GENOTYPE-ENVIRONMENT INTERACTION IN SELECTED HYBRID LINES OF SWEET POTATO

(Ipomoea batatas (L.) Lam.)

BY

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THESIS

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1980

DECLARATION

I hereby declare that this thesis entitled "Genotype-environment interaction in selected hybrid lines of sweet potato (Ipomoea batatas (L.) Lam.)" is a bona fide 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.

Vellayani,
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CERTIFICATE

Certified that this thesis, entitled "Genotype-environment interaction in selected hybrid lines of sweet potato (*Ipomoea batatas* (L.) Lam.)" is a record of research work done independently by Shri. K.K. IBRAHIM, 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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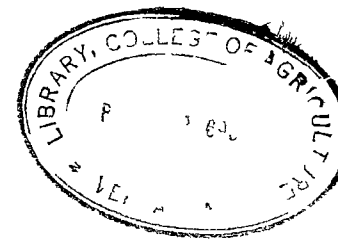
INTRODUCTION



INTRODUCTION

One of the most important advances in biometrical techniques during the last few years has been in the investigation, elucidation and understanding of the genotype x environment interactions (Breese, 1972). Genotype x environment interaction implies the joint regulation of the phenotype by the genotype and the environment. Plant breeders have been quite aware of the difficulties in crop improvement, that arise from the influence of non-genetic elements on the crop. Comstock and Moll (1963) stated that larger the interactions, lesser were the chances of progress under selection in a breeding programme. Complications arising from differential response of genotypes to environments have also been considered in detail by many workers including Allard and Bradshaw (1964), Breese (1969), and Hill (1975).

Sweet potato is a valuable tuber crop and forms an important source of food, especially among the people of lower economic class in Kerala. The production of the crop is greatly limited by the inherent low productivity of the existing varieties in the state. Hence it will be desirable to evolve varieties combining favourable attributes of yield and adaptability; and attempts in this line are in progress in the state.

The study of genotype x environment interaction is essential in breeding varieties for general adaptation. This is particularly important in a crop like sweet potato which is grown in diverse agro-climatic conditions of the state; Genotype x environment interaction had been reported for yield in sweet potato by Jong and Park (1975) and Kamalam et al. (1978).

Two alternative approaches of the plant breeders have been to develop varieties specifically adapted to different environments or adapted to a broad spectrum of environments. A high level of genotype x environment interaction is favoured in breeding for specific environments. Galle (1968) has evolved superior varieties of sweet potato specifically adapted to sandy loam soils. However, it leaves the possibility of changing environments in the same location over seasons or years unaccounted for. So the more effective alternative is to select varieties based on stability.

Different approaches to measure the stability of genotypes had been devised by several workers including Lewis (1954), Plaisted and Peterson (1959), Wricke (1962), Finlay and Wilkinson (1963) and Eberhart and Russell (1966). Three stability parameters viz., mean, regression coefficient and deviation from regression were used by Eberhart and Russell (1966) to assess the stability of

genotype and this method was utilized in this study.

The present investigation was undertaken to describe the phenotypic worth of 28 lines of sweet potato at three test sites, assess the genotype x environment interaction and find out the stability parameters. This study is presented both as a contribution to the knowledge of the genotype x environment interaction in this crop and to serve as a prelude to further trials of newly evolved genotypes.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

The genotype x environment interaction has been widely observed to play an important role in the expression of phenotype. The interdependence of inherent endowment and environmental influence had long been recognised in crop plants. In simple words, genotype x environment interaction can be considered as the variation that arises from the lack of correspondence between the genetic and non-genetic factors on the development of an individual. The breeders, engaged in the improvement of yield and other characters in crop plants, must, therefore, realise the importance of such interactions and plan their breeding programmes accordingly.

A review of the works that had been done so far in various crops by geneticists and biometricians, reflects the considerable importance that has now been attached to it in plant breeding programmes. It also gives an insight into the probable mechanism by which the plant species combat the fluctuations in the environment.

I. Environment.

When genotype x environment interaction is considered it will only be appropriate to have a clear understanding about the environment and its kinds. Environment is constituted by physical, chemical and biological factors to the influence of which a biological organism is subjected.

Comstock and Moll (1963) have classified the environments into two types

(i) Micro-environment: Micro-environment is the environment of a single organism as opposed to that of another growing at the same time and in almost the same place. It includes variables having small unrecognized individual effects like physical and chemical attributes of soil, climatic variables like temperature and humidity, distribution and quality of solar radiation, insect pests and diseases to which the plants are exposed.

(ii) Macro-environment: Macro-environment is composed of variables with large individual effects like locations, seasons or years, fertilizer levels, planting dates etc.

Allard and Bradshaw (1964) gave another classification of the environment.

(i) Predictable environment: It includes the permanent features of the environment such as climate, soil type and day length. It also includes the controllable variables like the level of fertilizer application, sowing dates, sowing density and the methods of harvesting.

(ii) Unpredictable environment: It comprises the weather fluctuations such as differences between seasons in the amount and distribution of rainfall and the prevailing temperatures.

A low level of genotype x environment interaction

will be desirable for the unpredictable environment so as to ensure maximum uniformity of performance. However, a high level of interaction is preferred in predictable environment to produce maximum increase in performance.

II. Genotype x environment interactions.

Genotype x environment interaction had long been known to occur in crop plants. Perhaps, one of the earliest workers to recognise the importance of environment in determining the phenotypic expression was Johannsen. He stated that genes alone were not responsible for the personal endowments of an individual; the environment also had a part to play in determining the 'life situation' (Johannsen, 1909). His pioneering work paved the way to a greater understanding of those processes by which the genotype and environment jointly regulate the development of particular individual; which was to have repurcussions far beyond the confines of plant breeding.

Keeble and Pellow (1910) found 'well-known seasonal fluctuations' affected height in peas, Akerman (1922) reported a genetic difference affecting the chlorophyll of oats which was undetectable when the plants were grown in subdued light, but revealed itself by the bleaching and death of one genetic class when they were grown in direct sunlight.

Hayes (1922) observed a very low correlation between

the protein content of self-fertilized ears of normal varieties of maize and the percentage of protein of their progeny grown in the following year; and he attributed it to the fluctuations in environment. Similar parent-offspring correlations were also obtained by Immer and Augenus (1931), and O'Kelley and Hull (1932, 1933).

The early reports on the environmental effects mentioned above can be regarded as mere casual observations, since no effort had been done to assess the interaction quantitatively. In later years, works had been done to measure the interaction effects and work out the stability parameters in various crops.

Though genotype x environment interaction have received considerable attention in recent years in many important crops very little work of this nature had been done in sweet potato to date. A crop-wise picture of some of the important research work in this line is presented below.

Rice

Okuno et al. (1971) reported significant interaction between varietal characters and environment. Ghosh (1972), based on his experiments at Central Rice Research Station, Cuttack, was able to observe significant interaction with environment for yield and identify varieties with general and specific adaptations to different fertility conditions.

Shankare Gowda et al. (1973) noticed considerable

variation in the phenotypic performance of yield over environments. Significant genotype x environment interaction in grain size was reported by Pathak and Upadhyay (1975).

Maurya and Singh (1977) observed significant interaction for yield and yield components and found that the significance in interaction was due to linear component.

Wheat

Kaltsikes and Larter (1970), in an experiment that involved 4 to 5 years and five locations in Western Canada, showed that a significant proportion of the interaction component of variance was linearly related to the additive environmental component for yield, plant height and days to maturity in some varieties.

Bains and Gupta (1972) reported significant genotype x environment interaction for yield and yield components. Bhullar et al. (1975) found the genotype x environment interaction for yield to be significant.

Borghi et al. (1975) noticed that environment had a marked influence on the expression of yield and 1000 seed weight in wheat.

Gautam and Jain (1977) found the non-linear deviation component to play a predominant role in the genotype x environment interaction. Gupta et al. (1977) and Tohlan et al. (1977) reported significant interaction of genotypes with environments for yield.

Chaudhary et al. (1978) reported that both linear and non-linear components contributed to genotype x environment interaction for the harvest index in wheat.

Genotype x environment interactions were found to be significant for straw length and ear length (Tail'ke et al., 1979a,b).

Maize

Yield was found to be influenced considerably by environmental differences in hybrids and composites of maize (Utikhede and Rai, 1974). Similar interaction for yield was also observed by Dhillon and Singh (1977), Gardner and Marcek (1977) and Meja Contreras and Munoz Orozco (1977).

Mokhtar-El-Nagar and El-Kadi (1978) reported significant genotype x environment interaction for yield and maturity. Interactions for yield and protein content were found to be significant by Poehmer et al. (1978).

Utz and Alber (1978) found the genotype x environment interaction to be highly significant for lodging resistance and moderately significant for early vigour, tiller number and yield.

Sorghum

Ganga Prasada Rao (1969) reported that genotype x environment interaction was significant for grain yield in sorghum. In a trial that comprised parental lines, hybrids, two-component blends of parental lines and two-component hybrid blends grown in nine environments over

two years in Iowa, Reich and Atkins (1970) observed significant interaction and found hybrid blends to be most stable population.

Jowett (1972) reported significant interaction for yield and suggested that three-way crosses followed by single-cross hybrids were most stable.

An evaluation trial of varieties and hybrids for yield stability over East African environments showed that genotypes usually differed significantly in their regression on environments (Majisu and Doggett, 1972).

Schaffert et al. (1972) showed that the genotype x environment interaction was significant for yield and seed weight. Significant interaction for yield was shown also by Kofoid et al. (1978) and Mao and Mao (1978).

Grasses

Lolium, Dactylis, Phleum and Festuca were shown to interact significantly with environment for forage yield (Aldrich, 1978).

Tan et al. (1978) noticed that differences in light and temperature had significant interaction with genotypes for seed weight, leaf number, leaf area, dry weight of seedlings and tillers in brome grass.

Genotype x environment interaction was found to be significant in brome grass for leaf yield by Tan et al. (1978) and Tan et al. (1979a). Morphological characters were shown to have significant genotype x environment interaction by

Tan et al. (1979b).

Pulses

In an experiment conducted at Oil Seed Research Station, Junagadh, Joshi (1972) observed significant genotype x environment interaction for yield in greengram and identified varieties with general and specific adaptations.

Ali-Khan and Youngs (1973) observed significant variation in the protein content of peas over environments. Yassin (1973) reported significant interaction for yield in broad beans and found that it was contributed by the non-linear component of interaction.

Significant interaction was observed for protein and methionine content in cowpea by Bliss (1975). Pandey and Gritton (1975) found the genotype x environment interaction to be significant for days to bloom, plant height, pods per plant, seeds per pod, seeds per plant, seed weight, yield and seed protein in peas.

Singh et al. (1976) reported considerable interaction of environment with genotypes for yield in black gram. Jermyn (1977) found that the protein content of peas varied significantly over environments.

Protein content in field beans was found to be influenced by environmental fluctuations (Abo-Hegazi et al., 1978). Khan and Drakine (1978) reported significant interaction for yield in winged bean.

Muller and Gottschalk (1970) found in peas that genotypes interacted with environment for the phenotypic expressions of characters, pod number per plant, seed number per plant, protein content and yield.

Soybean

Hanson (1970), in his biometrical studies on soybean, noticed the yield to be affected significantly by environmental fluctuations. The genotype x environment interaction was found to be due to highly significant linear component (Rohewal, 1970).

Buitrago et al. (1971), in a study comprising of 16 homozygous lines during six growing seasons, showed significant genotype x environment interaction and pinpointed varieties with general and specific adaptations.

Gopani et al. (1972) observed that genotic differences with respect to their regression on environmental indices were significant for seed and fodder yield, number of pods per plant, number of branches per plant and plant height.

Verma et al. (1972) noticed that grain yield and grain characters showed interaction effects.

A study conducted in Philippines revealed that varieties differed in physiological responses to seasonal conditions, yet yield stability was clearly recognizable as a genotypic character (Oka, 1973).

Groundnut

Ojono and Adelana (1970) reported genotype x environment interaction for yield in groundnut. Interaction was found to be significant for yield in bunch varieties in a trial conducted over a wide range of localities (Joshi et al., 1972).

Mohinder Singh et al. (1975) found the genotype x environment interaction for yield to be significant and linear component contributed towards the interaction whereas non-linear component was negligible.

Cotton

Meredith and Bridge (1972) found significant genotype x environment interaction for yield in upland cotton. However no such interaction was observed by Singh et al. (1975b).

Significant variation in characters of upland cotton over different environments was reported by Gridley (1975). Innes et al. (1975) showed that lint quality of cotton was markedly influenced by environmental variation.

Jute

A study on varieties of Corchorus capsularis and C. olitorius under drought and waterlogged conditions indicated the absence of genotype x environment interaction for maturity (Basak, 1963).

Tomato

Kerr (1969), based on his experiments conducted in Toronto over many years, showed that environmental factors

had influenced production and fruit size.

Significant interactions were shown for plant height and fruit yield by Peter and Rai (1976) and they attributed it to linear component. Butler (1978) found the interaction to be significant for the number of fruits.

Tobacco

Genotype x year interaction was found to be significant for economic characters in tobacco by Simms and Ayabe (1968). Similar results were also obtained by Chary et al. (1975). Espino (1977) observed changes in chemical composition over different environments.

Manifestation of interaction effects for yield was evident in doubled haploid lines of flue-cured tobacco (Oka et al., 1977). Poomi et al. (1978) showed the interaction to be of considerable magnitude for morphological characters.

Potato

A study involving diploid and tetraploid lines revealed significant genotype x environment interaction for tuber yield and other morphological characters (Sekhon and Rowe, 1969). Similar results were obtained by Darnier and Sinha (1970) and their study helped to locate the varieties suitable for specific locations.

Sekioka and Lauer (1970) reported genotype x environment interaction for plant height and tuber yield in potato variotal trials conducted in U.S.A.

Tai (1971) showed in his studies that highest yielders were often unstable while the seedlings with average stability had only medium yields.

Sawant and Mandloi (1974) found significant interaction for tuber yield. Interaction for tuber yield, tuber size and starch content were found to be significant by Gwiazynski et al. (1975).

Macarthur and Killick (1976) observed the interaction to be significant for tuber yield and specific gravity. Experiment by Tegge et al. (1976) showed the genotype x environment interaction to be more significant than genotypic effect for the viscosity properties of starch grain.

Tuber set and yield were found to be markedly influenced by environment (Hommonm and Ruhde, 1977). Lener and Desborough (1977) showed significant variation in protein content over environments.

Total solids and reducing sugars as well as tuber yield were found to be greatly influenced by environment (O'Keefe, 1977).

Carrot

A study conducted at National Vegetable Research Station, Wellesbourne revealed that genotype x environment interaction existed in carrot for root yield (Freeman and Dowker, 1973).

Poul (1974) found that β-carotene in carrot varied significantly over environments. The flavour and composition of volatile compounds were also found to be affected markedly

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by environment (Lund, 1975).

Doijer et al. (1976) reported significant genotype x environment interaction for yield, percentage of split roots and root length:diameter ratio.

Sugar beet

Root characters in sugar beet were found to be affected by the variation in the environments (Bornscheuer, 1973). Milley (1975) showed that the root yield differed markedly in expression over environments. Such interaction effects were also reported by Shimamoto and Hosokawa (1977).

Hsufe and Goldel (1978) reported significant genotype x environment interaction in sugarbeet for root yield.

Sweet potato

Kushman and Pope (1970) observed changes in pH and total acidity of the roots in response to changes in soil moisture content and soil temperature for the cultivars exposed to wet cold soil conditions before harvest.

Haynes and Wanley (1971) noticed variation in number and yield of tuber due to seasonal fluctuations. However, no attempt had been made to assess the extent of interaction in these experiments.

Harriott (1974) reported genotype x environment interaction in sweet potato for the chemical components of tuber. He found that carbohydrate content within a cultivar varied among the locations of cultivation greater than among the cultivars at any location. But carotene content showed

variation among cultivars more than among sites.

Jong and Park (1975) showed that the genotype x environment interaction had marked influence on the performance of sweet potato cultivars. Highly significant interactions were obtained for yield with respect to variety x site and variety x site x year interactions, whereas variety x year did not affect the yield appreciably.

Protein content in the roots was found to vary significantly over environments by Li (1975).

Kemalam et al. (1978) observed significant interaction in sweet potato for yield. The linear component of the interaction was found to be highly significant. However variance due to pooled deviations were negligible showing major component for the difference in stability was due to regression and not due to deviation from it.

III. Stability in crop plants.

Plants are equipped in a variety of ways to cope up with their environment. This is made possible by the general and specific adaptations developed in species or population during the course of evolution (Wallace and Srb, 1963). Considerable interest exists in the mechanism by which an individual stabilize its behaviour in the face of varying environmental influences (Grodzinsh, 1965).

Mather (1943) proposed that an adapted genotype or population is one which survives the selection pressure by exhibiting a better performance than that of the standard.

Wild populations of plants display a series of compromises between special and general adaptations, depending upon the prevailing ecological circumstances and post-evolutionary history (Mather, 1943).

Lerner (1954) termed 'genetic homeostasis' for the mechanism by which genotypes are flexible and can adjust their genotypic and phenotypic states in response to the different environmental conditions.

Grafius (1956), working on oats, explained the phenomenon of component compensation as a mechanism imparting homeostasis for the complex characters like yield. Similar biological explanations were reported by Saini and Gupta (1972) in wheat and Peter and Rai (1976) in tomato.

Adams and Shank (1959) reported that the coefficients of variability in different environments were larger for the inbreds than hybrids.

Jain and Allard (1960) found that the maintenance of genetic variability in self-pollinated crops depended not only on the low incidence of natural crossing among genetically diverse lines but also on the substantial heterozygote advantage.

Allard (1961), working on lima beans, reported that advanced generation hybrid population were highly buffered. Similar results were obtained by Finlay (1965) in barley.

Simmonds (1962) reviewed the evidences that mixed population in self-pollinated crops were more stable in yield

than their components.

Griffing and Longridge (1963) reported that the heterozygotes in self-pollinated crops did not differ in the heterotic response under favourable environments; but under unfavourable environments, the hybrids had a greater advantage over the homozygotes. Allard and Workman (1963) obtained similar results working on lima beans.

Allard and Bradshaw (1964) suggested two ways by which a variety can achieve stability and termed them individual buffering and population buffering.

Rao et al. (1969) disproved the belief that hybrids were meant for better farming conditions, in their studies on the stability of hybrids and varieties of sorghum under stress and non-stress conditions.

Heterozygosity was found to play a significant part in determining response to different environments in both diploids and tetraploid potatoes (Sokhon and Rowe, 1969). Reich and Atkins (1970) reported that two-component hybrid blends of sorghum were the most stable in a trial that involved parental lines, hybrids and two-component blends of parental lines besides hybrid blends.

Jowett (1972) found the hybrids in sorghum to be more stable than parents and obtained evidences which suggested that three-way crosses might be more stable than single cross hybrids. However, Majisu and Doggett (1972) obtained no convincing evidence of stability differences between varieties

and hybrids as broad genotype grouping.

Studies had also been carried out to relate stability directly to the metabolic and other functions occurring at cellular level.

Das and Jain (1972) reported significant correlation in stability of yield with chiasma frequency and mitotic index in wheat, thereby indicating the possibility of ascertaining stability by cytological parameters.

Tara Mohan and Jain (1975) working on wheat, found that a stable variety was equipped with the ability to maintain a relative constancy in the amount of DNA and relative plasticity in the synthesis of RNA.

IV. Development in Biometrical approaches.

One of the most important advances in biometrical techniques during the last few years had been in the investigation, elucidation and understanding of the genotype x environment interactions (Breese, 1972).

Even though, the importance of genotype x environment interactions were recognised well and these were known to be heritable (Jinks and Mather, 1955), and statistical techniques were available, yet these were regarded as intractable and main effort was to reduce them or scale them out. Though conventional statistical procedures of splitting the interaction into components yielded useful information in planning and apportioning of available resources, for

testing programmes and handling the breeding material, these analyses did not pinpoint genotypes which were stable in productivity, owing to the change in ranks at different environments.

Lewis (1954) suggested a simple measure of phenotypic stability which he termed 'stability factor' (S.F) and was expressed as

$$S.F. = \frac{\bar{X}_{H.E.}}{\bar{X}_{L.E.}}$$

where $\bar{X}$ was the mean value, H.E. and L.E. were high and low yielding environments respectively. Maximum phenotypic stability was when S.F. equals unity. Draw-back of this formula was that only two environments were taken into consideration in determining the stability.

Plaisted and Peterson (1959) described a procedure to characterize the stability of the performance of several varieties wherein a combined analysis of variance at all environments was computed for each pair of genotypes, ($g(g-1)/2$ pairs for 'g' varieties) and an estimate of variance due to the interaction ($\sigma^2 gl$) was obtained for each pair and for each variety. By this technique the variety having the smallest mean value will be most stable. However, this technique becomes laborious as the number of varieties to be incr

analysed increases.

Wricke (1962) developed a method to estimate 'ecological valence' or 'ecovalence'. Ecovalence is the contribution of each genotype to the genotype x environment interaction sum of squares. The variety with least ecovalence value would be more stable and vice-versa.

This technique had been used only to a very limited extent (Fejer, 1967 and 1973; Qualset, 1968). Fejer (1973) reported a significant negative correlation between yields and ecovalence values in raspberry. Qualset (1968) reported the absence of any correlation between ecovalence values and stability parameters of Eberhart and Russell (1966). Fejer (1967) concluded that this method was superior when the number of environments was limited.

A dynamic approach to the interpretation of varietal adaptation to varying environments was developed by Finlay and Wilkinson (1963). It led to the discovery of a linear relationship between genotype x environment interaction components and environmental effects, when these effects were measured on the same scale as the genotypic effects.

Eberhart and Russell (1966) modified the regression technique of Finlay and Wilkinson (1963), by adding another stability parameter, namely deviation from regression.

Tai (1971) presented a method of genotypic stability, based on the principle of structural relationship analysis,

where a genotype x environment interaction of a particular variety as partitioned into two components viz., the linear response to environmental effects and a deviation from the linear response.

The approach of Finlay and Wilkinson (1963), Eberhart and Russell (1966) and Tai (1971) was purely statistical and the components of those analyses had not been related to parameters in a biometrical genetic model. The second approach is based on the fitting of models which specify the contribution of genetic, environmental and genotype x environment interactions to the generation means and variances which allow for the contribution of additive, dominance and epistatic gene effects to the genetic and interaction components.

Bucio-Alanis (1966) developed a mathematical model to measure the genotype x environment interaction when only two homozygous parents were grown under a large number environments.

Bucio-Alanis and Hill (1966) extended the above model to include F_1 between two homozygous parents.

Perkins and Jinks (1968a) extended the technique of Bucio-Alanis (1966) and Bucio-Alanis and Hill (1966) to cover many inbred lines and crosses among them. In this technique, prediction of genotype x environment interaction of inbreds was not possible when remainder variance alone was significant. So a method had been devised wherein it can further be partitioned by the grouping of varieties into homogenous groups

on the basis of significance and direction of deviations from linear regression (Perkins and Jinks, 1968b).

Perkins and Jinks (1968a) further extended this methodology to a large number of miscellaneous F_1s which may not have any systematic relationship with one another.

Bucio-Alanis (1966) and Perkins and Jinks (1971) extended the model of Bucio-Alanis and Hill (1966) to include F_2 and the back crosses (B_1 and B_2). While Perkins (1970) extended this methodology to F_1 hybrids in a diallel set.

Freeman and Perkins (1971) proposed independent estimates of environmental indices by adopting special techniques.

Later on, where large number of cultivars were involved, multivariate analyses and cluster analyses had been used to further illuminate the nature of genotype x environment interaction; by describing associations among genotypes and by characterising environments (Mungomery et al., 1974; Byth et al., 1976; Byth, 1977; Shorter et al., 1977).

MATERIALS AND METHODS

MATERIALS AND METHODS

The present investigation was aimed at evaluating selected lines of sweet potato at three test sites to work out genotype x environment interaction and stability parameters for yield and other traits.

The materials for this study comprised 25 hybrid lines of sweet potato evolved through hybridization in the Department of Agricultural Botany and three local cultivars, details of which are furnished in Table 1.

The experiment was conducted in the paddy fields at the Instructional Farm, College of Agriculture, Vellayani, Model Agronomic Research Station, Karamana and Rice Research Station, Kayamkulam during the third crop season, 1979. The data regarding the crop period and meteorological variables for the respective periods are provided in Appendices I, II and III.

The soil types in the different test sites were clayey loam in Vellayani and Karamana and sandy loam in Kayamkulam.

I. Varietal evaluation.

The experiment was laid out uniformly in three locations in Randomised Block Design with three replications using 28 lines. The plot size was 10 sq.m. with 10 plants per plot planted on mounds one meter apart. Cultural operations had been carried out in conformity with the recommendations

Table 1. Names and parentage of 28 lines of sweet potato

Sl. No.	Name of genotype	Parentage
1	H.2412	J.29 x Chaldkaravalli
2	H.2416	"
3	H.2421	"
4	H.2648	Chaldkaravalli x Bodhrekalichumala
5	H.2712	Chaldkaravalli x J.29
6	H.2742	"
7	H.2743	"
8	H.2747	"
9	H.2750	"
10	H.2752	"
11	H.3032	Palchakram x J.29
12	H.3050	"
13	H.3115	Palcholkram x Chaldkaravalli
14	H.3402	Jaspur x H.42
15	H.3426	"
16	H.3802	Jallundar-5 x H.42
17	H.3805	"
18	H.4021	Chaldkaravalli x I.D.40
19	H.4024	"
20	H.4025	"
21	H.4026	"
22	H.4125	Chaldkaravalli x H.42
23	H.4126	"
24	H.4328	Palchakram x H.42
25	H.4329	"
26	Vichivella	Local Variety
27	Kottaram chumala	"
28	Bodhrakali-chumala	"

of Package of Practices of Kerala Agricultural University (Anon, 1978).

(i) Biometrical observations

Biometrical observations were recorded for the following traits at the time of harvest, from all the plants in each plot and the mean values worked out on per-plant basis.

(a) Top weight

The total weight of the shoot, cut at the base was recorded in grams for each plant and average worked out.

(b) Length of vine

The length of vine of the individual plants was measured from the base to the tip of the longest vine in centimeters.

(c) Number of branches

The number of branches within 50 cm from the base of the plant was counted and the average number of branches per plant worked out.

(d) Number of tubers

Total number of marketable tubers from each plant was counted and average worked out.

(e) Length of tubers

The length of largest tuber of each plant was measured in centimeters.

(f) Girth of tubers

The girth of the largest tuber used for length

measurement was recorded in centimetors as the average of the girth measurements at three different portions viz., one in the middle and the others, a quarter distance away from both ends of the tuber.

(g) Harvest index

Harvest index was calculated as the ratio of the tuber yield to total biomass.

(h) Dry weight of tubers

Sample tubers were taken from each plot, thoroughly washed with distilled water, weighed, chipped into pieces and sun-dried for two days. These were then oven-dried for 60°C until its weight became constant and the final weight was taken. From this, the percentage of dry matter of the tuber was calculated and recorded.

(i) Tuber yield

The total weight of the marketable tubers per plant in grams, was recorded and the average worked out.

(ii) Chemical analysis

The chemical analysis was conducted on the materials used for dry matter estimation, after making it into fine powder.

(a) Starch content

The percentage of starch in the samples of tuber was estimated using potassium ferricyanide method (Hard and Pigman, 1970). The values were expressed as percentage of dry weight of tubers.

(b) Sugar content

The sugar content of tuber was estimated according to A.O.A.C. (Anon, 1960) and expressed as percentage of dry weight of tuber.

(c) Carotene content

Ten grammes of dry sample was extracted with petroleum ether and acetone (50:50). The extract was then washed with water to remove acetone and then dried over anhydrous sodium sulphate. It was filtered and treated with aluminium oxide; again filtered and made upto 50 ml. The absorbance was measured at 943 nm. Carotene content was calculated from the standard graph (Suryanarayana Rao et al., 1963).

(iii) Baking index

The tubers harvested separately from each genotype were washed and stored at room temperature (about 28°C) for approximately three weeks before baking. Baking was done as per the method of Constantin et al. (1966) and screened for flavour, texture, sweetness, fibre content, moistness and general acceptability. The baking index was calculated as the mean of the rating for these characters. Scoring was done based on a scale of 0 to 10, 10 representing maximum favourable expression of all characters mentioned above and represented in a baking index table. The average baking indices of genotypes were classified into three groups as <4 = poor, 4 and <6 = medium and >6 = good.

In the present study, no scoring was given for the

colour because it had been shown by previous investigations that many of the white fleshed varieties had excellent cooking and edible qualities.

(iv) Statistical analysis

The data obtained from the field experiments and chemical analysis were subjected to statistical analysis as per Panse and Sukhatme (1957). By the usual method of analysis of variance, the genotypes were evaluated for each variable in each locality.

The total of the individual varieties over all the replications for each environment was calculated. The data thus obtained was analysed partitioning the total variability into variances due to environment, varieties and varieties x environment interaction.

The mean square due to varieties and environments were tested against mean square due to variety x environment, wherever variety x environment interaction was significant. However, the mean square due to pooled error was required to test mean square due to variety x environment interaction. The pooled error was obtained by the following formula.

$$\text{Pooled error} = \frac{(n_1-1)\ (\text{M.S.error } L_1) + \ldots\ldots (n_s-1)\ (\text{M.S.error } L_s)}{(n_1-1) + \ldots\ldots\ldots + (n_s-1)}$$

Where

(n_1-1) = degree of freedom for error in location 1

(n_s-1) = degree of freedom for error in location 's'

M.S. error L_s = Mean square due to error for the s^{th} location.

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In the case the variance due to variety x environment was found significant, the analysis was further proceeded to estimate the stability parameters.

II. Stability parameters

The statistical technique proposed by Finlay and Wilkinson (1963) and modified by Eberhart and Russell (1966) was utilized to estimate stability parameters and genotype x environment interactions with regard to various traits studied.

Eberhart and Russell (1966) suggested three parameters to measure the stability of varieties viz., mean, regression of individual mean performance on environmental indices and deviation from regression.

Suppose there were 't' varieties whose performance were tested in 's' environments, Y_{ij} was the observation of the i^{th} variety in j^{th} environment and was obtained by the summation over the replications. Now, the parameters can be defined in a mathematical model as follows.

$$Y_{ij} = m + B_i I_j + \delta_{ij}$$

Where Y_{ij} = observation of i^{th} variety in j^{th} environment.

m = mean of all the varieties over all the environments

B_i = The regression coefficient of i^{th} variety on the environmental indices which measure the response of the variety to different environments.

I_j = The environmental index which is defined as the deviation of the mean of all the varieties at a given location from the overall mean.

δ_{ij} = The deviation from the regression of the i^{th} variety at j^{th} environment.

The various computational steps involved in the estimation of stability parameters were as follows:

(i) Computation of environmental index (I_j)

$$I_j = \frac{\sum_i Y_{ij}}{t} - \frac{\sum_i \sum_j Y_{ij}}{ts}$$

(ii) Computation of regression coefficient (b_i) for each variety.

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

Where $\sum_j Y_{ij} I_j$ is the sum of products and

$\sum_j I_j^2$ is the sum of squares

$\sum_j I_j^2$ was common for each value of regression coefficient, on the other hand, $\sum_j Y_{ij} I_j$ for each variety was the sum of products of environmental indices (I_j) with the corresponding observation (Y) of that variety at each location. These values were obtained in the following manner.

$$\begin{bmatrix} X \end{bmatrix} \begin{bmatrix} I_j \end{bmatrix} = \begin{bmatrix} \sum_j Y_{ij} I_j \end{bmatrix} = \begin{bmatrix} S \end{bmatrix}$$

Where $[X]$ = matrix of treatment totals

$[I_j]$ = vector for environmental indices, and

$[S]$ = vector for sum of products, i.e. $\sum_j Y_{ij} I_j$

(iii) Computation of deviation from regression ($s^2 d_i$)

In a regression analysis it is possible to partition the sum of squares of the dependent variable (Y) into two parts, the one which explains the linearity between dependent and independent variables (sum of squares due to regression), and the other which explains the sum of squares due to deviations from the linearity.

Symbolically,

$S.S_y$ = S.S. regression + S.S.deviation from the regression

The sum of squares due to deviation from regression was computed by substracting sum of squares due to regression from the total sum of squares which in turn was utilized to estimate the deviation from regression. The sum of squares of means over different environments with regard to individual genotypes were obtained by the following mathematical formula:-

$$S.S_y = \frac{\sum Y_{ij}^2}{r} - \frac{Y_{i.}^2}{or}$$ where r is the number of replications. The sum of squares due to regression was calculated by the formula.

S.S. due to regression $= \frac{(\sum_j Y_{ij} I_j)^2}{r \sum_j I_j^2}$ which could be

simplified into a computational formula as follows:

S.S. due to regression $= \frac{b_i \sum_j Y_{ij} I_j}{r}$

The sum of squares due to deviation from regression ($\sum_j \delta^2_{ij}$) for a variety was calculated using the following formula:

$$\sum_j \delta^2_{ij} = \frac{\sum_j Y^2_{ij} - Y^2_i/s - b_i \sum_j Y_{ij} I_j}{r}$$

The stability parameter σ^2_{di} for each variety was computed from $\sum_j \delta^2_{ij}$ by the following formula

$$\sigma^2_{di} = (\sum_j \delta^2_{ij} / s-2) - (\sigma^2_e/r)$$

Where S^2_e is the mean square for pooled error.

III. Analysis of variance for genotype x environment interaction

The total sum of squares had been partitioned into three main parts i.e.(i) sum of squares due to varieties (ii) sum of squares due to environment + (variety x location) and (iii) pooled error. The other main feature of this analysis was that the sum of squares due to varieties x environment was further partitioned into two parts viz. sum of squares due to regression and deviation from regression. The latter was

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S.S. due to regression $= \frac{(\sum_j Y_{ij} I_j)^2}{r \sum_j I_j^2}$ which could be simplified into a computational formula as follows:

S.S. due to regression $= \frac{b_i \sum_j Y_{ij} I_j}{r}$

The sum of squares due to deviation from regression ($\sum_j \delta_{ij}^2$) for a variety was calculated using the following formula:

$$\sum_j \delta_{ij}^2 = \frac{\sum_j Y_{ij}^2 - Y_i^2/s - b_i \sum_j Y_{ij} I_j}{r}$$

The stability parameter S_{di}^2 for each variety was computed from $\sum_j \delta_{ij}^2$ by the following formula

$$S_{di}^2 = (\sum_j \delta_{ij}^2 / s-2) - (S_e^2/r)$$

Where S_e^2 is the mean square for pooled error.

III. Analysis of variance for genotype x environment interaction

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Table 2. Analysis of variance for Genotype x Environment interaction

Source	d.f.	S.S.	M.S.
Total	st-1	$\frac{1}{r}\left(\sum_i \sum_j Y_{ij}^2 - C.F.\right)$ = T.S.S.	
Variety	t-1	$\frac{1}{r}\left(\sum_i Y_{i.}^2/s - C.F.\right)$ = V.S.S.	MS_1
Environment	s-1	$\frac{1}{r}\left(\sum_j Y_{.j}^2/t - C.F.\right)$ = E.S.S.	
V x Env.	(t-1) (s-1)	T.S.S.-V.S.S.-E.S.S.	MS_2
Env.+(V x Env.)	t(s-1)	$\frac{1}{r}\left(\sum_i \sum_j Y_{ij}^2\right) - \left(\sum_i Y_{i.}^2/s\right)$	
Env.(linear)	1	$\left(\frac{1}{rt}\right)\left(\sum_j Y_{.j} I_j\right)^2 / \sum_j I_j^2$ = S.S.E.(linear)	
V x Env.(linear)	(t-1)	$\left[\sum_i \left(\sum_j Y_{ij} I_j\right)^2 / r \sum_j I_j^2\right]$ - S.S.E. (linear)	MS_3
Pooled deviation	t(s-2)	$\sum_i \left(\sum_j \delta_{ij}^2\right)$	MS_4
Variety 1	s-2	$\sum_j \left(\delta_{ij}^2\right)$	
Variety 't'	s-2	$\sum_j \left(\delta_{ij}^2\right)$	
Pooled error	s(t-1) (r-1)		MS_5

continued..

Table 2 continued

Where r = number of replications

s = number of environments

t = number of varieties

$C.F. = \frac{\text{Grand total}^2}{rst}$

Y_{ij} = The value of i^{th} variety in j^{th} environment and is obtained by the summation over replications

$Y_{i.}$ = the total value of i^{th} variety summed over j environments

$Y_{.j}$ = the total value of j^{th} environment summed over i varieties

I_j = the environmental index

$\frac{N}{j}\delta^2_{ij}$ = the variance due to deviations from regression

which can be represented mathematically as

$$P_i = \sum_j Y_{ij} / sr - \sum_i \sum_j Y_{ij} / ser$$

IV. Association between the means and regression coefficients.

The correlation coefficients between the phenotypic performance (mean) and phenotypic stability (regression coefficient) for various characters had been computed by using the formula:-

$$r_{x_1 x_2} = \frac{Cov\ (x_1, x_2)}{\sqrt{V(x_1) \cdot V(x_2)}}$$

Where x_1 = the mean,

x_2 = the regression coefficient

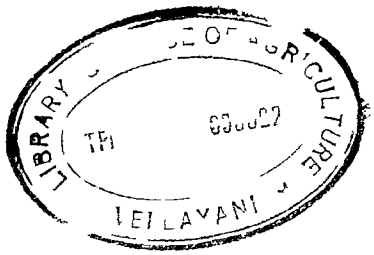
$r_{x_1 x_2}$ = the correlation coefficient between x_1 and x_2

$Cov\ (x_1, x_2)$ = covariance between x_1 and x_2

$V(x_1)$ = the variance of x_1

$V(x_2)$ = the variance of x_2

The observed value of correlation coefficients was tested against the table values for (n-2) degrees of freedom.



RESULTS

RESULTS

The present investigation was aimed at evaluating the performance of 28 lines of sweet potato for different characters at three test sites; to assess the genotype x environment interactions and work out the stability parameters for each genotype. The study also involved a test of baking index to ascertain the quality aspects of the genotypes. The results thus obtained are presented in the text.

I. Varietal Evaluation.

(1) Biometrical characters

The data collected on 12 characters from the three sites were analysed and the results presented in Table 3.

(a) Top weight

The data on the mean top weight per plant of the genotypes are presented in Table 4.

Highly significant differences were observed among the lines for top weight at all the three sites ($P<0.01$). The genotype H.4025 showed maximum expression for the character at Vellayani, its mean value being 4826.19 g per plant. At Kayamkulam the character showed its highest expression in H.2742 (3473 g/plant), and H.4328 was the top ranking genotype at Kayamkulam and was significantly superior to all other genotypes (2636.67 g/plant).

Table 3. Abstracts of analyses of variance of twelve characters in sweet potato at three locations

Characters	d.f for varieties	d.f for error	Mean squares					
			Vellayani		Karamana		Kayamkulam	
			Varieties	Error	Varieties	Error	Varieties	Error
Top weight	27	54	1745344.060**	290758.355	848961.280**	341759.324	369626.419**	115803.656
Length of vine	27	54	49232.529**	2448.324	9701.415**	1353.194	41030.174**	1134.832
Number of branches	27	54	165.099**	22.169	32.616**	13.100	78.893**	20.030
Number of tubers	27	54	22.054**	2.634	14.367**	1.344	10.605**	0.668
Length of tubers	27	54	40.798**	3.832	11.254**	5.175	11.959**	5.670
Girth of tubers	27	54	71.318**	5.243	53.791**	5.228	66.839**	9.564
Harvest index	27	54	0.043**	0.003	0.039**	0.004	0.061**	0.005
Dry weight of tubers	27	54	35.318**	4.351	49.315**	6.609	12.495**	4.432
Tuber yield	27	54	825444.102**	45073.622	456754.387**	33060.415	415483.842**	21776.410
Starch	27	54	20.958**	0.471	—	—	—	—
Sugar	27	54	7.795**	0.019	—	—	—	—
Carotene	27	54	6460.606**	0.042	—	—	—	—

**Significant at 1 per cent level of probability
— Chemical analysis was carried out at one location (Vellayani) only.

Table 4. Mean top weight per plant in twenty-eight genotypes of sweet potato at three locations

Genotypes	Top weight (g/plant)		
	Vellayani	Taramana	Kayamkulam
H.2412	2056.67	2066.67	933.33
H.2416	1913.00	1223.33	1008.33
H.2421	3066.67	2606.67	1946.67
H.2648	3620.00	2067.33	1013.33
H.2712	2066.67	5040.00	1500.00
H.2742	3372.22	3473.00	1169.17
H.2745	3244.45	2406.67	1170.00
H.2747	3011.67	2053.33	940.00
H.2750	3207.44	2460.00	1263.00
H.2754	1150.33	1576.67	1056.67
H.3032	4266.66	3006.67	1506.67
H.3050	3883.33	2353.33	1606.67
H.3115	2705.56	2600.00	1156.33
H.3402	3850.00	2856.67	2110.00
H.3426	3142.86	2220.00	1250.00
H.3802	3294.44	2420.00	1665.67
H.3803	2706.90	2313.33	1630.67
H.4021	3107.94	1930.00	1206.67
H.4024	2316.67	1566.67	1520.00
H.4025	4826.19	2633.33	1823.33
H.4026	3777.78	3253.33	1836.00

continued..

Table 4 continued

Genotypes	Top weight (g/plant)		
	Vellayani	Karamana	Kayamkulam
H.4125	3358.89	2000.00	1205.67
H.4126	3720.65	2553.33	1699.17
H.4328	3833.34	2700.00	2696.67
H.4329	3955.55	3210.67	1706.67
Pichivolla	3105.56	2293.33	1596.90
Kottarachumala	2763.33	1921.67	1329.33
Dadhrokallichumala	2094.44	1775.33	1596.67
C.D.	3221.00	2330.76	1496.06
S.E.	440.27	477.32	277.40
C.D.(0.05)	880.54	954.65	555.70

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H.2416 showed the least expression with respect to this character at Vellayani and Karamana, the values being 1013.89 and 1223.33 g per plant respectively. At Kayamkulam, H.2412 showed the lowest value for the character (933.33 g/plant).

(b) Length of vine

The mean length of vine per plant for the genotypes are furnished in the Table 5.

The results revealed that genotypes differed markedly on the length of vine ($P < 0.01$). The genotype H.4024 expressed highest mean values with respect to this character at all the sites, the values being 660.95, 351.33 and 382.20 cm at Vellayani, Karamana and Kayamkulam respectively. The lowest values were seen in H.2416 in all the three locations (146.11, 107.93 and 93.77 respectively).

(c) Number of branches

Table 6 shows the mean number of branches for each genotype.

The analysis of variance tables showed that the differences among the genotypes were highly significant with respect to number of branches at all the three sites ($P < 0.01$). H.3032 expressed the highest value for the character at Vellayani (45.17) and H.3e05, the lowest value (17.92). At Karamana H.2750 and H.4021 showed the

Table 5. Mean vine length in twenty-eight genotypes of sweet potato at three locations

Genotypes	Vine length (cm)		
	Vellayani	Karamana	Kayamkulam
H.2412	223.60	176.07	140.40
H.2416	146.11	107.93	95.77
H.2421	195.56	150.33	102.00
H.2648	365.09	233.33	275.70
H.2712	253.22	211.67	161.33
H.2742	206.59	128.67	104.40
H.2743	319.11	235.53	185.53
H.2747	233.52	142.80	146.47
H.2750	328.80	199.47	161.33
H.2752	183.33	179.60	110.73
H.3032	361.67	178.00	174.73
H.3050	475.62	263.20	323.33
H.3115	353.67	192.40	160.10
H.3402	251.25	158.00	156.67
H.3426	467.32	275.40	249.40
H.3602	353.33	192.00	203.27
H.3803	246.51	177.00	124.07
H.4021	426.39	216.70	225.27
H.4024	660.95	351.33	582.20
H.4025	562.30	294.80	370.00
H.4026	444.67	258.87	352.53

continued...

Table 5 continued

Genotypes	Vine length (cm)		
	Vellayani	Karamana	Kayamkulam
H.3125	347.22	166.93	200.20
H.4126	367.14	205.73	248.13
H.4328	191.67	152.97	143.47
H.4329	309.44	167.40	258.67
Pichivella	501.72	287.13	360.63
Kottaramchumala	528.33	258.43	408.73
Padhrakalichumala	378.47	250.47	260.63
G.M.	337.42	207.72	226.88
S.E.	40.40	30.03	27.50
C.D.(0.05)	80.80	60.07	55.01

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Table 6. Mean number of branches in twenty-eight genotypes of sweet potato at three locations

Genotypes	Number of branches		
	Vellayani	Karamana	Kayamkulam
H.2412	24.78	12.67	15.00
H.2416	26.78	13.47	16.00
H.2421	39.22	22.13	27.33
H.2648	29.54	16.53	17.60
H.2712	19.34	18.40	15.13
H.2742	31.22	16.07	19.00
H.2743	23.45	17.07	12.73
H.2747	22.19	14.07	13.87
H.2750	33.95	22.20	26.63
H.2752	23.34	15.93	18.33
H.3032	45.17	20.80	31.40
H.3050	38.22	18.07	23.20
H.3115	42.00	20.80	20.07
H.3402	24.89	19.83	21.00
H.3426	21.78	13.93	16.27
H.3802	26.45	16.73	16.93
H.3805	17.92	16.40	15.33
H.4021	23.28	11.47	14.07
H.4024	25.19	12.13	18.67
H.4025	30.67	20.80	22.33
H.4026	32.22	13.93	18.60

continued....

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Table 6 continued

Genotypes	Number of branches		
	Vellayani	Karamana	Kayamkulam
H.4125	25.22	13.07	15.80
H.4126	25.67	14.95	16.40
H.4328	43.78	21.60	31.73
H.4329	37.10	16.13	16.53
Pichivella	32.67	19.70	19.03
Kottarachumala	27.69	12.67	15.00
Sadhurakalichumala	23.61	17.53	24.53
G.M.	28.84	16.60	19.25
S.E.	3.88	2.96	3.65
C.D.(0.05)	7.76	5.92	7.30

maximum and minimum expression of the character respectively (22.2 and 11.47 respectively) H.4523 produced maximum number of branches at Kayamkulam (31.73), whereas minimum number of branches was seen in H.2743 (12.73).

(d) Number of tubers

The data on the mean number of tubers for various genotypes are given in the Table 7.

The genotypes were shown to produce considerable variation in the expression of this character at the three sites ($P < 0.01$). The manifestation of this character was the highest in H.5426 at Vellayani (13.14). H.2416 produced the highest number of tubers at Karamana (9.13). At Kayamkulam, maximum expression with respect to this character was seen in H.2421 (6.33). The check varieties Kottarakkunnala and Sadhrakalichunnala were consistently poor at all the sites with their values being less than one in all cases.

(e) Length of tubers

The mean length of tubers under various genotypes are presented in Table 8.

The differences among the genotypes with respect to this character was highly significant ($P < 0.01$). The maximum expression of this character was seen in H.3002 at Vellayani (24.18 cm) and check varieties Kottarakunnala and Sadhrakali chunnala showed very low values (9.25 and 9.78 cm respectively). H.4024 averaged the highest value for the length of tuber at Karamana (19.67 cm) and Kayamkulam (19.53 cm). Pichivella

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Table 7. Mean number of tubers in twenty-eight genotypes of sweet potato at three locations

Genotypes	Number of tubers		
	Vellayani	Karamana	Kayamkulam
H.2412	10.09	7.93	3.67
H.2416	10.81	9.13	6.20
H.2421	9.14	7.93	6.33
H.2648	5.28	5.27	0.30
H.2712	7.77	6.13	4.90
H.2742	7.44	7.80	2.63
H.2743	7.29	4.73	4.00
H.2747	7.76	5.33	3.80
H.2750	5.62	5.20	1.63
H.2752	7.19	5.33	4.80
H.3032	6.52	4.67	2.33
H.3050	6.00	4.13	1.60
H.3115	5.62	3.33	1.13
H.3402	8.86	4.67	2.53
H.3426	13.14	2.00	3.00
H.3802	7.67	3.67	1.03
H.3803	7.68	5.47	1.83
H.4021	5.93	4.20	3.23
H.4024	5.24	5.33	6.20
H.4025	3.19	1.87	0.40
H.4026	5.24	3.53	2.67

continued

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Table 7 continued

Genotypes	Number of tubers		
	Vellayani	Kovalam	Kayamkulam
H.4125	6.24	4.13	1.67
H.4126	8.64	4.27	3.67
H.4328	6.26	7.73	3.30
H.4329	3.43	1.60	0.17
Nichivella	5.11	2.60	0.97
Pottammchumala	0.65	0.77	0.07
Sadhrakaliehumala	0.99	0.97	0.27
C.M.	5.53	4.50	2.66
S.E.	1.32	0.94	0.76
C.D.(0.05)	2.65	1.89	1.52

Table 8. Mean tuber length in twenty-eight genotypes of sweet potato at three locations

Genotypes	Tuber length (cm)		
	Vellayani	Karamana	Kayamkulam
H.2412	18.15	14.97	12.60
H.2416	17.02	15.83	13.03
H.2421	16.43	15.63	11.67
H.2640	22.03	14.43	9.70
H.2712	19.10	15.60	14.03
H.2742	19.67	15.37	11.93
H.2743	21.60	17.30	21.40
H.2747	16.15	15.27	11.90
H.2750	12.16	15.03	11.30
H.2752	15.29	12.67	13.80
H.3032	21.57	18.93	14.90
H.3050	18.22	14.80	10.93
H.3115	16.07	16.50	11.30
H.3402	17.66	15.80	12.83
H.3426	12.13	14.00	11.70
H.3002	24.18	17.80	13.63
H.3803	17.46	12.53	11.43
H.4021	19.56	15.93	12.77
H.4024	21.52	19.67	19.53
H.4025	14.03	12.27	10.17
H.4026	12.03	12.97	11.73

continued..

Table 6 continued

Genotypes	Tuber length (cm)		
	Vellayani	Karamana	Kayamkulam
H.4125	17.79	17.06	13.53
H.4126	16.59	14.63	12.17
H.4328	18.72	17.00	13.37
H.4329	17.92	14.13	8.67
Vellayani	17.57	11.73	11.40
Kottarachumala	9.25	13.77	11.67
Sadhrakalichumala	9.78	13.73	14.33
G.M.	16.58	15.20	12.50
S.E.	1.60	1.86	1.94
C.D.(0.05)	3.20	3.72	3.89

(11.73 cm) and H.4329 (8.67 cm) ranked last with respect to this character at Karamana and Kayamkulam respectively.

(f) Girth of tubers

The mean girth of tubers for the genotypes are provided in Table 9.

The analysis of variance revealed that the effects of genotypes on this character were highly significant in all the locations ($P < 0.01$). H.4021 possessed the maximum expression for the character at Vellayani (23.59 cm). H.4126 (27.07 cm) and H.2712 (20.97 cm) showed highest values on mean girth of tubers at Karamana and Kayamkulam respectively. The least expression for this character was shown by Kottarakhumala, Sadhukelichumala and H.4329 which averaged values much lower than the general mean.

(g) Harvest index

The data on the mean harvest index under various genotypes are presented in Table 10.

The genotypes were shown to differ considerably with respect to the harvest index ($P < 0.01$). H.2752 possessed the highest values for the character at Vellayani (0.49) and Kayamkulam (0.457), whereas, at Karamana, the maximum expression of this character was seen in H.2416 (0.46). The check variety Kottarakhumala was the worst performer, in all the three locations.

(h) Dry weight of tubers

Table 11 gives the mean values for the dry weight of

Table 9. Mean tuber girth in twenty-eight genotypes of sweet potato at three locations

Genotypes	Tuber girth (cm)		
	Vellayani	Karamana	Kayamkulam
H.2412	17.43	14.20	15.23
H.2416	22.75	19.40	19.55
H.2421	20.75	17.93	22.53
H.2648	22.23	15.07	13.30
H.2712	22.08	21.12	26.97
H.2742	18.01	16.20	14.67
H.2743	21.40	17.77	21.60
H.2747	17.04	16.53	16.90
H.2750	13.73	11.53	15.97
H.2752	23.06	22.97	23.33
H.3032	15.21	16.37	14.60
H.3050	16.21	12.27	13.00
H.3115	19.09	16.17	13.63
H.3402	18.04	12.67	11.67
H.3426	7.70	11.37	15.23
H.3002	18.07	15.67	16.60
H.3803	13.46	13.37	13.37
H.4021	23.59	19.93	23.60
H.4024	15.54	20.27	18.03
H.4025	12.49	12.13	13.63
H.4026	18.04	11.63	14.43

continued..

Table 9 continued

Genotypes	Tuber girth (cm)		
	Vellayani	Karamana	Kayamkulam
H.4125	19.57	15.33	15.83
H.4126	22.50	27.07	28.33
H.4328	17.35	20.10	17.28
H.4329	10.56	9.97	10.83
Pichivella	15.18	10.77	10.77
Pottaramchumala	7.56	10.40	9.67
Sadharakalichumala	7.82	13.70	8.53
G.M.	16.58	15.89	16.54
S.E.	1.47	1.86	2.52
C.D.(0.05)	2.94	3.75	5.05

Table 10. Mean harvest index in twenty-eight genotypes of sweet potato at three locations

Genotypes	Harvest index		
	Vellayani	Karamana	Kayamkulam
H.2412	0.267	0.263	0.203
H.2416	0.440	0.460	0.397
H.2421	0.260	0.290	0.307
H.2648	0.257	0.143	0.001
H.2712	0.327	0.260	0.353
H.2742	0.223	0.170	0.123
H.2743	0.357	0.250	0.313
H.2747	0.210	0.243	0.250
H.2750	0.067	0.077	0.097
H.2752	0.490	0.390	0.457
H.3052	0.150	0.183	0.130
H.3050	0.163	0.147	0.060
H.3115	0.183	0.127	0.093
H.3402	0.153	0.147	0.040
H.3426	0.050	0.077	0.167
H.3902	0.293	0.217	0.060
H.3903	0.127	0.123	0.040
H.4021	0.327	0.310	0.225
H.4024	0.220	0.353	0.367
H.4025	0.050	0.033	0.013
H.4026	0.070	0.080	0.077

continued...

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Table 10 continued

Genotypes	Harvest index		
	Vellayani	Karamana	Koyamkulam
H.4125	0.200	0.223	0.077
H.4126	0.237	0.300	0.413
H.4328	0.167	0.297	0.133
H.4329	0.050	0.053	0.014
Pichivella	0.150	0.070	0.027
Kotteramchumala	0.010	0.030	0.001
Sadhrakalichumala	0.037	0.107	0.017
G.M.	0.201	0.194	0.159
S.E.	0.039	0.052	0.058
C.D.(0.05)	0.078	0.103	0.115

Table 11. Mean dry weight of tuber per plant in twenty-eight genotypes of sweet potato at three locations

Genotypes	Dry weight of tuber (/)		
	Vellayani	Karamana	Koyarkulam
H.2412	30.00	35.00	36.00
H.2416	33.00	31.56	34.10
H.2421	30.00	31.80	32.00
H.2648	28.00	26.00	31.00
H.2712	30.77	25.39	33.00
H.2742	32.94	28.00	33.00
H.2743	36.89	28.30	35.20
H.2747	34.29	28.27	35.10
H.2750	31.00	28.85	35.10
H.2752	38.00	40.40	38.30
H.3032	32.00	31.40	34.40
H.3050	28.50	30.00	33.00
H.3115	26.00	35.00	32.30
H.3402	31.50	30.00	36.40
H.3426	28.00	28.00	31.20
H.3802	35.00	33.50	33.00
H.3805	35.29	27.43	36.00
H.4021	27.10	25.00	31.00
H.4024	33.10	32.40	33.00
H.4025	29.21	30.10	32.00
H.4026	30.00	27.96	32.20

continued

Table 11 continued

Genotypes	Dry weight of tuber (%)		
	Vellayani	Karamana	Kayamkulam
H.4125	31.00	30.00	33.60
H.4126	32.00	32.00	34.00
H.4328	33.10	32.00	35.70
H.4329	34.20	32.97	36.00
Pichivella	31.40	29.61	33.60
Kottaramchumala	35.80	37.50	37.00
Bedhrakalichumala	38.90	40.44	38.00
C.H.	32.04	30.64	35.98
S.E.	1.70	2.11	1.72
C.D.(0.05)	3.41	4.22	3.44

tubers of various genotypes.

The results arising from the analysis indicated that the dry weight of tubers varied significantly with respect to the genotypes ($P < 0.01$). Highest values for this character was seen in Radhrakalichumala at Vellayani (30.9%) and Karamana (40.44%). H.2752 showed the maximum expression of the character at Kayamkulam (38.3%). H.2415 ranked last in terms of dry weight of tubers at Vellayani (26.0%) and Karamana (25.8%). The lowest values for the character at Kayamkulam were seen in H.2648 and H.4021 i.e. 31.0 per cent each.

(i) Tuber yield

The data on mean tuber yield for various genotypes are provided in Table 12.

Highly significant differences among lines were observed for tuber yield at all the three sites ($P < 0.01$). H.2743 was found to be the highest yielder at Vellayani with a yield of 1943.57 g per plant. At Karamana, the maximum tuber yield was expressed by H.2416 (1277.09 g/plant). H.4126 showed the highest value for tuber yield at Kayamkulam (1341.17 g/plant). In contrast, the check varieties performed poorly in all the locations, with their yields being much lower than the general mean.

(ii) Chemical analysis.

The sweet potato tubers harvested from Instructional Farm, College of Agriculture, Vellayani, were analysed for

Table 12. Mean tuber yield per plant in twenty-eight genotypes of sweet potato at three locations

Genotypes	Tuber yield (g/plant)		
	Vellayani	Karamana	Kayamkulam
H.2412	1142.46	822.33	277.70
H.2416	1671.27	1277.89	769.00
H.2421	1462.14	1110.33	886.33
H.2646	1313.57	400.00	2.60
H.2712	1554.70	1199.67	909.80
H.2742	1001.07	701.67	194.35
H.2743	1943.57	918.90	642.50
H.2747	853.09	719.30	369.20
H.2750	232.86	245.50	159.17
H.2752	1297.15	960.27	682.00
H.3032	840.24	696.00	255.83
H.3050	814.05	436.80	124.70
H.3115	640.24	387.50	120.60
H.3402	742.66	495.75	111.90
H.3426	524.29	174.50	304.83
H.3802	1270.52	707.00	129.83
H.3803	411.30	342.83	62.30
H.4021	1517.74	660.90	458.35
H.4024	636.00	908.10	1031.50
H.4025	264.05	140.10	26.07

continued..

Table 12 continued

Genotypes	Tuber yield (g/plant)		
	Vellayani	Karamana	Kayamkulam
M.4026	286.00	216.67	180.43
M.4125	688.21	625.33	120.90
M.4126	1211.05	1069.00	1041.17
M.4328	963.29	1229.33	406.17
M.4329	212.14	152.10	22.67
Pichivella	575.00	164.73	50.03
Kottaramchumala	26.29	56.67	1.67
Sadhuvakalichumala	64.16	212.43	27.33
G.M.	665.05	621.68	357.31
S.E.	173.35	148.46	120.49
C.D.(0.05)	346.69	296.92	240.98

starch, sugar and carotene and the data thus obtained were proceeded to statistical analysis. The data on the chemical constituents are provided in Table 13.

(a) Starch

Considerable differences among the genotypes were observed regarding the percentage of starch ($P<0.01$). It ranged from 30.43% in H.2745 to 32.3% in Kottarakkamala with other genotypes showing intermediate values.

(b) Sugar

Sugar content was found to vary appreciably depending upon the genotypes ($P<0.01$). The genotypes H.4021 and H.4025 were shown to possess the highest sugar content and H.2732, the lowest sugar content.

(c) Carotene

Genotypic differences were found to exist with regard to the carotene content ($P<0.01$). Highest value observed for the carotene was possessed by H.3032. The genotypes H.2712, H.3402, H.4024 and Kottarakkamala showed a low content of carotene.

(iii) Baking index.

The tubers from the genotypes were analysed for flavour, texture, sweetness, fibre content, moistness and general acceptability based on which suitable grades were given to each genotype.

The results of the analysis are presented in Table 14. H.3032 was found to be the best variety with regard to the

Table 13. Mean contents of the chemical constituents of tuber in twenty-eight genotypes of sweet potato

Genotypes	Starch (%)	Sugar (%)	Carotene (I.U.)
H.2412	58.50	12.73	41.67
H.2416	58.50	13.75	83.33
H.2421	58.50	13.22	27.50
H.2648	57.35	13.75	110.83
H.2712	58.50	13.75	14.17
H.2742	58.50	13.48	41.67
H.2743	58.43	12.54	41.67
H.2747	58.50	12.27	83.33
H.2750	58.50	10.56	27.50
H.2752	58.50	9.30	83.33
H.3032	58.50	12.54	166.66
H.3050	58.50	15.63	83.33
H.3115	58.50	14.03	55.83
H.3402	55.70	12.97	14.17
H.3426	58.45	14.63	110.83
H.3802	58.50	15.63	298.33
H.3803	52.20	14.04	110.83
H.4021	58.35	15.78	27.50
H.4024	59.70	13.48	14.17
H.4025	55.70	15.98	41.67
H.4026	55.70	15.63	83.33

continued..

Table 13. continued

Genotypes	Starch (%)	Sugar (%)	Carotene (I.U.)
H.4125	58.50	12.97	55.33
H.4126	54.17	15.22	69.17
H.4323	57.33	12.97	55.83
H.4329	56.25	12.26	83.33
Kothivalla	57.33	10.42	41.67
Kosteranchumala	62.30	14.03	14.17
Sadurakalichumala	56.23	15.75	27.50
G.M.	57.06	13.41	54.97
S.D.	0.56	0.11	0.17
C.D.(0.05)	1.12	0.23	0.34

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Table 14. Baking indices of twenty-eight genotypes of sweet potato

Genotypes	Flavour	Tex-ture	Sweet-ness	Fibre content	Moist-ness	General accept-ability	Average baking index
H.2412	3.0	6.0	6.0	6.0	6.0	3.5	5.4
H.2416	4.5	4.0	5.0	7.0	10.0	6.0	6.1
H.2421	3.5	3.5	5.5	6.5	9.0	3.5	4.9
H.2640	4.5	4.0	6.5	8.5	7.0	5.0	5.9
H.2712	3.5	8.5	6.5	8.5	9.0	6.5	7.1
H.2742	3.0	4.5	5.0	5.0	7.5	4.0	4.5
H.2743	4.0	8.0	4.5	8.5	9.5	5.0	6.6
H.2747	3.5	9.0	7.0	9.0	10.0	7.0	7.6
H.2750	3.0	4.0	4.5	8.0	9.0	4.0	5.6
H.2752	3.0	5.5	4.0	8.0	9.0	4.0	5.6
H.3032	5.0	8.5	7.0	8.5	9.5	7.5	7.6
H.3050	3.0	4.5	3.5	9.0	9.5	5.0	5.8
H.3115	5.0	4.5	5.5	6.5	9.0	4.0	5.4
H.3402	5.0	4.0	4.0	6.5	9.0	4.0	5.4
H.3426	4.5	4.5	4.5	6.0	8.5	4.5	5.4
H.3602	4.8	5.0	5.0	5.6	8.6	6.4	5.9
H.3603	5.0	4.8	5.0	5.4	8.8	6.4	5.9
H.4021	4.0	8.5	7.0	9.0	9.5	7.0	7.5
H.4024	3.0	4.5	5.0	5.0	7.5	4.0	4.8
H.4025	3.5	4.3	5.3	5.0	7.8	4.0	5.0
H.4026	4.0	5.6	5.0	5.0	8.0	4.0	4.9
H.4125	4.0	3.0	3.0	7.5	8.5	4.0	4.9
H.4126	3.0	4.0	4.0	6.0	8.5	4.0	4.9
H.4328	3.6	8.0	3.0	9.0	8.5	6.5	7.3
H.4329	3.0	5.0	4.0	8.0	7.6	6.5	5.7
Pichivella	3.0	8.0	6.5	9.0	9.0	5.0	6.8
Kottayam-chunnia	4.0	7.0	7.0	8.0	6.0	4.6	6.1
Nedhurali-chunnia	4.0	7.3	6.7	6.0	8.4	7.0	6.6

Grade < 4 = poor, Grade 4 and < 6= medium Grade 6 and >6 = good

quality aspects. Check varieties also showed their worth in terms of these aspects. Most of the genotypes were shown to have medium quality whereas none of the genotypes selected for this study possessed poor quality.

(iv) The components of variance and coefficients of variation

The genotypic, phenotypic and environmental components of variance and coefficients of variation were computed and are presented in Tables 15 and 16 respectively. The genotypic coefficient of variation was lowest in the starch content of tuber (4.58%). The tuber yield showed the highest genotypic coefficients of variation at all the three test sites. The genotypic coefficient of variation for each character was found to differ at different sites.

II. Genotype x Environment interaction.

The statistical technique proposed by Eberhart and Russell (1966) was utilized to estimate the stability parameters and genotype x environment interactions for different genotypes with respect to yield and other traits.

The analysis of variance for phenotypic stability of yield and other traits are presented in Tables17 and 18. The differences between varieties were highly significant for all characters ($P < 0.01$) except the number of tubers which was found to be significant at 5% level. The total environmental differences were found to be highly significant ($P < 0.01$) in the cases of yield, number of tubers, length of

Table 15. Components of variance for twelve characters in sweet potato at three locations

Characters	Environmental variance			Genotypic variance		
	Vellayani	Karamana	Kayamkulam	Vellayani	Karamana	Kayamkulam
Top weight	290750.356	341759.324	115803.656	484862.168	169067.319	91274.254
Length of vine	2440.324	1353.194	1134.092	15594.735	2782.740	13283.447
Number of branches	22.619	13.180	20.030	47.490	6.479	19.623
Number of tubers	2.634	1.344	0.868	6.473	4.341	3.245
Length of tuber	3.832	5.175	5.670	12.322	2.026	2.096
Girth of tuber	3.243	5.220	9.564	22.692	16.188	19.092
Harvest index	0.003	0.004	0.005	0.013	0.012	0.019
Dry weight of tuber	4.351	6.689	4.432	9.656	14.209	2.688
Tuber yield	45073.622	35060.415	21776.410	260123.455	134564.657	131235.611
Starch	0.471	—	—	6.829	—	—
Sugar	0.019	—	—	2.592	—	—
Carotene	0.042	—	—	2153.548	—	—

Table 15 continued.....

Table 15 continued

Phenotypic variance		
Vellayani	Karamana	Kayamkulam
775620.523	510826.643	207077.910
10043.059	4135.934	14423.279
70.109	19.659	39.653
0.107	5.685	4.113
16.154	7.201	7.766
25.935	21.416	28.656
0.016	0.016	0.024
14.007	20.698	7.120
303197.275	167625.072	153012.221
7.300	—	—
2.611	—	—
2153.590	—	—

— Chemical analysis was carried out at one location (Vellayani) only.

Table 16. Genotypic and phenotypic coefficients of variation for twelve characters in sweet potato at three locations

Characters	Genotypic coefficient of variation			Phenotypic coefficient of variation		
	Vellayani	Karamana	Kayamkulam	Vellayani	Karamana	Kayamkulam
Top weight	21.516	17.581	20.300	27.342	30.560	30.581
Length of vine	37.010	23.396	50.309	39.809	30.961	52.954
Number of branches	23.890	15.334	25.012	29.035	26.710	32.712
Number of tubers	38.962	46.300	67.722	46.214	52.904	76.244
Length of tuber	21.172	9.369	11.502	24.241	17.655	22.294
Girth of tuber	27.280	25.320	26.707	30.193	29.123	32.250
Harvest index	56.716	56.700	88.050	62.535	67.010	94.340
Dry weight of tuber	9.710	12.300	4.030	11.670	14.920	7.060
Tuber yield	59.095	56.006	101.387	64.011	65.657	109.476
Starch	4.580	—	—	4.735	—	—
Sugar	12.006	—	—	12.050	—	—
Carotene	71.427	—	—	71.428	—	—

— Chemical analysis was carried out at one location (Vellayani) only

Table 17 Analysis of variance for phenotypic stability with respect to shoot characters and harvest index

Source of variation	d.f.	M.S.			
		Top weight	Length of vine	Number of branches	Harvest index
Total	85	2593029.600	48039.859	201.848	0.044
Varieties	27	2397171.480**	90209.660**	280.570**	0.120**
Environment	2	63072139.510**	411698.330**	3406.160**	0.040*
V x Env.	54	452374.390*	9466.130**	40.850**	0.010**
Env.+(V x Env.)	56	2660795.149	23650.664	165.892	0.007
Env.(linear)	1	126144279.027	823396.660	6972.310	0.080
V x Env.(linear)	27	519516.974	11502.145	63.433**	0.014**
Pooled deviation	28	371474.670*	7203.331**	17.605	0.00002
Pooled error	162	249440.430	1645.450	18.610	0.004

*Significant at 5 per cent level of probability

**Significant at 1 per cent level of probability

Table 18. Analyses of variance for phenotypic stability with respect to tuber yield and tuber characters

Source of variation	d.f	M.S.				
		Yield of tubers	Number of tubers	Length of tubers	Girth of tubers	Dry weight of tubers
Total	83	675531.001	28.196	31.033	85.045	48.082
Varieties	27	1349723.120**	36.720*	39.510**	223.980**	105.350**
Environment	2	5374930.800**	314.430**	457.870**	10.220	235.630*
V x Env.	54	164364.330**	15.350**	12.370**	17.340**	12.500**
Env.+(V x Env.)	56	350475.260	24.009	20.283	17.009	20.461
Env.(linear)	1	10749861.500	628.050	915.730	20.430	471.600
V x Env.(linear)	27	243449.600**	7.238	17.400*	15.631	13.421
Pooled deviation	28	32271.070**	1.737**	7.082	18.376**	11.159**
Pooled error	162	33303.548	1.615	4.692	6.012	5.157

*Significant at 5 per cent level of probability

**Significant at 1 per cent level of probability

tubers, top weight, length of vine and number of branches; and moderately significant for harvest index and dry weight of tubers ($P<0.05$). Meanwhile the girth of tuber was observed not to be affected by environmental differences. The genotype x environment interaction was found to be moderately significant for top weight; ($P< 0.05$) and highly significant for all the other characters ($P< 0.01$) which indicated that there was a need for stability analysis of the genotypes. The genotype x environment interaction for yield was found to be due to both linear and non-linear components of interaction ($P< 0.01$). Linear component alone contributed towards the genotype x environment interaction in number of branches, harvest index ($P<0.01$) and length of tubers ($P<0.05$). Variance due to pooled deviation was observed to be significant for length of vine, number of tubers, girth of tubers, dry weight of tubers ($P< 0.01$) and top weight ($P<0.05$). The interaction due to linear component was low for top weight, length of vine, number of tubers, girth of tubers and dry weight of tubers.

III. Stability Parameters.

Stability parameters of each genotype for the nine characters are presented in the Table 19.

(1) Top weight

Sadhrakalichamala and H.2752 showed high stability ($b\rightarrow 0$). Pichivella, Kottarachumala, and most of the other genotypes were found to have shown average stability ($b\rightarrow 1$)

Table 19. Stability parameters for nine characters in twenty-eight genotypes of sweet potato

Genotypes	Tov weight			Vine length		
	P_1	b_1	S^2_{d1}	P_2	b_2	S^2_{d2}
H.2412	-363.71	1.1666	-70066.128	-77.32	0.4991	494.052
H.2416	-967.42	0.5241	-48025.185	-140.74	0.3498	-567.242
H.2421	490.73	1.1680	-9841.417	-108.04	0.5197	1182.638
H.2648	150.95	1.0470	185860.214	34.70	0.9546	291.368
H.2712	119.62	0.7826	420356.413*	-48.60	0.4959	1276.121
H.2742	322.19	1.2627	912841.430**	-110.69	0.7144	185.667
H.2743	-75.56	1.1955	-51373.724	-10.62	0.8382	1675.031*
H.2747	-347.60	1.1948	-76958.919	-85.01	0.7297	-494.310
H.2750	-12.46	1.1668	-55662.262	25.33	1.1758	1326.909
H.2752	-1152.05	0.0566	-54517.928	-62.54	0.2445	2208.235*
H.3032	59.74	1.5912	-55100.032	-19.21	1.5106	19.751
H.3050	291.84	1.2705	29827.640	96.71	1.5465	-75.669
H.3115	-194.64	0.8880	227024.463	-21.95	1.4178	1253.301
H.3402	589.62	1.0048	-75444.117	-58.37	0.7628	-434.673
H.3426	-144.98	1.0920	-82037.423	73.37	1.6486	1141.308

Table 19 continued..

Table 19 continued -2-

Genotypes	Top weight			Vine length		
	P_1	b_1	S^2_{d1}	P_2	b_2	S^2_{d2}
H.3802	110.77	0.9402	-81782.950	-7.14	1.2767	-484.665
H.3805	-105.64	0.6440	-74320.653	-74.81	0.7323	1736.181*
H.4021	-257.75	1.0936	-53749.198	32.10	1.6864	-261.299
H.4024	-548.16	0.4622	-4074.347	274.15	1.8119	19056.639**
H.4025	745.01	1.7375	210842.926	151.59	1.9515	179.872
H.4026	271.10	1.1277	106107.586	94.68	1.2268	1959.309*
H.4125	-167.42	1.2322	-40351.811	-18.56	1.3593	534.569
H.4126	308.44	1.1675	70420.122	16.33	1.1868	-351.531
H.4328	820.73	0.5445	158382.381	-94.64	0.5457	-416.029
H.4329	610.36	1.2949	26745.394	-18.77	0.9382	909.560
Pichivelle	-33.34	0.8757	-78870.147	125.82	1.5246	459.951
Kottaram-chumala	-339.16	0.8422	73644.907	161.16	1.5514	16066.374**
Sadhurkali-chumala	-527.79	0.2877	80092.054	39.25	1.0135	-506.878

Table 19 continued...

Table 19 continued

Genotypes	No.of branches			No. of tubers		
	P_3	b_3	$S^2_{\bar{d}3}$	P_4	b_4	$S^2_{\bar{d}4}$
H.2412	-4.083	0.9976	-6.152	2.667	1.6499	0.439
H.2416	-2.815	1.0970	-6.129	4.151	1.1853	-0.173
H.2421	7.997	1.3545	-4.849	3.239	0.7233	-0.492
H.2648	-0.343	1.1117	-4.366	-1.614	1.2821	-0.300
H.2712	-3.043	0.1787	1.062	1.705	0.7429	-0.527
H.2742	-1.463	1.2476	-6.129	1.395	1.2182	4.990**
H.2743	-3.013	0.6809	13.500	0.778	0.8573	-0.078
H.2747	-4.883	0.7171	-5.895	1.068	1.0265	-0.457
H.2750	6.027	0.9074	-4.062	-1.745	0.5063	0.281
H.2752	-2.493	0.6072	-5.463	1.211	0.6228	-0.296
H.3032	10.697	1.8427	10.851	-0.056	1.0793	-0.461
H.3050	4.937	1.6250	-5.849	-0.652	1.1335	-0.409
H.3115	6.057	1.8006	10.840	-1.201	1.1592	-0.535
H.3402	0.347	0.4114	-6.200	0.790	1.6427	-0.028
H.3426	-4.233	0.6235	-5.956	1.484	2.6698	22.043**

Table 19 continued...

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Genotypes	No. of branches			No. of tubers		
	P_3	b_3	σ^2_{d3}	P_4	b_4	σ^2_{d4}
H.3802	-0.663	0.7276	1.054	-0.440	1.7198	-0.357
H.3803	-5.015	0.1632	-5.025	0.430	1.5041	-0.053
H.4021	-5.293	0.9630	-6.202	-0.109	0.6997	-0.472
H.4024	-2.903	0.9695	2.095	1.020	0.2447	-0.426
H.4025	2.967	0.8353	-6.061	-2.744	0.7199	-0.525
H.4026	0.017	1.4746	-5.900	-0.683	0.6173	-0.396
H.4125	-5.553	0.9900	-6.197	-0.550	1.1795	-0.462
H.4126	-2.563	0.9014	-5.765	0.962	1.3002	1.537
H.4328	10.377	1.6517	9.897	1.201	0.7396	5.553**
H.4329	1.607	1.0209	4.119	-2.747	0.8558	-0.536
Pichivalla	2.237	1.1567	1.002	-1.671	1.0736	-0.463
Kottaram chamala	-3.043	1.2705	-5.642	-4.002	0.1995	-0.467
Sadhurkali chamala	0.327	0.3582	13.247	-3.322	0.1038	80.454

Table 19 continued....

Genotypes	Length of tubers			Girth of tubers		
	P_5	b_5	S^2_{d5}	P_6	b_6	S^2_{d6}
H.2412	0.48	1.2958	-0.537	-0.835	2.9328	-0.969
H.2416	0.43	0.9708	-1.618	4.105	2.7690	1.268
H.2421	-0.12	1.2185	-0.974	3.945	3.6829	1.602
H.2648	0.65	2.8511	6.005*	0.675	4.3700	30.471**
H.2712	1.48	1.1515	0.422	7.605	3.1596	29.491**
H.2742	1.03	1.8636	0.048	-0.095	1.0066	2.358
H.2743	2.98	1.8257	0.756	3.865	4.1623	-1.000
H.2747	-0.32	1.0701	-1.430	1.055	-1.6509	-1.769
H.2750	-1.93	0.3723	4.806*	-2.715	3.1241	2.849
H.2752	-0.77	0.2674	0.734	6.665	0.2253	-1.960
H.3052	3.71	1.6152	-1.536	-0.995	-1.3719	-1.643
H.3050	-0.11	1.7360	-1.044	-2.625	3.5094	0.823
H.3115	-0.14	1.2735	1.059	-0.155	1.6151	11.588*
H.3402	-0.67	1.1723	-1.598	-3.995	0.0217	-1.000
H.3426	-2.15	0.2083	0.986	-4.685	-1.4672	33.509**

Table 19 continued..

Genotypes	Length of tubers			Girth of tubers		
	P_5	b_5	S^2_{d5}	P_6	b_6	S^2_{d6}
H.3802	3.78	2.4422	3.462	1.125	2.6790	-1.031
H.3003	-0.95	1.3503	3.751	-3.035	0.0984	-0.621
H.4021	1.33	1.5961	-0.405	5.915	4.0825	0.084
H.4024	5.40	0.4277	-0.738	1.495	-4.4344	0.226
H.4025	6.16	0.9229	-1.498	-3.635	0.8236	-0.747
H.4026	-2.52	0.1269	-0.932	-1.495	6.6578	1.695
H.4125	1.37	1.0804	-1.305	0.455	3.5874	2.136
H.4126	-0.30	1.0596	-1.491	9.515	-3.2412	11.430*
H.4328	1.60	1.3159	-1.626	1.765	-3.0208	-1.490
H.4329	-1.19	2.2334	-1.349	-6.005	0.7519	-1.907
Pichivella	-1.19	1.3205	7.443*	-4.215	3.5649	4.446
Kottaram chunala	-3.20	0.4041	7.195*	-6.535	-2.4052	-0.835
Vadhraksali chunala	-2.15	-0.9920	2.114	-6.455	-6.2515	-1.430

Table 19 continued...

Genotypes	Harvest index			Dry weight of tubers		
	P_7	b_7	S^2_{d7}	P_8	b_8	S^2_{d8}
H.2412	0.0593	1.6258	-0.0013	1.45	0.4729	17.690**
H.2416	0.2473	1.3046	-0.0009	0.67	0.7485	-1.626
H.2421	0.1013	-0.9407	-0.0011	-0.95	0.1200	0.626
H.2648	-0.0507	5.5863	0.0015	-3.89	1.5001	-1.713
H.2712	0.1283	-1.3025	0.0016	-2.50	2.2084	1.451
H.2742	-0.0137	2.0530	-0.0070	-0.91	1.4050	3.627
H.2745	0.1323	0.1424	0.0044*	1.91	1.8196	37.444**
H.2747	0.0493	-0.7308	-0.0099	0.33	1.9439	4.869
H.2750	-0.1047	-0.6861	-0.0013	-0.57	1.8863	-1.573
H.2752	0.2613	-0.0780	0.0039*	6.68	-0.5801	-0.195
H.3032	-0.3070	0.8205	-0.0006	-0.38	0.9192	-1.455
H.3050	-0.0617	2.5270	-0.0013	-1.72	0.9864	3.306
H.3115	-0.5057	1.8150	-0.0004	-4.45	2.2515	1.065
H.3402	-0.0717	2.6805	-0.0012	0.41	1.9540	-0.795
H.3426	-0.0737	-2.1227	-0.0009	-3.15	1.0010	-0.530

Table 19 continued..

Genotypes	Harvest index			Dry weight of tubers		
	P_7	b_7	S^2_{d7}	P_8	b_8	S^2_{d8}
H.3802	0.0055	5.3441	-0.0008	0.95	0.1404	-1.663
H.3805	-0.0077	2.2235	-0.0001	0.69	2.4295	10.319**
H.4021	0.1023	2.5437	-0.0015	-4.52	1.0097	-1.605
H.4024	0.1203	-2.5759	0.0063*	0.61	0.1652	-1.586
H.4025	-0.1527	0.8025	-0.0013	-1.78	0.6220	0.161
H.4026	-0.1087	-0.0684	-0.0013	-2.17	1.2611	-1.673
H.4125	-0.0177	3.4116	-0.0002	-0.69	1.0941	-1.548
H.4126	0.1323	3.9644	-0.0007	0.45	0.6256	-1.255
H.4328	0.0213	2.4324	0.0070**	1.38	1.1222	-1.565
H.4329	-0.1457	0.0656	-0.0013	2.17	0.9085	-1.718
Pichivella	-0.1027	2.448	0.0007	-0.68	1.1908	-1.710
Kottaram chunala	-0.1707	0.4210	-0.0011	4.55	-0.1020	-0.251
Bodhavalali chunala	-0.1307	1.1746	0.0018	6.89	-0.7140	-1.542

Table 19 continued...

Table 19 continued -9-

Genotypes	Tuber yield		
	P_9	b_9	S^2_{d9}
N.2412	133.49	1.7154	-5390.288
N.2416	632.04	1.7462	-10590.257
N.2421	558.92	1.3390	-7151.423
N.2648	-40.29	2.5407	45123.524*
N.2712	607.40	1.2724	-9612.222
N.2742	45.21	1.6063	7104.991
N.2743	567.65	2.4682	107995.670**
N.2747	90.65	0.9225	5980.083
N.2750	-401.50	0.1487	-9578.403
N.2752	439.13	0.8138	-1707.409
N.3032	-16.65	1.1656	982.280
N.3050	-154.63	1.3603	-9676.126
N.3115	-231.16	1.0268	-11085.632
N.3402	-163.58	1.2509	-3078.034
N.3426	-346.30	0.0316	2005.749
N.3802	68.44	2.2544	-10687.816
N.3803	-335.20	0.6558	-5877.506
N.4021	341.65	2.0255	7155.778
N.4024	270.79	-0.7738	6808.691
N.4025	-467.94	0.4704	-11097.436
N.4026	-383.95	0.1897	-10770.896

Table 19 continued...

Table 19 continued -10-

Genotypes	Tuber yield		
	F_9	b_9	S^2_{d9}
H.4125	-69.66	1.5244	-4303.360
H.4126	593.66	-0.2696	16661.902
H.4328	252.25	1.1334	177403.143**
H.4329	-485.04	0.3704	-10486.040
Pichivalla	-350.76	1.0264	5894.551
Kottarem chunala	-585.13	0.0540	-9976.657
Badhrakali chunala	-512.70	0.0919	7170.426

*Significant at 5 per cent level of probability

**Significant at 1 per cent level of probability

Genotypes H.1032, H.3050, H.4025 and H.4329 expressed below average stability ($b>1$). High values of regression coefficients for these varieties indicated that they were influenced by the fluctuations in the environment.

Deviation from regression had been observed to be non-significant for all the genotypes except H.2712 and H.2742 both of which had expressed average stability in terms of b_i values. However, significant deviation from the linear regression for these two varieties pointed out the unpredictability of the phenotypic expression for this character based on the linear regression model and suggested the need of a regression of higher order for the prediction.

In terms of the phenotypic indices, the genotypes H.4328, H.4025, H.4329, J.5402 and H.2421 showed highest positive values in the order. Genotypes H.4329 and H.4025 showed specific adaptation to high yielding environments with respect to this character, as they were endowed with high p_i and b_i values. Combining average stability ($b\rightarrow 1$) and high p_i values, the genotypes H.4328, H.5402 and H.2421 expressed the general adaptation over different environments. Hence, these genotypes could be favourably considered if the top weight was to be considered a positive character for yield. Genotypes H.2412, H.2416, H.2747, H.4021 and H.4024 were found to be consistently poor performers over environments. Dadhrakalichumla and H.2752 having above average stability ($b\rightarrow 0$) had very low p_i values. No genotype could

be identified which was specially suitable for stress conditions.

(ii) Length of vine

Maximum stability ($b \rightarrow 0$) was exhibited by H.2752 with respect to this trait which indicated least response to the alterations in the environment. Genotypes like H.2640, H.4329 and Sadhrakalichimala showed average stability ($b \rightarrow 1$) over the environments whereas H.4025, H.4024 and H.4021 were found to be most inconsistent in performance ($b > 1$).

The linear regression model could be used to explain the expressivity of character for most of the genotypes, since deviation from regression tended to zero. However certain genotypes viz., H.2743, H.2752, H.3203, H.4024, H.4026 and Kottaramchumala lacked such correspondence between the phenotype and the environment, as evident from their significant deviation from regression.

High positive phenotypic indices were shown by genotypes H.4024, Kottaramchumala, H.4025 and Pichivella. Kottaramchumala and H.4024 were found to be highly unstable with high b_i values and deviation from regression significant from zero. Pichivella and H.4025 were characterised by high p_i and b_i values; and hence will show greater variation depending upon the environments. H.2640, H.4026 and Sadhrakalichumala possessed general adaptation with respect to this character, having b_i values tending to unity

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and positive p_i values. No genotype was found to be specifically adapted to low-yielding environments. A number of genotypes like H.2416, H.2421, H.2742 and H.4328 were found to be poorly adapted to all environments.

(iii) Number of branches

Average stability ($b \rightarrow 1$) was shown by most of the genotypes, H.3003 and H.2712 expressed above average stability with b_i values tending to zero. Some lines like H.3032, H.3115 and H.4329 were found to be very unstable under environmental fluctuations ($b > 1$).

None of the genotypes had deviation from linear regression differing significantly from the zero which indicated that the linear regression equation was quite satisfactory for the predictability of performance of these lines over environments.

The character had the highest expression in H.3032, followed by H.4328, H.2421, H.3115 and H.3050. They also possessed high b_i values, thereby showing specific adaptations to favourable environments. General adaptations were shown by H.2750 and H.4025 with positive p_i values and average stability. A number of genotypes like H.2412, H.2416, H.2648 and H.2747 were poorly adapted to all the environments. No genotype, that was specially adapted to poor environments, could be obtained.

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(iv) Number of tubers

Varieties Kottaramchumala, Badhrakalichumala and H.4024 showed above average stability ($b \to 0$) with respect to this character. Most of the genotypes expressed average stability ($b \to 1$) indicating moderate response to the changes in the environment. Below average stability ($b > 1$) was shown by H.2412, H.3402, H.3426, H.3602, H.3803 and H.4126.

Most of the genotypes had non-significant deviation from linear regression which indicated that their performance could be predicted with accuracy within the limits of sampling error. However, a few genotypes viz., H.2742, H.3426 and H.4320 were found not to be amenable to such predictions based on a simple linear model of regression, as their deviation from regression differed significantly from zero.

H.2412, H.3402, H.3426, H.3803 and H.4126 combined positive phenotypic indices and high regression coefficients ($b > 1$) which implied their adaptation to good environments. However H.3426 also showed significant deviation from regression which invalidated its' slope on the environmental indices. Genotypes H.2416, H.2421, H.2712, H.2742, H.2747 and H.2752, having positive p_i values and b_i values tending to unity, expressed general adaptability. Varieties Pichivolla, Kottaramchumala, Badhrakalichumala, H.2750 etc. showed poor adaptability in all the environments. H.4024, with positive p_i values and b_i tending to zero, was found to be suitable for stress conditions.

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(iv) Number of tubers

Varieties Kottaramchumala, Sadhrakalichumala and H.4024 showed above average stability (b→0) with respect to this character. Most of the genotypes expressed average stability (b→1) indicating moderate response to the changes in the environment. Below average stability (b>1) was shown by H.2412, H.3402, H.3426, H.3802, H.3803 and H.4126.

Most of the genotypes had non-significant deviation from linear regression which indicated that their performance could be predicted with accuracy within the limits of sampling error. However, a few genotypes viz., H.2742, H.3426 and H.4328 were found not to be amenable to such predictions based on a simple linear model of regression, as their deviation from regression differed significantly from zero.

H.2412, H.3402, H.3426, H.3803 and H.4126 combined positive phenotypic indices and high regression coefficients (b>1) which implied their adaptation to good environments. However H.3426 also showed significant deviation from regression which invalidated its' slope on the environmental indices. Genotypes H.2416, H.2421, H.2712, H.2742, H.2747 and H.2752, having positive p_i values and b_i values tending to unity, expressed general adaptability. Varieties Pichivella, Kottaramchumala, Sadhrakalichumala, H.2750 etc. showed poor adaptability in all the environments. H.4024, with positive p_i values and b_i tending to zero, was found to be suitable for stress conditions.

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coefficients indicating their highly unstable nature with respect to this character. Average stability (b→1) was exhibited by a very few varieties namely H.2742, H.4025 and H.4329. Genotypes H.2752, H.3402 and H.3805 expressed above average stability (b→0) which point out that they could perform uniformly inspite of the fluctuations in the environment.

Significant deviation from regression was observed in H.2646, H.2712, H.3115, H.3426 and H.4126 which showed their unpredictability in phenotypic expression in terms of their b_i values. All other genotypes showed low S^2_{di} values that were not significantly different from zero.

Genotypes H.2416, H.2421 and H.2743, combining positive p_i values and b_i values higher than unity, expressed their specific adaptations to high yielding environments, whereas H.2712 and H.2648 had positive p_i values, high b_i values and significant S^2_{di} values. H.4025 and H.4329 performed poorly in all the environments. Some genotypes were identified as specifically adapted to poor environments viz., H.2747, H.2752, H.4024, H.4126 and H.4328.

(vii) Harvest index

Genotypes H.2743, H.2752 and H.4026 expressed above average stability (b→0). Average stability (b→1) was shown by H.3032, H.4025, H.4329, Kottarachumala and Bodhrakali-chumala. Most of the genotypes were found to be unstable

in terms of b_i values.

A few genotypes M.2743, M.2752, M.4024 and M.4328 had significant S^2_{di} values which invalidated their b_i values. All other varieties had low S^2_{di} values, hence b_i values showed correct trend of response of genotypes to the environments.

M.2412, M.2416, M.4021 and M.4126 were characterised by positive p_i values and significant b_i values indicating their suitability for high-yielding environments. M.2743 and M.2752 had positive p_i values and b_i values tending to zero, but were shown to have significant S^2_{di} values. Consistently poor performances were shown in all test sites by varieties Sadhrahalichunala, Kotteranchunala, M.3052, M.4025 and M.4329. M.4024 and M.2421 were found to be specifically adapted to poor environments.

(viii) Dry weight of tubers

Above average stability (b→0) was expressed by M.2421, M.3002 and M.4024 and hence showed least response to the environmental variation. Most of the genotypes showed average stability (b→1) with respect to this character. Below average stability (b>1) was expressed by varieties such as M.2343, M.2712, M.3119, M.3403 and M.3402.

Deviation from linear regression significantly deviating from zero, was expressed by only very few genotypes namely M.2412, M.2743 and M.3005. All other varieties had low S^2_{di} values.

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H.2747 and H.3402 were characterised by positive p_i values and high b_i values and hence, were adapted to good environments. Genotypes H.2743 and H.3003 had positive p_i values, high b_i values and significant S^2_{di} values. H.2412, H.2416, H.3032, H.4126, H.4328 and H.4329 were endowed with positive p_i values and b_i values tending to unity. However, H.2412, in addition, had significant S^2_{di} values.

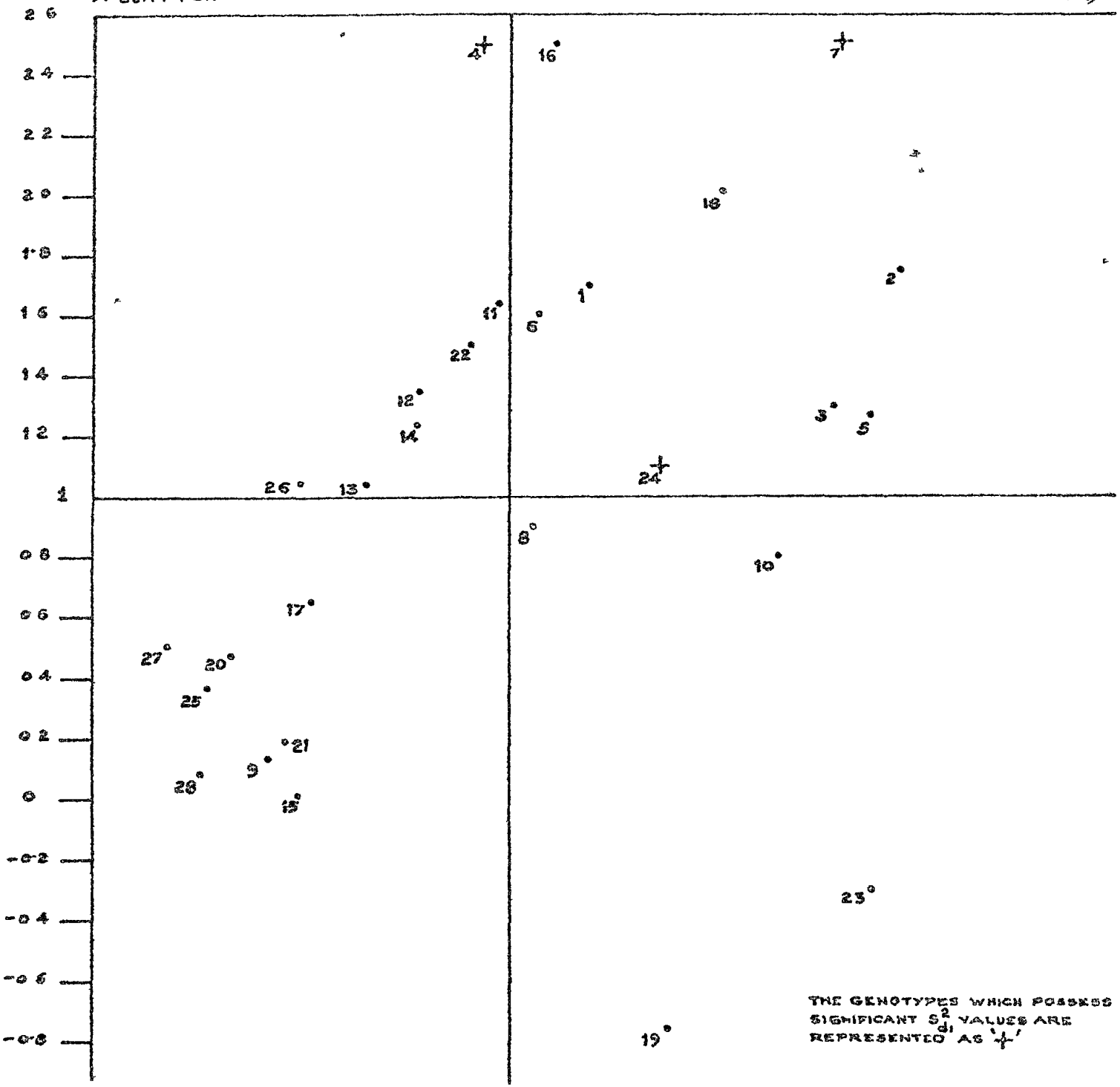
(ix) Tuber yield

Above average stability (b→0) was shown by H.2750, H.3426, H.4026, Kottarasuchumala and Budhrakallichumala. Genotypes Pichivolla, H.2712, H.2747, H.2752, H.3032, H.3115, H.3603, H.4025, H.4126, H.4328 and H.4329 expressed average stability (b→1). All other genotypes had b_i values significantly different from unity.

Most of the genotypes had low S^2_{di} values hence simple linear regression model could be fitted to explain their performance. However, H.2648, H.2743 and H.4328 had S^2_{di} values deviating significantly from zero.

A scatter diagram of all the genotypes with respect to phenotypic indices (p_i), regression coefficients (b_i) and deviation from regression (S^2_{di}), is given in Figure 1. which describes the relative positions of each line based on above parameters. Hence it is easy to visualise the adaptation patterns of the genotypes.

A SCATTER DIAGRAM FOR 28 LINES OF SWEET POTATO OF THEIR PHENOTYPIC INDICES AND REGRESSION COEFFICIENTS ON TUBER YIELD



THE GENOTYPES WHICH POSSESS SIGNIFICANT S^2_{di} VALUES ARE REPRESENTED AS '+'

1	H 2412
2	H 2416
3.	H 2421
4.	H 2643
5	H 2712
6	H 2742
7	H 2743
8	H 2747
9	H 2750
10	H 2752
11.	H 3032
12.	H 3050
13	H 3115
14	H 3402
15	H 3426
16	H 3802
17	H 3803
18	H 4021
19	H 4024
20	H 4025
21	H 4026
22	H 4125
23.	H 4126
24	H 4328
25	H 4329
26	PICHIVELLA
27	KOTTARAM CHUMALA
28	BADRAKALI CHUMALA

IV. Association between stability parameters

The correlation coefficients between mean values and regression coefficients with respect to various characters were worked out and presented in Table 20. Top weight, length of vine and number of branches showed a highly significant, positive correlation between mean values and regression coefficients ($r < 0.01$). Positive and significant correlation at 5% level was obtained between stability parameters for number of tubers and tuber yield. Dry weight of tubers was the only character that showed a negative significant correlation between the parameters ($P < 0.01$) and length of tubers, girth of tubers and harvest index showed no correlation between the mean values and regression coefficients.

Table 20. Correlation coefficients between the mean values and regression coefficients of nine characters in sweet potato.

Sl. No.	Characters	r(correlation coefficients)
1.	Top weight	0.642**
2.	Length of vine	0.820**
3.	Number of branches	0.642**
4.	Number of tubers	0.377*
5.	Length of tubers	0.368
6.	Girth of tubers	0.182
7.	Harvest index	-0.136
8.	Dry weight of tubers	-0.644**
9.	Tuber yield	0.390*

*Significant at 5 per cent level of probability
**Significant at 1 per cent level of probability

FIG 2a TUBERS OF THE PROMISING GENOTYPES OF SWEET POT,

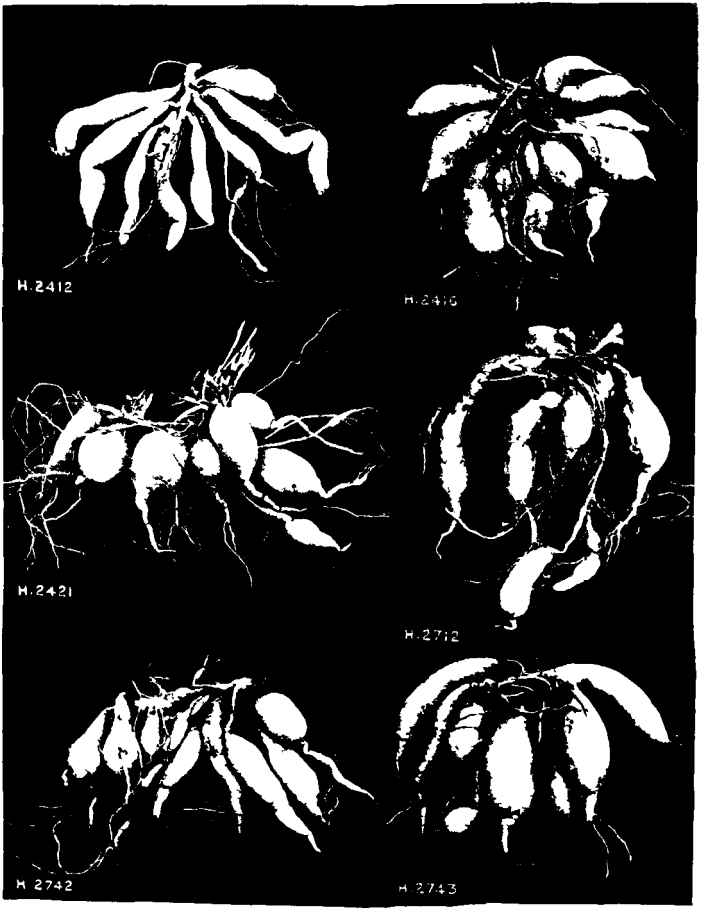
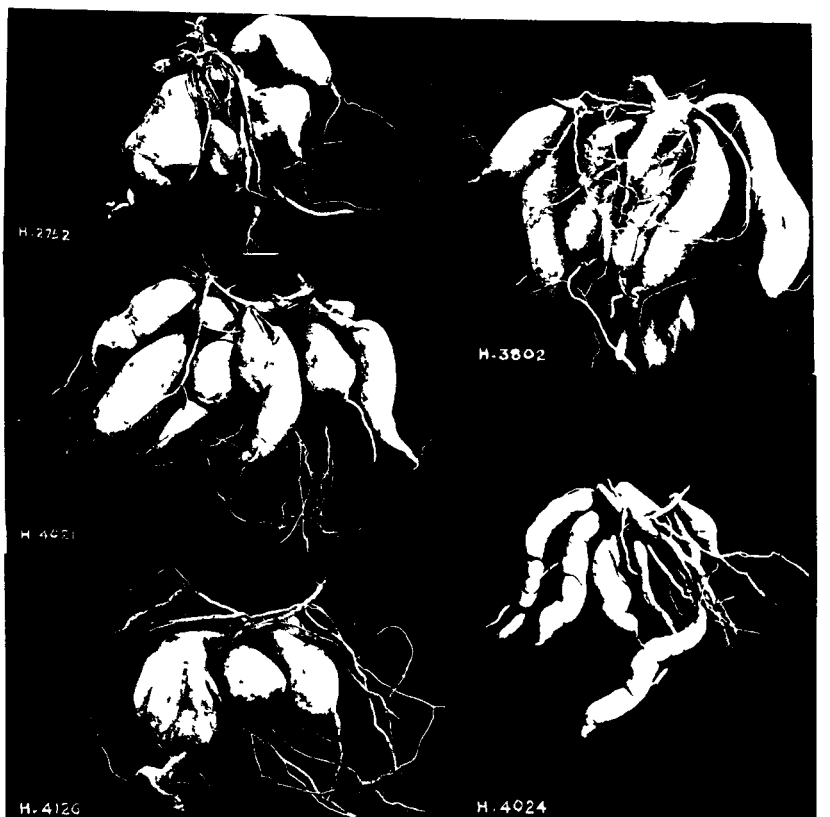
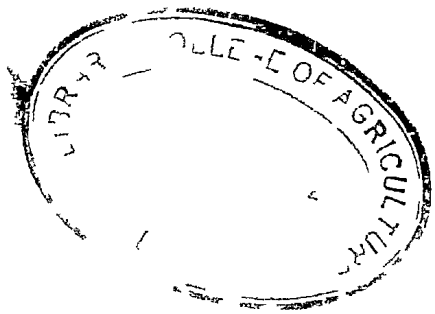


FIG 2b TUBERS OF PROMISING GENOTYPES OF SWEET POTATO





DISCUSSION

DISCUSSION

The importance of sweet potato as a subsidiary food crop in Kerala is realised well, especially among the poorer sections of the people. However the production of sweet potato in the state is greatly impeded by the inherent low productivity of the local varieties. Naturally the emphasis must be placed on evolving varieties equipped with high potential for yield and wide adaptability.

Phenotypically stable varieties are particularly of great importance in a state like Kerala where climatic and soil conditions vary considerably from place to place. Identification of varieties responding to favourable environments and better inputs as well as varieties for marginal farmers or poor environments are equally important. Success of any breeding programme aimed at developing phenotypically stable variety lies in the understanding of the extent of genotype x environment interaction in the characters of interest. Allard and Bradshaw (1964) suggested the use of genetic mixture rather than homogenous or pure line varieties, as a solution to reduce the interaction. This method may not be of much use in a crop like sweet potato where varieties differ considerably in tuber characters like colour, shape, size, quality aspects etc. thereby affecting the marketability of the produce. Therefore the viable alternative would be to select varieties based on stability.

The present investigation was taken up to evaluate certain newly evolved hybrid lines of sweet potato along with the local varieties based on the above considerations. The results of the present investigation are presented in the previous section and discussed hereunder.

I. Varietal evaluation.

The selected genotypes were evaluated in replicated trials at three test sites and results presented in Table 3. Significant variability was observed among the genotypes for all the characters under study in all the locations ($P < 0.01$). This was also observed in the higher genotypic and phenotypic coefficients of variation, especially in the tuber yield and harvest index (Table 16). The high variability present in the crop with regard to tuber yield indicates that the genotypes differs on their ability to express the final character, and these findings are in conformity with the results of Steinbauer et al. (1943), Massey et al. (1957), Scott and Wood (1962), Jones et al. (1969), Maier et al. (1970), Solpico et al. (1970), Haynes and Wheley (1971), Thamburaj and Muthukrishnan (1976), Kamalam et al. (1977) and Joseph (1979). The relatively large contribution of genotypic variance to the total variability suggest its scope for selection.

The comparatively higher phenotypic coefficients of variation expressed in the length of tuber indicate the large

environmental influence on the expression of this character. The genotypes varied to great extent with respect to tuber characters. Variation in such characters were also reported by Steinbauer et al. (1943), Massey et al. (1957), McDonald (1965), Jones et al. (1969), Haynes and Wholey (1971), Thamburaj and Muthukrishnan (1976), Kamalam et al. (1977) and Joseph (1979).

Statistical analysis of the chemical constituents revealed highly significant variation in carotene, starch and sugar contents among genotypes. These results are in accordance with the findings of Massey et al. (1957), Scott and Wood (1962) and Solpico et al. (1970) on carotene, Singh et al. (1969), and Solpico et al. (1970) on starch; and Singh et al. (1969) on sugar. However the genotypic and phenotypic coefficients of variation were comparatively low for starch and sugar content.

The differential expression and the differences in the relative ranking of genotypes with respect to yield and other characters at the three sites indicate the modification of the expression of character to a considerable extent by the fluctuations in environment. Such environmental effects may complicate selection programmes for superior genotypes.

Since sweet potato tubers are utilized for edible purposes, it would be desirable to improve the cooking and nutritional quality of the tuber. Usually, in plant breeding programmes that involve the exploitation of hybrid vigour,

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the traits such as quality aspects that fall out of the heterotic spectrum, may show low expressions. Hence screening must be done to select the genotypes that combine desirable characteristics for yield and quality. The major factors affecting the quality viz., flavour, texture, sweetness, fibre content, moistness and general acceptability of the tuber, are studied for each genotype after baking and baking indices worked out. The results thus obtained (Table 14) showed that all the genotypes are characterised by either high or medium baking indices.

II. Genotype x environment interaction.

Biologists concerned with the development and testing of new plant materials have been aware of the manifold difficulties encountered when varieties interact with the environment. Genotype x environment interactions constitute an important limiting factor in the estimation of variance components and the efficiency of selection programmes. However, little is known about the environmental factors which contribute to such interactions. Even if such information were available, the possibility of materially reducing such interactions under field conditions appear somewhat questionable (Sprague, 1966). Larger the interactions, lesser are the chances of progress under selection in a breeding programme, as shown by Comstock and Moll (1963).

Two alternative options are commonly recognised for plant breeders with respect to manipulating environmental interactions viz., to develop genotypes specially adapted to particular sub-regions or locations, or to develop genotypes that possess general adaptation. The former is often preceded by the stratification of environment into sub-regions such that all the environments in a sub-region will be somewhat similar. This stratification is usually based on macro-environmental differences like temperature gradient, rainfall distributions, soil types etc. However, even with this refinement of technique, the interaction of genotypes with locations in a sub-region, and with environments encountered at the same location in different seasons or years, frequently remain too large. Allard and Bradshaw (1964) termed as 'unpredictable', the environmental variation for which stratification was not effective.

Since little additional progress can be expected to reduce genotype x environment interaction by the stratification of environments, other methods need to be investigated. One such method is to select stable genotypes that interact less with the environments in which they are to be grown.

The stability analyses of variance (Tables 17 & 18) prove that differences between genotypes were significant for all the characters studied. The linear component of interaction was observed to be significant for the number of

branches, length of tubers, harvest index and tuber yield. These results show that the tested genotypes differed in their regression on environmental indices with respect to these characters. Such differences with respect to yield were also noticed by Biswas (1974) in jute, Lal et al. (1974) in soybean; Saini et al. (1974) in rice; Choudhury and Haque (1977) in green gram and Ramalam et al. (1976) in sweet potato. Non-linear component of interaction alone was significant for the top weight, length of vine, girth of tuber and dry weight of tuber, thereby indicating that the interaction was fully accounted for by the unpredictable nature of the characters. These results are in agreement with the findings of Yassin (1975) in field bean and Gautam and Jain (1977) in wheat for yield.

Both linear and non-linear components of interaction were highly significant for yield ($P < 0.01$). These results suggest that the interaction for yield in sweet potato is due to both the response of genotypes to varying environments and the deviation from the regression. This is in contrast to the finding of Ramalam et al. (1976) in this crop. However, the results of the present study are in agreement with that of several workers in different crops with respect to yield (Malhotra, 1971 in lentil; Verma et al., 1972 in soybean, Parode et al., 1975 in fodder sorghum; Choudhury and Haque, 1977 in green gram; Chaudhary et al., 1976 in wheat).

III. Stability parameters.

The selection for stability would not be possible until a model with suitable parameters is available to provide the criteria necessary to rank varieties for stability. In the present study the genotype H.2416 possessed the highest yield but the phenotypic stability was very poor, thereby indicating that it is adapted to rich environments. Similar is the case with genotypes H.2743, H.4021 etc. In the absence of information on phenotypic stability such lines will get selected in a breeding programme on the basis of yield alone, but they may be relative failures under adverse conditions. A strong positive correlation between mean performance and corresponding regression coefficients obtained in this study confirms the above point.

It is evident from the above discussion that some measure of stability must be made available to avoid the complications arising from the interaction of genotypes with environment. Various methods to measure stability were suggested by several workers including Lewis (1954), Plaisted and Peterson (1959) and Wricke (1962). A dynamic approach to the interpretation of varietal adaptation to varying environments was developed by Finlay and Wilkinson (1963). It led to the discovery of a linear relationship between genotype x environment interaction and environmental effects, when these effects were measured on the same scale as the genotypic effects. Finlay and Wilkinson (1963) defined

a stable variety as one that is having a mean value greater than the grand mean and a regression coefficient (phenotypic stability) tending to zero'.

The term 'stable variety' according to Finlay and Wilkinson (1963) means a variety that does relatively the same over a wide range of environments. This means that a 'stable variety' by its definition perform relatively better under adverse conditions than it would do in favourable environments. Eberhart and Russell (1966) have indicated that the maize hybrids with regression coefficients less than one usually have mean yields less than grand mean. However, a variety having above average productivity in all environment is preferred by the breeder. Eberhart and Russell (1966) defined stable variety as one that possesses a mean greater than grand mean, regression coefficient equal to one and deviation from regression tending to zero.

Later, Breese (1969), Sammel et al. (1970), Parodа and Fayos (1971) and Parodа et al. (1973) emphasized that linear regression should simply be regarded as a measure of response of a particular genotype, whereas the deviation from regression line should be considered as a measure of stability, genotypes with the lowest deviation being the most stable and vice-versa. But Raina and Gupta (1972) considered all the three parameters to be equally important in determining stability.

Frey (1964) reported that a good adaptable variety gives superior production over a wide range of environments. Bains and Gupta (1972) suggested that, the potential of genotype to express greater mean over environments should be the most important criterion, if at all an importance must be attached to a particular parameter, since the other parameters may not be of any practical utility, if the genotype is potentially weak. The genotypes H.2416, H.2421, H.2712, H.2743, H.2752, H.4021, H.4126, H.4328 and H.4024 showed very high mean values for tuber yield and thus satisfy the concept of Frey (1964) and Bains and Gupta (1972). These lines can be cultivated under favourable conditions with proper management.

Finlay and Wilkinson (1963) stated that regression coefficient tending to unity indicate average stability, when this is associated with high mean yield, varieties have general adaptability; and poorly adapted to all environments when associated with low mean yields. The genotypes H.2712, H.2747, H.2752 and H.4328 which showed average stability were well-adapted to a wide range of environments. The genotypes H.3032, H.3115, H.3402, H.3803, H.4025, H.4329 and Pichivella were poorly adapted to all environments (Table 19).

Eberhart and Russell (1966) suggested that a desired variety should have high mean, regression coefficient tending to unity and deviation from regression equal to zero.

In the present study the term 'mean' was substituted by another term 'phenotypic index' (Ram et al., 1968), for easy interpretation. It also makes possible a relative comparison, when there is differential response of genotypes to the environments.

Most of the varieties with respect to the various characters studied showed no significant S^2_{di} values (deviation from regression). This indicates that a linear regression model will suffice to explain the trend of response of these genotypes and predict the phenotypic expression of these characters in different environments with accuracy within the limits of sampling error. However certain varieties showed no such correspondence between phenotypes and environments, which was evident from their significant S^2_{di} values. Hence a linear model will not suffice for the predictability of the characters in the environments. This suggests for the need of a higher order regression to measure the response more accurately (Jinks and Pooni, 1979). It has been pointed out that the best polynomial regression would be a (n-1) regression model when there are 'n' sets of observations. Since there are only three test environments in the present study, a quadratic equation can be utilized to obtain an accurate trend of response of genotypes to environments. Verma et al. (1978) proposed two intersecting straight lines model to fit the observations. The limited number of test environments

may be one of the limitations in this particular work.

In the final selection of cultivars, it is usually considered necessary to identify separate genotypes performing well under high, low and wide range of environments. The scatter diagram gives the relative position of each genotype with respect to the three parameters of stability and helps in visualising the adaptability features. The genotypes H.2752 and H.2712 were found to satisfy all the three parameters fixed by Eberhart and Russell (1966), hence they can be recommended for general cultivation. Specific adaptations to rich environments were shown by H.2412, H.2416, H.2421, H.2742, H.2743, H.3302 and H.4021, since they combined positive phenotypic indices, low S^2_{di} values and b_i values greater than one. The genotypes H.4024 and H.4126 were particularly suited to poor environments, as suggested by their negative b_i values positive p_i and low S^2_{di} values. H.3052, H.3115, H.3603 and Michivelle were poorly adapted to all the environments, since they had negative phenotypic indices, low S^2_{di} value and b_i values approaching unity. H.4328, a high yielding genotype with b_i value tending to one, was unstable because of the unpredictability($S^2_{di} > 0$). Another high yielder H.2743 was found to be highly sensitive to fluctuations in the environment ($b_i > 1$) and had high S^2_{di} value thereby indicating that the prediction of yield based on the regression slope is not possible. The genotype H.2548 showed undesirability with respect to all

the stability parameters.

IV. Association between stability parameters

The correlation between the stability parameters viz., means and regression coefficients may give an insight into the selection strategies for the improvement in this crop. A significant positive correlation for yield ($r = 0.39$, $P < 0.05$) existed over genotypes between the parameters i.e., responsive genotypes tend to be high yielding. This is in agreement with the findings of Perkins and Jinks (1968a), Hanson (1970), Tai (1971), Verma et al. (1972), Brennan and Byth (1979) and Mehra and Ramanujam (1979), but is in contrast to the findings of Finlay and Wilkinson (1963). These findings suggest that there may be only a limited scope for the independent manipulation of mean yield and response, and that selection for yield or response may result in strong correlated response of other parameter. It can be concluded from this study that high yields over environments will result from the set of genotypes responsive to good environment and genotypes with low responsiveness would be expected to be low-yielding in general.

The study of genotype x environment interaction and stability parameters in crops have been a great boon to plant breeders engaged in developing varieties adapted to a broad spectrum of environments. Development of this study, to the present state is traceable to the contributions

by breeders and biometricians for the last two decades. This developing branch of quantitative genetics may find its application not only in the much familiar role of partitioning variances and finding out stability, but also be exploited in other biometrical studies for better conclusions. However, the regression analysis used for this study is not without some limitations. If these limitations are recognized well, the regression analysis would help the plant breeder in selecting genotypes combining high yield and stability. Further, it would be possible to make predictions regarding the performance of genotypes across environments as well as generations.

The present study has made it possible to identify genotypes adapted to specific ecological conditions and to a wide range of environments. The genotypes showing general adaptation can be expected to give a uniform performance over the diverse agro-climatic conditions. However, it was not within the scope of the present investigation to study the effects of different years or seasons on the performance of this crop. Studies may be taken up in this direction to derive meaningful information on genotype x year or season interaction and identify varieties that will perform uniformly across the time.

SUMMARY

SUMMARY

Twenty eight lines of sweet potato were tested in replicated trials in three test environments and data collected on nine biometrical characters. Chemical analysis was carried out to estimate the chemical constituents for one location. Analysis of variance of the data revealed highly significant differences among the genotypes with respect to all the characters studied. Genotypic coefficients of variation exceeded 25 per cent for six out of the twelve characters. Very high phenotypic coefficients of variation compared to the genotypic coefficients of variation for certain characters indicated a larger environmental influence. A baking index test conducted pointed out that all the genotypes could be categorised into good and medium quality.

The analysis of variance for the stability revealed the existence of significant genotype x environment interaction for all the characters studied. The linear component of interaction alone was significant for three characters, suggesting the varieties differed in their regression on environmental indices. The interaction was due to non-linear component for five characters which indicated that the interaction was contributed by the unpredictability. However, both linear and non-linear components of interaction were observed to play significant role in the genotype x

environment interaction with respect to yield. The interaction, in general, speaks of the influence of environment on the varietal performance and suggest the need for the selection of varieties based on stability.

Stability parameters viz., phenotypic indices, regression coefficients and deviation from regression, were worked out for all the genotypes with respect to the biometrical characters. Genotypes characterised by different adaptability features were identified with respect to various characters. The genotypes H.2752 and H.2712 satisfied all the three parameters for yield and hence can be recommended for general cultivation. Specific adaptations to favourable environments were shown by H.2412, H.2416, H.2421, H.2742, H.2743, H.3802 and H.4021. The genotypes H.4024 and H.4126 were particularly suited to poor environments. H.3032, H.3115, H.3803 and Kichivella showed poor adaptation to all the environments. Two high yielding genotypes H.2745 and H.4328 were unstable because of the unpredictability of the performance.

The correlation between the mean values and regression coefficients of the various characters were worked out. Significant positive correlation was observed between the parameters of five characters and significant negative correlation was shown by only the dry weight of tubers. All the other characters showed no association between the two

parameters. The significant correlation obtained in various characters indicates that the manipulation of the individual parameters is not possible and selection based on one will have a correlated response on the other.

REFERENCES

REFERENCES

*Abo-Hegazi, A.M.T., Ibrahim, A.A. and Nassib, A. (1976). Environmental effects on seed protein content in relation to yield components in field bean. Poliow. Annu. Smotra, 46: 95-104.

Adams, M.W. and Shank, D.B. (1959). The relationship of heterozygosity to homeostasis in maize hybrids. Genetics, 44: 777-786.

*Akerman, A. (1922). Untersuchungen uber eine in directem sonnenlichte nicht lebensfahige eigne von Avena sativa. Hereditas, 3: 147-177.

*Aldrich, D.T.A. (1973). The effect of years and locations on the performance of grass species and varieties. J. Sci. Food Agric., 29: 305.

Ali-Khan, S.T. and Youngs, C.G. (1973). Variation in protein content of field peans. Can. J. Plant. Sci., 53: 37-41.

Allard, R.W. (1961). Relationship between genetic diversity and consistency of performance in different environments. Crop Sci., 1: 127-133.

Allard, R.W. and Bradshaw, A.D. (1964). Implications of genotype-environmental interaction in applied plant breeding. Crop Sci., 4: 503-508.

*Allard, R.W. and Workman, P.L. (1963). Population studies in predominantly self-pollinated species. IV. Seasonal fluctuations in estimated values of genetic parameters in lima bean populations. Evolution, 17: 470-480.

Anonymous (1960). Official Methods of Analysis. Association of Official Agricultural Chemists. Washington 4, D.C. pp. 417-447. 9th Ed.

Anonymous (1978). Package of Practices Recommendations. Directorate of Extension Education, Kerala Agricultural University, Vellanikkara pp. 78-80.

Bains, K.S. and Gupta, V.P. (1972). Stability of yield and yield components in bread wheat. Indian J. Genet., 32: 306-312.

*Bernier, B.d. and Sinha, S.P. (1970). Estimation of the components of the variety x locality interaction in a series of experiments. Agric. tec., Santiago, 30: 100-104.

Bosak, S.L. (1968). Suggestions for genetic improvement of jute for fibre yield. Indian J. Genet., 28: 260-265.

*Chuller, S.S., Gill, K.S. and Khehra, A.S. (1975). Combining ability in successive generations of diallele crosses in wheat (Triticum aestivum L.) Genet. Agrar., 29: 317-325.

Biswas, S.R. (1974). Stability parameters of some varieties of white jute. Indian J. agric. Sci., 44: 491-494.

*Dilss, F.A. (1975). Cowpeas in Nigeria. Nutritional Improvement in Food Legumes by Breeding. II. Status and Potential for Genetic Improvement of Food Legumes (Ed. Milner, M.). John Wiley & Sons, New York. pp.151-158.

*Dorghi, P., Testoni, A., Cattaneo, M. and Corbellini, M. (1975). Effects of genetic-environment interaction on different tests for bread making quality evaluation Genet. Agrar., 29: 391-404.

*Dornscheuer, F. (1973). Influence of climatic regions on various characteristics determining the performance of genetically distinct sugarbeet varieties. Zucker, 26: 263-266.

Bradshaw, A.D. (1965). Evolutionary significance of phenotypic plasticity in plants. Adv. Genet., 13: 115-155.

Breese, E.L. (1969). The measurement of significance of genotype-environment interaction in grasses. Heredity, 24: 26-44.

*Breese, E.L. (1972). Biometrical genetics and its application. Proc. VI. Eucarpia Congr., Cambridge: 139-146.

Brennan, P.S. and Byth, D.E. (1979). Genotype x environmental interactions for wheat yields and selection for widely adapted genotypes. Aust. J. Agric. Res., 30: 221-232.

Bucio-Alanis, L. (1966). Environmental and genotype-environmental components of variability. I. Inbred lines. Heredity, 21: 387-397.

Bucio-Alanis, L. and Hill, J. (1966). Environmental and genotype-environmental components of variability II. Heterozygotes. Heredity, 21: 399-405.

*Buitrago, G.L.A., Orozco, S.F.H. and Camacho, M.L.H. (1971). Studies on stability of the yield in 16 homozygous lines of soybean (Glycine max (L.) Merr). Acta Agron., 21: 93-102.

Butler, I. (1978). Effect of different environments on fruit size in the tomato. Can. J. Genet. Cytol., 20: 441.

*Byth, D.E. (1977). A conceptual basis of G x E interactions for plant - improvement. Proc. 3rd Int. Congr. SABRAO, Canberra, Feb. 1977, Sect. 3(d), pap.1.

Byth, D.E., Eisemann, R.L. and DeLacy, I.H. (1976). Two-way Pattern analysis of large data set to evaluate genotypic adaptation. Heredity, 37: 215-230.

Chary, T.S., Patel, G.J. and Jaisani, B.G. (1975). Interactions of tobacco genotypes with varying environments. Tob. Res., 1: 119-121.

*Choudhury, B.S., Paroda, R.S. and Singh, V.P. (1975). Stability and genetic architecture of harvest index in wheat (Triticum aestivum L.). Z. Pflanzenzucht., 81: 312-316.

Chowdhury, S.K. and Haque, M.N. (1977). Stability performance of some green gram varieties. Indian J. agric. Sci., 44: 217-220.

*Comstock, R.E. and Moll, R.H. (1963). Genotype-environment interactions. Stat. Genet. and Pl. Breed., NAS-NRC, Publ., 982: 164-196.

Constantin, M.J., Hernandez, T.P., Muller, J.C. and Hamlet, M.L. (1966). Inheritance of baking quality in the sweet potato. Ipomoea batatas. Proc. Amer. Soc. Hort. Sci., 88: 490-500.

Das, P.K. and Jain, H.K. (1972). Studies on adaptation in wheat. III. Chiasma formation and varietal adaptability. Indian J. Genet., 32: 181-184.

Dhillon, B.S. and Singh, J. (1977). Inheritance of grain yield and other quantitative traits in maize. Exp. Agric., 13: 253-256.

Dowker, B.D., Jackson, J.F. and Phelps, K. (1976). Variation studies in carrots as an aid to breeding. VI. Genotype-environment interactions in contrasting field environments. J. Hortic. Sci., 52: 151-157.

Eberhart, S.A. and Russell, W.A. (1966). Stability parameters for comparing varieties. Crop Sci., 6: 36-40.

*Espino, R.R., Barroso, A. and Martin, J. (1977). Effects of genotype-environment interaction on chemical composition on Cuban-dark tobacco. Agrotecnia, 3: 45-51.

*Fejer, S.O. (1967). Growth and phenotypic stability under controlled environments in inbred and outcrossed Lolium populations and individual plants. Z. Pflanzenzucht., 58: 151-196.

*Fejer, S.O. (1973). Genotype x years interactions in ecovalence in raspberry selections. Can. J. Genet. Cytol., 15: 228-229.

*Finlay, K.W. (1963). Adaptation - its measurement and significance in barley breeding. Proc. 1st. Int. Barley Gen. Symp. Wageningen. 351-359.

Finlay, K.W. and Wilkinson, G.N. (1963). The analysis of adaptation in plant breeding programme. Aust. J. Agric. Res., 14: 742-754.

Freeman, G.H. and Dowker, B.D. (1973). The analysis of variation between and within genotypes and environments. Heredity, 30: 97-109.

Freeman, G.H. and Perkins, J.M. (1971). Environmental and genotype-environmental components of variability. VIII. Relation between genotypes grown in different environments and measures of the environments. Heredity, 27: 15-23.

Frey, K.J. (1964). Adaptation reaction of oat strains selected under stress and non-stress environmental conditions. Crop Sci., 4: 55-58.

*Gallo, M.A.C. (1968). Sweet potato cultivars. 1940-1964. Final Rep. Agric. Res., Pretoria, Parts 1-3, p.171.

Ganga Prasada Rao, N. (1969). Genotype x environment interaction in grain sorghum hybrids. Indian J. Genet., 29: 75-80.

*Gardner, C.O. and Harvock, J.H. (1977). Stability of yield of original and improved populations of maize grown over a wide range of environments. Agron. Abst., 1977. 55-56.

*Gautam, P.L. and Jain, K.B.L. (1977). Nature of genotype x environmental interactions for various characters in durum and common wheats. Genetics and Wheat Improvement. VII Durum and Triticales (M. Gupta, A.K.). Oxford and IBH Publishing Co. New Delhi. p.225-231.

Ghosh, A.K. (1972). Stability in rice varieties. Oryza, 9(2): 1-18.

Gopani, D.D., Kabaria, L.N. and Joshi, S.N. (1972). Stability parameters for comparing varieties of soybean (Glycine max (L.) Merr). Indian J. agric. Sci., 42: 400-404.

Grafius, J.E. (1956). Components of yield in oats-a geometrical interpretation. Agron. J., 48: 419-423.

Gridley, H.E. (1975). Breeding implications from a diallel analysis in two environments of yield and yield component characters in upland cotton (Gossypium hirsutum.). Theor. Appl. Genet., 46: 401-406.

*Griffing, B. and Langridge, J. (1963). Phenotypic stability of growth in the self-fertilized species. Arabidopsis thaliana. Stat. Genet. and Pl. Breed. NAS-NRC. Publ. 982: 369-394.

*Gupta, V.P., Khehra, A.S. and Bains, K.S. (1977). Concepts in stability analysis, Genetics and Wheat Improvement. V. Genetics of adaptability and Physiology. (M.Gupta, A.K.). Oxford and IBH Publishing Co. New Delhi. pp.141-184.

*Hammett, H.L. (1974). Total carbohydrate and carotenoid content of sweet potato as affected by cultivar and area of production. Hortscience, 9: 305.

*Hanneman, R.E. Jr. and Ruhde, R.W. (1977). Evaluation of group Tuberosum haploids for tuber set, yield, specific gravity, chipping and dormancy. Am. Potato J., 54: 494.

Hanson, W.D. (1970). Genotypic stability. Theor. Appl. Genet., 40: 226-231.

*Haufe, W. and Geidel, H. (1978). Assessing the yield stability of varieties and breeding lines. I. Definitions, parameters of stability and the possibilities of their interpretations. Z. Pflanzenzucht., 80: 24-37.

Hayes, H.K. (1922). Production of high protein maize by Mendelian methods. Genetics, 7: 237-257.

Haynes, P.H. and Wholey, D.W. (1971). Variability in commercial sweet potato (Ipomoea batatas (L.) Lam) in Trinidad. Exp. Agric., 7: 27-32.

Hill, J. (1975). Genotype-environment interactions - a challenge for plant breeding. J. agric. Sci., Camb., 85: 477-493.

*Immer, F.R. and Ausemus, E.R. (1931). A statistical study of wheat and oat strains grown in rod-row trials. J. Am. Soc. Agron., 23: 118-131.

Innes, N.L., Wimble, R.H. and Gridley, H.E. (1975). Estimates of genetic parameters for lint quality in upland cotton (Gossypium hirsutum). Theor. Appl. Genet., 46: 249-256.

*Jain, S.K. and Allard, R.W. (1960). Population studies in predominantly self-pollinated species. I. Evidence for heterozygote advantage in a closed population of barley. Proc. U.S. Nat. Acad. Sci., 46: 1371-1377.

*Jermyn, W.A. (1977). Limitation on breeding high protein field peas. Proc. Agron. Soc. NZ., 7: 89-91.

*Jinks, J.L. and Mather, K. (1955). Stability in development of heterozygotes and homozygotes. Proc. Roy. Soc. B., 143: 561-578.

Jinks, J.L. and Pooni, H.S. (1979). Non-linear genotype x environment interactions arising from response thresholds. I. Parents, F_1s and selections. Heredity, 43: 57-70.

*Johannsen, W. (1909). Elemente der exakten Erblichkeitslehre. 1st ed. 515 pp, Jena, Gustav Fisher.

Jones, A., Steinbauer, C.E. and Pope, D.T. (1969). Quantitative inheritance of ten root traits in sweet potatoes. J. Amer. Soc. Hort. Sci., 94: 271-275.

*Jong, S.K. and Park, K.I. (1975). Variety x environmental interaction in sweet potato (Ipomoea batatas Lam.) tests in Korea. Res. Rep. Office Rural Develop., Korea, 17: 125-130.

Joseph, C.A. (1979). Genetic studies in sweet potato (Ipomoea batatas (L.) Lam.) - a biometric approach, Ph.D. Thesis, Kerala Agricultural University.

Joshi, S.N. (1972). Stability parameters for comparing green gram (Phaseolus aureus Roxb.) varieties. Madras agric. J., 59: 195-197.

Joshi, S.N., Vaishnani, N.P. and Kabaria, M.M. (1972). Stability parameters in bunch varieties of groundnut (Arachis hypogea L.). Indian J. agric. Sci., 42: 145-147.

Jowett, D. (1972). Yield stability parameters for sorghum in East Africa. Crop Sci., 12: 314-317.

Kaltsikes, P.J. and Larter, E.N. (1970). The interaction of genotype and environment in durum wheat. Euphytica, 19: 236-242.

Kannan, P., Sivadas, A.S. and Unnithan, K. (1978). Stability parameters in sweet potato (Ipomoea batatas Lam.) J. Root Crops, 4(1): 35-39.

Kanalam, P., Biradar, T.S., Hrishi, N. and Rajendran, P.C. (1977). Path analysis and correlation studies in sweet potato (Ipomoea batatas Lam.). J. Root Crops, 3(1): 5-11.

Keeble, F. and Pellew, C. (1910). The mode of inheritance of stature and time of flowering in peas (Pisum sativum) J. Genet., 1: 47-56.

*Kerr, T.A. (1969). Do tomato cultivars deteriorate after they are introduced. Rep. Hortic. Res. Inst., Ont., Toronto, for 1969 pp. 71-75.

Khan, A.A. and Jenkins, W. (1970). The adaptation of winged bean (Psophocarpus tetragonolobus (L.) DC) in Papua New Guinea. Aust. J. Agric. Sci., 29: 281-289.

Kofoid, K.D., Rees, D.M. and Kumm, H.F. (1970). Yield stability of sorghum random-mating populations. Crop Sci., 10: 677-679.

Kushman, L.J. and Pope, W.T. (1970). Changes in pH and total acidity of sweet potatoes exposed to cold soil conditions before harvest. Hortscience, 5: 510-511.

Lal, M.S., Mishra, S.K. and Pandya, B.C. (1974). Stability of performance of soybean varieties in Madhya Pradesh. Indian J. Agric. Sci., 44: 217-220.

Land, D.G. (1975). Carrot flavour and the factors which influence it. J. Sci. Food Agric., 26: 1610.

Lauer, F.I. and Deborough, S. (1977). Variation in potato tuber protein content in the cultivated Solanum groups and selected hybrids. Am. Potato J., 54: 501-502.

Lerner, I.M. (1954). Genetic Homeostasis. Oliver and Boyd, London.

Lewis, D. (1954). Gene-environment interaction. A relationship between dominance, heterosis, phenotypic stability and variability. Heredity, 8: 333-356.

*Li, L. (1975). Studies on the influence of environmental factors on the protein content of sweet potato. J. Agric. Assoc., China, No. 92, 64-72.

Macarthur, A.W. and Killick, R.J. (1976). Environmental and genetic variation in some economically important traits in potatoes. J. Agric. Sci., UK. 87, 39-45.

*Maior, I., Duta, A., Popescu, V. and Paunel, I. (1970). New contributions to the knowledge of the biology and technology of the sweet potato (Ipomoea batatas Poir. fam. Convolvulaceae). Lucr. Stiint. Inst. Agron. Nicolae Balcescu. 11: 45-51.

*Majiwa, B.M. and Doggett, H. (1972). The yield stability of sorghum varieties and hybrids in East African environments. East Afr. Agric. For. J., 38: 179-192.

Malhotra, L.S., Singh, K.B., Muller, J.C. and Sethi, S.C. (1971). Phenotypic stability in lentil. Indian J. Genet., 31: 21-25.

Massey, P.H. Jr., Wheart, J.T., Young, W.W. and Gamper, H.M. (1957). The effects of variety on the yield and vitamin content of sweet potatoes. Proc. Amer. Soc. Hort. Soc., 69: 431-435.

*Mather, K. (1943). Polygenic inheritance and natural selection. Biol. Rev., 18: 32-64.

Maurya, D.M. and Singh, D.P. (1977). Adaptability in rice. Indian J. Genet., 37: 403-410.

*McDonald, A.S. (1955). Variation in open pollinated sweet potato seedlings in Bujanda, East Africa. East Afr. Agric. For. J., 21: 181-183.

*Moddhat-El-Hagar, A. and El-Fadl, M.A. (1978). Testing yield in interline hybrids of maize consisting of Bulgarian and Egyptian conditions. Genet. Sel., 11: 234-241.

Mohra, R.D. and Ramanujam, S. (1979). Adaptation in segregating population of Bengalgram. Indian J. Genet., 39: 492-500.

*Mejia Contreras, J.A. and Munoz Orozco, A. (1977). Evaluation of local maizes for the rainy season in Yucatan State. Chapingo, No.5: 7-12.

Moroditch, S.N. Jr. and Bridge, R.R. (1972). Heterosis and gene action in cotton, Gossypium hirsutum L. Crop Sci., 12: 304-310.

Mohinder Singh, Bodwal, O.S. and Jaswal, S.V. (1975). Stability of pod yield in groundnut. Indian J. Genet., 35: 26-26.

*Muller, H.P. and Gottschalk, W. (1978). Gene-ecological investigation on the protein production of different Pisum genotypes. Seed protein Improvement by Nuclear Technique Proc. Tec Mee. Co-ord. Meetings Baden, Vienna pp. 26-30, 301-314.

Mungomery, V.E., Shorter, R. and Byth, D.E. (1974). Genotype x environmental interactions and environmental adaptation. I. Pattern analysis-application to soyabean populations. Aust. J. Agric. Res., 25: 59-72.

*Oinuma, T. and Ayabe, T. (1969). Environmental variation of genetic statistics in flue-cured tobacco. Bull. Justo. Tob. Imp. Sta., (1): 45-54.

Ojomo, O.A. and Adelna, E.O. (1970). Variety x environment interactions in groundnut variety tests in Western Nigeria. J. agric. Sci., Camb., 75: 477-493.

*Oka, H.I. (1973). Performance in Central Luzon of soybean varieties selected in Taiwan for wide adaptability. SABRAO Newsl., 5(1): 29-30.

*Oka, H., Nakamura, A. and Yonada, T. (1977). Adaptability to cultural environments of doubled haploid lines of flue cured tobacco. SABRAO J., 9(2): 111-116.

*O'Keefe, R.B. (1971). Effect of genotype-environment and their interactions on potato yields and quality. Am. Potato J., 54: 495-496.

O'Kelly, J.F. and Hull, W.W. (1952). Parent-progeny correlations in corn. J. Am. Soc. Agron., 24: 061-067.

O'Kelly, J.F. and Hull, W. . (1953). Parent-progeny correlations in cotton. J. Am. Soc. Agron., 25: 115-119.

*Okuno, T., Mukuchi, F., Kumagai, T., Okuno, C., Shiyomi, H. and Tabuchi, H. (1971). On methods of evaluating the interactions between varietal characters and environment. Bull. Nat. Inst. Agric. Sci. Ser. A., 18: 93-147.

Pandey, S. and Gritton, E.T. (1975). Genotypic and phenotypic variances and correlations in peas. Crop Sci., 15: 353-356.

Panse, V.G. and Sukatme, P.V. (1961). Statistical Methods for Agricultural Workers. Indian Council of Agricultural Research. New Delhi. pp. 134-141. 2nd ed.

Parode, B.S. and Hayes, J.D. (1971). An investigation of genotype-environment interactions for rate of ear emergence in spring barley. Heredity, 26: 157-175.

Parode, B.S., Panwar, D.V.S. and Sharma, C.B. (1973). Genotype x environment interactions for fodder yield in sorghum. Indian J. agric. Sci., 43: 306-310.

*Tathak, A.M. and Upadhyay, V.M. (1975). Influence of agro-climatic on the quality characteristics of rice. Int. Rice Comm. Newsl., 24(2): 121-127.

Perkins, J.M. (1970). Environmental and genotype-environmental components of variability. VI. Diallele sets of crosses. Heredity, 25: 29-40.

Perkins, J.M. and Jinks, J.L. (1968a). Environmental and genotype-environmental components of variability III. Multiple lines and crosses. Heredity, 23: 339-356.

Perkins, J.M. and Jinks, J.L. (1968b). Environmental and genotype-environmental components of variability. IV. Non-linear interaction for multiple inbred lines. Heredity, 23: 525-535.

Perkins, J.M. and Jinks, J.L. (1971). Specificity of the interaction of genotypes with contrasting environments. Heredity, 26: 465-474.

Peter, K.V. and Rai, B. (1976). Stability parameters and genotype x environment interactions in tomato. Indian J. agric. Sci., 46: 395-398.

*Plaisted, R.L. and Peterson, L.C. (1959). A technique for evaluating the ability of selection to yield consistently in different locations and seasons. Am. Potato J., 36: 381-385.

*Pollmer, W.G., Eberhard, D. and Klein, D. (1978). Inheritance of protein and yield of grain and stover in maize. Crop Sci., 18: 797-799.

Rooni, H.S., Jinks, J.L. and Jayaseelhare, N.P.M. (1975). An investigation of gene action and genotype x environment interaction in two crosses of Nicotiana rustica by triple test cross and inbred line analysis. Heredity, 41: 83-92.

*Quaglot, C.C. (1966). Population structure and performance in wheat. III. Intern. Wheat Genet. Symp. (Eds. Finlay, K.W. and Shepherd, K.W.). pp.397-402.

*Ram, J., Jain, O.P. and Murty, B.R. (1968). Stability performance of some varieties and hybrid derivatives of rice under high yielding varieties programme. Ann. Conf. Indian Soc. Agric. Stat., Patna December 1968.

Rao, P.G.P., Venkataraman, R., Raipathi, D.P., Rama, V.L.S. and Sachan, J.S. (1969). Comparitive performance of hybrids and some improved varieties in grain sorghum. Indian J. Genet., 29: 79-87.

Rao, K.S. and Rao, P.V. (1978). Genotypic stability of sorghum varieties and hybrids. Indian J. agric. Sci., 48: 691-695.

Reich, V.H. and Atkins, R.E. (1970). Yield stability of four population types of grain sorghum, Sorghum bicolor (L.) Moench., in different environments. Crop Sci., 10: 511-517.

Rohoual, S.S. (1970). Stability of some superior soybean varieties. Indian J. Genet. 30: 650-655.

Saini, S.S., Sidhu, G.S., Ish Kumar and Goomber, P.S. (1974). Phenotypic stability for yield of some rice varieties. Indian J. agric. Sci., 44: 644-647.

Samuel, C.J.A., Mill, J., Breese, E.L. and Davis, A. (1970). Assessing and predicting environmental response in Lolium perenne. J. agric. Sci., Camb., 75: 1-9.

Sawant, A.R. and Mandloi (1974). Genotype x environment interaction, heritability and genetic advance for yield in potato (Solanum tuberosum L.). Indian J. agric. Sci., 44: 159-164.

*Schaffert, R.E., Osvalt, D.L. and Pickett, R.C. (1972). Genotype by environment interaction effects for grain yield, protein lysine, oil and seed weight of Sorghum bicolor (L.) Moench. Agron. Abst., 19.

*Scott, P.R. and Wood, C.B. (1962). 1961 variety trials: tomato, sweet potato. Res. Rev. Va. agric. Exp. Sta., No.61 pp.30.

*Sekhon, B.S. and Howe, P.C. (1969). Influence of environments on diploid and tetraploid potatoes. Agron. Abst., 17.

*Sekioka, T.T. and Lauer, F.I. (1970). Some estimates of genotype x environment interactions in potato variety tests. Am. Potato J., 47: 304-310.

Shankara Gowda, B.T., Mahadevappa, M., Shivappa, T.G. and Shivananda iah, H.T. (1975). Yield stability of rice varieties in uniform varietal trials. Indian J. agric. Sci., 43: 449-451.

*Shimamoto, T. and Hosokawa, S. (1977). Response of varieties of sugarbeet to various locations and years. SABRAO J., 9: 117-126.

Shorter, R., Byth, D.E. and Mungomery, V.E. (1977). Genotype x environment interactions and environmental adaptations. II. Assessment of environmental contributions. Aust. J. Agric. Res., 28: 223-235.

Simmonds, N.W. (1962). Variability in crop plants its use and conservation. Biol. Rev., 37: 422-465.

Singh, B.P., Agnihi, D.N. and Singh, L.B. (1969). Potentiality of sweet potato starch industry in India. Plant Sci., 1: 176-180.

Singh, H.B., Mittal, R.K. and Upadhyay, R. L. (1973). Variety x environment interaction in American cotton (Gossypium hirsutum L.) in Uttar Pradesh. Indian J. agric. Sci., 43: 465-466.

*Singh, P., Singh, I.S. and Singh, V. (1976). Phenotypic stability in black gram (Vigna mungo (L.) Hilezek). Tron. Grain Leg. Bull., No.6, 13-14.

*Solpico, J.O., Virtucio, R.R. and Cabueen, A.M. (1970). Screening of sweet potato varieties. Philipp. J. Plant Ind., 35: 71-78.

Sprague, G.F. (1966). Quantitative genetics in plant breeding. Plant Breeding Symp. Iowa State University (Ed. Frey, K.J.). pp. 315-354.

*Steinbauer, C.E., Hoffman, C.P. and Khazal, J.D. (1943). Why are single plant yields of sweet potato highly variable within plants. Proc. Amer. Soc. Hort. Sci., 43: 249-254.

Suryanarayana Rao, K., Rukmini, C. and Mohan, V.S. (1968). Carotene content of some yellow endosperm varieties of sorghum. Indian J. agric. Sci., 38: 366-372.

*Sulczynski, K.M., Kocyk, B. and Wojcik, K. (1975). The interaction clones x sites and clones x years in the evaluation of potato breeding materials. Bul. Inst. Ziemniaka, No. 15, 7-25.

Tai, G.C.C. (1971). Genotypic stability analysis and its application to potato regional trials. Crop Sci., 11: 184-190.

Tan, G.Y., Tan, W.K. and Walton, P.D. (1978). Seedling growth of smooth bromegrass measured in five environments. Crop Sci., 18: 601-604.

*Tan, W.K., Tan, G.Y. and Walton, P.D. (1978). The significance of genotype-environment interaction in breeding smooth bromegrass. Agron. Abst., 64.

Tan, W.K., Tan, G.Y. and Walton, P.D. (1979a). Genotype x environment interactions in smooth brome grass. I. Yield. Can. J. Genet. Cytol., 21: 57-65.

Tan, ".E., Tan, G.Y. and Walton, P.D. (1979b). Genotype x environment interactions in smooth brome grass. II. Morphological characters and their association with forage yield. Can. J. Genet. Cytol., 21: 73-80.

Tara Mohan, S. and Jain, H.F. (1975). Adaptation in wheat. IV. Nucleic acid synthesis and varietal adaptation. Indian J. Genet., 35: 428-431.

*Teggo, G., Putz, B. and Meitmann, H.D. (1976). Effect of cultivar and site on viscosity properties of potato starch. Starke 28: 130-135.

*Tehlan, H.S., Sharma, S.C. and Singh, K.K. (1977). Measurement of phenotypic stability in wheat. Genetics and Wheat Improvement. V. Genetics of Adaptability and Physiology. (Ed.Gupta, A.K.) Oxford and Publishing Co. New Delhi. pp.157-166.

Thamburaj, S. and Muthukrishnan, C.R. (1976). Association of metric traits and path analysis in sweet potato (Ipomoea batatas Lam.) Madras agric. J., 63: 1-3.

*Toul, V. (1974). The influence of the cultivation site on the β-carotene content of carrots. Bull. Vyskumny ustav Zelinarsky, Olomouc, No.18, 49-60.

*Toll'ke, R.A., Kachur, O.I. and Sadykova, S.A. (1979a). Variation in genetic parameters in a diallele analysis of quantitative characters in spring bread wheat. II. Straw length. Genetika, 15: 275-285.

*Toll'ke, R.A., Kachur, O.I. and Sadykova, S.A. (1979b). Variation in genetic parameters in a diallele analysis of quantitative characters in spring bread wheat. III. Ear length. Genetika, 15: 286-297.

*Utkhede, A.S. and Mai, T.B. (1974). Stability performance of some composites and hybrids in maize (Zea mays L.). Proc. Fifth East Afr. Cereal Res. Conf., 126-135.

*Utz, H.F. and Alber, K.D. (1978). An extended analysis of a series of trials of experimental maize hybrids. Z. Pflanzenzucht., 80: 177-187.

Verma, M.M., Chahal, G.S. and Murty, B.R. (1978). Limitations of conventional regression analysis - a proposed modification. Theor. Appl. Genet., 53: 89-91.

Verma, M.M., Murty, B.R. and Harbhajan Singh (1972). Adaptation and genetic diversity in soybean. Indian J. Genet., 32: 266-275.

Wallace, B. and Srb, A.M. (1963). Adaptation. Prentice-Hall of India, New Delhi. pp. 89-95.

Ward and Pigman (1970). The carbohydrates. Analytical Methods for Carbohydrates Vol. II. D. Academic Press, New York and London. pp.765.

*Williams, R.A. (1975). Varietal response in sugarbeet to times of sowing and harvesting and the duration of growing seasons. J. Nat. Inst. Agric. Bot., 8: 380-385.

*Wricke, G. (1962). Über eine methode zur erfassung der ökologischen streubreite in feldversuchen. Z. Pflanzenzucht., 47: 92-96.

Yassin, T.E. (1973). Analysis of yield stability in field beans (Vicia faba L.) in the Northern Province of the Sudan. J. Agric. Sci. Camb., 80: 119-124.

*Original not seen

APPENDICES

Appendix I

Weather data (weekly average) from 21st February to 6th June 1979 (Velleyani)

Date	Weeks	Temperature °C		R.H.	Total R.F. . mm
		Maximum	Minimum		
Feb.21 - Feb. 27	1	31.5	23.0	95.5	2
Feb.28 - March 6	2	31.6	23.2	89.5	29
March 7 - March 13	3	31.8	23.2	89.0	9
March 14 - March 20	4	31.9	23.2	92.0	15
March 21 - March 27	5	32.3	24.1	90.0	-
March 28 - April 3	6	31.8	23.8	90.15	-
April 4 - April 10	7	33.5	24.2	87.0	11
April 11 - April 17	8	33.5	24.4	90.1	3
April 18 - April 24	9	33.3	25.0	89.0	-
April 25 - May 1	10	33.2	25.1	89.5	83
May 2 - May 8	11	31.8	23.8	92.5	85
May 9 - May 16	12	32.0	25.0	90.0	14
May 17 - May 23	13	32.3	25.1	88.6	-
May 24 - May 30	14	32.0	24.6	87.6	11
May 31 - June 6	15	31.3	24.3	84.5	75

Appendix II

Weather data (weekly averages) from 14th February to 30th May 1979 (Haromana)

Date	Weeks	Temperature °C		R.H.	Total r.f. mm
		Maximum	Minimum		
Feb.14 - Feb.20	1	32.33	23.56		47.5
Feb.21 - Feb. 27	2	33.16	23.50		4.5
Feb.28 - March 6	3	33.00	25.80	Not available	21.5
March 7 - March 13	4	33.70	24.00		-
March 14 - March 20	5	34.33	24.17		-
March 21 - March 27	6	34.33	24.42		18.5
March 28 - April 3	7	33.50	22.33		-
April 4 - April 10	8	33.25	26.00		-
April 11 - April 17	9	37.00	26.00		-
April 18 - April 24	10	33.16	26.08		47.5
April 25 - May 1	11	33.10	26.08		3.5
May 2 - May 8	12	33.00	26.40		24.0
May 9 - May 15	13	34.00	33.00		58.5
May 17 - May 23	14	33.83	25.50		33.0
May 24 - May 30	15	33.73	25.06		-

Appendix III

Weather data (weekly averages) from 7th February to 23rd May 1971 (Kayamkulam)

Date	Weeks	Temperature °C		R.H.	Total R.F. mm
		Maximum	Minimum		
Feb.7 - Feb.13	1	33.9	23.2	87	-
Feb.14 - Feb. 20	2	34.2	23.0	91	-
Feb.21 - Feb. 28	3	34.6	21.4	88	-
Feb.29 - March 6	4	33.4	24.1	95	39.6
March 7 - March 13	5	33.1	24.7	94	5.8
March 14 - March 20	6	34.3	24.8	92	2.4
March 21 - March 27	7	34.9	24.6	93	1.0
March 28 - April 3	8	34.8	25.7	90	4.2
April 4 - April 10	9	34.1	25.8	94	4.6
April 11 - April 17	10	34.9	25.9	92	9.2
April 18 - April 24	11	34.8	24.8	91	3.2
April 25 - May 1	12	33.5	25.0	93	93.0
May 2 - May 8	13	31.2	24.6	94	371.0
May 9 - May 15	14	31.2	25.4	94	46.2
May 16 - May 23	15	29.8	24.0	94	126.2

ABSTRACT

Twenty eight lines of sweet potato were grown under three environments during third crop season, 1979 in a Randomised Block Design. The varieties were evaluated for the biometrical observations and chemical constituents of the tubers. Significant variation among the genotypes with respect to these characters were observed. A baking index test was carried out to determine the quality aspects of tubers.

The field data from these environments were used to calculate the stability parameters by the methods suggested by Eberhart and Russell(1966)estimates of stability parameters for yield indicated that only two genotypes viz., H.2752 and H.2712 satisfied all the three parameters showing general adaptations. H.2412, H.2416, H.2421, H.2742, H.2743, H.3002 and H.4021 showed specific adaptations to favourable environments. Specific adaptations to poor environments were shown By H.4024 and H.4126. The genotypes H.3032, H.3115, H.3003 and Pkdivella were poorly adapted to all the environments. In a correlation study between the mean values and regression coefficients, some characters showed either a positive or negative association, whereas non-significant correlation was observed in other characters.

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