 0.8	106.9±17.6	1.7±0.3
	E_3	37.8± 0.9	1.5 ±0.1	12.0± 1.5	21.6± 3.0	16.1± 0.7	18.1± 0.7	150.3±16.0	3.5±0.4
	E_4	40.4± 0.4	1.2 ±0.2	10.1± 0.9	27.8± 2.0	15.8± 0.5	17.5± 0.6	78.9±10.2	1.6±0.1
gcv	E_1	5.75	13.20	15.31	5.03	11.77	9.28	18.47	18.65
	E_2	6.87	18.13	17.31	9.53	12.96	9.47	20.16	25.08
	E_3	5.49	5.88	5.40	8.97	12.70	11.65	10.82	14.48
	E_4	4.92	8.30	10.87	8.56	13.97	9.80	19.40	19.80
pcv	E_1	6.20	14.46	17.47	13.38	13.31	11.87	22.73	24.20
	E_2	7.79	20.88	21.32	14.21	14.22	11.65	30.38	33.52
	E_3	6.46	13.07	18.18	17.58	14.00	12.74	19.22	22.14
	E_4	5.12	19.98	16.06	13.61	14.58	10.97	26.62	24.23
ecv	E_1	2.32	6.12	8.41	14.30	6.23	7.41	13.22	15.38
	E_2	3.68	10.46	12.45	10.55	5.87	6.86	22.74	22.63
	E_3	3.41	11.76	17.37	19.73	5.91	5.17	15.02	16.78
	E_4	1.40	18.95	11.83	10.57	4.15	5.00	18.24	14.00

E_1 = High yielding environment in the first crop season
E_2 = Low " " " "
E_3 = High " " second crop season
E_4 = Low " " " "

Genetic, phenotypic and environmental variability were calculated in a unit free scale (Table 6.). Considerable variation for all the characters under study were observed. The range for days to fruit set was 35 to 52 days after sowing. Plant height ranged from 0.52 m to 2.70 m. Internodal length ranged from 5 cm to 19.90 cm. Leaves/plant ranged from 15 to 33. The fruit length varied from 12.2 cm to 23.8 cm. Fruit weight varied from 13 g to 26.5 g. Fruit yield ranged from 0.67 kg to 5.72 kg in 10 plants. The highest estimate of gcv was observed for pod yield/10 plants followed by fruits/10 plants. The gcv was the lowest for days to first fruit set. The data indicated considerable variability for fruit yield and pods/10 plants which should be exploited in further breeding programme.

B. <u>Phenotypic stability analysis</u>

1. <u>Pooled analysis of variance</u>

The pooled analysis of variance was conducted for each quantitative character for all the environments Table (7 and 8). The varieties were significantly different over all the environments. The environments were significantly different among one another. Genotype x environment interaction was highly significant (p = 0.01) for days to fruit set, fruits/10 plants and yield/10 plants. The interaction was significant at 5 per cent level for plant height, internodal length and fruit weight. No significant genotype x environment interaction was observed for leaves/plant and fruit length. The significance of genotype x environment interaction for many of the characters indicated that the effects of genotypes and environments were not additive. The genotypes interact specifically with environments resulting a positive or negative phenotypic effect.

2. Stability analysis of variance

The linear effect of environment was highly significant (Table 7.). The linear component of genotype x environment interaction was highly significant for days to first fruit set and fruit weight (P = 0.01) and significant for plant height internodal length and leaves/plant (P = 0.05), indicating thereby the significant differences existing in the genotypes for regression coefficients (b_i and β_i).

Table 7. Stability analysis of variance for phenotypic stability with respect to yield and yield components (Eberhart and Russell's model).

Sources of variation	Day to first fruit set	Plant height (m)	Internodal length (cm)	Leaves/ plant	Fruit length (cm)	Fruit weight (g)	Fruits/ 10 plants	Fruit yield/ 10 plants (kg)
	Mean squares							
Genotypes (G)	14.63**	0.18**	11.63**	7.53**	17.72**	12.05**	1392.60**	0.72**
Environments (E)	205.55**	5.75**	92.35**	339.32**	2.15**	7.56**	78491.80**	46.38**
G x E	4.10**	0.03*	2.04*	4.63	0.33	0.91	702.86**	0.32**
E + G x E	12.16	0.26	5.63	18.02	0.03	1.19	3814.42	2.17
E (linear)	616.65**	17.18**	277.80**	1017.97**	6.44**	22.67**	235475.39**	139.14**
G x E (linear)	7.45**	0.04*	3.02*	6.91*	0.61	1.49**	905.10	0.30
Pooled deviation	2.33	0.02	1.67	3.38	0.59	0.59	577.67	0.32
Pooled Error	0.71	0.02	1.30	5.10	0.40	0.61	269.09	0.12

* P = 0.05
** P = 0.01

Table 8. Stability analysis of variance for phenotypic stability with respect to yield and yield components (Perkins and Jinks' model).

Sources of variation	Mean squares							
	Days to first fruit set	Plant height (m)	Inter-nodal length (cm)	Leaves/plant	Fruit length (cm)	Fruit weight (g)	Fruits/10 plants	Fruit yield/10 plants (kg)
Lines (difference between genotypes)	14.63**	0.18**	11.63**	7.53**	17.12**	12.05**	1392.60**	0.72**
Environment (joint regression)	205.55**	5.73**	92.60**	339.32**	2.15**	7.56**	78491.80**	46.38**
Line x environment	4.10**	0.03*	2.04*	4.63	0.33	0.94*	702.86**	0.32**
Heterogeneity between regression	7.45**	0.04*	3.02*	6.91*	0.60	1.49**	905.10	0.30
Reminder	2.43	0.02	1.67	3.62	0.61	0.62	601.74	0.33
Error	0.71	0.02	1.30	5.10	0.40	0.61	269.09	0.12

* P = 0.05

** P = 0.01

3. Stability parameters

Stability parameters for fruit yield and its components, days to first fruit set, plant height, internodal length, leaves/plant, fruit length, fruit weight and fruits/10 plants were estimated as proposed by Finlay and Wilkinson (1963), Eberhart and Russell (1966), Perkins and Jinks (1968), Ram *et al.* (1970) and Chaudhury *et al.* (1972).

a) Days to first fruit set

Considering grand mean over all the environments, Pusa Sawani was the earliest (39 days after sowing) (Table 9.). Co1 was the latest (46 days). Considering $b_i \rightarrow 1$, $\beta_i \rightarrow 0$, $S^2 d_i \rightarrow 0$, $P_i \mp$ ve and A_i - ve Pusa Sawani, IC 24908, IC 18974 and IC 1542 were the stable genotypes. The value of S^2d_i was significant for Selection 2-2, Cochin Local, Selection 1, IC 15593, Selection 27-2, Co 1 and Pusa Sawani x 4203 indicating unstable nature of the above genotypes.

b) Plant height

The variety Pusa Sawani was the tallest (1.89 m) and Cochin Local the dwarfest (0.95 m) (Table 10.). Vaishalivadhu, IC 23592, IC 13999, IC 1542, Selection 27-1, Belts Five, IC 15593, Selection 27-2

Pusa Sawani x 4203 and Co 1 were the stable genotypes. S^2d_i was significant for Selection 2-2 indicating unstable nature of the genotype.

c) Internodal length

Lam Selection had the longest internodal length (15.99 cm) and Cochin Local the shortest (7.30 cm) (Table 11,). Vaishalivadhu, IC 23592 and IC 15055 were stable genotypes. The significance of S^2d_i for Selection 2 indicated its unstable nature.

d) Leaves/plant

Cochin Local had the highest number of leaves (25) and IC 12933 the lowest (19)(Table 12.). AC 95, IC 1542, Selection 27-2 and Co 1 were the stable genotypes. Pusa Sawani, Lam Selection, IC 7194, Vaishalivadhu, Selection 1-1, IC 15055, IC 13999, Cochin Local, Selection 27-1, Pusa Makhmali, Hybrid Selection 1 and IC 15593 were below average stable genotypes. IC 24908, IC 18974 and Selection 2 were above average stable genotypes.

e) Fruit length

Selection 2 had the longest fruit length (22.88 cm) and IC 12933 the shortest (12.99 cm) (Table 13.). Selection 27-1 was the only stable genotype. IC 24908, IC 18974 and Co 1 were above average stable genotypes. The performance of AC 95 was below average stable.

f) Fruit weight

Vaishalivadhu had the highest fruit weight (24.41 g) followed by Selection 2 (21.21 g) and IC 12933, the lowest (15.53 g)(Table 14.). No stable genotype was observed for fruit weight. Lam Selection, Vaishalivadhu, IC 23592, Selection 2 and hybrid Selection 1 were above average stable genotypes. IC 24908, AC 95, Cochin Local and Selection 27-1 were below average stable genotypes.

g) Fruits/10 plants

Hybrid Selection 1 had the highest number of fruits (173.50) followed by Pusa Sawani (164.88), the lowest number of fruits (77.38) was observed in Cochin Local. (Table 15.). Pusa Sawani, IC 13999, IC 1542, Pusa Makhmali and IC 15593 were observed as stable genotypes. S^2d_i was significant in Vaishalivadhu indicating the unstable nature of the genotype. Selection 2, Belts Five and Pusa Sawani x 4203 were above average stable genotypes.

h) Fruit yield/10 plants

The highest yield overall the environments was recorded in Pusa Sawani (3.61 kg) followed by

Hybrid Selection 1 (3.57 kg) and Lam Selection (3.35 kg) (Table 16.). Pusa Sawani, Lam Selection, Hybrid Selection 1, and Pusa Makhmali were observed as the stable genotypes. The above genotypes confirmed well to the statistical parameters given for stability by Finlay and Wilkinson (1963), Eberhart and Russell (1966), Perkins and Jinks (1968), Ram et al. (1970) and Chaudhury et al. (1972). Belts Five and IC 1542 were above average stable genotypes. IC 15593 was a below average stable genotype. S^2d_i was significant for Selection 2-2, Vaishalivadhu, IC 23592, IC 13999, Cochin Local and Pusa Sawani x 4203 indicating the unstable nature of the genotypes.

Table 9. Stability parameters as proposed by Finlay and Wilkinson (1963), Eberhart and Russell (1966), Perkins and Jinks (1968), Ram *et al.* (1970) and Chaudhury *et al.* (1972) for days to first fruit set.

Genotypes	Mean	$b_i/b_i/\beta_i$	S^2d_i	P_i	Λ_i
Pusa Sawani	38.75	0.84 0.85 -0.16	-0.21	-2.43	-5.24
Lam Selection	39.50	0.70 0.70 -0.30	-0.52	-1.68	-2.92
IC 24908	39.13	0.99 0.98 - 0.01	0.68	-2.06	-5.24
Selection 2-2	40.75	2.16 2.19 1.16	5.36**	-1.72	-3.82
IC 7194	40.00	0.71 0.71 -0.29	0.01	-1.18	-2.06
Vaishalivadhu	41.38	0.88 0.87 -0.12	-0.63	0.20	0.47
IC 23592	40.75	0.73 0.73 -0.21	0.72	-0.43	-0.74
Selection 1-1	41.50	0.75 0.74 -0.25	-0.35	0.32	0.66
AC 95	42.00	1.75 1.75 0.75	0.46	0.82	3.02
IC 15055	40.88	0.53 0.53 -0.47	-0.14	0.31	0.30

(Contd.......)

(Contd.. Table 9.)

Genotypes	Mean	$b_i/b_i/\beta_i$	S^2d_i	P_i	A_i
IC 13999	41.13	0.53 0.52 -0.47	0.18	-0.06	-0.01
IC 18974	40.25	0.91 0.91 -0.09	0.15	-0.93	-2.17
Cochin Local	44.63	0.09 0.09 -0.91	6.01**	3.46	0.80
Selection 1	45.38	2.13 2.13 1.13	19.71**	4.20	20.90
Selection 2	42.00	1.98 1.90 0.98	-0.10	-0.31	-0.92
IC 1542	40.88	1.15 1.14 0.15	-0.10	-0.31	-0.92
Selection 27-1	40.75	1.47 1.47 0.47	0.68	-0.43	-1.92
Belts Five	39.75	0.65 0.65 -0.35	0.12	-1.43	-2.30
Pusa Makhmali	39.63	0.84 0.88 -0.16	0.44	-1.12	-3.26
Hybrid Selection 1	39.75	0.80 0.79 -0.20	0.11 ~~0.79~~ ~~-0.20~~	-1.43	-2.85

(Contd.......)

(Contd.....Table 9.)

Genotypes	Mean	$b_i/b_i/\beta_i$	S^2d_i	P_i	A_i
IC 15593	42.00	1.09 1.09 0.09	1.86*	0.82	2.11
Selection 27-2	39.38	0.47 0.46 -0.53	2.20*	-1.81	-2.08
Co 1	46.38	0.85 0.85 -0.15	1.87*	5.20	10.26
IC 12933	39.38	0.38 0.37 -0.62	0.62	-1.81	-1.72
Pusa Sawani x 4203	41.75	1.59 1.57 0.59	1.60*	0.51	2.63

*P = 0.05

**P = 0.01

Table 10. Stability parameters as proposed by Finlay and Wilkinson (1963), Eberhart and Russell (1966), Perkins and Jinks (1968), Ram *et al*. (1970)and Chaudhury *et al*. (1972) for plant height (m).

Genotypes	Mean	$b_i/b_i/\beta_i$	S^2d_i	P_i	A_i
Pusa Sawani	1.89	1.23 1.23 0.23	0.01	0.24	16.51
Lam Selection	1.81	0.82 0.82 -0.18	0.01	0.15	4.70
IC 24908	1.77	0.88 0.88 -0.12	0.02	0.11	6.56
Selection 2-2	1.32	0.47 0.47 -0.53	0.03*	-0.44	-17.06
IC 7194	1.63	1.26 1.26 0.26	0.02	-0.02	-6.11
Vaishalivadhu	1.68	1.15 1.14 0.15	0.00	0.03	0.45
IC 23592	1.72	1.14 1.14 0.14	0.01	0.06	3.60
Selection 1-1	1.78	1.28 1.28 0.28	0.00	0.12	7.93
AC 95	1.42	0.89 0.89 -0.11	0.00	-0.23	-14.89
IC 15055	1.70	1.24 1.24 0.24	0.00	0.05	2.17

(Contd. . . . .)

(Table 10 Contd....)

Genotypes	Mean	$b_i/b_i/\beta_i$	S^2d_i	r_i	A_i
IC 13999	1.74	1.13 1.13 0.13	0.00	0.09	5.93
IC 18974	1.63	0.94 0.94 -0.06	-0.01	-0.02	-0.91
Cochin Local	0.95	0.43 0.43 -0.57	0.07	-0.70	-20.00
Selection 1	1.45	0.69 0.69 -0.31	0.00	-0.20	-9.03
Selection 2	1.64	0.93 0.93 -0.07	0.00	-0.01	-0.90
IC 1542	1.71	1.14 1.14 0.14	0.00	0.06	3.58
Selection 27-1	1.76	1.08 1.08 0.08	0.00	0.11	6.55
Belts Five	1.84	1.04 1.04 0.04	0.00	0.18	12.87
Pusa Makhmali	1.59	1.26 1.26 0.25	0.02	-0.07	-10.01
Hybrid Selection 1	1.88	0.87 0.87 -0.13	0.00	0.23	13.70

(Contd . . . .)

(Table 10 Contd.....)

Genotypes	Mean	$b_i'/b_i/\beta_i$	S^2d_i	P_i	A_i
IC 15593	1.84	1.05 1.05 0.05	0.00	0.19	12.46
Selection 27-2	1.68	0.99 0.99 -0.01	0.01	0.03	0.95
Co 1	1.73	0.83 0.83 -0.17	0.01	0.07	4.12
IC 12933	1.54	0.95 0.96 -0.05	0.02	-0.11	-7.58
Pusa Sawani x 4203	1.73	1.19 1.19 0.19	0.00	0.08	4.63

*P = 0.05

Table 11. Stability parameters as proposed by Finlay and Wilkinson (1963), Eberhart and Russell (1966), Perkins and Jinks (1968), Ram *et al.* (1970) and Chaudhury *et al.* (1972) for internodal length (cm).

Genotypes	Mean	$b_i/b_i/\beta_i$	S^2d_i	P_i	A_i
Pusa Sawani	14.36	1.90 1.90 0.90	-0.33	1.75	23.60
Lam Selection	15.99	1.61 1.42 0.61	-0.69	3.39	42.24
IC 24908	14.48	1.74 1.78 0.74	1.86	1.79	22.8
Selection 2-2	10.01	0.07 0.08 -0.93	1.19	-2.58	-1.93
IC 7194	12.73	1.47 1.47 0.47	-0.44	0.67	5.37
Vaishalivadhu	14.16	1.15 1.15 0.15	-0.96	1.57	14.27
IC 23592	12.66	0.88 0.88 -0.12	-1.10	0.06	0.60
Selection 1-1	12.90	0.58 0.59 -0.42	-1.16	0.30	1.82
AC 95	10.80	0.05 0.05 -0.95	0.07	-1.80	-0.87
IC 15055	12.65	1.29 1.26 0.29	0.95	0.06	1.10

(Contd . . . . . .)

(Table 11 Contd......)

Genotypes	Mean	$b_i/b_i/\beta_i$	S^2d_i	P_i	A_i
IC 13999	12.55	0.74 0.52 -0.26	0.32	-0.05	-0.13
IC 18974	11.86	0.77 0.77 -0.25	0.82	0.73	5.05
Cochin Local	7.30	0.43 0.44 -0.51	1.45	-5.30	-32.93
Selection 1	11.87	0.27 0.28 -0.73	1.07	-0.73	-1.79
Selection 2	12.86	0.70 0.69 -0.30	2.73	0.26	1.29
IC 1542	12.08	0.91 0.90 -0.09	1.32	-0.38	-2.95
Selection 27-1	12.27	0.80 0.80 -0.20	0.87	-0.33	-2.00
Delta Five	12.11	0.51 0.51 -0.49	1.26	-0.49	-1.76
Pusa Makhamali	11.89	1.13 1.13 0.13	-0.25	-0.071	-7.50
Hybrid Selection 1	12.36	1.18 1.18 0.18	-0.51	-0.22	-3.06

(Contd . . . .)

(Table 11 Contd......)

Genotypes	Mean	$b_i/b_i/\beta_i$	S^2d_i	P_i	A_i
IC 15593	13.73	1.26 1.26 0.26	0.80	1.13	18.70
Selection 27-2	12.08	1.24 1.24 0.24	-0.40	-0.51	-6.70
Co 1	13.61	1.65 1.65 0.65	3.89	1.02	10.81
IC 12933	14.41	1.22 1.23 0.22	4.39	1.81	17.28
Pusa Sawani x 4203	13.29	1.48 1.48 0.48	-1.27	0.94	4.32

Table 12. Stability parameters as proposed by Finlay and Wilkinson (1963) Eberhart and Russell (1966), Perkins and Jinks (1968), Ram *et al.* (1970) and Chaudhury *et al.* (1972) for Leaves/plant.

Genotypes	Mean	$b_i/b_i/\beta_i$	S^2d_i	P_i	A_i
Pusa Sawani	21.46	0.80 0.80 -0.20	-4.58	-1.23	-5.17
Lam Selection	20.60	0.61 0.66 -0.39	-4.20	-2.08	-6.01
IC 24908	23.03	1.68 1.70 0.68	-0.72	0.35	0.12
Selection 2-2	22.84	1.48 1.48 0.48	2.48	0.15	-1.41
IC 7194	22.64	0.66 0.66 -0.34	-1.96	-0.05	0.09
Vaishalivadhu	24.01	0.34 0.34 -0.66	-4.21	1.32	2.36
IC 23592	23.06	0.89 0.89 -0.11	-4.52	0.37	1.66
Selection 1-1	22.40	1.03 1.03 0.03	-2.85	-0.28	-1.61
AC 95	24.73	1.13 1.13 0.13	-4.08	2.03	10.01
IC 15055	24.36	0.20 0.30 -0.80	-1.68	1.82	1.72

(Contd....)

(Table 12 Contd......)

Genotypes	Mean	$b_i/b_i/\beta_i$	S^2d_i	P_i	A_i
IC 13999	21.51	1.24 1.24 0.24	-0.48	-1.17	-8.52
IC 18974	22.95	1.38 1.14 0.38	-4.19	1.01	5.54
Cochin Local	24.96	0.66 0.66 -0.34	7.23	7.28	7.17
Selection 1	22.65	1.17 1.17 0.17	3.06	-0.11	-1.20
Selection 2	24.78	1.77 1.17 0.17	-0.94	2.09	13.99
IC 1542	22.88	1.23 1.23 0.23	-5.10	0.19	0.46
Selection 27-1	22.31	0.73 0.73 -0.27	-3.79	-0.38	-0.99
Belts Five	22.45	1.15 1.15 0.15	-2.20	-0.24	-1.79
Pusa Makhmali	22.31	0.56 0.56 -0.44	-2.03	-0.38	-0.69
Hybrid Selection-1	22.40	0.97 0.97 -0.03	1.96	-0.29	-1.82

(Contd . . . . . .)

(Table 12 Contd......)

Genotypes	Mean	$b_i/b_i/\beta_i$	S^2d_i	P_i	A_i
IC 15593	20.64	0.68 0.68 -0.32	-3.00	-2.05	-6.70
Selection 27-2	22.94	1.26 1.26 0.26	-2.64	0.25	0.63
Co 1	23.14	1.22 1.22 0.22	-1.76	0.05	1.45
IC 12933	19.05	1.07 1.07 0.07	-3.77	-3.64	-21.64
Pusa Sawani x 4203	22.39	1.15 1.15 0.15	1.56	-0.33	-2.66

Table 13. Stability parameters as proposed by Finlay and Wilkinson (1963), Eberhart and Russell (1966), Perkins and Jinks (1968), Ram *et al*. (1970) and Chaudhury *et al*. (1972) for fruit length (cm).

Genotypes	Mean	$b_i/b_i/\beta_i$	S^2d_i	P_i	A_i
Pusa Sawani	15.46	2.79 2.70 1.79	-0.37	-0.52	-9.70
Lam Selection	15.75	3.56 3.60 2.56	-0.15	-0.23	-0.54
IC 24908	16.34	1.70 1.66 0.70	-0.38	0.36	3.47
Selection 2-2	15.70	0.54 0.55 -0.46	0.05	-0.28	-1.85
IC 7194	14.90	0.57 0.53 -0.43	0.65	-1.08	-4.25
Vaishalivadhu	14.74	2.76 2.76 1.76	-0.37	-1.40	-26.79
IC 23592	15.27	2.68 2.69 1.68	-0.35	-0.71	-12.85
Selection 1-1	15.70	4.64 4.60 3.64	-0.25	-0.28	-10.13
AC 95	21.94	0.46 0.46 -0.54	-0.08	5.97	17.18
IC 15055	15.54	3.27 3.20 2.27	-0.40 ~~3.20~~ ~~2.27~~	-0.44	-9.98

(Contd....)

(Table 13 Contd...)

Genotypes	Mean	$b_i/b_i/\beta_i$	S^2d_i	P_i	A_i
IC 13999	15.98	1.71 1.70 0.71	-0.38	-0.01	-0.01
IC 18974	16.42	1.69 1.70 0.69	-0.06	0.44	4.60
Cochin Local	15.40	3.49 3.52 2.49	-0.35	-0.58	-0.04
Selection 1	14.54	0.14 0.15 -0.71	-0.05	-1.44	-1.40
Selection 2	22.88	0.29 0.29 -0.71	-0.16	-6.90	0.43
IC 1542	14.56	0.70 0.70 -0.30	-0.16	-1.42	-6.89
Selection 27-1	16.12	1.22 1.23 0.22	-0.28	0.65	4.92
Belts Five	15.18	0.34 0.34 -0.66	-0.19	-0.80	-1.82
Pusa Makhmali	14.57	0.55 0.55 -0.45	-0.37	-1.41	5.31
Hybrid Selection 1	16.24	0.28 0.27 -0.72	-0.37	-0.44	-1.17

(Contd. . . .)

(Table 13 Contd....)

Genotypes	Mean	$b_i/b_i/\beta_i$	S^2d_i	P_i	A_i
IC 15593	16.07	0.70 0.70 -0.30	-0.24	-0.09	-0.04
Selection 27-2	15.36	2.00 1.98 1.00	-0.33	-0.64	-8.61
Co 1	16.52	3.11 3.12 2.11	-0.26	0.54	10.34
IC 12933	12.99	0.69 0.69 -0.31	-0.34	-2.99	-15.90
Pusa Sawani x 4203	14.85	1.29 1.29 0.29	-0.39	-1.13	-9.84

Table 14. Stability parameters as proposed by Finlay and Wilkinson (1963), Eberhart and Russell (1966), Perkins and Jinks (1968), Ram *et al.* (1970) and Chaudbury et al. (1972) for fruit weight (g).

Genotypes	Mean	$b_i/b_i/\beta_i$	S^2d_i	P_i	A_i
Pusa Sawani	18.37	0.19 0.04 -0.81	-0.20	-0.42	-0.23
Lam Selection	18.74	2.41 2.41 1.41	0.00	0.65	8.36
IC 24908	18.18	0.65 0.65 -0.35	0.60	0.24	5.26
Selection 2-2	17.64	0.66 0.66 -0.34	-0.57	-0.84	-1.15
IC 7194	17.73	1.53 1.54 0.53	-0.59	-0.22	-2.00
Vaishalivadhu	24.41	1.84 1.85 0.84	-0.58	6.47	66.25
IC 23592	18.25	3.62 1.62 2.62	0.91	0.31	4.46
Selection 1-1	16.46	1.94 1.95 0.94	-0.26	-1.48	-18.59
AC 95	18.37	0.29 0.29 -0.71	-0.37	0.43	0.73
IC 15055	17.30	0.32 0.36 -0.68	-0.37	-0.65	-1.20

(Contd,.....)

(Table 14 Contd.....)

Genotypes	Mean	$b_i/b_i/\beta_i$	S^2d_i	P_i	A_i
IC 13999	17.67	0.76 0.76 -0.24	-0.34	-0.27	-1.19
IC 18974	16.84	1.62 1.62 0.62	1.08	-1.11	-11.31
Cochin Local	17.96	0.19 0.19 -0.81	-0.57	0.02	0.03
Selection 1	16.49	0.00 0.05 -1.00	-0.02	-1.53	-0.10
Selection 2	21.21	2.11 2.11 1.11	0.01	3.26	38.19
IC 1542	17.66	0.41 0.41 -0.59	-0.40	-0.28	-0.65
Selection 27-1	18.14	0.05 0.05 -0.95	-0.61	-1.08	-3.90
Belts Five	16.86	0.60 0.60 -0.40	-0.09	-1.08	-3.90
Pusa Makhmali	16.35	2.09 2.09 1.09	0.40	-1.60	-21.30
Hybrid Selection 1	18.76	1.67 1.68 0.67	0.10	0.82	7.52

(Contd.........)

(Table 14 Contd.......)

Genotypes	Mean	$b_i/b_i/\beta_i$	S^2d_i	P_i	A_i
IC 15593	17.74	0.29 0.29 -0.71	-0.57	-0.21	-0.34
Selection 27-2	17.15	0.97 0.97 -0.03	-0.47	-0.80	-4.66
Co 1	16.75	2.71 2.77 1.71	0.95	-1.20	-2.55
IC 12933	15.53	2.50 2.81 1.50	-0.40	-2.42	-40.16
Pusa Sawani x 4203	18.11	2.10 3.65 1.10	3.26*	0.17	0.75

*P = 0.05

Table 15. Stability parameters as proposed by Finlay and Wilkinson (1963), Eberhart and Russell (1966), Perkins and Jinks (1968), Ram et al. (1970) and Chaudhury et al. (1972) for fruits/10 plants.

Genotypes	Mean	$b_i/b_1/\beta_i$	S^2d_i	P_i	A_i
Pusa Sawani	164.88	0.93 0.93 -0.07	103.56	28.33	21.98
Lam Selection	151.12	1.23 1.22 0.23	-19.73	14.58	11.49
IC 24908	126.38	0.89 0.89 -0.11	-42.59	-10.18	-8.58
Selection 2-2	116.38	0.25 0.25 -0.75	1574.41	-2.16	-11.16
IC 7194	119.87	0.79 0.78 -0.22	290.22	-16.68	-10.70
Vaishalivadhu	115.37	1.19 1.08 0.19	3029.52**	-20.46	-33.42
IC 23592	132.13	1.40 1.40 0.40	175.28	-4.30	-78.55
Selection 1-1	129.12	1.17 1.17 0.17	-17.51	-7.43	-13.06
AC 95	135.13	1.14 1.14 0.14	676.13	-1.43	- 4.10
IC 15055	124.62	0.95 0.98 -0.05	-10.96	-11.93	-10.19

(Contd.......)

(Table 15 Contd......)

Genotypes	Mean	$b_i/b_i/\beta_i$	S^2d_i	P_i	A_i
IC 13999	152.25	1.17 1.17 0.17	264.96	17.70	13.55
IC 18974	136.25	0.91 0.91 -0.09	-170.95	-0.30	-0.23
Cochin Local	77.38	0.19 0.19 -0.81	1340.79	-59.17	-17.39
Selection 1	132.00	1.29 1.20 0.20	-119.37	-4.42	-10.51
Selection 2	148.62	1.54 1.54 0.54	360.39	12.08	1.57
IC 1542	142.50	1.03 1.03 0.03	-164.70	5.95	4.13
Selection 27-1	130.75	1.14 1.14 0.14	-117.47	-5.80	-9.77
Belts Five	156.75	1.32 1.32 0.32	-261.61	20.20	16.16
Pusa Makhmali	140.00	1.10 1.10 0.10	-53.25	3.45	0.59
Hybrid Selection 1	173.50	0.69 0.69 -0.31	-169.14	36.95	23.70

(Contd.........)

(Table 15 Contd.....)

Genotypes	Mean	$b_i/b_1/\beta_i$	S^2d_i	P_i	A_i
IC 15593	143.37	0.82 0.82 -0.18	684.08	6.83	6.43
Selection 27-2	134.62	1.00 1.00 0.00	-193.78	-1.93	-1.98
Co 1	128.88	0.86 0.86 -0.14	169.39	-1.43	-6.10
IC 12933	138.25	0.80 0.86 -0.14	-39.19	1.625	2.63
Pusa Sawani x 4203	145.87	1.29 1.29 0.29	436.14	9.33	5.30

** P = 0.01

Table 16. Stability parameters as proposed by Finlay and Wilkinson (1963), Eberhart and Russell (1966), Perkins and Jinks (1968), Ram *et al.* (1970) and Chaudhury *et al.* (1972) for fruit yield/10 plants(Kg)

Genotypes	Mean	$b_i/b_i/\beta_i$	S^2d_i	P_i	A_i
Pusa Sawani	3.61	1.18 1.15 0.18	-0.11	0.84	38.32
Lam Selection	3.35	0.98 0.98 -0.02	-0.03	0.58	25.35
IC 24908	2.52	0.76 0.76 -0.24	-0.02	-0.25	-6.18
Selection 2-2	2.43	0.76 0.75 -0.24	0.81**	-0.42	-15.52
IC 7194	2.30	0.77 0.78 -0.23	-0.03	-0.47	-14.82
Vaishalivadhu	2.73	1.38 1.38 0.38	2.06**	-0.04	-31.23
IC 23592	2.69	1.24 1.39 0.24	0.42*	-0.09	-12.88
Selection 1-1	2.86	1.39 1.39 0.39	0.01	-0.43	-24.71
AC 95	2.34	0.75 0.75 -0.25	0.08	-0.17	- 4.61
IC 15055	2.61	0.92 0.99 -0.08	0.02	-0.17	- 5.65

(Contd.....)

(Table 16 Contd.....)

Genotypes	Mean	$b_i/b_i/\beta_i$	S^2d_i	P_i	A_i
IC 13999	3.28	1.15 1.15 0.15	0.36*	0.51	23.10
IC 18974	2.80	1.08 1.09 0.08	-0.11	0.04	0.13
Cochin Local	1.67	0.41 0.40 -0.59	1.41**	-1.10	-40.09
Selection 1	2.65	0.94 0.94 -0.06	0.11	-0.12	-6.13
Selection 2	2.77	1.18 1.18 0.18	-0.01	-0.001	-9.21
IC 1542	2.98	1.18 1.18 0.18	-0.09	0.21	5.93
Selection 27-1	2.55	1.05 1.05 0.05	-0.04	-0.99	-6.94
Belts Five	3.28	1.29 0.89 0.29	-0.09	0.51	20.75
Pusa Makhmali	2.83	0.99 0.99 -0.01	0.01	0.06	1.74
Hybrid Selection 1	3.57	1.00 1.00 0.00	0.02	0.89	35.10

(Contd.....2)

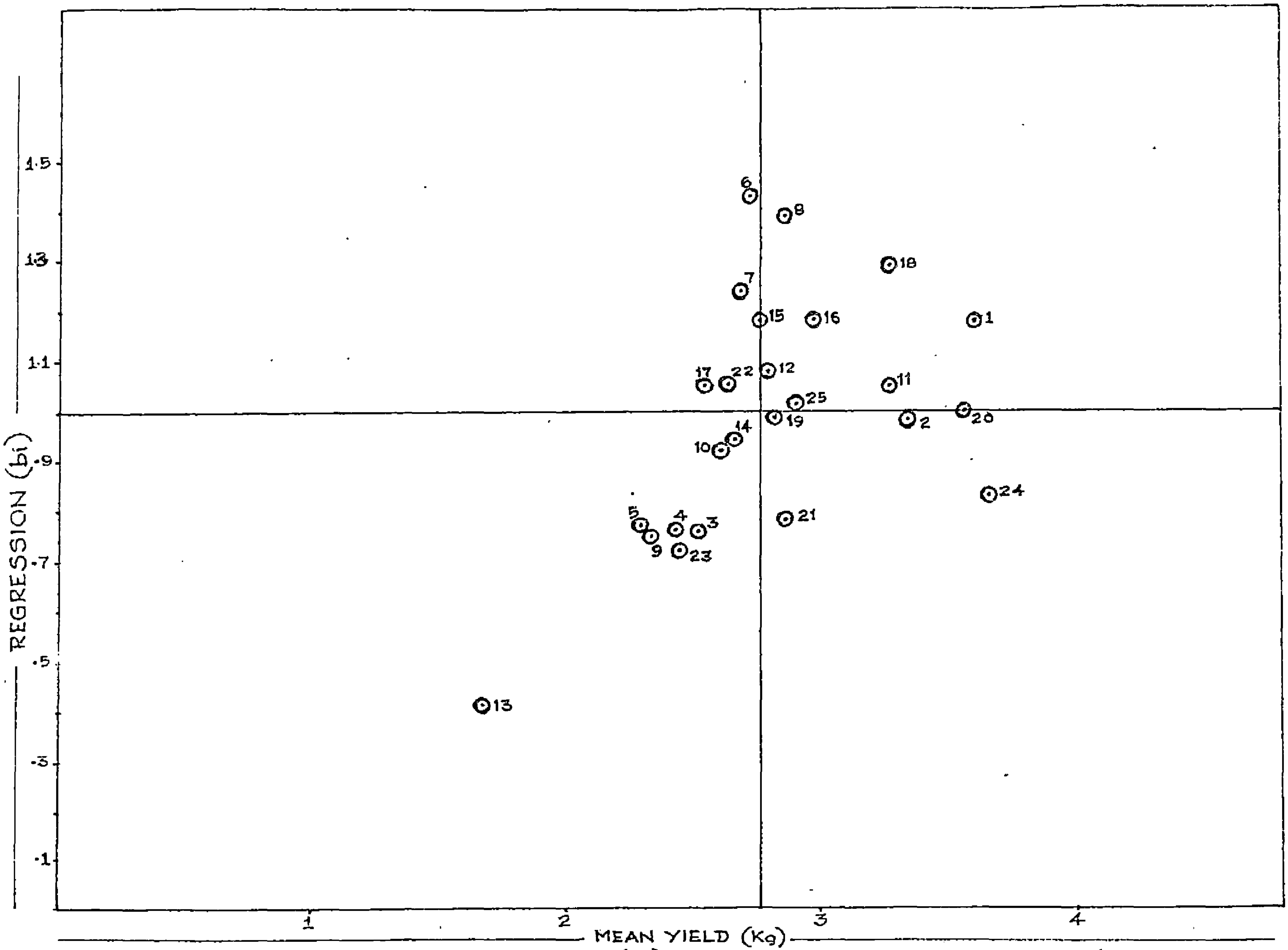

FIG. 1. PARAMETERS OF STABILITY (bi) PLOTTED AGAINST THE MEAN PERFORMANCE OF INDIVIDUAL VARIETIES.

* SEE TABLE 1. FOR DETAILS OF VARIETIES.

DISCUSSION

DISCUSSION

Bhindi is one of the most important warm season fruit vegetables grown throughout tropics. Introduced to India from its Ethiopean centre of origin the crop is being grown at present in all the States. A good number of varieties have been evolved to suit the local conditions and local preferences. Availability of a varied number of varieties creats managerial problems in a seed industry. Catering to needs of rich, marginal and poor farmers, identification of a phenotypically stable variety is all the more important in such a crop. Phenotypically stable varieties are particularly of great importance in countries like India, where environmental conditions differ from one climatic zone to other and even within the one climatic zone itself. A breeding programme aimed at developing phenotypically stable varieties, requires information on the extent of genotype x environment interactions for yield and more particularly the interactions between component characters of yield and environment. This programme could have two approaches. One approach is to identify developmental sequences which can counteract the fluctuations in environmental conditions. The other approach may be identifying component characters, whose stability, if manipulated and regulated could bring out stability for the expression of yield. It is also likely that phenotypic stability for yield could be due to mutual balance of different rotes of changes in stability for the characters contributing to yield (Rana and Murthy, 1971). The other approach may be genetical, where buffering capacity is created through genetic mixtures or through gene pools from contrasting environments as a mean to reduce genotype x environment interaction. Being an often crosspollinated crop the second approach may be more tenable in bhindi. As a first step genotypes including popular varieties were grown continuously in two seasons under two contrasting environments. Observations were recorded on yield and its seven components. The data were analysed as proposed by Finlay and Wilkinson (1963), Eberhart and Russell (1966), Perkins and Jinks (1966), Ram et al. (1970) and Chaudhury et al. (1972).

No detailed information was available in bhindi regarding genotype x environment interaction except for the observation made by Korla and Rastogi

(1979). This necessitated a detailed analysis to estimate the genotype x environment interaction and also stability parameters fordifferent genotypes, so that stable genotype(s) could be recommended to the farmers.

Finlay and Wilkinson (1963) considered regression of individual mean performance over site mean (b_i) as a measure of stability. The genotype with a regression value of zero was considered the most stable. Statistically this may be quite justified, but in a plant breeders view this alone may not be sufficient to isolate a stable genotype, which would be acceptable to farmers. Eberhart and Russell (1966) accordingly considered a stable genotype as one with higher mean performance regression coefficient $b_i \rightarrow 1$ and deviation from regression $S^2d_i \rightarrow 0$. Perkins and Jinks (1966) modified the estimation of regression to eliminate statistical limitations of Finlay and Eberhart model. The statistical parameters of stability as proposed by Finlay and Wilkinson (1963) and Eberhart and Russell (1966) and Perkins and Jinks (1968) involved tedious calculations. Ram et al. (1970) suggested a simple method of estimation of phenotypic index (P_i).

The genotypes with + ve value of phenotypic index were considered to be stable. Further Chaudhury *et al*. (1972) suggested adaptability index value (A_i). The magnitude of A_i indicates its degree of adaptability and its sign determines the nature of performance. This value revealed the latent potentialities of a strain in its yielding capacity over other genotypes which have got the same P_i value. In this study all the above methods were used to isolate stable genotypes for yield and its components.

In the present investigation genotype x environment interaction was significant for days to first fruit set, plant height, internodal length, fruit weight, fruits/10 plants and fruit yield/10 plants. This indicates that the effects of environments and genotypes were not linear for the above characters. Significant genetic differences among genotypes for regression coefficient were observed for days to first fruit set, plant height, internodal length, leaves/plant and fruit weight.

A combination of the concept of Finlay and Wilkinson (1963), Eberhart and Russell (1968), Perkins and Jinks (1968), Ram *et al*. (1970) and

Chaudhury et al. (1972) was tried to classify genotypes under study for their adaptability to low, medium and high yielding environments. The detailed analysis indicated that Belts Five and IC 1542 could be recommended for high yielding environments, they have higher mean, regression coefficient and deviation from regression approaching zero. The genotypes suited for medium yielding environments are Pusa Sawani, Hybrid Selection 1, Lam Selection and Pusa Makhmali. These genotypes have high mean, regression coefficient tending to 1 and deviation from regression approaching zero. IC 15593 could be suited for low yielding environment, it retained and manifested its inherent potentiality fully well in low yielding environments and had higher mean performance regression coefficient tending to zero and deviation from regression zero. Salient feature of the classification of environments and genotypes studied for the environments have been given in Table 17.

The experiment conducted by Korla and Rostogi (1979) revealed the stability of Pusa Sawani over 4 ~~seasons~~ years. The present study confirmed the phenotypic stability of Pusa Sawani over contrasting environments. This could be due to the fact that the parental lines of Pusa Sawani, viz., Pusa Makhmali and IC 1542 were stable lines and possessed buffering gene systems. The genotype Hybrid Selection 1 has distinct advantage over Pusa Sawani in markets with preference for long fruited types this is more so in Kerala.

Table 17. Mean, regression coefficient, deviation from regression, phenotypic index and adaptabiliting index for various bhindi genotypes suited for high, medium and low yielding environments.

Genotypes	Environments														
	High					Medium					Low				
	Mean	b_i	S^2d_i	P_i	A_i	Mean	b_i	S^2d_i	P_i	A_i	Mean	b_i	S^2d_i	P_i	A_i
Belts Five	3.28	1.29	-0.09	0,51	20.75										
IC 1542	2.98	1.18	-0.09	0.21	5.93										
Pusa Sawani						3.61	1.18	-0.11	0.84	38.32					
Hybrid Selection 1						3.57	1.00	0.02	0.80	35.10					
Lam Selection						3.35	0.98	-0.03	0.58	25.35					
Pusa Makhmali						2.83	0.99	0.01	0.06	1.74					
IC 15593											2.87	0.78	0.22	0.02	2.92

SUMMARY

SUMMARY

The 25 bhindi genotypes were grown in a randomised block design with two replications during two crop seasons (May-August 1980 and September-January 1980-81) in the Instructional Farm of Kerala Agricultural University, Vellanikkara. Two contrasting environments - high fertile and low fertile - were created in each season by manurial and fertilizer dose variations. Observations were recorded on yield and its seven components, days to first fruit set, plant height, internodal length, leaves/plant, fruit length, fruit weight and fruits/10 plants.

1. The data were analysed as per Finlay and Wilkinson (1963), Eberhart and Russell (1966), Perkins and Jinks (1968), Ram *et al*. (1970) and Chaudhury *et al*. (1972).

2. The 25 bhindi genotypes exhibited highly significant differences for all the characters studied in all the four environments. The environments were significantly different among one another in their effects on genotypes.

3. The genotype x environment interaction which measures the deviation from the additive effective

of genotype and environment was highly significant for days to first fruit set, fruits/10 plants and fruit yield/10 plants. The linear component of genotype x environment interaction was highly significant for days to first fruit set and fruit weight (P = 0.01) and significant for plant height, internodal length and leaves/plant (P = 0.05) indicating the significant difference existing in the genotypes for regression coefficients (b_i and B_i).

4. Pusa Sawani was the earliest (39 days after sowing) and Co 1 the latest (46 days). The genotypes Pusa Sawani, IC 24908, IC 18974 and IC 1542 were observed stable genotypes as for days to first fruit set.

5. The variety Pusa Sawani was the tallest (1.89 m) and Cochin Local the dwarfest (0.95 m). Vaishalivadhu, IC 23592, IC 13999, IC 1542, Selection 27-1, Belts Five, IC 15593, Selection 27-2, Pusa Sawani x 4203 and Co 1 were stable genotypes as for plant height.

6. Lam Selection had the longest internodal length (15.99 cm) and Cochin Local the shortest (7.30 cm). Vaishalivadhu, IC 23592 and IC 15055 were observed as stable genotypes for internodal length.

7. Cochin Local had the highest number of leaves (25) and IC 12933 the lowest (19). AC 95, IC 1542, Selection 27-2 and Co 1 were the stable genotypes.

8. Selection 2 had the longest fruit length (22.88 cm) and IC 12933 the shortest (12.99 cm). Selection 27-1 was the only stable genotype.

9. Vaishalivadhu had the highest fruit weight (24.41 g) followed by Selection 2 (21.21g) and IC 12933 the lowest (15.53 g). Lam Selection, Vaishalivadhu, IC 23592, Selection 2 and Hybrid Selection 1 were above average stable genotypes. No stable genotypes were observed for fruit weight.

10. Hybrid Selection 1 had the highest number of fruits (173.50) followed by Pusa Sawani (168.88), the lowest number of fruits (77.38) was observed in Cochin Local. The stable genotypes were Pusa Sawani, IC 13999, IC 1542, Pusa Makhmali and IC 15593.

11. The highest yield over all the environments was recorded in Pusa Sawani (3.61 kg) followed by Hybrid Selection 1 (3.57 kg) and Lam Selection (3.35 kg). Pusa Sawani, Lam Selection, Hybrid Selection 1 and Pusa Makhmali were observed as stable genotypes. Belts Five and IC 1542 were

above average stable genotypes suitable for high yielding environments.

12. The stability parameters estimated as per Finlay and Wilkinson (1963), Eberhart and Russell (1966), Perkins and Jinks (1968), Ram *et al.* (1970) and Chaudhury *et al.* (1972) were being utilized to arrive at useful information on phenotypically stable genotype(s).

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PHENOTYPIC STABILITY ANALYSIS IN BHINDI
(*Abelmoschus esculentus* (L.) Moench.)

By
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ABSTRACT OF A THESIS
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VELLANIKKARA - TRICHUR
1981

ABSTRACT

Twenty five genotypes of bhindi were grown continuously in two seasons under two contrasting environments in a randomised block design. Observations were recorded on yield and its seven components. Significant variation among the genotypes with respect to these characters were observed.

The data were analysed as proposed by Finlay and Wilkinson (1963), Eberhart and Russell (1966), Perkins and Jinks (1968), Ram et al. (1970) and Chaudhury et al. (1972) to classify genotypes for their adaptability to low, medium and high yielding environments. Detailed analysis showed that four genotypes Pusa Sawani, Hybrid Selection 1, Lam Selection and Pusa Makhmali satisfied all the parameters showing adaptability to medium yielding environments. Belts Five and IC 1542 could be recommended for high yielding environments. The genotype IC 15593 could be suited for low yielding environments.

The genotypes based on their adaptation features, can be recommended for cultivation in specific or a broad spectrum of environments.