EVALUATION OF BRINJAL (*Solanum melongena* L.) GENOTYPES FOR YIELD AND RESISTANCE TO SHOOT AND FRUIT BORER (*Leucinodes orbonalis* Guen.)

By

DALIYA. T.

THESIS

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DECLARATION

I hereby declare that this thesis entitled Evaluation of brinjal (Solanum melongena L.) genotypes for yield and resistance to shoot and fruit borer (Leucinodes orbonalis Guen.).is a bonafide record of research work done by me during the coursr of research and that the thesis has 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,

25 - 8 - 2001.

Daliya T.

DALIYA.T.

CERTIFICATE

Certified that this thesis entitled "Evaluation of brinjal (*Solanum melongena* L.) genotypes for yield and resistance to shoot and fruit borer (*Leucinodes orbonalis* Guen.)" is a record of research work done independently by Ms. Daliya.T. under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to her.

Dr. D. Wilson
(Chairman, Advisory Committee)
Associate Professor
Department of Plant Breeding and Genetics
College of Agriculture, Vellayani.

Vellayani,
25 - 8 - 2001

Approved by

Chairman:

Dr.D.Wilson
(Chairman, Advisory Committee)
Associate Professor
Department of Plant Breeding and Genetics
College of Agriculture, Vellayani.

24/9/01

Members:

1. Dr.P. Manikantan Nair
   Professor and Head
   Department of Plant Breeding and Genetics
   College of Agriculture, Vellayani.

   24/9/01

2. Dr. Vijayaraghava Kumar
   Associate Professor
   Department of Agricultural Statistics
   College of Agriculture, Vellayani.

   24/9/01

3. Dr. Thomas Biju Mathew
   Associate Professor
   Department of Agricultural Entomology
   College of Agriculture, Vellayani.

   24/9/01

External Examiner:

T. S. Raveendran
24.9.01
Professor & Head
Dept. of Cotton
TNAU. Coimbatore

Dedicated to
my Loving Parents

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Introduction

1. INTRODUCTION

Vegetables being protective foods constitute an important item of human diet. They are cheap sources of nutrients, minerals and vitamins.

Brinjal (*Solanum melongena* L.) (syn: aubergine, eggplant) has been one of the important vegetables in our diet since ancient times. It belongs to the family Solanaceae. It is a tropical vegetable believed to be a native of India. This is a perennial soft wooded shrub, but an annual under cultivation. It is of major importance as a commercial crop and is grown all over India except higher altitudes. It is highly productive and rated as poor man's tomato. The unripe fruit is used as a vegetable. It contains vitamin A and B and is quite high in nutritive value. It contains 91.5% water, 6.4% carbohydrates, 1.3% protein, 0.3% fat, 0.5% mineral matter (which includes, 0.02% Ca, 0.06% P, 0.0013% Fe). It has some medicinal properties (Choudhury, 1976) and white brinjal is said to be good for diabetic patients.

Average productivity of brinjal in India is 20 - 35 t/ha, depending upon the variety (Veeraraghavathatham, 1998). This low productivity is attributed to non-availability of high yielding varieties and incidence of serious pests and diseases. Among the pests the most serious one is the shoot and fruit borer (*Leucinodes orbonalis* Guen, Fa: Pyralidae). Control measures using chemicals are not only uneconomical, but invites environmental pollution also. The short pinkish caterpillar of this pest attacks developing young shoots and causes dead hearts as a result of which shoots wither and dry (David and Kumaraswami, 1999). It will also infest the fruits at all its stages of growth leading to fruit damage making it unsuitable for marketing.

The success of any crop improvement programme largely depends on the extent of genetic variability available in the concerned population. A lot of variability exists in this crop; however, it has not been exploited to the extent possible.

Objectives of the present study are:

- Evaluation of the brinjal genotypes for the yield and related characters
  - Analysis of variance
  - Estimation of variability components, heritability and genetic advance
  - Correlation and path coefficient analysis
  - Construction of Selection Index for yield
- Screening of brinjal genotypes for shoot and fruit borer resistance
  - Analysis of variance for the damage parametres
  - Correlation between damage parameters
  - Hierarchical clustering to identify the genotypes having similar nature in resistance to shoot and fruit borer as well as in the production potential.

Review of Literature

2. REVIEW OF LITERATURE

Brinjal is an important solanaceous vegetable crop, which is rich in protein, minerals, vitamins and dietary fiber. Apart from this it has some medicinal properties also (Choudhury, 1976). It can cure toothache if fried brinjal in till oil is taken and acts as an excellent remedy for those suffering from liver complaints (Chauhan, 1981).

Vavilov (1928) was of the opinion that the centre of origin of this crop was in the Indo-Burma region. According to Purewal (1957) it is still found growing wild in India. The cultivated brinjal is undoubtedly of Indian origin and has been in cultivation for long time (Thompson and Kelly, 1957).

India being the centre of diversity for brinjal provided a large amount of variation for its genetic improvement (Ganabus, 1964). Wide range of variability can be observed in its fruit characteristics. Singh *et al.* (1999) evaluated 325 brinjal accessions and divided into groups based on fruit shape: long (105 accessions), round (103 accessions), oblong (97 accessions) and oval (20 accessions). Further grouping was made on the basis of fruit colour: green (54 accessions), white (6 accessions), varigated (20 accessions) and purple (245 accessions).

Three main botanical varieties have been reported under the species *melongena.* The round or egg-shaped cultivars were grouped under var. *esculentum,* the long slender types were included under var. *serpentinum* and the dwarf brinjal plants were under var. *depressum* (Choudhury, 1976).

The available literature are reviewed under the following headings

2.1. Yield and yield components

2.2. Brinjal shoot and fruit borer resistance evaluation.

2.1. Yield and yield components

2.1.1. Genetic parameters

(i) Genetic variability

The efficiency of selection in crop improvement programmes largely depends on the extent of genetic variability present in the population. The variation present in the plant population is of three types viz., phenotypic, genotypic and environmental. Of these the genetic variance can be further partitioned to additive, dominance and epistatic variance components.

Variance component analysis is used to assess the variability present in breeding populations. The phenotypic, genotypic and environmental coefficient of variation (PCV, GCV and ECV respectively) give an idea about the magnitude of variability present in the population.

Anserwadekar *et al.* (1979) compared growth and yield of five cultivated varieties of eggplants and found significant difference in plant height between varieties. Cultivated variety 'Gondegaon' produced maximum leaves. Mediterranean varieties were found to be more vigorous with more leaves and high total leaf area compared to the varieties from far east.

Chadha and Sidhu (1983) evaluated 39 brinjal accessions and a wide variation was observed particularly in number of fruits, weight of fruit, fruit yield/plant and insect incidence. Yield/plant, numbers of fruits, breadth of fruit, weight of fruit and insect incidence were found to have comparatively high phenotypic and genotypic coefficient of variation than other characters.

Thirty strains of brinjal were evaluated for 14 characters and genetic variability was observed for total fruit yield and other characters. High genotypic and error variance were recorded for total fruit yield, number of fruits, weight of fruit, length and girth of fruit, days to 50% flowering and fruiting and number of branches (Dhankhar and Singh, 1983).

In a study conducted by Sinha (1983), fruits/plant and the ratio of fruit length to its circumference recorded high GCV. Genetic variability and correlation studies conducted by Chadha and Paul (1984) revealed high genetic coefficient of variation for number of fruits/plant. Genetic variability studies conducted in 27 brinjal varieties revealed that yield had the highest PCV (98.85%) while GCV was maximum for single fruit weight (98.2%). (Gopimony *et al.*, 1984).

A wide range of phenotypic variation has been observed for days to first flowering, plant height, number of fruits/plant, fruit yield/plant. The genetic coefficient of variation was high for yield/plant, fruit length, girth and weight of fruits (Vadivel and Bapu, 1989). Vadivel and Bapu (1990a) evaluated 19 brinjal accessions. The genotypic variances were high for fruit length, fruit girth, fruit weight, number of fruits/plant and fruit yield/plant suggesting improvement through pureline selection.

Varma (1995) observed considerable variation for plant height, number of primary branches and fruit yield/plant. GCV was high for fruit yield/plant, total fruits/plant and average fruit weight. Eight eggplant genotypes and four related *Solanum* spp., viz.,*S. gilo, S. anomalum, S. incanum* and *S. indicum* were evaluated by Behera *et al.* (1999) for characters related to yield and they observed high genotypic and phenotypic coefficients of variation for length and diameter of fruits and yield of fruits/plant.

Forty one genotypes of brinjal were evaluated by Patel *et al.* (1999) and they observed highest GCV for fruit volume followed by seed to pulp ratio. Rai *et al.* (1999) analysed variability in long shaped brinjal hybrids and found high coefficient of variation for average fruit weight, total number of fruits, equatorial fruit length and yield. In an experiment conducted by Rajyalakshmi *et al.* (1999), lowest genotypic and phenotypic variances were recorded for fruit diameter. Higher PCV and GCV were observed for number of fruits/plant and yield/plant, suggesting better scope of selection for these characters.

Seventy eight accessions were studied by Singh and Gopalakrishnan (1999) and reported that PCV was maximum (60.90%) for number of fruits/plant followed by yield/plant (57.12%). Genotypic variation was also maximum for the above two characters (54.8% and 52.67% respectively).

For all characters other than yield/plant, the coefficients of variation were below 50%. Genotypic coefficient of variation for number of fruits/plant, mean fruit weight and yield/plant were found to be higher in a study conducted by Sharma and Swaroop (2000) using 27 brinjal accessions.

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Fruit length recorded the highest genotypic and phenotypic variance in a study conducted in summer chilli (Das and Choudhary, 1999a). Jabeen *et al.* (1999) observed high PCV and GCV for fruit yield/plant, fruit number/plant and average fruit weight in an experiment on genetic variability in hot pepper.

(ii) Heritability (H^2) and Genetic advance (GA)

Heritability and genetic advance are important selection parameters. The ratio of genotypic variance to phenotypic variance is known as heritability. Heritability (%) was categorised into low (0 -30%), moderate (30 - 60%) and high (above 60%) as suggested by Robinson *et al* (1949). Higher H^2 indicates the least environmental influence on the character. The difference between the mean phenotypic value of the progeny of selected plants and the base or parental population is called as the genetic advance. The genetic advance was categorised into low (<20%) and high (>20%) as suggested by Robinson *et al.* (1949). High GA indicates that additive genes govern the character and low GA shows that non-additive gene action is involved. Heritability along with GA helps us in predicting the gene action and the method of breeding to be practiced.

Hiremath and Rao (1974) observed high heritability accompanied by high genetic advance for fruits/plant, seed weight/fruit and rind thickness. Dharmegowda *et al.* (1979) observed a narrow sense of heritability of 63.48% and 67.48% for number of fruits/plant and number of seeds/fruit respectively. Chadha and Sidhu (1983) evaluated 39 brinjal accessions and recorded high heritability and genetic advance for number of fruits, weight of fruit, fruit yield/plant and breadth of fruit.

In an experiment conducted by Dhankhar and Singh (1983) using 30 strains of brinjal, observed high GA with high H^2 for total fruit yield, number of fruits, weight of fruit and number of branches. Sinha (1983) observed high heritability values for fruits/plant and fruit length : circumference ratio. Chadha and Paul (1984) observed high genetic advance for number of fruits/plant. Dixit *et al.* (1984) obtained high heritability for fruits/plant and fruit weight.

Highest heritability (99.12%) and genetic advance (201.38%) were observed for single fruit weight by Gopimony *et al.* (1984). Nualsri *et al.* (1986) reported low heritability for yield/plant. An analysis of 36 diverse *Solanum melongena* genotypes revealed high heritability for 14 characters studied ranging from 85.6% for secondary branches/plant to 98.7% for fruits/plant. High values for genetic advance were observed for fruits/plant, fruit weight and fruit index. It is suggested that yield can be improved using a selection pressure of 5% (Kalda *et al.*, 1988).

High H^2 coupled with high GA for fruit yield/plant, number of fruits/plant, fruit girth and fruit length suggesting predominance of additive gene effects (Vadivel and Bapu, 1990a). Gautham and Srinivas (1992) observed High GA for plant spread and number of fruits/plant. High H^2 and GA were observed for fruit yield/plant, total fruits/plant and average fruit weight (Varma, 1995).

Rai *et al.* (1998) observed high estimate of H^2 (0.935) along with GA (68.48%) for fruit weight. However, number of primary branches, longitudinal and equatorial fruit length, leaf length and leaf breadth recorded low H^2 and low GA. High H^2 together with high GA was observed for fruit diameter, length of fruit and fruit yield (Behera *et al.*, 1999).

Characters like fruit weight, fruit volume, plant height and seed to pulp ratio had high H^2 coupled with high GA as percentage of mean which suggested that these traits are under the control of additive gene action and would be improved through simple selection (Patel *et al.*, 1999). Rai *et al.* (1999) obtained high value of heritability coupled with GA for fruit weight, yield, equatorial fruit length and total number of fruits, which indicates preponderance of additive genes.

High heritability values were observed for fruit weight, fruit diameter, plant height and number of fruits/plant. Heritability and genetic advance were high for fruit/plant and fruit weight indicating additive gene effect (Rajyalakshmi *et al.*, 1999).

Singh and Gopalakrishnan (1999) evaluated 78 brinjal accessions. They observed high heritability for fruit weight and days to last harvest. Yield/plant both in number and weight of fruits had high values of H^2 and GA indicating scope for improvement through selection. For days to flower and fruit set, the GA was very low and may be due to the involvement of non-additive gene action. Heritability estimates were high for length of fruit, number of fruits/plant, mean fruit weight and yield/plant (Sharma and Swaroop, 2000).

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Investigations carried out by Das and Choudhary (1999a) in summer chilli revealed very high heritability (>80%) for fruit length, fruit diameter, fruits/plant, weight of fruit and yield/plant. Jabeen *et al.* (1999) evaluated 71 hot pepper lines and obtained high heritability associated with high genetic advance for fruit yield/plant, fruit number/plant, pericarp thickness and average fruit weight. The results suggest that these have fixable additive gene effects.

2.1.2. Correlation Studies

Yield is a complex character determined by several component characters (Singh, 1999). Improvement in yield is possible only through selection for the desired component characters. Hence the knowledge of association between yield and its component characters, and among component characters is essential for yield improvement through selection programme.

Hiremath and Rao (1974) observed that yield/plant had high significant positive correlation with number of fruits/plant, but showed negative correlation with fruit weight and girth of fruit. Positive correlation was found among the characters viz., fruit weight, seed weight and girth of fruit. Correlation studies in eggplant by Singh and Khanna (1978) indicated significant positive association between plant spread and number of branches, and between fruit number and yield.

The study conducted by Vijay *et al.* (1978) showed significant positive correlation of yield/plant with weight and size/fruit, and negative correlation with days to bloom. Mak and Vijayarungam (1980) studied variability and inter-relationships of some characters in 27 varieties of brinjal. Yield/plant was positively correlated with number of fruits/plant, mean fruit weight, mean fruit length, number of primary branches and number of seeds/fruit.

Singh and Singh (1981) reported that yield in brinjal is positively correlated with length, weight and number of fruits, and negatively correlated with days to flowering, plant height and fruit girth. Chadha and Sidhu (1983) evaluated 39 accessions and found that total yield/plant was highly correlated with height of plant, number of branches, weight of fruit, marketable yield, unmarketable yield and insect incidence.

Total fruit yield exhibited strong positive association with number of fruits and branches while negative association was shown with characters like days to 50% flowering and fruiting. Another important association was between number of fruits and number of branches (Dhankhar and Singh, 1983). Chadha and Paul (1984) observed positive correlation between yield and number of fruits/plant.

In a correlation study conducted by Krusteva (1985) using six cultivars of brinjal, the highest correlation with yield was obtained for fruits/plant and mean fruit weight. Khurana *et al.* (1988) evaluated 17 genotypes of both long and round types, and found that fruit yield had positive correlation with fruit diameter and mean fruit weight. These characters showed significant positive correlation with number of branches, stem weight, leaf weight, area, length, width and number of leaves, but correlation was negative with fruit length. Number of fruits was negatively correlated with fruit diameter, stem weight and leaf width.

Randhawa *et al.* (1989) studied 22 long fruited brinjal varieties. Fruit yield showed highly positive and significant correlation with number of fruits/plant and negative association with short styled flowers. Fruits/plant were negatively correlated with weight, length and girth of fruits and positively correlated with total yield. Height expressed a significant correlation with branches/plant.

The yield/plant is positively associated with plant height, girth of main stem, fruit weight, number of branches, flower and fruits/plant. Positive correlation was observed between fruit length, fruit girth and fruit weight, while fruits/plant was negatively correlated with fruit girth and weight (Mishra and Mishra, 1990). Vadivel and Bapu (1990b) reported high coheritability of fruit yield, fruit number/plant and number of branches indicating the scope of selection for these characters.

In a study conducted by Gautham and Srinivas (1992), they observed that plant spread and number of fruits/plant showed significant positive correlation with yield. Ushakumari and Subramanian (1993) analysed the genotypic and phenotypic correlation among ten yield components in 54 genotypes of aubergine and found that the number of fruits had the highest positive correlation followed by number of branches with fruit yield.

Seventeen brinjal genotypes were evaluated by Ponnuswami and Irulappan (1994) and found that yield/plant had significant and positive correlation with plant height, number of branches/plant, fruit weight, fruit length and number of fruits/plant. The intercorrelation among fruits/plant, fruit length and branches/plant were all positive and significant and revealed that fruit weight and plant height are the important yield components.

Narendrakumar (1995) evaluated 21 genotypes for correlation analysis. Yield/plant showed significant positive association with fruit length, primary branches/plant and fruits/plant, but nonsignificant correlation with fruit diameter. Most of the environmental correlations were not significant. Thus the characters, fruit length, primary branches/plant, number of fruits/plant and early yield could form a sound basis for selection.

Yield showed significant positive correlation with total fruits/plant and average fruit weight, while it showed significant negative correlation with days to first flowering (Varma, 1995). Sharma and Swaroop (2000) evaluated 27 brinjal accessions and found that number of fruits/plant, mean fruit weight and diameter of fruits were positively correlated with yield, while days to 50% flowering showed no correlation.

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In a study conducted in summer chilli by Das and Choudhary (1999b) the fruit yield was found to have positive significant correlation with weight of fruit, fruits/plant and primary branches/plant. Fruit diameter showed negative association with fruit length. Fruits/plant and weight of fruits exhibited highest positive effect on yield. It was concluded that selection based on fruits/plant, weight of fruit and primary branches/plant would be effective to improve the yield.

Eighteen hot pepper varieties were evaluated by Legesse *et al.* (1999). Fruit yield/plant had positive and significant correlation with canopy width, plant height, leaf area and fruit number/plant. Aliyu *et al.* (2000) did correlation studies in *Capsicum annuum* and found positive and highly significant correlation between fresh fruit yield and total dry weight, leaf area index, leaf number/plant and plant height. The association between yield, fruit number, fruit diameter was also positive and highly significant.

2.1.3. Path Coefficient Analysis

Certain characters might indirectly influence yield, but their correlation with yield may not be statistically significant. In such cases, path coefficient analysis is an efficient technique, which permits the separation of coefficient into components of direct and indirect effects.

Path analysis conducted by Vijay *et al.* (1978) revealed that number of fruits/plant and weight of fruits exhibited positive direct effect on yield. Size of fruits showed low negative direct effect. Days to bloom had negative direct effect on yield. Path analysis indicated that fruits/plant and fruit length : circumference ratio had the maximum direct effect on yield (Sinha,1983).

Khurana *et al.* (1988) suggested that to increase fruit yield selection for leaf area, number of branches and stem weight should be done as these showed the highest direct positive effects in path coefficient analysis. Randhawa *et al.* (1989) observed that fruits/plant had maximum direct effect on yield. From the path coefficient analysis Mishra and Mishra (1990) found that fruits/plant, fruit weight and branches/plant were the most important characters contributing to yield. Number of fruits/plant and number of branches/plant had the highest direct effect on yield (Randhawa *et al.*, 1993).

Path coefficient analysis done by Ushakumari and Subramanian (1993) revealed that number of fruits and fruit breadth had the highest direct effect on fruit yield followed by fruit length. Varma (1995) conducted experiments in green fruited brinjal and found that total fruits/plant had maximum positive direct effect on yield. Results on path analysis for yield components suggested the importance in the order of number of fruits/plant, number of branches/plant, plant height and fruit weight on fruit yield (Vadivel and Bapu, 1998).

Sharma and Swaroop (2000) evaluated 27 brinjal accessions and observed that number of fruits/plant, mean weight of fruits and diameter of fruits had maximum direct effect at genotypic level and hence direct selection could be made for these characters for improving yield, while maximum direct effect at phenotypic level was showed by number of fruits/plant, mean fruit weight and diameter of fruits. Number of branches/plant, plant height and length of fruit had positive indirect effect towards yield/plant *via*, number of fruits/plant and hence simultaneous selection for these characters can be made for the improvement of yield.

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Canopy width, leaf area, fruit number/plant and pericarp thickness had positive direct effect on fruit yield/plant. Therefore selection based on these characters will lead to an increase in fruit yield/plant (Legesse *et al.*, 1999). Fruit diameter, dry weight and leaf area index had a positive and high direct effect on yield in *Capsicum annuum*. Plant height had a negative direct contribution to the final yield. Dry biomass, leaf area index, fruit diameter and number of seeds/plant were also greatly involved in the contribution of other characters to fruit yield (Aliyu *et al.*, 2000)

2.1.4. Selection Index

Selection index helps in selecting plants for crop improvement based on several characters of economic importance. This method is aimed at the simultaneous improvement of several or multiple characters.

Vadivel and Bapu (1991) conducted an index score character analysis of some exotic eggplants. The types Murena (Netherland), Solara (Netherland), Nagpur type and Annamalai recorded the highest index score value and proved to be excellent source for hybridization programme. The local types from Maharashtra had higher scores form secondary branches and number of fruits/plant, whereas Black Beauty (USA) was superior for fruit length, girth and weight. Such genotypes may prove useful for the breeder, as the hybridization programme between them will result in more variability for further selection and improvement.

2.2. Brinjal Shoot and Fruit Borer Resistance Evaluation

The brinjal varieties showed considerable variations in their response towards the infestation by *Leucinodes orbonalis.*

Eight eggplant genotypes and four related *Solanum* spp, viz., *S. gilo, S anomalum, S. incanum and S. indicum* were evaluated for characters related to yield and fruit borer infestation. High genotypic and phenotypic coefficients of variation were observed for percentage of infested yield and percentage of infested fruits/plant (Behera *et al.*, 1999)

2.2.1. About the pest

Among the various pests which infests brinjal, shoot and fruit borer *Leucinodes orbonalis* Guen. is the most destructive and ubiquitous pest (Dhamdhere and Sharma, 1991). The damage symptoms include the withered shoots, fruits with bore holes plugged with excreta (Nair, 1999), shedding of flower buds and drying of leaves due to boring of petioles by larvae (Regupathy and Palaniswamy, 1997). In severe infestation the rotting of fruits may result (Saha, 1995). It is a serious pest of brinjal all over the country causing a yield loss of up to 70% (Lall, 1964 and David and Kumaraswami, 1999 and Nair, 1995). Hampson (1896) first reported the occurrence of this pest on eggplant in India. Its infestation is the main constraint in brinjal production not only in Indian subcontinent but also in South Africa, Congo, Malaysia (Patil, 1990), Myanmar, Sri Lanka, Pakistan, Germany and East Africa (Atwal and Dhaliwal, 1999).

Indiscriminate use of insecticides to control this pest contributed to the development of insecticide resistance in *Leucinodes orbonalis* and resurgence of white flies and mite in brinjal (Mishra and Mishra, 1996). The loss caused by this pest ranges from 28 - 80% fruits (Nighut and Taley, 1979 and Ahmad, 1974). One caterpillar may destroy as many as 4-6 fruits (Atwal and Dhaliwal, 1999).

Brinjal shoot and fruit borer also seen feeding on potato and tomato (Hargreaves, 1937), green pea pods (Hussai, 1925 and Atwal and Dhaliwal, 1999), cape gooseberry (Pillai, 1922) and mango shoots (Hutson, 1930).

This pest infests about 73.33% of top shoots during the end of August, which peaked 86.66% in the third week of September. On initiation of flowering, the pest infestation is continuously declined on shoots and reached zero level in the end of October, but at this critical stage the borer infestation shifted over to flowers and fruits which was 33.33% in the beginning of October and reached at 66.66% with a week and gradually decreased with the advent of winter season. There was a positive role of temperature on the multiplication of the pest and the relative humidity responded negatively. The economic injury level of shoot and fruit borer was determined 0.67% on fruits and 0.91% on its shoots (Singh *et al.*, 2000). In July planted brinjal crops the peak infestation levels (59.2-75.5%) were mostly recorded at 64-88.3 days after transplanting and such peaks occurred in the months of September and October (Patnaik, 2000).

2.2.2. Plant characters and fruit borer resistance in brinjal

Srinivas and Basheer (1961) found that the varieties Coimbatore, H - 128 (Cluster White), H - 129 (IC - 1855) and H - 158 (Gudiatham) were tolerant to shoot and fruit borer and the tolerance is due to toughness of skin and pulp of the fruit. Panda *et al.* (1971) found that the resistance shown by the varieties Black Pendy, Thorn Pendy, H - 165, and H - 407 are due to compact vascular bundles, lignified cells, low pith area, tight calyx, hard fruit rind and seeds arranged compactly in mesocarp.

The lower susceptibility shown by the varieties Ex.Beckwai and Musk Brinjal (IHR 191) may be due to hardiness of fruit skin and flesh, a character which is very distinctly seen in these varieties (Krishnaiah and Vijay, 1975). Resistance shown by *Solanum incanum, S. integrifolium and S. khasianum* are due to tightly arranged seeds in mesocarp of fruit (Lal *et al.*, 1976).

Dhooria and Chadha (1981) reported that round varieties are more attacked than long fruited varieties. According to Ahmad *et al.* (1985) long narrow fruits had less infestation. Dhankar (1988) observed two long fruited varieties namely S-5 and PPL despite of having thick fruit skin and hard pulp and tightly arranged seeds showed high susceptibility. Similarly, susceptibility increased, as the days to first bloom were more.

Mishra *et al.* (1988) also observed shoot and fruit borer resistance in long fruited variety, Katrain-4. Tightly arranged seeds in mesocarp and thick fruit skin were identified as possible mechanisms of resistance. Bajaj *et al.* (1989) revealed that low incidence of fruit borer infestation is associated with higher levels of glycoalkaloids, peroxidase and polyphenol in fruits.

Singh and Chadha (1991) reported that the resistance in SM-17-4, PBR-129-5 and Punjab Barsati against *Leucinodes orbonalis* could be attributed to a large number of small sized fruits/plant along with late and longer fruiting period. Long narrow fruited varieties are less infested than those with spherical fruits (Pradhan, 1994).

2.2.3. Field screening techniques and resistance evaluation

For screening of brinjal germplasm Lal *et al.* (1976) employed grades on fruit infestation both on the basis of number of infested fruits as well as weight of infested fruits. Grade 1 (immune) was given for those genotypes with 0% fruit infestation. Grade 2 (highly resistant) for those with 1-10% fruit infestation. Grade 3 (fairly resistant) for those with 11-20% fruit infestation. Grade 4 (tolerant) for those with 21-30% fruit infestation. Grade 5 (susceptible) for those with 31-40% fruit infestation. Grade 6 (highly susceptible) for those showing 41% and above fruit infestation. The above scale was used by Kale *et al.* (1986) for screening of brinjal genotypes.

Dhankhar *et al.* (1977) screened some varieties of brinjal along with its wild types and found that the varieties Aushey and PPC-2, and wild type *Solanum sisymbrifolium* are resistant to shoot and fruit borer. They also observed that this pest causes about 63% yield loss. In a study conducted by Gill and Chadha (1979), the varieties H-4, Punjab Chamkila, PPC, PPL, S-4 and S-6 are found to be resistant to shoot and fruit borer.

Raut and Sonone (1980) reported that the varieties H-4, PPL, Pusa Kranti and SM-41 showed tolerance to shoot and fruit borer. A-61, Arka Kusumkar, AC 3698, Kalyanpur, T-2, Long Green, Muktakeshi, Nimbkar Green, Pusa Kranti, SM-2 and SM-213 showed resistance to shoot and fruit borer (Mote, 1981). Relative tolerance to shoot and fruit borer was found in Pusa Kranti, H-4, A-61 and Arka Kusumkar (Subbratnam and Butani, 1981).

Of 13 aubergine cultivars studied by Baksha and Ali (1982) none was found resistant to *Leucinodes orbonalis*. Moderate tolerance to shoot infestation was noted in Baromashi, Jhumki, Indian and Bogra Special, and to fruit infestation was noted in Noyankajal, Singnath, Japani, Jhumki, Indian and Baromashi. Tolerance to both shoot and fruit infestation was highest in Jhumki, Indian and Baromashi.

Nair (1983) evaluated 40 accessions and found that SM-88, *Solanum indicum* and *S. incanum* were resistant. SM-1, SM-45, SM-48 and SM-71 were moderately susceptible. SM-6, SM-56, SM-72 and SM-74 form the highly susceptible group. Ringan Giant, PPC and SM-62 were found to be tolerant to shoot and fruit borer (Nathani, 1983).

Kabir *et al.* (1984) evaluated 12 brinjal varieties of which the variety Singnath had the lowest infestation. Duodo (1986) reported that fruits of Black Beauty and Florida Market were significantly least infested. The brinjal variety, Manjarigota was found to be tolerant to shoot and fruit borer (Khaire and Lawande, 1986).

Pawar *et al.* (1987) screened 32 varieties and 22 local accessions of brinjal against jassids and the fruit borer and identified Banaras Giant, S-34, Arka Kusumkar, SM-125, S-258, SM-62, P 5-8, SM-2, S 2070 and Six Seer as most resistant varieties to *Leucinodes orbonalis*. Among the accessions, Malkapuri, Shirur, Khandala, Khamapur were resistant to fruit borer.

Studies conducted on 150 aubergine cultivars by Singh and Sidhu (1988) showed that the variety Punjab Chamkila is the most susceptible one to *Leucinodes orbonalis.* SM-17-4 was the most resistant. PPC, PBR-129-5 were fairly resistant. Yield performance of the cultivars differed between insecticide treated and untreated plots.

Dharekar *et al.* (1991) screened nine varieties of aubergine against shoot and fruit borer and identified PBR-129-5, Arka Kusumkar and Wild Brinjal as resistant varieties. Tejarathu *et al.* (1991) found *Solanum gilo* as resistant to borer and crossable with *Solanum melongena.*

Mukhopadhyay and Mandal (1994) exposed the experimental plots to natural infestation of major insect pests and found that Nishchindipur Local, Muktajhuri, Shyamala Dhepa, Banaras Long Purple and BBI were tolerant to shoot and fruit borer. Nazir *et al.* (1995) evaluated 13 varieties and none of them was found tolerance to fruit borer. All were severely infested. The lowest attack of 19.20% was observed in 88066-2, while the highest value was 38.54% in White Egg Round.

Studies conducted on 18 brinjal cultivars by Srinivas and Peter (1995) showed that Arka Kusumkar, Arka Shirish and Neelam were significantly less infested by *Leucinodes orbonalis* than Early Long Fellow and Nagpur Round.

Brinjal varieties viz., Annamalai, Pant Samrat, Bhagyamati, Aushay, PPC, AM 62, *Solanum gilo* and *S. anomalum* were found to be tolerant to shoot and fruit borer (Ram 1997). According to Sharma *et al.* (1998) out of eight cultivars of brinjal evaluated for their response to shoot and fruit borer, none of the cultivars were absolutely tolerant. Awasthi (2000) studied the susceptibility of 12 brinjal genotypes to *Leucinodes orbonalis* and lowest fruit infestation values were recorded for the genotypes Nurki (27%) and CH-150-16-4-1 (20%).

TOMATO

Lal (1985) studied 28 tomato cultivars for resistance against *Heliothis armigera*, and reported that the cultivars Parker, Bonus and VFN8 were highly resistant (1-2.5% infestation) while Super Marmand, Bonset F_1 hybrid and No.502 VFN F_1 hybrid were highly susceptible (22.6 - 44.7%). Seeja (1995) recorded that the major pest of tomato was fruit borer. She also reported that fruit borer incidence is minimum in Sakthi (0.68%) and high in Arka Abha (13.04%).

Rath and Nach (1997) screened 112 tomato genotypes for resistance against *Heliothis armigera* and reported that a very poor response of feeding was observed in genotypes HT 64, Hybrid No.37 and PTH 106 which indicated their less susceptibility to the fruit borer. Varghese (1998) reported that the hybrid Arka Alok x PKM-1 is free from fruit borer attack and diseases like mosaic.

2.2.4. Correlation and Path Analysis

Khurana *et al.* (1988) evaluated 17 genotypes and found that the percentage of infestation of fruits with *Leucinodes orbonalis* was negatively correlated with number of fruits and positively correlated with mean fruit weight, fruit diameter, number of leaves, number of branches and plant height.

Shoot thickness, leaf area and preflowering period have some correlation with the shoot infestation (Grewal and Singh, 1992). Patil and Ajri (1993) reported a negative correlation of number of seeds/fruit, yield/plant and fruit thickness with fruit infestation.

Path analysis conducted by Kumar and Ram (1998) revealed that diameter, weight and volume of the fruit could be used as the indirect negative selection criteria for improving resistance to shoot and fruit borer. Sebastian (2000) noticed shoot and fruit borer resistance in land races S1, S13, S28, S35, S36 and S37. A negative association was noticed between fruit borer incidence and fruits/plant.

Materials and Methods

3. MATERIALS AND METHODS

The present investigation on evaluation of brinjal (*Solanum melongena* L.) genotypes for yield and resistance to shoot and fruit borer (*Leucinodes orbonalis* Guen.) was conducted at the Department of Plant Breeding and Genetics, College of Agriculture, Vellayani, during the period from August 2000 to February 2001.

The study was conducted in two separate experiments. The first experiment was carried out for the evaluation of yield and yield attributes and the second one was laid out for assessing the shoot and fruit damage caused by the pest *Leucinodes orbonalis* Guen.

3.1 Experiment 1: Evaluation of genotypes for yield

3.1.1 Materials

The experimental material comprised of twenty five genotypes of brinjal collected from different parts of the country. The list of genotypes used for the experiment along with the morphological features is given in table 1. Plate 1, 2 and 3 shows the variation in fruit characters of these brinjal genotypes.

3.1.2. Methods

3.1.2.1.Design and layout

The experiment was laid out in a randomised block design (RBD) with 25 treatments in three replications. Thirty five days old seedlings

Plate. 1 Variability in fruit characters of the brinjal genotypes V 1 to V 9

Swetha

Surya

CO - 2

Nedumangad local - 1

Nedumangad local - 2

Nedumangad local - 3

Neyyattinkara local

Alappuzha local

Thikkodi local

Plate. 2 Variability in fruit characters of the brinjal genotypes V 10 to V 18

Vellayani local - 1

Vellayani local - 2

Kalliyoor local

Peringamala local

Poomkulam local

Pachalloor local

Venganoor local

Pusa Kranti

Pusa Purple Cluster

Plate. 3 Variability in fruit characters of the brinjal genotypes V 19 to V 25

Arka Kusumkar

Kuttalam local

Brinjal Suphal

Palappur local

Brinjal supriya

Manjarigota local

Pragathy

Plate. 4 A view of the experimental field

Table. 1. Morphological features and sources of genotypes used for evaluation

Sl.No.	Name of genotype	Source	Prominent morphological features
1	Swetha (V1)	KAU *	Long white fruits, purple stem with out spines
2	Surya (V2)	KAU *	Oblong purple fruits, purple stem without spines
3	CO - 2 (V3)	TNAU *	Round varigated fruits, green stem without spines
4	Nedumangad local-1 (V4)	Nedumangad, Trivandrum District	Oblong purple fruits, green stem without spines
5	Nedumangad local-2 (V5)	Nedumangad, Trivandrum District	Oblong varigated fruits, green stem without spines
6	Nedumangad local-3 (V6)	Nedumangad, Trivandrum District	Oblong purple fruits, purple stem without spines
7	Neyyattinkara local (V7)	Neyyattinkara, Trivandrum District	Round purple fruits, purple stem without spines
8	Alappuzha local (V8)	Alappuzha District	Long green fruits, green stem with spines
9	Thikkodi local (V9)	Thikkodi, Kozhikode District	Long purple fruits, purple stem with spines
10	Vellayani local-1 (V10)	Vellayani, Trivandrum District	Oblong varigated fruits, purple stem without spines
11	Vellayani local-2 (V11)	Vellayani, Trivandrum District	Long white fruits, purple stem without spines
12	Kalliyoor local (V12)	Kalliyoor, Trivandrum District	Oblong black fruits, purple stem without spines
13	Peringamala local (V13)	Peringamala, Trivandrum District	Long purple fruits, purple stem without spines
14	Poomkulam local (V14)	Poomkulam, Trivandrum District	Oblong green fruits, green stem without spines

15	Pachlloor local (V15)	Pachlloor, Trivandrum District	Oblong dark purple fruits, purple stem without spines
16	Venganoor local (V16)	Venganoor, Trivandrum District	Round green fruits, green stem without spines
17	Pusa Kranti (V17)	I A R I, * New Delhi	Oblong dark purple fruits, purple stem without spines
18	Pusa Purple Cluster (V18)	I A R I, * New Delhi	Long purple fruits, purple stem without spines
19	Arka Kusumkar (V19)	I I H R, * Banglore	Long pale green fruits, green stem without spines
20	Kuttalam local (V20)	Kuttalam, Tamil Nadu	Round white fruits, green stem without spines
21	Brinjal Suphal (V21)	Indo-American Hybrid Seeds (India) Ltd	Oblong black fruits, purple stem without spines
22	Palappur local (V22)	Palappur, Trivandrum District	Oblong purple fruits, purple stem with spines
23	Brinjal Supriya (V23)	Indo-American Hybrid Seeds (India) Ltd	Round purple fruits, purple stem without spines
24	Manjarigota local (V24)	Mahatma Phule Krishi Viswavidyalay, Maharashtra	Round varigated fruits, green stem with spines
25	Pragathy (V25)	Mahatma Phule Krishi Viswavidyalay, Maharashtra	Oblong varigated fruits, green stem without spines

*

KAU - Kerala Agricultural University, TNAU - Tamil Nadu Agricultural University,
IARI - Indian Agricultural Research Institute, IIHR - Indian Institute of Horticultural Research.

having 8 - 10 cm height were transplanted into the main field at a spacing of 60 x 75 cm (Plate. 4).

The cultural and management practices as per Package of Practices Recommendations (Kerala Agricultural University, 1996) were followed throughout the experiment.

3.1.2.2. Biometric Observations

Biometric observations were taken from five plants selected at random from each replication for each treatment, and averages were worked out adopting standard procedures.

(a) Yield per plant (g):

The fruits were harvested from the sample plants separately at regular intervals and average yield per plant was worked out.

(b) Days to first flowering:

The number of days taken from transplanting to 50 % flowering in each treatment was recorded as the days to first flowering.

(c) Plant height at first and last harvests (cm):

The height of the plant from base to tip of terminal bud was measured in centimeters from the sample plants and the average was worked out.

(d) Number of primary branches per plant:

The number of branches arising from the main stem was recorded from all the sample plants at the peak harvest stage and the average was worked out.

(e) Number of secondary branches per plant:

The number of secondary branches produced from each plant was recorded and the average value was recorded.

(f) Number of fruits per plant:

The total number of fruits produced in each sample plant was taken to find out the average number.

(g) Number of leaves per plant:

The total number of leaves produced per plant at the time of first harvest was recorded.

(h) Fruit length (cm) :

The length of five randomly selected fruits was taken from each sample plant and was averaged to obtain the mean fruit length.

(i) Fruit girth (cm) :

The same sample fruits taken for measuring the fruit length were used to measure the mean fruit girth.

(j) Mean fruit weight (g) :

The weight of fruits used for measuring mean fruit length and girth were taken and average was worked out.

(k) Number of harvests :

The total number of harvests made in each genotype was recorded.

3.1.2.3. Statistical Analysis

The data collected were subjected to statistical analyses.

3.1.2.3.1. Analysis of variance and covariance

The analysis of variance was carried out

(a) to test the significance of differences among the genotypes with respect to various characters, and

(b) to estimate the variance components and other genetic parameters like coefficients of variation, heritability and genetic advance.

Covariance analysis was done for the estimation of correlation coefficients and path coefficient analysis.

Table. 2. Analysis of variance / covariance for two traits x & y

Source	Degrees of freedom	Observed mean square for X	Expected mean square for X	Observed mean square for Y	Expected mean square for Y	Observed mean sum of products for X& Y	Expected mean sum of products for X & Y
Block	(r-1)	MSB(x)		MSB(y)		Bxy	
Genotype	(v-1)	MST(x)	$\sigma e_x^2 + r\sigma g_x^2$	MST(y)	$\sigma e_y^2 + r\sigma g_y^2$	Gxy	$\sigma e_{xy} + r\sigma g_{xy}$
Error	(r-1)(v-1)	MSE(x)	σe_x^2	MSE(y)	σe_y^2	Exy	σe_{xy}

Where, r = number of replications

v = number of treatments.

The mean squares between treatment consists of variance attributed to genotype, environment and phenotype (Singh and Chaudhary, 1985)

The components are estimated for a trait 'x' as,

(a) Genotypic variance, $\sigma g_x^2 = \frac{MST(x) - MSE(x)}{r}$

(b) Environmental variance, $\sigma e_x^2 = MSE(x)$

(c) Phenotypic variance, $\sigma p_x^2 = \sigma g_x^2 + \sigma e_x^2$

The covariances are estimated for two traits 'x' and 'y' as,

Environmental covariance (σe_{xy}) = Exy

Genotypic covariance (σg_{xy}) = $\frac{G_{xy}.E_{xy}}{r}$

Phenotypic covariance (σp_{xy}) = $\sigma g_{xy} + \sigma e_{xy}$

3.1.2.3.2. Grouping of genotypes

Based on the performance of each character under study all the 25 genotypes were grouped into three categories using the following criterion.

Category	**Criterion**
Poor	<mean - 2SE
Medium	Between ± 2SE
Better	> mean + 2SE

For the character days to first flowering a modification in the above criterion was made. For this, those genotypes having mean <mean - 2SE were grouped as better (early to flower) and those with mean > mean + 2SE as poor (late to flower).

3.1.2.3.3. Coefficient of variation

The phenotypic, genotypic and environmental coefficient of variation for a trait 'x' (as % of mean) were worked out using the following formulae:

(a) Phenotypic coefficient of variation (PCV) = $\frac{\sigma p_x}{\overline{X}}$ X 100

(b) Genotypic coefficient of variation (GCV) = $\frac{\sigma g_x}{\bar{x}} \times 100$

c) Environmental coefficient of variation (ECV) = $\frac{\sigma e_x}{\bar{x}} \times 100$

3.1.2.3.4. Heritability (Broad sense)

It is the ratio of genotypic variance to phenotypic variance and it gives an estimate of the heritable component of variation. It is expressed in percentage (Jain, 1982)

Heritability, $H^2 = \frac{\sigma g_x^2}{\sigma p_x^2} \times 100$

Heritability (%) was categorised as suggested by Robinson *et al* (1949) viz., low (0-30%), moderate (30-60%) and high (above 60 %).

3.1.2.3.5. Genetic Advance (Johnson *et al,* 1955 and Allard, 1960)

This measures the change in mean genotypic level of the population brought about by selection.

Genetic advance (GA) = $kH^2\sigma p_x$

Genetic advance as percent of mean = $\frac{kH^2\sigma p_x}{\bar{x}} \times 100$

where, k is the selection differential whose value is 2.06 at 5% and 1.76 at 10% selection intensity (Miller *et al.,* 1958).

The genetic advance was categorised into low (<20%), and high (>20%) as suggested by Robinson *et al* (1949).

3.1.2.3.6. Correlation Studies

The correlation coefficients (phenotypic, genotypic, and environmental) were worked out for two traits 'x' and 'y' as,

$$\text{Genotypic correlation } (r_{gxy}) = \frac{\sigma g_{xy}}{\sigma g_x . \sigma g_y}$$

$$\text{Phenotypic correlation } (r_{pxy}) = \frac{\sigma p_{xy}}{\sigma p_x . \sigma p_y}$$

$$\text{Environmental correlation } (r_{exy}) = \frac{\sigma e_{xy}}{\sigma e_x . \sigma e_y}$$

3.1.2.3.7. Path Coefficient Analysis

The path coefficients were worked out by the method suggested by Wright (1954) using those characters, which showed high genotypic correlation with yield. The simultaneous equations, which give the estimates of path coefficients, are as follows

$$\mathbf{R_y} = \mathbf{R_x} . \mathbf{P_i}$$

$$\therefore \mathbf{P_i} = \mathbf{R_x}^{-1} . \mathbf{R_y}$$

where, $\mathbf{R_y}$ is the vector of r_{iy}, the genotypic correlation between i^{th} trait with yield, y.

$\mathbf{R_x}$ is the matrix of r_{ij}, the genotypic correlation between i^{th} trait with j^{th} trait.

$i, j = 1, 2, \ldots k$

$\mathbf{P_i}$ = path coefficient of x_i.

The residual factor (h), which measures the contribution due to other factors not defined in the causal scheme, was estimated by the formula,

$$h = \sqrt{(1 - \sum_{i=1}^{k} P_i r_{iy}}$$

Indirect effect of different characters on yield is obtained as $P_i\, r_{iy}$ for the i^{th} character via, j^{th} character.

3.1.2.3.8. Selection Index

The selection index developed by Smith (1937) using discriminant function of Fisher (1936) was used to discriminate the genotypes based on all the characters.

The selection index is described by the function, $I = b_1 x_1 + b_2 x_2 + \ldots + b_k x_k$ and the merit of a plant is described by the function, $H = a_1G_1 + a_2G_2 + \ldots + a_kG_k$ where $x_1, x_2, \ldots x_k$ are the phenotypic values and $G_1, G_2, \ldots G_k$ are the genotypic values of the plants with respect to characters, $x_1, x_2, \ldots x_k$ and H is the genetic worth of the plant. It is assumed that the economic weight assigned to each character is equal to unity ie., $a_1, a_2, \ldots a_k = 1$.

The Regression coefficients (b) are determined such that the correlation between H and I is maximum. The procedure will reduce to an equation of the form, $b = P^{-1}Ga$ where, P is the phenotypic variance-covariance matrix and G is the genotypic variance-covariance matrix.

3.2. Experiment 2 : Evaluation of brinjal genotypes for resistance to shoot and fruit borer (*Leucinodes orbonalis* Guen.) .

3.2.1. Materials

The same as that of experiment 1.

3.2.2. Methods

3.2.2.1. Design and layout

The experiment was laid out in randomised block design (RBD) with 25 treatments in two replications. Thirty five days old seedlings having 8 - 10 cm height were transplanted at a spacing of 60 x 75 cm.

All cultural practices as per Package of Practices Recommendations (Kerala Agricultural University, 1996) were followed. As the experiment was to screen genotypes tolerant to shoot and fruit borer under natural conditions, pesticide spraying was avoided, but fungicides were applied to control the diseases.

3.2.2.2. Observations

The observations were recorded on different damage parameters as described below

(a) Percentage of plants infested:

Number of plants showing damage symptoms (on shoots or on fruits or on both) were recorded and from this the percentage of plants infested is calculated. The observations were recorded at ten days interval from 30 DAT (days after transplanting) up to 90 days.

$$\% \text{ of plants infested} = \frac{\text{No of plants showing damage symptoms}}{\text{Total number of plants}} \times 100$$

(b) Percentage of young shoots infested:

The total number of shoots, which showed the wilting symptoms, was recorded for calculating the percentage of young shoots infested. Observations recorded at ten days interval from 30 DAT up to 90 days.

$$\% \text{ of shoots infested} = \frac{\text{Number of shoots with damage symptoms}}{\text{Total number of shoots}} \times 100$$

(c) Percentage of damaged fruits:

The total number of fruits with bore holes was recorded and the percentage of damaged fruits was worked out. Observations were taken at ten days interval from 60 DAT up to 90 days.

$$\% \text{ of damaged fruits} = \frac{\text{Number of fruits with bore holes}}{\text{Total number of fruits on sample plants}} \times 100$$

(d) Severity of fruit damage:

For estimating fruit damage the following two parameters were used and observations on these parameters made at peak fruiting period.

(i) Number of bore holes per fruit:

Ten fruits were selected at random and the number of bore holes on the fruits was recorded and the average was worked out.

(ii) Number of larvae per fruit:

Fruits taken for recording the number of bore holes were cut open and the number of larvae present was noted and the average was worked out.

3.2.2.3. Statistical Analysis

The data collected were subjected to following statistical analyses.

3.2.2.3.1. Analysis of variance

The data on the damage parameters were subjected to analysis of variance for the varietal differentiation.

3.2.2.3.2. Grouping of genotypes

The 25 genotypes were grouped into three categories using the following criterion.

Category	Criterion
Less susceptible	<mean - SE
Moderately susceptible	Between ± SE
Highly susceptible	> mean + SE

3.2.2.3.3. Correlation Studies

A correlation analysis was done to determine the degree of association between the different damage parameters.

3.2.2.3.4. Hierarchical Clustering

The data were subjected to Hierarchical clustering following the Graph Theory model proposed by Chatfield and Collins (1980). The observations on the above six damage parameters along with yield of Experiment I were converted to scores in suitable scales and the genotypes having similar nature in resistance to shoot and fruit borer incidence as well as in their production potential were identified.

Results

4. RESULTS

The results of the present investigation are presented under two major headings.

4.1. Yield evaluation

4.2. Screening for brinjal shoot and fruit borer resistance.

4.1. Yield evaluation

The data on fruit yield and 11 other characters collected from the field experiment with 25 genotypes were subjected to statistical analysis. The results are presented below

4.1.1. Analysis of variance

The analysis of variance revealed significant difference among the 25 genotypes for all the 12 characters studied.

4.1.2. Mean performance of the genotypes

The mean values of each of the 25 genotypes for the 12 characters studied are presented in table 3.

Among the different genotypes the yield per plant ranged from 169.17g to 984.22g. Pusa Purple Cluster (V18) recorded the highest value for yield per plant and no other genotype was on par with V18. The least value was for V25 (Pragathy) and the genotypes V4 (Nedumangad local-1) and V23 (Brinjal Supriya) were on par with this.

Days to first flowering ranged between 52.00 and 77.33. Surya (V2) was the earliest to flower and was on par with V1 (Swetha). The genotype

Table 3 Varietal difference with respect to various characters among the genotypes used for the evaluation

Genotypes	Yield per Plant (gm)	Days to 50% flowering	Plant height at 1st harvest (cm)	Plant height at last harvest (cm)	No. of primary branches per Plant	No. of secondary branches per Plant	No. of fruits per Plant	No. of leaves per Plant	Length of fruit (cm)	Girth of fruit (cm)	Weight of fruit (gm)	No. of harvests
Swetha (V1)	775.08	56.00	50.00	88.01	3.44	9.00	12.02	58.8	13.98	10.56	87.50	6.00
Surya (V2)	679.83	52.00	43.33	67.89	3.56	9.50	8.49	54.12	10.23	15.95	91.63	5.00
CO-2 (V3)	628.19	67.33	53.33	87.50	4.75	11.38	4.78	65.00	9.00	17.13	94.08	4.67
Nedumangad local-1 (V4)	235.83	68.33	77.33	86.67	6.33	8.50	2.78	81.67	11.07	20.77	80.36	2.33
Nedumangad local-2 (V5)	426.67	76.67	72.50	83.33	4.89	5.07	3.50	89.29	12.04	24.27	98.84	3.00
Nedumangad local-3 (V6)	409.72	72.33	58.50	91.22	8.00	9.58	4.78	95.00	11.93	21.60	99.97	3.67
Neyyattinkara local (V7)	674.30	69.67	45.33	125.19	12.17	23.00	6.60	47.00	8.45	18.40	77.22	5.33
Alappuzha local (V8)	242.66	72.67	65.87	85.56	8.44	12.54	1.36	80.60	11.75	9.92	56.38	2.67
Thikkodi local (V9)	259.33	77.33	84.60	138.33	9.17	14.27	2.91	126.73	21.58	11.00	102.50	2.00
Vellayani local-1 (V10)	580.56	64.67	69.40	121.75	7.89	17.30	4.04	114.67	10.50	21.40	98.35	3.00
Vellayani local-2 (V11)	407.72	65.67	46.67	71.92	7.00	10.75	5.13	37.00	12.22	13.03	82.22	4.33
Kalliyoor local (V12)	372.22	64.67	53.52	80.00	10.00	13.28	2.67	72.33	10.82	17.98	99.27	2.33
Peringamala local (V13)	512.50	65.00	57.56	133.33	9.37	14.99	6.84	65.84	12.93	14.77	77.42	5.33
Poomkulam loca (V14)	562.33	64.00	53.11	98.33	12.00	16.64	6.61	71.17	9.18	14.98	88.75	4.33
Pachalloor local (V15)	404.44	61.33	43.12	97.50	8.89	20.75	4.58	50.13	11.05	18.88	105.28	3.00
Venganoor local (V16)	584.44	60.67	45.50	120.33	11.00	18.84	8.88	68.55	8.40	16.84	93.33	4.33
Pusa Kranti (V17)	732.50	68.33	42.13	52.50	10.08	22.50	4.83	68.23	18.05	25.07	243.52	3.33
Pusa Purple cluster (V18)	984.22	72.33	62.33	93.33	6.44	9.58	16.73	85.00	12.63	10.93	95.00	6.33
Arka Kusumkar (V19)	342.36	72.33	82.99	92.50	8.50	12.61	7.67	66.75	13.27	9.27	82.50	3.33
Kuttalam local (V20)	453.75	67.33	46.07	78.67	12.92	31.11	4.25	60.28	8.25	17.03	99.07	2.67
Brinjal Suphal (V21)	697.50	64.67	38.24	100.00	9.00	21.41	6.50	61.67	9.80	22.25	118.75	6.00
Palappur local (V22)	300.00	69.00	67.78	71.67	10.22	19.53	2.94	261.93	11.80	18.07	93.67	2.00
Brijal Supriya (V23)	186.67	66.33	45.35	72.50	9.50	21.56	2.28	52.76	9.15	23.97	87.67	1.67
Manjari Gota local (V24)	247.50	68.33	45.33	52.00	7.10	20.45	2.11	165.00	5.95	17.87	118.99	1.00
Pragathy (V25)	169.17	70.00	48.33	61.67	5.50	9.46	2.17	80.33	8.18	15.84	63.17	1.33
Mean	474.78	67.08	55.93	90.07	8.25	15.34	5.42	83.20	11.29	17.11	97.42	3.56
F	12.69^{**}	4.91^{**}	23.03^{**}	18.38^{**}	12.46^{**}	26.08^{**}	16.29^{**}	259.79^{**}	22.10^{**}	40.1887^{**}	24.65^{**}	16.43^{**}
SE	59.1107	2.5940	3.9561	5.4391	0.7316	1.2057	0.8579	2.8660	0.6770	0.7259	6.7712	0.3788
CD	168.0261	7.3736	7.9121	15.4610	2.0796	3.4273	2.4389	8.1469	1.9243	2.0635	19.2477	1.0769

** significant at 1 percent

V9 (Thikkodi local) was the latest to flower and was on par with the genotypes V5 (Nedumangad local-2) and V8 (Alappuzha local).

Plant height at first harvest ranged from 38.24cm to 84.60cm. Thikkodi local (V9) was the tallest and was on par with V4 (Nedumangad local-1) and V19 (Arka Kusumkar). Brinjal Suphal (V21) was the shortest and was on par with V2, V7, V15, N16, V17, V20, V23 and V24.

Plant height at last harvest ranged from 52.00cm to 138.33cm. Thikkodi local (V9) was the tallest and was on par with V7 (Neyyattinkara local) and V13 (Peringamala local). Manjarigota local (V24) was the shortest and was on par with V17 (Pusa Kranti) and V25 (Pragathy).

The number of primary branches per plant ranged from 3.44 to 12.92. The highest number was recorded for V20 (Kuttalam local) and the genotypes V7 (Neyyattinkara local), V14 (Poomkulam local) and V16 (Venganoor local) were on par with this. The least value recorded in V1 (Swetha) and V2, V3, V5 and V25 were on par with this.

The number of secondary branches per plant ranged from 5.07 to 31.11 and the highest number were recorded for V20 (Kuttalam local) and no other genotype was on par with this. The least number of secondary branches was recorded for V4 (Nedumangad local-1) and V5 (Nedumangad local-2) was on par with this.

The mean values for the number of fruits per plant ranged from 1.36 to 16.73. The highest number was recorded by V18 (Pusa Purple Cluster) and no other genotype was on par with this. The least number recorded for

V8 (Alappuzha local) and the genotypes V4, V5, V9, V12, V22, V23, V24 and V5 were on par with this.

Number of leaves per plant ranged between 37.00 and 261.93. The highest number recorded for V22 (Palappur local) and no other genotype was on par with this. The least number recorded for V11 (Vellayani local-2) and no other genotype was on par with this as far as this character is considered.

Among the 25 genotypes the length of fruit ranged from 5.95cm to 21.58cm. The longest fruit was obtained from V9 (Thikkodi local) and no other genotype was on par with this. The shortest fruit was obtained from V24 (Manjarigota local) and no other genotype was on par with this.

The girth of fruit ranged from 9.27cm to 25.07cm. Fruits of V17 (Pusa Kranti) recorded maximum girth, and V5 (Nedumangad local-2) and V23 (Brinjal Supriya) were on par with this. The minimum girth was recorded for V19 (Arka Kusumkar) and V1 (Swetha), V8 (Alappuzha local) and V18 (Pusa Purple Cluster) were on par with this.

The weight of individual fruit ranged from 56.38g to 243.52g. The fruits obtained from V17 (Pusa Kranti) recorded the maximum weight and no other genotype was on par with this. The lowest weight was recorded by V8 (Alappuzha local) and was on par with V25 (Pragathy).

The number of harvests ranged from 1.00 to 6.33. Pusa Purple Cluster (V18) recorded the highest value and V1, V2, V7, V13 and V21 were on par with this. The least value recorded for V24 (Manjarigota local) and was on par with V4, V8, V9, V12, V20, V22, V23 and V25.

4.1.3. Grouping of genotypes

Based on the performance of each character under study all the 25 genotypes were grouped into three categories viz. poor, medium and better performing groups. The distribution of genotypes into the above three categories is given in table 4.

The genotypes V1, V2, V3, V7, V17, V18 and V21 were found to be performing better as far as yield per plant is concerned. But for number of fruits per plant, the genotypes viz., V1, V2, V16, V18 and V19 were found to be the better performing ones. The genotypes, V1, V2, V3, V7, V11, V13, V14, V16, V18 and V21 were found to be in the better performing group for number of harvests.

The genotypes V1 (Swetha), V2 (Surya) and V15 (Pachalloor local) were fond to be the earliest to flower. For the character fruit length V1, V9, V13, V17 and V19 were found to be better, while the genotypes V4, V5, V6, V10, V15, V17, V21 and V23 had better fruit girth. Weight of fruit was found to be better for the genotypes V17, V21 and V24.

The genotypes V7, V9, V10, V13 and V16 had the better performance for plant height. For number of primary branches per plant, V7, V12, V14, V16, V17, V20 and V22 were found to be the better ones, while for number of secondary branches per plant, V7, V15, V16, V17, Table.4.

Grouping of 25 brinjal genotypes into better, medium and poor performing classes with respect to each character.

Characters	Better	Medium	Poor
Yield / plant	V1, V2, V3, V7, V17, V18, V21.	V5, V6, V10, V11, V12, V13, V14, V15, V16, V20.	V4, V8, V9, V19, V22, V23, V24, V25.
Days to first flowering	V1, V2, V15, V16.	V3, V4, V7, V10, V11, V12, V13, V14, V17, V20, V21, V22, V23, V24, V25.	V5, V6, V8, V9, V18, V19.
Plant height	V7, V9, V10, V13, V16.	V1, V3, V4, V5, V6, V8, V12, V14, V15, V18, V19, V21.	V2, V11, V17, V20, V22, V23, V24, V25.
Number of primary branches / plant	V7, V12, V14, V16, V17, V20, V22.	V6, V8, V9, V10, V11, V13, V15, V19, V21, V23, V24.	V1, V2, V3, V4, V5, V18, V25.
Number of secondary branches / plant	V7, V15, V16, V17, V20, V21, V22, V23, V24.	V9, V10, V12, V13, V14.	V1, V2, V3, V4, V5, V6, V8, V11, V18, V19, V25.
Number of fruits /plant	V1, V2, V16, V18, V19.	V3, V6, V7, V10, V11, V13, V14, V15, V17, V20, V21.	V4, V5, V8, V9, V12, V22, V23, V24, V25.
Number of leaves / plant	V5, V6, V9, V10, V22, V24.	V4, V8, V18, V25.	V1, V2, V3, V7, V11, V12, V13, V14, V15, V16, V17, V19, V20, V21, V23.
Fruit length	V1, V9, V13, V17, V19.	V2, V4, V5, V6, V8, V10, V11, V12, V15, V18, V22.	V3, V7, V14, V16, V20, V21, V23, V24, V25.
Fruit girth	V4, V5, V6, V10, V15, V17, V21, 23.	V2, V3, V7, V12, V16, V20, V22, V24, V25.	V1, V8, V9, V11, V13, V14, V18, V19.
Weight of fruit	V17, V21, V24.	V1, V2, V3, V5, V6, V9, V10, V12, V14, V15, V16, V18, V20, V22, V23.	V4, V7, V8, V11, V13, V19, V25.
Number of harvests	V1, V2, V3, V7, V11, V13, V14, V16, V18, V21.	V5, V6, V10, V15, V17, V19.	V4, V8, V9, V12, V20, V22, V23, V24, V25.

V20, V21, V22, V23 and V24 were better. The genotypes V5, V6, V9, V10, V22 and V24 produced more number of leaves.

4.1.4. Variability Studies

The phenotypic, genotypic and environmental variance and coefficients of variation for the 11 characters are presented in table 5. Fig.1 indicates phenotypic and genotypic coefficient of variation (PCV & GCV in %) for 11 characters.

The values of genotypic variance (σg^2) were greater than environmental variance (σe^2) for all the characters studied which indicated that σg^2 contributes much to the total phenotypic variance (σp^2).

The maximum value for GCV was observed for number of fruits per plant (61.91) followed by number of leaves per plant (55.42), yield per plant (42.56), number of harvests (41.81) and number of secondary branches per plant (39.35). The GCV was the lowest for days to first flowering (7.56).

The highest PCV was observed for number of fruits per plant (67.72) followed by number of leaves per plant (55.74), yield per plant (47.72), number of harvests (45.69) and number of secondary branches per plant (41.64). PCV was lowest for days to first flowering (10.17).

The difference between genotypic and phenotypic coefficients of variation was least for number of leaves per plant (0.32) followed by girth of fruit (1.00) and was high for number of fruits per plant (5.80) and yield per plant (5.15).

Table. 5. Estimates of genetic parameters with respect to various characters

Character	Variance			Coefficient of variation			Heritability (H^2) (%)	Genetic advance (as % of mean)
	σp^2	σg^2	σe^2	PCV	GCV	ECV		
Yield / Plant	51319.56	40837.35	10482.21	47.72	42.56	5.15	79.58	78.22
Days to first flowering	46.50	26.31	20.19	10.17	7.65	2.52	56.59	11.85
Plant height at last harvest	602.91	514.16	88.75	27.26	25.18	2.09	85.28	47.89
No. of primary branches / plant	7.74	6.13	1.61	33.73	30.03	3.70	79.25	55.07
No. of secondary branches / plant	40.82	36.46	4.3	41.64	39.35	2.29	89.32	76.62
No. of fruits / plant	13.46	11.25	2.21	67.72	61.91	5.80	83.60	116.61
No. of leaves / plant	2150.36	2125.71	24.64	55.74	55.42	0.32	98.85	113.51
Length of fruit	11.42	10.04	1.38	29.93	28.07	1.86	87.96	54.23
Girth of fruit	22.23	20.65	1.58	27.56	26.56	1.00	92.89	52.73
Weight of fruit	1222.08	1084.53	137.55	35.89	33.81	2.08	88.75	65.60
No. of harvests	2.65	2.22	0.43	45.69	41.81	3.88	83.73	78.80

4.1.5. Heritability and Genetic advance

The estimates of heritability and genetic advance for 11 characters are presented in table 5 and their graphical representation is given in Fig 2.

The heritability estimates of all the characters except for days to first flowering were high (above 60%) with maximum value for number of leaves per plant (98.85%) followed by girth of fruit (92.89%), number of secondary branches per plant (89.32%), weight of fruit (88.75%) and length of fruit (87.96%). The least value was recorded for number of primary branches per plant (79.25%). Days to first flowering showed moderate heritability (56.59%).

Expected genetic advance as percentage of mean was high for number of fruits per plant (116.61) followed by number of leaves per plant (113.51), number of harvests (78.80), yield per plant (78.22) and number of secondary branches per plant (76.62). The expected genetic advance was moderate for days to first flowering (11.85).

The heritability and genetic advance were categorised as suggested by Robinson *et al* (1949).

High values of heritability coupled with high genetic advance were observed for all the characters except for days to first flowering.

Fig. 1

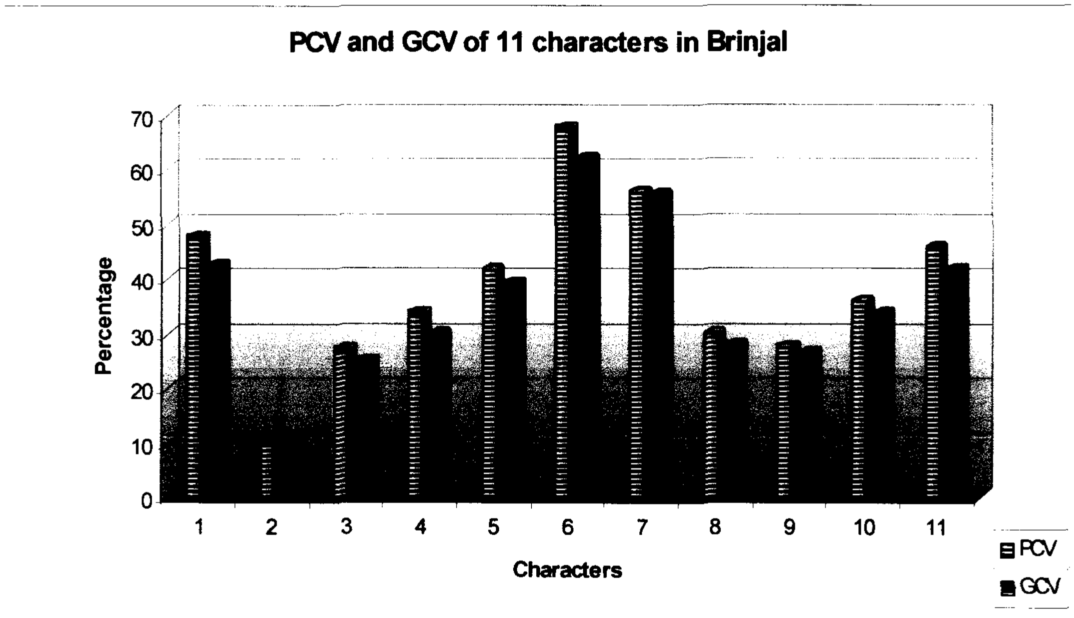
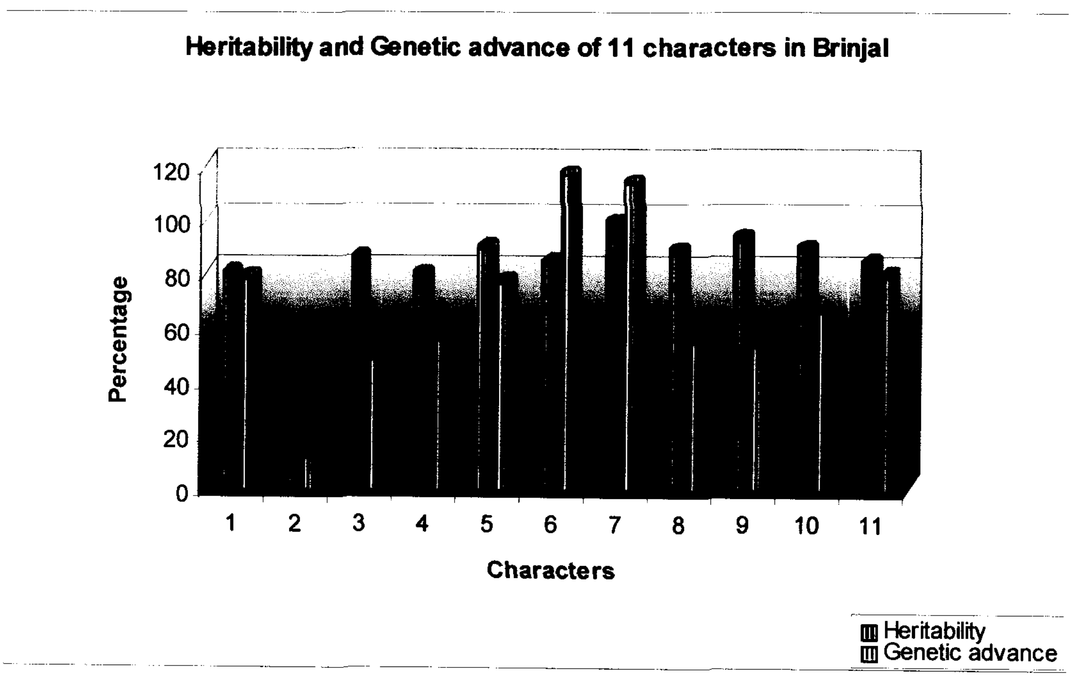


Fig. 2



Characters:

1 - Yield /plant
2 - Days to first flowering
3 - Plant height
4 - No. of primary branches/plant
5 - No. of secondary branches/plant
6 - No. of fruits/plant
7 - No. of leaves/plant
8 - Fruit length
9 - Fruit girth
10 - Weight of fruit
11 - No. of harvests.

4.1.6. Correlation Studies

The genotypic, phenotypic and environmental correlation coefficients were estimated for all the pairs of characters and are presented in table 6, 7 & 8.

(a) Correlation between yield and other characters

The phenotypic correlation was found to be high and positive for number of harvests (0.8213) and number of fruits per plant (0.8030). Days to first flowering (-0.3138) recorded high negative correlation with yield per plant.

Genotypic correlation of fruit yield per plant with number of harvests (0.8910), number of fruits per plant (0.8365) and fruit weight (0.3466) showed high positive correlation. The correlation of yield with days to first flowering (-0.4035) and number of leaves per plant (-0.3212) were high but negative.

While considering the environmental correlation of fruit yield with other characters, number of fruits per plant (0.6599) had the highest positive correlation followed by number of harvests (0.5158) and number of secondary branches per plant (0.3038).

(b) Correlation among the yield component characters

The results of phenotypic, genotypic and environmental correlation coefficients analysis among the yield components are presented below.

Table.6. Phenotypic correlation coefficients among the characters

Characters	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11
Fruit yield / plant (X1)	1.0000										
Days to first flowering (X2)	-0.3138*	1.0000									
Plant hight at final harvest (X3)	0.1437	0.0750	1.0000								
No. of primary branches / plant (X4)	-0.1117	0.1748	0.2804*	1.0000							
No. of secondary branches / plant (X5)	0.0427	-0.0469	0.0181	0.7058**	1.0000						
No. of fruits / plant (X6)	0.8030**	-0.2985*	0.1746	-0.1752	-0.1521	1.0000					
No. of leaves / plant (X7)	-0.2806*	0.2516	-0.1174	0.0478	0.0679	-0.2587	1.0000				
Fruit length (X8)	0.0768	0.2669	0.1981	-0.0497	-0.2023	0.1074	0.0714	1.0000			
Fruit girth (X9)	-0.0268	-0.0052	-0.2011	0.1032	0.2538	-0.3596*	0.0469	-0.1885	1.0000		
Weight of fruit (X10)	0.2719	0.0600	-0.2775	0.1692	0.3450	-0.0233	0.0415	0.3451*	0.4460**	1.0000	
No. of harvests (X11)	0.8213**	-0.3015*	0.3139	-0.1216	-0.1231	0.8019**	-0.4226**	0.0821	-0.2107	-0.0289	1.0000

Table.7. Genotypic correlation coefficients among the characters

Characters	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11
Fruit yield / plant (X1)	1.0000										
Days to first flowering (X2)	-0.4035**	1.0000									
Plant hight at final harvest (X3)	0.2352	0.0958	1.0000								
No. of primary branches / plant (X4)	-0.0906	0.1545	0.3164*	1.0000							
No. of secondary branches / plant (X5)	-0.0026	-0.1497	0.0575	0.8161**	1.0000						
No. of fruits / plant (X6)	0.8365**	-0.3354**	0.2636	-0.2030	-0.2045	1.0000					
No. of leaves / plant (X7)	-0.3212	0.3454**	-0.1301	0.0638	0.0638	-0.2900*	1.0000				
Fruit length (X8)	0.0898	0.3374*	0.2662	-0.0616	-0.2359	0.0944	0.0698	1.0000			
Fruit girth (X9)	-0.0591	0.0080	-0.2284	0.1507	0.3032*	-0.4163**	0.0453	-0.2306	1.0000		
Weight of fruit (X10)	0.3466**	-0.0406	-0.3204	0.1553	0.3518*	0.0037	0.0439	0.3990**	0.5104**	1.0000	
No. of harvests (X11)	0.8910**	-0.4369**	0.4001**	-0.1503	-0.1623	0.8278**	-0.4678**	0.0384	-0.2424	-0.0186	1.0000

** - significant at 1 %   * - significant at 5%

Table.8 Environmental correlation coefficients among the characters

Characters	X1	X2	X3	X5	X6	X7	X8	X9	X10	X11
Fruit yield / plant (X1)	1.0000									
Days to first flowering (X2)	-0.1446	1.0000								
Plant hight at final harvest (X3)	-0.2885*	0.0334	1.0000							
No. of primary branches / plant (X4)	-0.1930	0.2376	0.1161							
No. of secondary branches / plant (X5)	0.3038*	0.2763	-0.2562	1.0000						
No. of fruits / plant (X6)	0.6599**	-0.2539	-0.3086*	0.1859	1.0000					
No. of leaves / plant (X7)	0.0895	-0.0944	0.0506	0.2268	0.1143	1.0000				
Fruit length (X8)	0.0111	0.1264	-0.2440	0.0591	0.1880	0.1706	1.0000			
Fruit girth (X9)	0.1994	-0.0628	0.0213	-0.2570	0.0665	0.1216	0.2162	1.0000		
Weight of fruit (X10)	-0.1277	0.4017**	0.0097	0.2900*	-0.1948	0.0096	-0.0632	-0.1945	1.0000	
No. of harvests (X11)	0.5158**	-0.0028	-0.1559	0.1309	0.6692**	0.0683	0.3511*	0.0285	-0.0951	1.0000

** - significant at 1%

* - significant at 5%

(1) Days to first flowering

The only character with which this character showed a high phenotypic correlation was number of harvests (-0.3015) which was negative. High positive genotypic correlation with days to first flowering was recorded by number of leaves per plant (0.3454) followed by length of fruit (0.3374), while high negative genotypic correlation with days to first flowering was shown by number of harvests (-0.4369) followed by number of fruits per plant (-0.3354). Fruit weight showed high positive environmental correlation (0.4017) with days to first flowering.

(2) Plant height at last harvest

Number of harvests recorded high positive phenotypic correlation (0.3139) with plant height. Number of harvests recorded positive and high genotypic correlation (0.4001) with plant height followed by number of primary branches per plant (0.3164), while fruit weight recorded high negative genotypic correlation (-0.3204) with plant height. Number of fruits per plant showed high but negative environmental correlation (-0.3086) with plant height.

(3) Number of primary branches per plant

Number of secondary branches per plant showed high and positive phenotypic correlation (0.7058) with number of primary branches per plant. Number of secondary branches per plant also showed a high positive genotypic correlation (0.8161) followed by plant height (0.3164). No characters showed a high environmental correlation with number of primary branches per plant.

(4) Number of secondary branches per plant

High positive phenotypic correlation with number of secondary branches per plant was shown by number of primary branches per plant (0.7058) followed by fruit weight (0.3450). Number of primary branches per plant also recorded high and positive genotypic correlation (0.8161) followed by fruit weight (0.3518) and girth of fruit (0.3032). For this particular character there was no environmental correlation with any other yield related character.

(5) Number of fruits per plant

Number of harvests showed high positive phenotypic correlation (0.8019) with number of fruits per plant, while fruit girth recorded high but negative phenotypic correlation (-0.3596) with number of fruits per plant.

Number of harvests showed high positive genotypic correlation (0.8278) with number of fruits per plant, while high negative genotypic correlation with this particular character was shown by fruit girth (-0.4163) followed by days to first flowering (-0.3354).

The environmental correlation between number of harvests and number of fruits per plant (0.6692) was high and positive while it was high but negative with plant height (-0.3086).

(6) Number of leaves per plant

Number of harvests showed high but negative phenotypic correlation (-0.4226) with number of leaves per plant. Days to first flowering recorded high positive genotypic correlation (0.3454) with number of leaves per plant while high negative genotypic correlation (-0.4678) was recorded by number of harvests. No characters showed high environmental correlation with number of leaves per plant.

(7) Fruit length

Fruit weight showed high positive phenotypic correlation (0.3451) with fruit length. Genotypic correlation of fruit length with fruit weight (0.3990) and days to first flowering (0.3374) were high and positive. Number of harvests showed high positive environmental correlation with fruit length (0.3511).

(8) Fruit girth

Fruit weight recorded high positive phenotypic correlation (0.4460) with fruit girth, while number of fruits per plant recorded high but negative correlation (-0.3596). High positive genotypic correlation with fruit girth was shown by fruit weight (0.5104) followed by number of secondary branches per plant (0.3032) while number of fruits per plant showed a negative genotypic correlation (-0.4163) with fruit girth. Environmental correlation between fruit girth and rest of the yield components were negligible.

(9) Fruit weight

Fruit weight recorded high positive phenotypic correlation with fruit girth (0.4460), fruit length (0.3451) and number of secondary branches per plant (0.3450). Fruit weight showed high positive genotypic correlation with fruit girth (0.5104) followed by length of fruit (0.3990) and number of secondary branches per plant (0.3518), while plant height recorded high genotypic correlation (-0.3204) with fruit weight but was negative. The character showed high positive environmental correlation (0.4017) with days to first flowering.

(10) Number of harvests

Number of harvests showed high positive phenotypic correlation with number of fruits per plant (0.8019) followed by plant height (0.3139). High but negative phenotypic correlation was observed with number of leaves per plant (-0.4226) followed by days to first flowering (-0.3015).

High positive genotypic correlation was recorded with number of fruits per plant (0.8278) followed by plant height (0.4001), while number of leaves per plant (-0.4678) and days to first flowering (-0.4369) showed negative genotypic correlation with number of harvests. Number of fruits per plant showed high positive environmental correlation (0.6692) with number of harvests followed by length of fruit (0.3511).

4.1.7. Path Analysis

In path coefficient analysis, the genotypic correlation coefficients among yield and its component characters were partitioned, to find out the direct and indirect contribution of each character to fruit yield (Table 9). The characters viz., days to first flowering, plant height (at last harvest), number of fruits per plant, number of leaves per plant, fruit weight and number of harvests having high genotypic correlation with yield were selected for Path Coefficient Analysis.

Path diagram showing the direct and indirect effects of component characters on yield is provided in Fig 3.

The maximum direct effect on yield was shown by number of harvests (0.6908) followed by fruit weight (0.3585) and number of fruits per plant (0.2741).

The direct effect of days to first flowering towards yield was low and negative (-0.0225). The indirect effect *via* number of harvests was comparatively high but negative (-0.3018) and its total genotypic correlation was -0.4035. The indirect effects through other characters were almost negligible.

The direct effect of plant height was the lowest but positive (0.0134). But it had a total correlation of about 0.2351. The indirect effect of plant height through number of harvests was high and positive (0.2764). Indirect effect *via* fruit weight was negative (-0.1149). The other characters had not contributed towards yield *via* plant height.

The direct effect of the character number of fruits per plant was 0.2741. It had a high positive indirect effect *via* number of harvests (0.5719) and its total genotypic correlation towards yield was 0.8365.

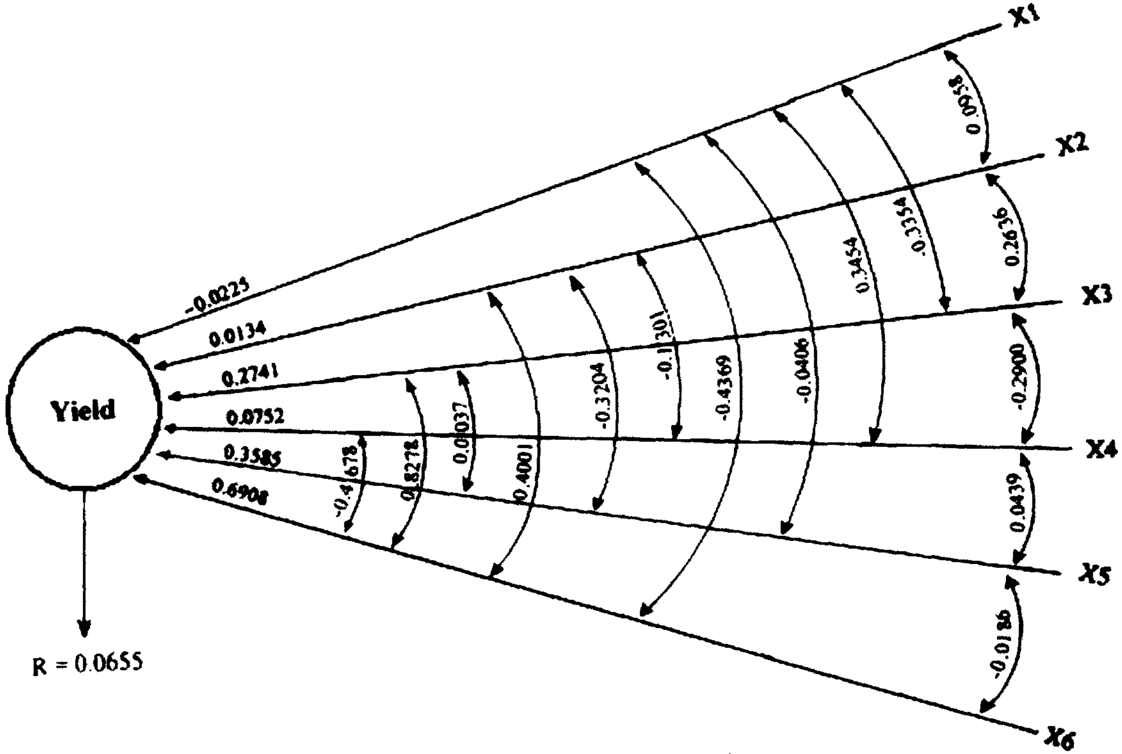
Table 9 Direct and indirect effects of yield components on yield

Characters	X1	X2	X3	X4	X5	X6	Total correlation
Days to first flowering (X1)	-0.0225	0.0013	-0.0919	0.0260	-0.0146	-0.3018	-0.4035
Plant hieght (X2)	-0.0022	0.0134	0.0722	-0.0098	-0.1149	0.2764	0.2351
No of fruits per plant (X3)	0.0075	0.0035	0.2741	-0.0218	0.0013	0.5719	0.8365
No of leaves per plant (X4)	-0.0078	-0.0017	-0.0795	0.0752	0.0157	-0.3232	-0.3213
Fruit weight (X5)	0.0009	-0.0043	0.0010	0.0033	0.3585	-0.0128	0.3466
No of harvests (X6)	0.0098	0.0053	0.2269	-0.0352	-0.0067	0.6908	0.8909

Residual effect ® = 0.0655

Figurs in RED represent Direct effects
Figures in BLACK represent Indirect effects

Fig.3 Path diagram showing the direct and indirect effects of the components on yield



Figures in 'Red' represent Direct effects, Figures in 'Black' represent Indirect effects

X 1 - Days for first flowering
X 2 - Plant height
X 3 - Number of fruits per plant
X 4 - Number of leaves per plant
X 5 - Fruit weight
X 6 - Number of harvests
R - Residual effect

The direct effect of number of leaves per plant on fruit yield was low but positive (0.0752). But the indirect effect *via* number of harvests was high but negative (-0.3232) which was almost equal to the total correlation (-0.3213) which was also negative. The indirect effects *via* other character were almost nullified.

The direct effect of the character fruit weight on yield was high and positive (0.3585) and was found to be higher than the total correlation of the character on yield (0.3466). The other characters exerted very low and negative indirect effects *via* fruit weight.

Number of harvests recorded the highest positive direct effect (0.6908) on yield as well as the highest total correlation (0.8909). The indirect effect *via* number of fruits per plant was 0.2269 while the indirect effects *via* other characters were negligible.

The residue obtained (0.0655) indicated that the path coefficient analysis based on these characters could explain 93.4 percent of variation, of fruit yield.

4.1.8. Selection Index

Discriminant function technique was adopted for the construction of selection index for yield, using fruit yield per plant and the component characters viz., days to first flowering, plant height, number of primary branches per plant, number of secondary branches per plant, number of fruits per plant, number of leaves per plant, fruit length, fruit girth, fruit weight and number of harvests (denoted as X_1, X_2,... X_{11} respectively).

These component characters showed high associations with yield and a valuable selection index for yield in this crop was obtained.

The selection index value for each genotype was determined using the formula,

$I = 0.3855\ X_1 + (-1.1855)\ X_2 + 2.3184\ X_3 + 2.0008\ X_4 + (-3.4503)\ X_5 + 8.7592\ X_6 + 0.9725\ X_7 + (-9.3873)\ X_8 + (-2.2539)\ X_9 + 3.2311\ X_{10} + 34.0147\ X_{11}$.

The genotypes were ranked according to their selection index values. The selection indices along with the ranking of each genotype are presented in table 10.

The highest index value was recorded by the variety V18 (Pusa Purple Cluster) followed by V17 (Pusa Kranti), V21 (Brinjal Suphal), V1 (Swetha) and V16 (Venganoor local). These five top ranking genotypes were identified to be genetically superior.

4.2. Screening for brinjal shoot and fruit borer resistance

Screening of genotypes based on the extent of damage to shoots and fruits was done in this study. The data on damage parameters collected from field experiment with 25 genotypes were subjected to statistical analysis. The results are presented below.

4.2.1. Analysis of Variance

The damage parameters viz., percentage of plants infested and percentage of young shoots infested showed no consistency in variation at 30 DAT, 40 DAT, 50 DAT, 60 DAT and 70 DAT as there was only very

Table.10 Selection Indices

Rank	Genotypes	Selection Index
1	V18	3294.7130
2	V17	3145.7740
3	V21	2792.2190
4	V1	2719.6750
5	V16	2597.6980
6	V7	2478.5400
7	V10	2416.3240
8	V13	2392.4360
9	V2	2380.0780
10	V3	2340.4480
11	V14	2330.3430
12	V6	2063.7190
13	V22	1958.2710
15	V5	1890.8410
16	V9	1856.0770
17	V19	1802.2830
18	V20	1760.4550
19	V24	1739.7730
20	V12	1734.7350
21	V11	1718.5600
22	V4	1458.7440
23	V8	1229.6250
24	V23	1131.9580
25	V25	1012.7830

low incidence of pest attack during these periods. The analysis of variance revealed significant difference among the 25 genotypes for all the damage parameters studied at 80 and 90 DAT.

4.2.2. Mean performance of the genotypes

The mean values of each of the 25 genotypes for the damage parameters studied are presented in tables. 11, 12, 13 and 14.

The genotypes V3, V7, V12, V13, V17, V20, V22 and V23 showed symptoms of attack from 30 DAT onwards. The percentages of plants and young shoots infested by the brinjal shoot and fruit borer at the peak fruiting period (at 80 DAT and 90 DAT) were compared.

The percentage of plants affected ranged fr6m 15.50% for V19 (Arka Kusumkar) to 90.55% for V13 (Peringamala local-1) and 11.25% for V10 (Vellayani local-1) to 52.80% for V13 and V15 (Pachalloor local) at 80 DAT and 90 DAT respectively. The genotype V19 was the least susceptible (15.50%) while V13 (90.55%) was the highly susceptible one at 80 DAT. The genotype V10 (11.25%) showed less susceptibility which was on par with V5 (Nedumangad local-2), V12 (Kalliyoor local) and V24 (Manjarigota local) at 90 DAT, while the genotype V13 and V15 were the highly susceptible genotypes at 90 DAT which was on par with genotypes V1 (Swetha), V22 (Palappur local), and V25 (Pragathy). Percentage infestation by *Leucinodes orbonalis* in selected brinjal genotypes (which showed comparatively less infestation on plants) at different intervals is presented in Fig 4.

Table 11 Percentage of plants infested at different intervals

Genotypes	30 DAT	40 DAT	50 DAT	60 DAT	70 DAT	80 DAT	90 DAT
V1	0.00	0.00	25.00	47.78	31.67	67.50	50.00
V2	0.00	0.00	5.00	25.00	60.00	35.15	36.65
V3	5.00	0.00	0.00	0.00	15.00	18.75	25.00
V4	0.00	5.00	5.00	5.00	44.47	65.05	27.75
V5	0.00	0.00	0.00	5.56	5.56	32.20	21.10
V6	0.00	0.00	5.00	10.00	27.78	44.40	38.85
V7	5.00	10.00	35.00	58.33	36.49	59.55	26.80
V8	0.00	0.00	0.00	0.00	5.56	52.80	40.95
V9	0.00	0.00	0.00	0.00	5.00	48.16	38.75
V10	0.00	0.00	10.56	23.61	33.75	41.61	11.25
V11	0.00	0.00	0.00	0.00	7.15	49.45	40.20
V12	5.00	10.00	0.00	13.34	13.40	41.20	13.40
V13	5.00	5.00	10.00	20.00	47.78	90.55	52.80
V14	0.00	0.00	5.00	10.00	20.00	70.00	30.00
V15	0.00	0.00	0.00	11.11	29.86	75.33	52.80
V16	0.00	0.00	25.00	35.00	50.00	59.18	35.00
V17	10.00	15.00	0.00	0.00	0.00	25.00	25.00
V18	5.00	0.00	15.00	23.34	30.00	43.20	36.65
V19	0.00	0.00	5.00	12.50	8.34	15.50	30.95
V20	10.00	0.00	0.00	10.00	5.00	35.40	35.40
V21	0.00	0.00	15.00	16.67	31.67	57.14	30.00
V22	5.00	0.00	0.00	23.61	5.56	47.61	50.00
V23	15.00	0.00	5.00	20.00	20.00	38.75	27.50
V24	0.00	0.00	0.00	5.00	42.20	31.65	15.55
V25	0.00	0.00	15.00	21.67	27.77	48.34	45.00
MEAN	2.60	1.80	7.22	15.90	24.16	47.74	33.49
F						102.73	9.71
SE						0.1843	5.2948
CD						0.3804	10.9285

Table 12 Percentage of young shoots infested at different intervals

Genotypes	30 DAT	40 DAT	50 DAT	60 DAT	70 DAT	80 DAT	90 DAT
V1	0.00	0.00	5.41	6.18	10.35	16.05	5.90
V2	0.00	0.00	4.50	5.73	20.84	12.70	1.70
V3	1.85	0.00	0.00	0.00	5.15	7.80	2.75
V4	0.00	3.03	4.88	2.78	3.67	17.10	5.95
V5	0.00	0.00	0.00	0.84	1.25	22.55	5.80
V6	0.00	0.00	2.82	1.67	3.95	12.15	2.85
V7	1.67	4.55	13.26	7.42	3.25	12.45	4.65
V8	0.00	0.00	0.00	0.00	3.70	12.40	10.80
V9	0.00	0.00	0.00	0.00	0.56	11.45	6.50
V10	0.00	0.00	4.59	4.22	5.00	10.40	4.50
V11	0.00	0.00	0.00	1.57	0.85	13.95	11.60
V12	1.73	6.45	0.00	2.64	2.05	11.40	2.80
V13	0.98	1.87	5.24	7.24	13.90	23.70	3.30
V14	0.00	0.00	2.00	1.88	3.65	7.35	3.75
V15	0.00	0.00	0.00	1.73	4.59	16.45	4.75
V16	0.00	0.00	4.42	4.15	7.50	17.70	2.55
V17	1.93	2.73	0.00	0.00	0.00	4.40	4.00
V18	1.85	0.00	5.98	5.80	4.15	3.05	5.10
V19	0.00	0.00	2.97	1.73	2.15	10.25	4.25
V20	1.64	0.00	0.00	1.43	3.75	4.15	3.43
V21	0.00	0.00	2.71	1.67	8.50	7.85	3.00
V22	0.86	0.00	0.00	3.08	1.25	6.95	7.30
V23	2.00	0.00	1.80	2.42	6.70	12.90	6.35
V24	0.00	0.00	0.00	1.11	7.55	5.80	2.55
V25	0.00	0.00	8.01	5.63	8.80	7.80	4.70
MEAN	0.58	0.74	2.74	2.83	5.32	11.55	4.83
F						34.24	5.46
SE						1.2932	1.4552
CD						2.6692	3.0035

Table 13 Percentage of damaged fruits

Genotypes	60 DAT	70 DAT	80 DAT	90 DAT
V1	33.75	41.67	54.17	58.56
V2	42.50	44.34	65.29	67.63
V3	34.17	31.63	57.00	54.61
V4	62.50	61.81	77.73	81.88
V5	44.50	46.60	64.32	69.74
V6	45.00	46.32	55.45	58.93
V7	62.84	60.11	79.42	85.54
V8	34.87	45.00	53.34	54.99
V9	37.78	45.86	56.66	61.69
V10	43.67	48.81	65.30	67.80
V11	37.39	42.68	52.23	58.27
V12	43.10	46.46	61.17	69.43
V13	64.08	67.48	71.75	79.16
V14	42.22	47.98	64.95	87.22
V15	43.67	43.84	57.88	62.40
V16	59.45	57.40	76.56	87.21
V17	42.20	47.11	61.21	62.72
V18	46.37	46.06	74.95	81.55
V19	44.70	47.21	52.91	65.08
V20	51.67	55.00	69.86	71.83
V21	55.00	67.78	83.23	86.85
V22	44.39	50.13	77.51	82.28
V23	47.84	54.28	75.55	84.05
V24	27.67	31.67	47.74	55.68
V25	38.42	43.16	56.36	59.55
MEAN	45.19	48.81	64.50	70.18
F	14.78	18.32	25.21	35.21
SE	3.5066	2.9832	2.8782	2.756
CD	7.2376	6.1573	5.9406	5.6884

Table 14 Severity of fruit damage

Geotypes	No: of larvae/fruit	No: of bore holes/fruit
V1	4.35	8.90
V2	3.65	7.96
V3	3.77	6.09
V4	4.50	8.90
V5	4.26	8.85
V6	4.26	4.77
V7	4.31	3.86
V8	2.07	6.10
V9	2.95	6.93
V10	3.23	3.67
V11	3.64	5.05
V12	3.75	4.95
V13	3.25	7.96
V14	3.02	3.76
V15	4.56	8.87
V16	4.67	4.05
V17	4.21	3.87
V18	4.05	5.99
V19	3.98	3.61
V20	4.33	3.70
V21	4.60	4.63
V22	4.01	7.98
V23	4.06	8.85
V24	2.38	4.30
V25	2.70	5.70
MEAN	3.78	5.97
F	4.33	65.24
SE	0.487	0.3511
CD	1.0052	0.7247

The percentage of young shoots infested was least in case of V18 (Pusa Purple Cluster-3.05%) at 80 DAT, and was highest for V13 (Peringamala local, - 23.70%). The genotypes V17 (Pusa Kranti) and V20 (Kuttalam local) were on par with V18, while the genotype V13 was on par with V5 (Nedumangad local-2). At 90 DAT the genotype V2 (Surya) showed only 1.70% damage on shoots which was on par with V3, V6, V7, V10, V12, V13, V14, V16, V17, V19, V20, V21, V24, and V25. The highly susceptible one at 90 DAT was V11 (Vellayani local-2, - 11.60%) which was on par with V8 (Alappuzha local, - 10.80%). Percentage infestation by *Leucinodes orbonalis* in selected brinjal genotypes (which showed comparatively less infestation on young shoots) at different intervals is presented in Fig 5. Plate 5 shows the infested shoots.

The percentage of damaged fruits was only 27.67% for V24 (Manjarigota local) while it was 64.08% for V13 (Peringamala local) at 60 DAT. The genotypes V1 (Swetha), V3 (CO-2) and V8 (Alappuzha local) were on par with V24 while the genotypes V4 (Nedumangad local-1), V7 (Neyyattinkara local) and V16 (Venganoor local) were on par with V13. At 70 DAT, the genotype V3 was the least susceptible one (31.63%) and V21 (Brinjal Suphal) was the highly susceptible one (67.78%). The genotype V24 was on par with V3 and the genotypes V4 and V13 were on par with V21 at this period. V24 was showing low susceptibility (47.74%) when compared to other genotypes at 80 DAT which was on par with V8 (Alappuzha local), V11 (Vellayani local-2) and V19 (Arka Kusumkar)

Fig. 4

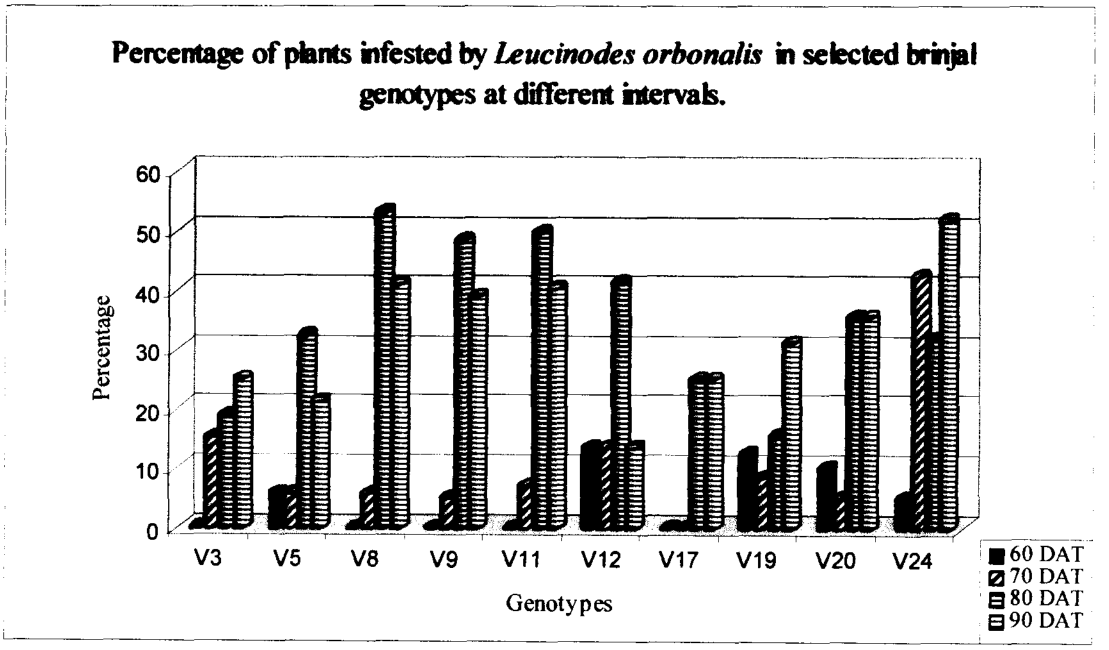

Percentage of plants infested by *Leucinodes orbonalis* in selected brinjal genotypes at different intervals.
60
50
40
30
20
10
0
Percentage
V3
V5
V8
V9
V11
V12
V17
V19
V20
V24
Genotypes
60 DAT
70 DAT
80 DAT
90 DAT

Fig. 5

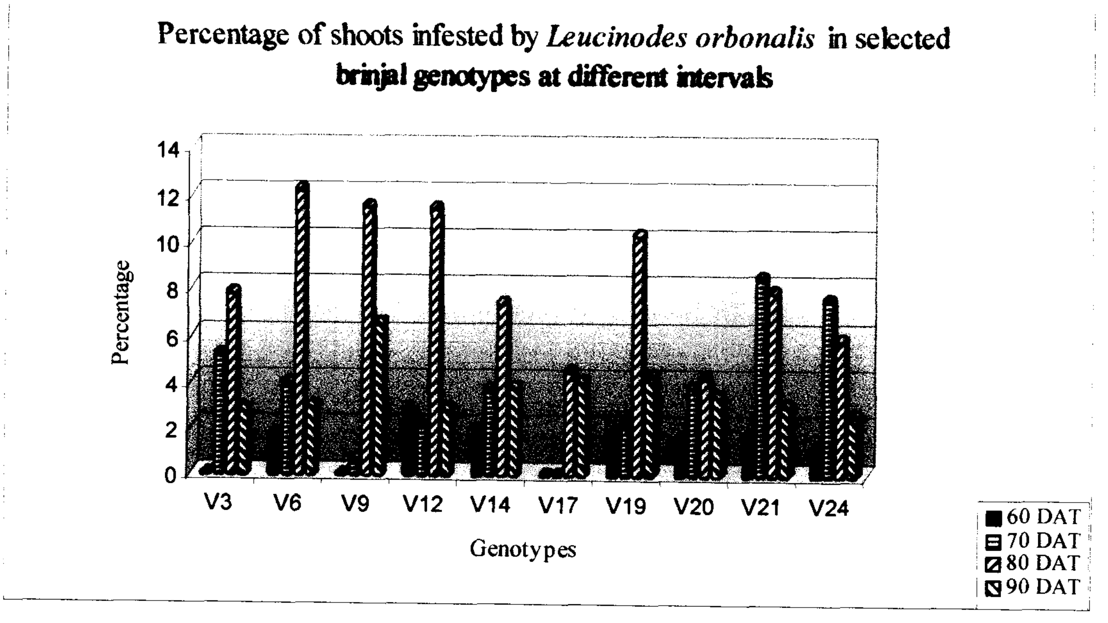

Percentage of shoots infested by *Leucinodes orbonalis* in selected brinjal genotypes at different intervals
14
12
10
8
6
4
2
0
Percentage
V3
V6
V9
V12
V14
V17
V19
V20
V21
V24
Genotypes
60 DAT
70 DAT
80 DAT
90 DAT

Plate. 5

(a) Initial symptom of infestation by *Leucinodes orbonalis*- Drooping of affected shoots

(b) Advanced stage of infestation by *Leucinodes orbonalis*- Drying of affected shoots

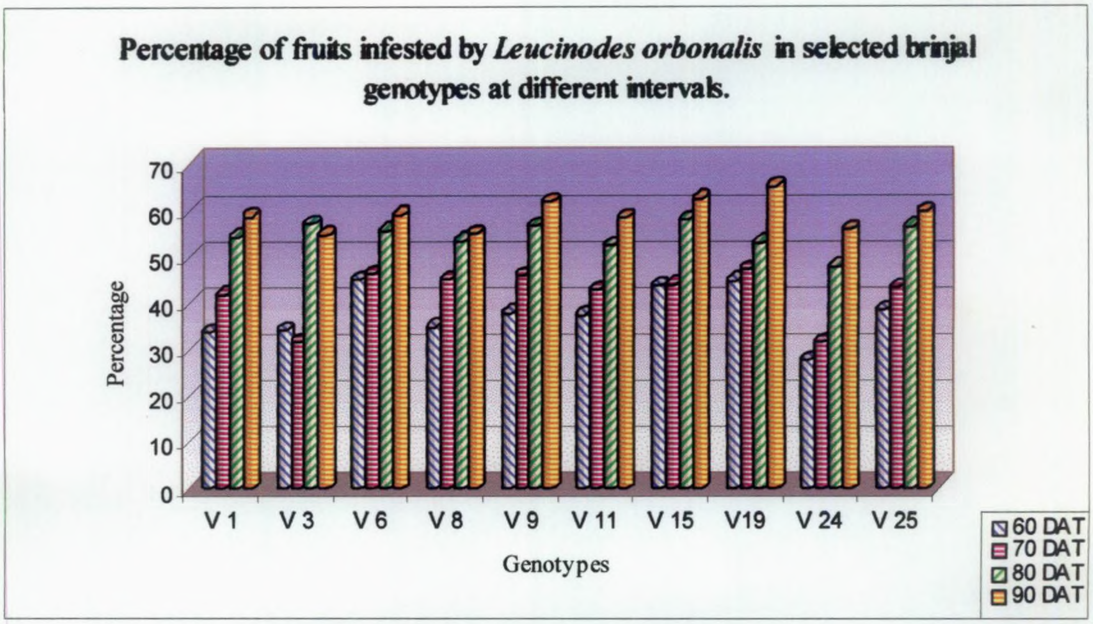
(c) Close up of larva inside the shoot.

while V21 was the highly susceptible one (83.23%) which was on par with V4, V7 and V22 (Palappur local). At 90 DAT V3 was the less affected one (54.61%) which was on par with V1, V6, V8, V11, V24 and V25 while V14 (Poomkulam local, - 87.22%) was the highly susceptible one which was on par with V4, V7, V16, V18, V21, V22 and V23. Percentage infestation by *Leucinodes orbonalis* in selected brinjal genotypes (which showed comparatively less infestation on fruits) at different intervals is presented in Fig 6. Plate 6. (i) shows symptoms of infestation on the fruits.

Extent of fruit damage by *Leucinodes orbonalis* in selected genotypes High yielding [V1 (Swetha), V2 (Surya), V7 (Neyyattinkara local), V17 (Pusa Kranti), V18 (Pusa Purple Cluster) & V21 (Brinjal Suphal)] and less susceptible genotypes [V3 (CO-2), V6 (Nedumangad local-3), V9 (Thikkodi local), V19 (Arka Kusumkar) & V24 (Manjarigota local)] in relation to the yield observed from Experiment I is given in the Fig 7.

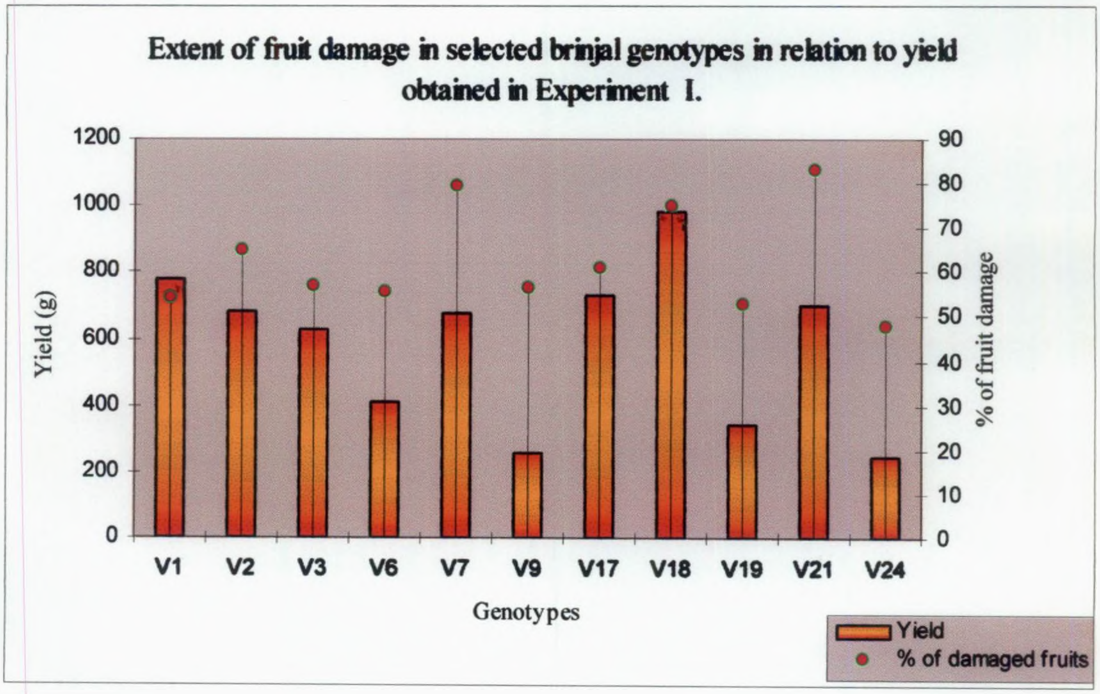
To find out the severity of fruit damage two parameters viz., number of larvae per fruit and number of bore holes per fruit were estimated. As far as the number of larvae per fruit is concerned, the genotype V8 (Alappuzha local) had the lowest number (2.07), which was on par with V9, V14, V24 and V25. The highest number (4.67) recorded in V16 (Venganoor local) which was on par with V1, V4, V15, V20 and V21. The number of bore holes per fruit was lowest (3.61) in case of V9 (Thikkodi local) which was on par with V7, V10, V14 and V20 while the highest

Fig. 6



Percentage of fruits infested by *Leucinodes orbonalis* in selected brinjal genotypes at different intervals.
70
60
50
40
30
20
10
0
Percentage
V 1
V 3
V 6
V 8
V 9
V 11
V 15
V19
V 24
V 25
Genotypes
60 DAT
70 DAT
80 DAT
90 DAT

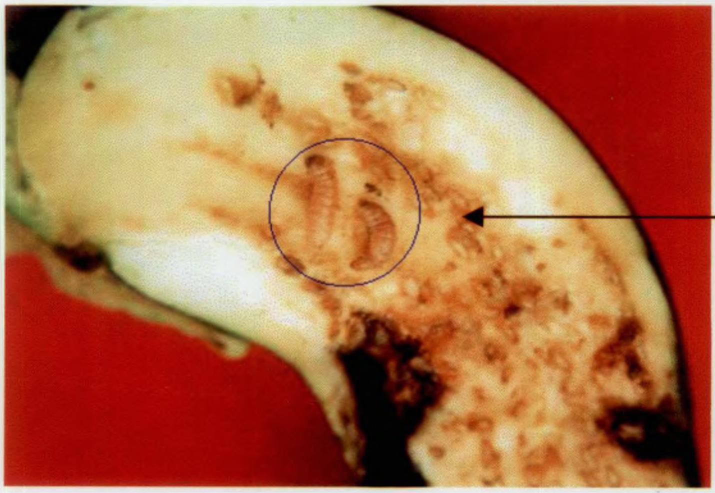
Fig. 7



Extent of fruit damage in selected brinjal genotypes in relation to yield obtained in Experiment I.
1200
1000
800
600
400
200
0
Yield (g)
90
80
70
60
50
40
30
20
10
0
% of fruit damage
V1
V2
V3
V6
V7
V9
V17
V18
V19
V21
V24
Genotypes
Yield
% of damaged fruits

Plate .6(i)

(a) Fruits infested by *Leucinodes orbonalis* showing exit holes plugged with excreta



(b) The close up of *Leucinodes orbonalis* larva inside the fruit

Plate.6(ii) Fruits of less susceptible genotypes

Pusa Kranthi
(V 17)

Arka Kusumkar
(V 19)

Manjarigota
(V 24)

CO - 2
(V 3)

number recorded in genotypes V1 (Swetha) and V4 (Nedumangad local-1) ie, 8.9 and was on par with V5, V15 and V23. The genotypes V14 (Poomkulam local) and V24 (Manjarigota local) had the lowest number of larvae per fruit as well as the lowest number of bore holes per fruit, while the genotypes V4, V5, V15 and V23 recorded the highest number of larvae per fruit and bore holes per fruit.

4.2.3. Grouping of genotypes

The 25 brinjal genotypes were grouped into less, moderately and highly susceptible groups for each of the damage parameters.

Distribution of genotypes into less susceptible, moderately susceptible and highly susceptible groups is given in the table 15.

The genotypes V2, V3, V5, V6, V10, V12, V17, V18, V19, V20, V23 and V24 were found to be in the less susceptible group as far as the percentage of plants affected is considered. When percentage of young shoots infested is considered, the genotypes V3, V14, V17, V18, V19, V20, V21, V22, V24 and V25 were found to be less susceptible. Percentage of fruits infested is less for the genotypes V1, V3, V6, V8, V9, V11, V12, V15, V17, V19, V24 and V25.

The genotypes V8, V9, V10, V13, V14, V24 and V25 were having the least number of larvae per fruit, while the genotypes V6, V7, V10, V11, V12, V14, V16, V17, V18, V19, V20 and V21 recorded the lowest number of bore holes per fruit.

Plate.6.(ii) show the fruits of less susceptible genotypes.

Table.15. Grouping of 25 brinjal genotypes into different classes based on the extent susceptibility.

Damage parameters	Less susceptible	Moderately susceptible	Highly susceptible
Percentage of plants infested	V2, V3, V5, V6, V10, V12, V17, V18, V19, V20, V23, V24.	V9, V22.	V1, V4, V7, V8, V9, V11, V13, V14, V15, V16, V21, V25.
Percentage of young shoots infested	V3, V14, V17, V18, V19, V20, V21, V22, V24, V25.	V2, V6, V7, V8, V9, V10, V12.	V1, V4, V5, V11, V13, V15, V16, V23.
Percentage of fruits damaged	V1, V3, V6, V8, V9, V11, V12, V15, V17, V19, V24, V25.	V2, V5, V10, V14.	V4, V7, V13, V16, V18, V20, V21, V22, V23.
Number of larvae / fruit	V8, V9, V10, V13, V14, V24, V25.	V2, V3, V5, V6, V11, V12, V17, V18, V19, V22, V23.	V1, V4, V7, V15, V16, V20, V21.
Number of bore holes / fruit	V6, V7, V10, V11, V12, V14, V16, V17, V19, V20, V21, V24.	V3, V8, V18, V25.	V1, V2, V4, V5, V9, V13, V15, V22, V23.

4.2.4. Correlation Studies

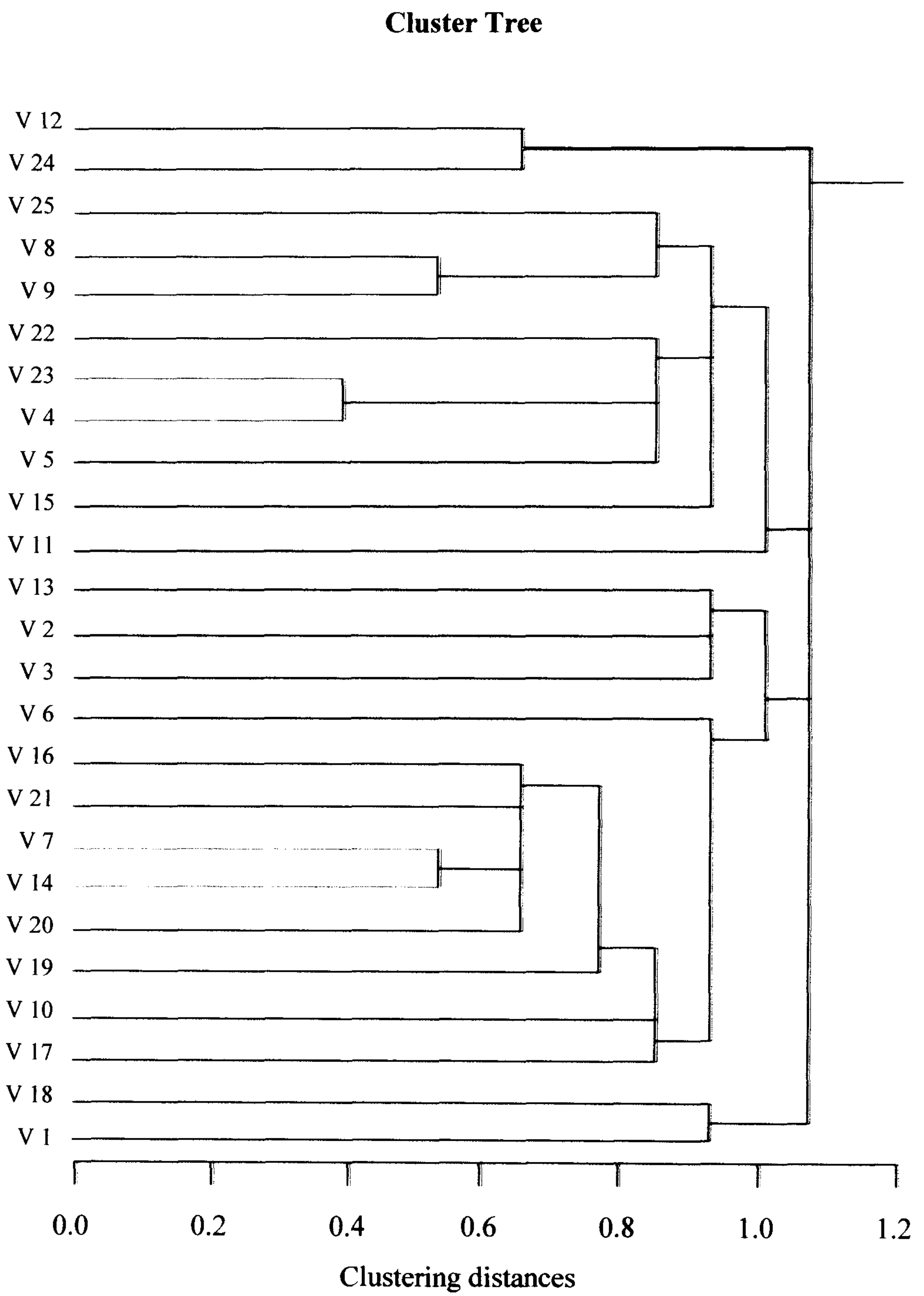
The correlation coefficients were estimated for all the pairs of damage parameters and are presented in the table 16.

The damage parameter, percentage of plants infested showed high and positive correlation (0.4133) with number of bore holes per fruit. Percentage of fruits infested showed high positive correlation (0.3752) with number of larvae per fruit. Correlations between other damage parameters were negligible.

4.2.5. Hierarchical Clustering

Six variables including yield of first experiment were used for hierarchical clustering. The cluster tree using single link method was given in Fig.8. Accessions V4 & V24, V8 & V9 and V7 &V14 were found to be the most similar pairs of genotypes, which were joined at group values 0.378, 0.535 and 0. 535 respectively. The grouping of genotypes when five clusters were attempted using this method was given in table. 17. Among the five clusters formed, cluster I was the largest one holding nine members followed by cluster II with seven members. Cluster IV was the smallest one with only two members. Maximum dissimilarity was noticed in the genotype V17 (Pusa Kranti) with a high dissimilarity value from many other genotypes like V13, V15, V18 and V24.

Fig. 8



Cluster Tree
V 12
V 24
V 25
V 8
V 9
V 22
V 23
V 4
V 5
V 15
V 11
V 13
V 2
V 3
V 6
V 16
V 21
V 7
V 14
V 20
V 19
V 10
V 17
V 18
V 1
0.0
0.2
0.4
0.6
0.8
1.0
1.2
Clustering distances

Table. 16. Correlation among the damage parameters

Damage parameters	X1	X2	X3	X4	X5
Percentage of plants infested (X1)	1.0000				
Percentage of shoots infested (X2)	0.2340	1.0000			
Percentage of damaged fruits (X3)	-0.0618	-0.1672	1.0000		
Number of larvae per fruit (X4)	0.0838	-0.1758	0.3752*	1.0000	
Number of bore holes per fruit (X5)	0.4133*	0.2505	-0.0018	0.1257	1.0000

* – significant at 5 %

Table.17. Grouping of brinjal genotypes by hierarchical clustering.

Cluster Number	Genotypes
I	V4, V5, V8, V9, V11, V15, V22, V23, V25
II	V7, V10, V14, V16, V17, V20, V21
III	V6, V12, V19, v24
IV	V1, V18
V	V2, V3, V13

Discussion

5. DISCUSSION

Field experiments were conducted to study the variation in brinjal genotypes for yield and resistance to brinjal shoot and fruit borer. The experimental results are discussed under different headings.

5.1. Evaluation of yield and yield components

As in many other crops, in brinjal too, the major efforts for the crop improvement have been directed towards stepping up the yield. Yield is very complex and polygenic in nature. The knowledge of the association among the yield components is the touchstone to a breeder to evolve potentially a better plant type through selection either from the existing genotypes or from the segregants of a cross (Bose *et al.* 1993). Hence the genetic potentialities of yield contributing characters and their interrelationship should be properly assessed for improving the crop.

5.1.1. Grouping of genotypes

Based on the performance of each character all the 25 genotypes were grouped into three categories viz., low, medium and better performing groups.

The genotypes V1, V2, V3, V7, V17, V18 and V21 were found to be performing better as far as yield per plant is concerned. But for number of fruits per plant, the genotypes viz., V1, V2, V16, V18 and V19 were found to be the better performing ones. The genotypes, V1, V2, V3, V7, V11, V13, V14, V16, V18 and V21 were found to be in the better performing group for number of harvests.

The genotypes V1 (Swetha), V2 (Surya) and V18 (Pusa Purple Cluster) were found to be in the better performing group as far as yield per plant, number of fruits per plant and number of harvests are concerned, and thus we can select these genotypes for the simultaneous improvement of these three characters.

The genotypes V1 (Swetha), V2 (Surya) and V15 (Pachalloor local) were found to be the earliest to flower.

For the character fruit length V1, V9, V13, V17 and V19 were found to be better, while the genotypes V4, V5, V6, V10, V15, V17, V21 and V23 had better fruit girth. Weight of fruit was found to be better for the genotypes V17, V21 and V24. The genotype V17 (Pusa Kranti) showed better performance for the above three characters, which determines the size of the fruit. So this genotype will be a better choice for large sized fruits.

The genotypes V7, V9, V10, V13 and V16 had the better performance for plant height. For number of primary branches per plant, V7, V12, V14, V16, V17, V20 and V22 were found to be the better ones while for number of secondary branches per plant, V7, V15, V16, V17, V20, V21, V22, V23 and V24 were better. The genotypes V5, V6, V9, V10, V22 and V24 produced more number of leaves. Anserwadekar *et al.*

(1979) reported that the variety 'Gondegaon' is better as far as number of leaves is considered.

5.1.2. Variability Studies

The magnitude of variability present in a population is of utmost importance as it provides the basis for effective selection. Since the observed variability in a population is the sum of variation arising due to the genotypic and environmental effects, knowledge on the nature and magnitude of genetic variation contributing to gain under selection is essential. The PCV, GCV and ECV are the components used to measure the variability present in a population.

The genotypic variance were greater than environmental variance for all the characters studied which indicates that genotypic variance contributes much to the total phenotypic variance. Similarly the existence of high genotypic variance for several characters in brinjal genotypes were reported by Dhankar and Singh (1983), Vadivel and Bapu (1990a) and Singh and Gopalakrishnan (1999) while Das and Choudhary (1999a) reported this in summer chilli. But, a low genotypic variance for fruit diameter in brinjal was reported by Rajyalakshmi *et al.* (1999).

Coefficient of variation is another measure of variability and is more efficient as it is a unit free measurement and hence comparisons can be made among various characters that are measured in different units. Phenotypic coefficient of variation (PCV) gives an idea about the extent of variation present in the expression of the trait. In the present study, the highest PCV was observed for number of fruits per plant followed by number of leaves per plant, yield per plant, number of harvests and number of secondary branches per plant, which indicates that much variability is present in the expression of these characters. Similar results were reported in brinjal by Chadha and Sidhu (1983), Gopimony *et al.* (1984), Behera *et al.* (1999), Rajyalakshmi *et al.* (1999) and Singh and Gopalakrishnan (1999). Jabeen *et al.* (1999) reported similar results in hot pepper. In the present study PCV was least for days to first flowering, which means the phenotypic expression of this character does not show much variability.

The phenotypic expression is influenced by the environmental deviations and hence selection based on the phenotypic performance alone will not be efficient. The genotypic coefficient of variation (GCV) provides a precise measure of genetic variability present in a population. The maximum value for GCV was observed for number of fruits per plant followed by number of leaves per plant, yield per plant, number of harvests and number of secondary branches per plant. Reports of studies conducted in brinjal by Chadha and Sidhu (1983), Sinha (1983), Chadha and Paul (1984), Vadivel and Bapu (1989), Varma (1995), Behera *et al.* (1999), Rajyalakshmi *et al.* (1999) and Sharma and Swaroop (2000) were in conformity with this result. Similar results were also reported by Jabeen *et al.* (1999) in hot pepper. The least GCV was recorded for days to first flowering.

In this study, high values of PCV with correspondingly high values of GCV were observed for number of fruits per plant followed by number of leaves per plant, yield per plant, number of harvests and number of secondary branches per plant which indicated the presence of a great extent of genetic variability for these characters. Thus there is better scope for improving these characters through selection. Chadha and Sidhu (1983) and Rajyalakshmi *et al.* (1999) reported high PCV and GCV values for yield per plant and number of fruits per plant in brinjal. Jabeen *et al.* (1999) reported this in hot pepper. Behera *et al.* (1999) reported high PCV and GCV in brinjal for yield of fruits per plant. So for these characters phenotypic selection would be reliable.

5.1.3. Heritability and Genetic Advance

The variability existing in a population is the sum total of heritable and non-heritable components. A high value of heritability indicates that the phenotype of that trait strongly reflects its genotype. The magnitude of heritability indicates the effectiveness with which selection of the genotypes can be made based on the phenotype.

In the present study, the heritability estimates of all the characters, except for days to first flowering were high with maximum value for number of leaves per plant and minimum for number of primary branches per plant. Days to first flowering recorded moderate heritability.

High heritability for yield per plant was reported in brinjal by Chadha and Sidhu (1983), Dhankar and Singh (1983), Vadivel and Bapu

(1990a), Varma (1995), Behera *et al.* (1999), Rai *et al.* (1999), Singh and Gopalakrishnan (1999) and Sharma and Swaroop (2000). Similar results were reported by Das and Choudhary (1999a) in summer chilli and Jabeen *et al.* (1999) in hot pepper. Contrary to these to findings, Nualsri *et al.* (1986) reported low heritability in brinjal for yield per plant.

Patel *et al.* (1999) and Rajyalakshmi *et al.* (1999) reported high heritability for plant height in brinjal. In contrast to the present findings low heritability for number of primary branches per plant in brinjal was reported by Rai *et al.* (1998). High heritability for number of secondary branches per plant was reported by Kalda *et al.* (1988) and Dhankar and Singh (1983) reported high heritability for number of branches in brinjal.

High heritability for number of fruits per plant in brinjal was reported by Hiremath and Rao (1974), Dharmegowda *et al.* (1979), Chadh and Sidhu (1983), Dhankhar and Singh (1983), Sinha (1983), Dixit *et al.* (1984), Kalda *et al.* (1988), Vadivel and Bapu (1990a), Varma (1995), Rai *et al.* (1999), Rajyalakshmi *et al.* (1999), Singh and Gopalakrishnan (1999) and Sharma and Swaroop (2000). Similar results were obtained in summer chilli by Das and Choudhary (1999a) and in hot pepper by Jabeen *et al.* (1999).

High heritability for length of fruit was reported by Vadivel and Bapu (1990a), Behera *et al.* (1999), Sharma and Swaroop (2000) in brinjal and Das and Choudhary (1999a) in summer chilli. Contrary to these findings low heritability in brinjal was reported by Rai *et al.* (1998) for fruit length.

Girth of fruit recorded a high heritability in the studies conducted in brinjal by Chadha and Sidhu (1983), Vadivel and Bapu (1990a), Behera *et al.* (1999), Rai *et al.* (1999) and Rajyalakshmi *et al.* (1999). Das and Choudhary (1999a) reported the same in summer chilli. But Rai *et al.* (1998) reported low heritability for this character in brinjal.

Sinha (1983) reported high heritability in brinjal for fruit length:circumference ratio, while Patel *et al.* (1999) reported high heritability for fruit volume.

High heritability for fruit weight in brinjal was reported by Chadha and Sidhu (1983), Dhankhar and Singh (1983), Dixit *et al.* (1984), Gopimony *et al.* (1984), Varma (1995), Rai *et al.* (1998), Patel *et al.* (1999), Rai *et al.* (1999), Rajyalakshmi *et al.* (1999), Singh and Gopalakrishnan (1999) and Sharma and Swaroop (2000). Same results were obtained in summer chilli by Das and Choudhary (1999a) and in hot pepper by Jabeen *et al.* (1999).

Environmental effects least influence the characters with high heritability and there could be greater correspondence between phenotypes and breeding value while selecting individuals. High heritability estimates indicate the effectiveness of selection based on good phenotypic performance but does not necessarily mean high genetic gain for the particular character. Johanson *et al.* (1955) pointed out that high heritability along with high genetic advance would be useful than heritability values alone in predicting the resultant effect of selecting the best genotype.

High values of genetic advance as percentage of mean were recorded for all the characters except for days to first flowering. Days to first flowering recorded low genetic advance and may be due to the involvement of non-additive gene action. Singh and Gopalakrishnan (1999) reported similar results in brinjal.

High genetic advance for yield per plant in brinjal was reported by Chadha and Sidhu (1983), Dhankhar and Singh (1983), Vadivel and Bapu (1990a), Varma (1995), Behera *et al.* (1999), Rai *et al.* (1999) and Singh and Gopalakrishnan (1999).

High genetic advance for plant height in brinjal was reported by Patel *et al.* (1999). Number of primary branches per plant showed low genetic advance in a study conducted by Rai *et al.* (1998) in brinjal which is contradictory to the present findings. Dhankhar and Singh (1983) reported high genetic advance for number of branches.

High genetic advance for number of fruits per plant reported by Hiremath and Rao (1974), Chadha and Sidhu (1983), Dhankhar and Singh (1983), Chadha and Paul (1984), Kalda *et al.* (1988), Vadivel and Bapu (1990a), Gautham and Srinivas (1992), Varma (1995), Rai *et al.* (1999), Rajyalakshmi *et al.* (1999) and Singh and Gopalakrishnan (1999) in brinjal. Jabeen *et al.* (1999) reported this in hot pepper.

In the present study yield/plant, plant height, number of primary branches/ plant, number of secondary branches/plant, number of fruits/plant, number of leaves/plant, length of fruit, girth of fruit, weight of fruit and number of harvests recorded high heritability associated with high genetic advance. Days to first flowering recorded low genetic advance and moderate heritability.

Chadha and Sidhu (1983), Dhankhar and Singh (1983), Vadivel and Bapu (1990a), Varma (1995), Behera *et al.* (1999), Rai *et al.* (1999) and Singh and Gopalakrishnan (1999) reported high heritability coupled with high genetic advance for yield per plant in brinjal. Jabeen *et al.* (1999) reported this in hot pepper.

As in the present study Patel *et al.* (1999) also reported high heritability coupled with high genetic advance for plant height. Rai *et al.* (1998) reported low heritability and low genetic advance for number of primary branches per plant in contrary to the present findings. Number of branches recorded high heritability with high genetic advance in a study conducted by Dhankhar and Singh (1983).

High heritability with high genetic advance for number of fruits per plant in brinjal was reported by Hiremath and Rao (1974), Chadha and Sidhu (1983), Dhankhar and Singh (1983), Vadivel and Bapu (1990a), Varma (1995), Rai *et al.* (1999), Rajyalakshmi *et al.* (1999) and Singh and Gopalakrishnan (1999) while, Jabeen *et al.* (1999) reported this in hot pepper.

Vadivel and Bapu (1990a) and Behera *et al.* (1999) reported high heritability and genetic advance for length of fruit in brinjal, as against the reports of Rai *et al.* (1998).

High heritability and genetic advance for brinjal fruit girth was also reported by Chadha and Sidhu (1983), Vadivel and Bapu (1990a), Behera *et al.* (1999) and Rai *et al.* (1999). But Rai *et al.* (1998) reported low heritability and genetic advance for this particular character.

High heritability and genetic advance for weight of fruit in brinjal was reported by Chadha and Sidhu (1983), Dhankhar and Singh (1983), Gopimony *et al.* (1984), Varma (1995), Rai *et al.* (1998), Patel *et al.* (1999), Rai *et al.* (1999), Rajyalakshmi *et al.* (1999) and Singh and Gopalakrishnan (1999). In hot pepper same results were recorded by Jabeen *et al.* (1999).

High heritability coupled with high genetic advance indicates the presence of flexible additive gene effects and will be an useful criterion for selection.

5.1.4. Correlation Studies

Correlation coefficient analysis measures the mutual relationship between various plant characters and determines the component characters on which selection can be based for improvement in yield. Correlation provides information on the nature and extent of relationship between all pairs of characters. So when the breeder applies selection for a particular character, not only it improves that trait, but also those characters associated with it. The genotypic correlation between the characters provides a reliable measure of genetic association between them, which is useful in the breeding programmes.

5.1.4.1. Correlation between yield and other characters

In the present study the phenotypic correlation of fruit yield with number of harvests and number of fruits per plant were found to be high and positive while, the phenotypic correlation with days to first flowering was high but negative. Genotypic correlation of fruit yield per plant with number of harvests, number of fruits per plant and fruit weight were high and positive while those with days to first flowering and number of leaves per plant were high but negative.

Positive genotypic correlation of yield with number of fruits per plant was in line with the results reported by Hiremath and Rao (1974), Singh and Khanna (1978), Mak and Vijayarangam (1980), Singh and Singh (1981), Dhankhar and Singh (1983), Chadha and Paul (1984), Krusteva (1985), Randhawa *et al.* (1989), Mishra and Mishra (1990), Vadivel and Bapu (1990b), Gautham and Srinivas (1992), Ushakumari and Subramanian (1993), Ponnuswami and Irulappan (1994), Narendrakumar (1995), Varma (1995) and Sharma and Swaroop (2000) in brinjal. Das and Choudhary (1999b), Legesse *et al.* (1999) and Aliyu *et al.* (2000) obtained similar results in chilli.

Positive correlation between fruit yield per plant and fruit weight in brinjal was also reported by Vijay *et al.* (1978), Mak and Vijayarungam

(1980), Singh and Singh (1981), Chadha and Sidhu (1983), Krusteva (1985), Khurana *et al.* (1988), Mishra and Mishra (1990), Ponnuswami and Irulappan (1994), Varma (1995) and Sharma and Swaroop (2000). Similar results were recorded in summer chilli by Das and Choudhary (1999b). The reports of Hiremath and Rao (1974) showed negative correlation with fruit weight in brinjal.

The negative correlation of yield per plant with days to first flowering is in line with the findings of Vijay *et al.* (1978), Singh and Singh (1981), Dhankhar and Singh (1983), and Varma (1995) while reports of Sharma and Swaroop (2000) showed no correlation between yield and days to first flowering.

Negative correlation of yield with number of leaves was observed in this study. However Aliyu *et al.* (2000) reported high and positive correlation of yield with number of leaves in *Capsicum*.

Positive and high phenotypic and genotypic correlation of fruit yield per plant with number of fruits per plant and number of harvests imply that selection for these characters would lead to simultaneous improvement of yield in brinjal. The other characters that can be taken into consideration for indirect selection for yield include fruit weight and plant height.

In general the magnitude of genotypic correlation coefficients was higher than the corresponding phenotypic correlation coefficients for the characters positively correlated with yield indicating low environmental influence on these characters.

5.1.4.2. Correlation among the yield component characters

Correlation among the yield components will provide more reliable information for effective selection based on yield components.

Days to first flowering showed high positive genotypic correlation with number of leaves per plant followed by length of fruit while high negative correlation was showed by number of harvests followed by number of fruits per plant

Number of harvests recorded high positive correlation with plant height followed by number of primary branches per plant while fruit weight recorded high negative correlation with plant height. Correlation between plant height and branches was also reported by Randhawa *et al.* (1989) in brinjal.

Number of secondary branches per plant showed high positive correlation with number of primary branches per plant followed by fruit weight and girth of fruit. High positive correlation of fruit diameter and mean fruit weight with number of branches was reported by Khurana *et al.* (1988). Number of leaves showed high negative correlation with number of harvests.

Number of fruits per plant showed high positive correlation with number of harvests while negative correlation with fruit girth. The findings of Khurana *et al.* (1988), Randhawa *et al.* (1989) and Mishra and Mishra (1990) supported the negative correlation with fruit girth.

Fruit length showed high positive correlation with fruit weight but Khurana *et al.* (1988) reported negative correlation between fruit length and fruit weight. Fruit girth showed positive and high correlation with fruit weight. Positive association between fruit girth and weight was supported by the reports of Hiremath and Rao (1974).

Yield showed high positive correlation with number of harvests, number of fruits per plant and fruit weight. Of these, number of harvests and number of fruits per plant are correlated with each other. Even though fruit length and fruit girth were not directly correlated with yield, they can be considered for improving yield as they are related to fruit weight which had high correlation with yield. Days to first flowering is correlated with number of harvests and number of fruits per plant which suggests that selection based on days to flowering can also be utilised for yield improvement. High heritability coupled with high genetic advance for number of harvests, number of fruits per plant, fruit weight, fruit length and fruit girth indicates the effectiveness of phenotypic selection based on these characters.

5.1.5. Path Analysis

The path analysis unravels whether the association of the component characters with yield is due to their direct effect on yield, or is a consequence of their indirect effect *via* some other trait(s). Thus path coefficient analysis helps in partitioning the genotypic correlation coefficient into direct and indirect effects of the component characters on the yield on the basis of which improvement progrmmes can be devised effectively. If the correlation between yield and any of its components is due to the direct effect, it reflects a true relationship between them and selection can be practiced for such a character in order to improve yield. But if the correlation is mainly due to indirect effect of the character through another component trait, the breeder has to select the latter trait through which the indirect effect is exerted.

The maximum direct effect on yield was shown by number of harvests followed by fruit weight and number of fruits per plant. Days to first flowering had negative direct effect on yield, which was similar to the results reported by Vijay *et al.*

The direct effect of plant height on yield was the lowest but its indirect effect through number of harvest was high and positive which resulted in comparatively high total genotypic correlation. Indirect effect *via* fruit weight is also contributing to the total correlation but was negative

The direct effect of the character number of fruits per plant along with the high and positive indirect effect through number of harvests had contributed to the high positive total genotypic correlation of number of fruits per plant on yield The direct effect of number of fruits per plant on yield was supported by the reports of Vijay *et al.* (1978), Sinha (1983), Randhawa *et al.* (1989), Mishra and Mishra (1990), Randhawa *et al.* (1993), Ushakumari and Subramanian (1993), Varma (1995), Vadivel and

Bapu (1998) and Sharma and Swaroop (2000) in brinjal. Legesse *et al.* (1999) reported this in hot pepper.

The direct effect of fruit weight on yield was high and positive and was found to be higher than the total correlation of this character with yield and this reduction in total correlation was due to the very low and negative indirect effects of other characters on yield. The direct effect of fruit weight on yield of brinjal was supported by the findings of Vijay *et al.* (1978), Mishra and Mishra (1990), Vadivel and Bapu (1998) and Sharma and Swaroop (2000).

Number of harvests recorded the highest positive direct effect on yield as well as the highest total correlation. This direct effect along with the indirect effect *via* number of fruits per plant accounts for the high total correlation of number of harvests on yield while the indirect effects *via* other characters were negligible.

Thus number of harvests, fruit weight and number of fruits per plant can be identified as major characters contributing towards yield directly and indirectly and selection based on these characters can be effective for developing high yielding brinjal varieties.

5.1.6. Selection Index

Selection index exploits genotypic correlation with several traits having high heritability and it combines information on all the characters associated with the yield and thus aids indirect selection for the improvement of yield. Here the desirable genotypes are discriminated from the undesirable ones, based on the combination of various characters.

In the present study the highest index value was recorded by V18 (Pusa Purple Cluster) followed by V17 (Pusa Kranti), V21 (Brinjal Suphal), V1 (Swetha)and V16 (Venganoor local). These five top ranking genotypes were identified to be genetically superior. Vadivel and Bapu (1991) also constructed an index score character analysis of some exotic eggplants and the types Murena, Solara, Nagpur Type and Annamalai recorded the highest index score values.

5.2. Brinjal shoot and fruit borer resistance evaluation

Serious infestation by shoot and fruit borer will lead to a crop loss of 70%. Indiscriminate use of chemicals to control this pest will lead to environmental pollution and resurgence of other pest species. Hence the use of host plant resistance is an economic and eco-friendly pest control measure. To identify less susceptible genotypes in comparison to others a field screening was taken up.

5.2.1. Grouping of genotypes

The brinjal genotypes used in the present study showed considerable variation in their response towards the infestation by *Leucinodes orbonalis*. Behera *et al.* (1999) also observed high genotypic and phenotypic variation in characters related to borer infestation.

Lal *et al.* (1976) and Kale *et al.* (1986) employed grades on fruit infestation both on the number of infested fruits as well as on weight of infested fruits. When this grading was employed in the present study for grouping of genotypes on the basis of number of infested fruits it was found that the genotype V24 (Manjarigota local) was tolerant at 60 DAT while V1, V3, V8, V9, V11 and V25 were the susceptible ones and rest of the genotypes comes under the highly susceptible group. At 70 DAT, none was found to be tolerant while V3 (CO-2) and V24 (Manjarigota local) were found to be the susceptible genotypes and rest of them were found to be highly susceptible. At 80 DAT and 90 DAT all the genotypes were found to be highly susceptible.

Thus from the above grading it was observed that the genotypes V3 (CO-2) and V24 (Manjarigota local) were less susceptible to brinjal shoot and fruit borer in comparison to other genotypes used in the present study.

Another grouping was attempted to classify genotypes into less, moderately and highly susceptible categories for each of the damage parameters. The genotypes V2, V3, V5, V6, V10, V12, V17, V18, V19, V20, V23 and V24 were found to be in the less susceptible group as far as the percentage of plants affected is considered. When percentage of young shoots infested is considered, the genotypes V3, V14, V17, V18, V19, V20, V21, V22, V24 and V25 were found to be less susceptible. Percentage of fruits infested is less for the genotypes V1, V3, V6, V8, V9, V11, V12, V15, V17, V19, V24 and V25.

To find out the severity of fruit damage, number of larvae per fruit and number of bore holes per fruit were recorded. The genotypes V8, V9, V10, V13, V14, V24 and V25 were having the least number of larvae per fruit, while the genotypes V6, V7, V10, V11, V12, V14, V16, V17, V18, V19, V20 and V21 recorded the lowest number of bore holes per fruit. The genotypes V10 (Vellayani local-1), V14 (Poomkulam local) and V24 (Manjarigota local) recorded the lowest number of larvae per fruit as well as lowest number of bore holes per fruit which indicates that these genotypes shows less severity of fruit damage. The genotypes V3 (CO-2), V17 (Pusa Kranti), V19 (Arka Kusumkar) and V24 (Manjarigota local) came under the less susceptible category for all the damage parameters viz., percentage of plants infested, percentage of shoots infested and percentage of damaged fruits.

5.2.2. Less susceptible genotypes identified

This study revealed that none of the genotypes were absolutely resistant. This is in conformity with the results of Nazir *et al.* (1995) and Sharma *et al.* (1998). The genotypes V3 (CO-2), V17 (Pusa Kranti), V19 (Arka Kusumkar) and V24 (Manjarigota local) recorded less susceptibility when compared to other genotypes. Pusa Purple Cluster (V18) and Kuttalam local (V20) recorded less percentage of infested plants and shoots. Genotypes V6 (Nedumangad local-3) and V12 (Kalliyoor local) showed less percentage of plants and fruits infested.

Tolerance to shoot and fruit borer by Pusa Kranti was also reported by Raut and Sonone (1980), Mote (1981) and Subbratnam and Butani (1981). Pusa Purple Cluster was reported to be tolerant by Dhankar *et al.*

(1977), Gill and Chadha (1979), Nathani (1983), Singh and Sidhu (1988) and Ram (1997). Arka Kusumkar was reported to be resistant by Mote (1981), Subbratnam and Butani (1981), Pawar *et al.* (1987), Dharekar *et al.* (1991)and Srinivas and Peter (1995). Resistance of Manjarigota to this borer pest was reported by Khaire and Lawande (1986). Many other genotypes were reported to be tolerant to shoot and fruit borer from various other studies. Baksha and Ali (1982) observed tolerance in Jhumki, Indian and Baromashi. Nair (1983) found that SM-88, *Solanum indicum* and *Solanum incanum* were resistant to this pest. Kabir *et al.* (1984) observed lowest infestation in a variety called Singnath. Fruits of Black Beauty and Florida Market were significantly least infested (Duodo, 1986). Tejarathu *et al.* (1991) found *Solanum gilo* as resistant to borer. Mukhopadhyay and Mandal (1994) found that Nishchindipur local, Muktajhuri and Banaras Long Purple were tolerant to shoot and fruit borer. Lowest fruit infestation values recorded for Nurki and CH-150-16-4-1 (Awasthi, 2000).

Tomato, another important solanaceous vegetable crop is also attacked a fruit borer called *Heliothis armigera.* Various workers attempted screening of tomato genotypes against this pest. Lal (1985) reported that the tomato cultivars Parker, Bonus and VFN-8 were found to be highly resistant. Seeja (1995) reported that fruit borer incidence is minimum in Sakthi. Rath and Nach (1997) observed less susceptibility in genotypes HT

64, Hybrid No. 37 and PTH 106. Varghese (1998) reported Arka Alok x PKM-1 is free from fruit borer attack.

5.2.3. Plant characters and fruit borer resistance in brinjal

The resistance / tolerance shown by the pest towards certain genotypes may be due to the specific morphological or biochemical features of these genotypes which results in poor response of feeding by the pest.

According to Dhooria and Chadha (1981), Ahmed *et al.* (1985) and Pradhan (1994) long narrow fruited varieties are less infested. Singh and Chadha (1991) reported that a large number of small sized fruits per plant along with late and long fruiting period could be the reason for low susceptibility to this pest. In this present study the genotype V24 (Manjarigota local) was very late in fruiting and this may be one of the reason for its low susceptibility. According to Srinivas and Basheer (1961), Panda *et al.* (1971), Krishnaiah and Vijay (1975), Dhankar (1988) and Mishra *et al.* (1988) low susceptibility may be due to the thick fruit skin. Compactly arranged seeds in mesocarp may be the reason for resistance as suggested by Panda et al. (1971), Lal *et al* (1976), Dhankar (1988) and Mishra *et al.* (1988). Compact vascular bundles, lignified cells, low pith area and tight calyx contributes to resistance (Panda *et al.* 1971). Bajaj *et al.* (1989) reported that higher level of glycoalkaloids, peroxidase and polyphenol in fruits results in low incidence of fruit borer.

5.2.4. Correlation among damage parameters

The correlation among the damage parameters was worked out. The percentage of plants affected showed high positive correlation with number of bore holes per fruit followed by percentage of shoots affected. The percentage of shoots affected was positively correlated with number of bore holes per fruit. Percentage of fruits infested and number of larvae per fruit also showed high positive correlation. Correlation between other damage parameters was negligible.

There are reports of correlation of these damage parameters with yield related characters. Khurana *et al.* (1988) found a positive correlation of fruit infestation with mean fruit weight, fruit diameter, number of leaves and number of branches. Preflowering period showed correlation with shoot infestation (Grewal and Singh, 1992). There is negative correlation between seeds per fruit, fruit thickness and yield per plant with fruit infestation (Patil and Ajri, 1993). Fruit diameter, fruit weight and fruit volume was having negative effect on infestation (Kumar and Ram, 1998). Sebastian (2000) reported negative correlation between fruit borer incidence and fruits per plant.

5.2.5. Hierarchical Clustering

This clustering was done to sort out the 25 brinjal genotypes into clusters with fair amount of intracluster similarity and intercluster isolation. This clustering is useful for selecting genotypes with an appreciable degree of genetic divergence as parents for hybridization programmes.

Among the five clusters formed, Cluster I was the largest one holding nine members followed by Cluster II with seven members. Cluster IV was the smallest with only two members. The high yielding genotypes V18 (Pusa Purple Cluster) and V1 (Swetha) were grouped under the same cluster (IV). The less susceptible genotypes viz., V19 (Arka Kusumkar) and V24 (Manjarigota local) were coming under the same cluster (III). V17 (Pusa Kranti) which was also found to be less susceptible to the borer was coming under a separate cluster (II) as it gave high yield as that of the remaining genotypes in this cluster. This genotype has got maximum dissimilarity value from V13, V15, V18 and V24.

Mathew *et al.* (2001) employed this clustering procedure for classifying 51 cultivars of *Piper nigrum*.

5.3. Promising genotypes identified on the basis of yield performance and resistance to shoot and fruit borer

In the present study V18 (Pusa Purple Cluster) was identified as the top yielder. Several other genotypes including V1, V2, V3, V7, V17 and V21 were also found to be high yielding though not on par with V18. Of these, the genotype V17 (Pusa Kranti) showed comparatively high tolerance to shoot and fruit borer. V3 (CO-2) also showed some degree of tolerance when compared to rest of the genotypes and hence these are found to be suitable for cultivation in shoot and fruit borer endemic areas.

Fruits are found to be the major feeding sites of this pest. The genotype which showed the least susceptibility (Manjarigota local) was a low yielder. Combination breeding using the high yielding variety (Pusa Purple Cluster) and shoot and fruit borer resistant one (Manjarigota local) identified in the present study as parents is recommended for developing borer resistant varieties with high yield. The genotypes which showed low percentage of infested plants (V3, V5, V6, V10, V19 and V24) and low percentage of infested shoots (V3, V14, V17, V18, V19 and V24) and percentage of damaged fruits (V3, V17, V19 and V24) can be used for developing genotypes which shows less susceptibility with respect to each of these damage parameter.

Summary

6.SUMMARY

The study entitled "evaluation of brinjal genotypes for yield and resistance to shoot and fruit borer" was conducted at the Department of Plant Breeding and Genetics, College of Agriculture, Vellayani, during the period 2000 - 2001. The data for the study were collected from two field experiments.

In experiment I, 25 brinjal genotypes collected from different parts of the country were evaluated for yield and yield component characters in a field experiment in randomised block design with three replications. Observations were recorded on twelve characters viz., yield per plant, days to first flowering, plant height at first harvest, plant height at final harvest, number of primary branches per plant, number of secondary branches per plant, number of fruits per plant, number of leaves per plant, length of fruit, girth of fruit, weight of fruit and number of harvests.

Analysis of variance revealed significant difference among the genotypes for all the twelve characters studied. Pusa Purple Cluster (V18) recorded the highest yield (984.22 g) while Pragathy (V25) recorded the lowest yield (169.17 g). Pusa Purple Cluster (V18) recorded the highest number of fruits per plant (16.73) and Alappuzha local (V8) recorded the lowest number (1.36). Pusa Kranti (V17) recorded the maximum fruit weight (243.52 g) and Alappuzha local (V8) recorded the lowest value

(56.38 g). Number of harvests was maximum for Pusa Purple Cluster (6.33) and Manjarigota local (V24) recorded the lowest number (1.00).

Grouping of genotypes revealed that the genotypes Swetha (V1), Surya (V2) and Pusa Purple Cluster (V18) were found to be in the better performing group as far as yield per plant, number of fruits per plant and number of harvests are concerned.

The genotypic variance contributed the major portion of phenotypic variance for all the characters studied. Phenotypic coefficient of variation and genotypic coefficient of variation were high for yield per plant, number of fruits per plant, number of harvests, number of leaves per plant and number of secondary branches per plant while both were low for days to first flowering.

The heritability estimates were high for all the characters studied except for days to first flowering with maximum value for number of leaves per plant (98.85%) and minimum for days to first flowering (56.59%). High values of genetic advance as percentage of mean were recorded for all the characters except for days to first flowering. Days to first flowering recorded low genetic advance. High values of heritability coupled with high genetic advance were observed for all characters except for days to first flowering.

At genotypic level yield per plant showed high positive correlation with number of harvests, number of fruits per plant and fruit weight while those with days to first flowering and number of leaves were high but negative. Number of harvests recorded the highest genotypic correlation with yield.

Path coefficient analysis revealed that number of harvests, number of fruits per plant and fruit weight were the characters with high direct effect as well as indirect effect through other characters on yield per plant. The genotypic correlation of these characters on yield was also high. The characters selected for path analysis would explain the major portion of variation in yield as the residual effect obtained was very low (R = 0.0655).

In the present study the highest index value was recorded by V18 (Pusa Purple Cluster) followed by V17 (Pusa Kranti), V21 (Brinjal Suphal), V1 (Swetha) and V16 (Venganoor local).

In experiment II, the 25 brinjal genotypes were screened for shoot and fruit borer resistance in field experiment in randomised block design with two replications. Data on damage parameters viz., percentage of plants affected, percentage of young shoots infested, percentage of damaged fruits, number of larvae per fruit and number of bore holes per fruit were recorded.

Significant difference was observed among the genotypes for all the above mentioned damage parameters. When the grades employed as suggested by Lal *et al.* (1976) and Kale *et al.* (1986) it was found that the genotypes V3 (CO-2) and V24 (Manjarigota local) were less susceptible to brinjal shoot and fruit borer in comparison to other genotypes used in the study.

The genotypes V3 (CO-2), V17 (Pusa Kranti), V19 (Arka Kusumkar) and V24 (Manjarigota local) came under the less susceptible category for all the damage parameters viz., percentage of plants infested, percentage of shoots infested and percentage of fruits damaged. The genotypes V10 (Vellayani local-1), V14 (Poomkulam local) and V24 (Manjarigota local) recorded the lowest number of larvae per fruit as well as the lowest number of bore holes per fruit which indicates that these genotypes shows less severity of fruit damage.

The correlation studies of damage parameters showed that there was a high positive correlation between percentage of plants affected and number of bore holes per fruit. Percentage of shoots affected also showed a high positive correlation with number of bore holes per fruit. Percentage of fruits damaged showed a high positive correlation with number of larvae per fruit. But there was no correlation of percentage of fruits damaged with percentage of plants infested and percentage of shoots infested.

Clustering of 25 brinjal genotypes based on the shoot and fruit borer damage parameters and the yield obtained from experiment I was done using hierarchical clustering. Among the five clusters formed, cluster I was the largest one holding nine members followed by cluster II with seven members. Cluster IV was the smallest with only two members. The clusters II and III were having the less susceptible genotypes. For developing the shoot and fruit borer resistant varieties the genotype V17 (Pusa Kranti) of cluster II and the genotypes V19 (Arka Kusumkar) and V24 (Manjarigota local) of cluster III will be of better use in combination breeding programme. The high yielding varieties V1 (Swetha) and V18 (Pusa Purple Cluster) were grouped under the same cluster (IV).

Considering both yield performance and resistance to shoot and fruit borer, it is suggested that the genotype V17 (Pusa Kranti) is suitable for cultivation in borer endemic areas as it was one of the less susceptible genotypes which was also included under the group of high yielding genotypes. Better yielding genotypes viz., V18 (Pusa Purple Cluster), V1 (Swetha), V2 (Surya), V3 (CO-2) and V7 (Neyyattinkara local) and genotypes which showed less susceptibility to shoot and fruit borer viz., V3 (CO-2), V17 (Pusa Kranti), V19 (Arka Kusumkar) and V24 (Manjarigota local) identified in the present study would be of useful as parents in combination breeding programme for developing high yielding and shoot and fruit borer resistant varieties in brinjal.

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EVALUATION OF BRINJAL (*Solanum melongena* L.) GENOTYPES FOR YIELD AND RESISTANCE TO SHOOT AND FRUIT BORER (*Leucinodes orbonalis* Guen.).

By

DALIYA.T.

ABSTRACT OF THE THESIS

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ABSTRACT

The present investigation on evaluation of yield and resistance to shoot and fruit borer of brinjal genotypes was conducted at the Department of Plant Breeding and Genetics, College of Agriculture, Vellayani, during the period 2000 - 2001. Data for the study was collected from two field experiments.

For the evaluation of yield and its component characters of the 25 brinjal genotypes, a field experiment was conducted in randomised block design with three replications. Analysis of variance revealed significant difference among the genotypes for all the characters studied.

Grouping of genotypes revealed that the genotypes V1 (Swetha), V2 (Surya) and V18 (Pusa Purple Cluster) were better as far as yield per plant, number of fruits per plant and number of harvests were concerned. Pusa Kranti (V17) had better fruit length, girth and weight.

High phenotypic coefficient of variation and genotypic coefficient of variation were observed for yield per plant, number of fruits per plant, number of harvests, number of leaves per plant and number of secondary branches per plant. High heritability coupled with high genetic advance was also observed for these characters.

At genotypic level, yield per plant showed high positive correlation with number of harvests, number of fruits per plant and fruit weight. The path analysis showed that number of harvests, fruit weight and number of

fruits per plant were the characters having high direct effect on yield per plant.

The genotypes V18 (Pusa Purple Cluster) followed by V17 (Pusa Kranti), V21 (Brinjal Suphal), V1 (Swetha) and V16 (Venganoor local) were having the highest index values.

For screening of brinjal genotypes for resistance to shoot and fruit borer, a field experiment was laid out in randomised block design with two replications. All the 25 genotypes were significantly different for all the damage parameters.

The genotypes V3 (CO-2), V17 (Pusa Kranti), V19 (Arka Kusumkar) and V24 (Manjarigota local) came under the less susceptible category for all the damage parameters viz., percentage of plants infested, percentage of shoots infested and percentage of damaged fruits.

The correlation studies on damage parameters revealed high positive correlation of number of bore holes per fruit with percentage of plants infested and percentage of shoots infested, while these damage parameters did not show correlation with percentage of damaged fruits. Percentage of damaged fruits showed high correlation with number of larvae per fruit.

Cluster analysis based on different damage parameters and the yield obtained from the yield evaluation experiment enabled to group the genotypes into five clusters. The clusters II and III were having the less susceptible genotypes viz., V3 (CO-2), V17 (Pusa Kranti), V19 (Arka Kusumkar) and V24 (Manjarigota local) would be useful as parents for developing shoot and fruit borer resistant varieties. Cluster IV had the high yielding genotypes viz., V1 (Swetha) and V18 (Pusa Purple Cluster). So hybridization programmes using genotypes from these three clusters could lead to the production of high yielding varieties with high level of shoot and fruit borer resistance.

Based on the superior yield performance and low level of susceptibility to shoot and fruit borer, the genotype V17 (Pusa Kranti) was found to be suitable for cultivation in borer endemic areas. Genotypes which showed high yield and those showed less susceptibility to shoot and fruit borer attack could be used in developing better yielding varieties with resistance to shoot and fruit borer.