INTERNATIONAL JOURNAL OF PLANT PROTECTION
VOLUME 10 | ISSUE 2 | OCTOBER, 2017 | 206-228

● e ISSN-0976-6855 | Visit us : *www.researchjournal.co.in*

IJPP

RESEARCH PAPER

DOI : 10.15740/HAS/IJPP/10.2/206-228

Study on biophysical and biochemical basis of shoot and fruit borer tolerance in brinjal

■ SHUBHAM SHUKLA[1]*, DEVENDRA SINGH[1], BIRBAL BAIRWA[1] AND BHANWAR LAL JAT[2]

[1]Department of Agriculture, Bhagwant University, AJMER (RAJASTHAN) INDIA
[2]Department of Agricultural Biotechnology, Bhagwant University, AJMER (RAJASTHAN) INDIA

ARITCLE INFO

Received : 08.06.2017
Revised : 01.08.2017
Accepted : 15.08.2017

KEY WORDS :
GCV, PCV, DFF, Cluster,
Solanum melongena

***Corresponding author:**
kripa38156@gmail.com

ABSTRACT

Brinjal or eggplant or aubergine, *Solanum melongena* L. is one of the most important vegetable crops grown in India and other parts of the world. It is highly cosmopolitan and popular vegetable grown as poor man's crop in India. Brinjal, being a native to India has great variability existing in the country. However, it is highly infested by shoot and fruit borer, *Leucinodes orbonalis* Guen., an obnoxious pest causing fruit damage upto 92.5 per cent. The pest is very active during the summer and rainy season and often causes more than 90 per cent damage. Pesticide application is not the only solution of managing the pest as repeated use of pesticide leads to health hazards, destruction of beneficial insects, pest resurgence and environmental pollution. Thus, in order to develop varieties resistant to this pest we need to know the biophysical and biochemical traits that often result intolerance mechanism. Thirty six diverse brinjal genotypes were grown in RBD with three replications at the Vegetable Research Farm, BAC, Sabour during spring-summer season of 2015-16 and morphological and biochemical studies were performed to accomplish these objectives. The findings revealed that sufficient genetic variability was present among the genotypes which provide ample scope for selection of promising genotypes under study. Shoot borer infestation was least in pusa purple cluster (3.28%) followed by BRBR-01 while fruit borer infestation percentage by both number and weight was least in BRBL-01. Pusa purple long was the highest yielder (1100.02g/plant) followed by BRBL-01 (1046.38g/plant). The morphological characters such as average fruit weight, fruit/plant, yield/plant, shoot borer infestation and fruit borer infestation percentage by number possessed high heritability coupled with high genetic advance. All the biochemical characters except leaf chlorophyll and ascorbic acid exhibited high heritability coupled with high genetic advance. Therefore, selection will be more effective for these characters since they are highly heritable and easily fixable due to additive gene effect. D^2 cluster analysis grouped the thirty genotypes into 7 clusters. The inter and intra cluster distance between the genotypes under study indicate the existence of higher level of genetic divergence among them. The highest inter cluster distance was observed between cluster III (comprising of BRBL-01) and cluster IV and intra cluster distance was observed within cluster IV which suggest that hybridization between the members of these

clusters may lead to creation of higher variability and heterosis. Total fruit anthocyanin had maximum contribution towards genetic divergence (27%), followed by fruit borer infestation percentage by weight (21%), fruit borer infestation percentage by number (18%), polyphenol oxidase activity (15%), leaf anthocyanin (8%), yield/plant (6%) and number of fruits/plant (4%). Trichome density showed highly significant negative correlation with shoot infestation also days to first flowering and 50 per cent flowering exhibited significant negative correlation with shoot infestation and fruit infestation by weight. Days to first flowering and fruit length showed significant and positive correlation with fruit yield/plant. So selection for these two characters can be rewarding for yield and quality improvement in brinjal. Fruit weight and trichome density possessed high direct effect and hence direct selection for these characters can be rewarding for yield and pest resistance improvement. Total phenol content of fruit exerted highly significant and negative correlation with fruit borer infestation by weight and fruit borer infestation percentage by number. So selection for these traits can lead to quality improvement, particularly for pest resistance. The genotypes BRBL-01, pusa purple long, pusa purple cluster and BRBL-04 have been found to be high yielders as well as possessing moderate resistance towards fruit and shoot borer besides having good biochemical properties that may be effective in imparting the resistant trait in the genotypes. Therefore, these superior genotypes may be used in future breeding programme for improvement of yield and especially quality.

How to view point the article : Shukla, Shubham, Singh, Devendra, Bairwa, Birbal and Jat, Bhanwar Lal (2017). Study on biophysical and biochemical basis of shoot and fruit borer tolerance in brinjal. *Internat. J. Plant Protec.*, **10**(2) : 206-228, **DOI : 10.15740/HAS/IJPP/10.2/206-228**.

INTRODUCTION

Vegetable is the most important component of our balanced diet and acts as a protective food, have made significant contribution in providing food and nutritional security of the country. As a result of concerted efforts made in the research and development of vegetable crops in the post-independence era, India has emerged as the second largest producer of vegetables after China, contributing to about 14 per cent to the world vegetable production. The eggplant, *Solanum melongena* L. is the most common, popular and major vegetable grown in India and other parts of the world. It is called brinjal in India, and in Europe aubergine. The name eggplant derives from the shape of the fruit of some varieties, which are white and shaped very similarly to chicken eggs. Brinjal is main vegetable in plains areas of India and almost available throughout the year. The area under brinjal cultivation in India is 0.711million hectares producing 13.55 million tonnes yield with an average national productivity of 19.06 tonnes/ha. In Bihar the area, production and productivity are 0.057 million hectares, 1.291 million tonnes and 21 tonnes/ha, respectively (NHB Database, 2014). It can be grown in almost all parts of India except higher altitudes. The major brinjal producing states are Bihar, Karnataka, Orissa, West Bengal, Andhra Pradesh, Maharashtra and Uttar Pradesh. West Bengal is the leading brinjal producing state. Eggplant is a perennial but grown commercially as an annual crop. Eggplant is essentially a warm weather crop which is grown extensively in India, Bangladesh, Pakistan, China, Japan, and the Philippines. Eggplant, *S. melongena* L. belongs to the family Solanaceae (Nightshade family), having chromosome number 2n=24 (X=12). Botanically, there are three main varieties under the species *melongena*. The round or egg-shaped cultivars are grouped under var. *esculentum*, common eggplant whereas, extra long fruits with prickly leaves are grouped under var. *serpentine* and var. *depressum* has extensively short and dwarf plant. The long, slender types are suitable for processing purposes. The glycoalkaloid contents in the Indian commercial cultivars vary from 0.37mg/100 g to 4.83mg fresh weight. Unripe brinjal fruit is consumed as cooked vegetable in various ways. Due to its low calorific value and high potassium content, has anti-diabetic, hypertensive and anti-obesity properties. Brinjal occupies a prestigious position among diversified group of consumers who frequently keep it in their food menu and ceremonial functions. It is a rich source of nutrients, particularly, carbohydrates, proteins, dietary fibre and vitamins like Thiamin, Niacin, Pantothenic acid and folic acid as well as minerals like calcium, iron, potash, zinc, copper and manganese. It is one the most-consumed vegetable in India, making it one of the main sources of cash for many farmers (Miller, 2007). Wild eggplant varieties are very bitter-almost inedible and interestingly nearly all wild eggplants seem to be resistant to the pests and diseases that commonly affect domesticated

varieties. However, brinjal *(Solanum melongena* L.) is infested by a complex of pests like sucking, defoliators, shoot and fruit borer and stem borer at different stages of the crop. Of these, the most serious and destructive one is the shoot and fruit borer (*Leucinodes orbonalis* Guen.), which occurs throughout the year with a degree of variance in pest incidence. It is a monophagous pest. Owing to its feeding habit, the larvae on emergence bore into the young shoots and fruits. The drooping shoots in the crop is an indication of its presence. Plant growth gets stunted. Due to the attack of this pest considerable damage occurs each year affecting the quality and yield of the crop. Only the larvae cause 12-16 per cent damage to shoots and 20-60 per cent to fruits. The pest is very active during the summer and rainy season and often causes more than 90 per cent damage. The loss caused by this deleterious pest was reported upto 95 per cent in India and has become a major threat for brinjal cultivation. The shoot and fruit borer has been considered as one of the chief constraints in the successful cultivation of brinjal crop, as this pest causes significant damage to fruits ranging from 40.79 to 71.84 per cent (Pareek and Bhargava, 2009). Survey of sixty farmer's fields was conducted in Orissa, India regarding the severity of *L. orbonalis* infestation in aubergine and local practices used for their management. Farmers found this insect pest as the most dangerous for the brinjal crop and considered blanket spraying as the most important management tool using Carbaryl, Endosulfan, Carbofuran and Cypermethrin. Brinjal fruit and shoot borer act as the limiting factor in qualitative as well as quantitative harvest of brinjal fruit. Chemical control is widely used means of managing insect pests in brinjal. Brinjal also happens to be the most sprayed crop. Repeated use of broad spectrum synthetic chemicals also results in environmental Contamination bioaccumulation and biomagnification of toxic residues and disturbance in ecological balance. Thus, chemical control of shoot and fruit borer may reduce the pest attack to a greater extent, but it causes adverse effects on the environment and human health. There are a number of brinjal varieties available in the subcontinent including Bangladesh. But none has been found to be resistant to BSFB with an appreciable level. Utilization of resistant varieties has been recognized as a vital tool in bio-intensive pest management system. The physico-morphic characteristics of plants and fruits are correlated with attraction, oviposition and feeding of the insect pests. The recognition of physical, morphological and biochemical characteristics of insect resistance varieties may lead to introduction of resistance character to favoured genotypes. Biochemical factors of the host plant have been reported to play an important role on resistance to various insect and disease pests and relatively resistant varieties contained higher amount of secondary metabolites inherently. In brinjal, biochemical characters, such as free amino acids, crude protein, ash and sugar content (total and reducing sugars) showed a high positive and silica contents, poly phenol oxidase, phenylalanine ammonia lyase, peroxidase, glycoalkaloids and lignin content showed a highly negative correlation with shoot and fruit borer infestation. An understanding of different biophysical and biochemical components of resistance is essential for developing strategies to breed for resistance to insect pests. Hence, the present investigation was carried out to identify the eggplant genotypes for resistance against EFSB and to understand the biophysical and biochemical basis of resistance (Prasad *et al.,* 2014). Hence, there is an urgent need to look to an alternate and safer method of control. Host-plant resistance, biological control, sex pheromone and mechanical control are some alternatives to the use of pesticides. Although numerous reports from India have indicated the availability of BSFB-resistant cultivars, these reports were based on testing of a few, rarely over a dozen, local commercial cultivars. More intensive breeding programmes to develop resistant cultivars should be taken up. Before initiating any breeding programme, one must have enough information about the ways and means by which the resistance can be exploited. It is important to know the basis of tolerance to the fruit and shoot borer in brinjal. Physical traits such as calyx spininess, pedicel spininess and leaf spininess may be important for imparting tolerance to the genotype. The biochemical defence mechanism would certainly be helpful in the selection of plants as a source of resistance. Exploiting host plant resistance through breeding approaches will be highly beneficial to develop superior high yielding genotypes with resistance to the shoot and fruit borer in brinjal. Identification of resistance is possible through quantifying the biochemical components present in the genotype. The biochemical constituents like glycoalkaloid (solasodine), phenols, phenolic oxidase enzymes namely poly phenol oxidase and peroxidase are

available in brinjal and these biochemical constituents possess insect resistance properties. The use of wild forms in breeding crop plants, particularly to obtain vigour and resistance has been well studied. Keeping this information in mind, the present investigation has been framed with the following objectives. (i) To identify the biophysical traits for shoot and fruit borer tolerance in brinjal. (ii) To identify the biochemical traits for shoot and fruit borer tolerance in brinjal. (iii) To study the inter-relationship between the biophysical and biochemical traits and their influence on shoot and fruit borer resistance. (iv) Diversity studies in brinjal genotypes for shoot and fruit borer resistance.

MATERIAL AND METHODS

Experimental materials:

Plant material :

The plant materials comprised of thirty six diverse lines of brinjal differing in morphological features as well as biochemical characters which were selected out of the germplasm collection being maintained at the Department of Horticulture at BU, Ajmer.

Agronomical practices:

Crop husbandry :

Farm yard manure was thoroughly mixed in the soil at the time of field preparation. The fertilizer dose NPK is applied in the field in the ratio 160:88:90 kg/ha (Thamburaj and Singh, 2013). The complete dose of phosphatic and potassic fertilizers and one third dose of nitrogenous fertilizers were given at last ploughing. The remaining dose of nitrogenous fertilizer was applied in two split doses as top dressing at one and two months after transplanting. Recommended plant protection measures were followed during the course of experimentation to raise a good crop.

Transplanting of seedlings:

Nursery bed was irrigated a day prior to transplanting in order to facilitate uprooting of seedlings. Well developed, healthy and uniform seedlings attaining an age of 35 days, of each line were uprooted from the nursery and transplanted in the experimental plot in the evening. Transplanting was followed by irrigation with the help of rose can for 5 days in the morning and evening till the plants established properly. Transplanting of seedlings was accomplished on 21' March, 2016.

Gap filling :

The plants were carefully observed from the second day of transplanting. The sign of permanent wilting and the advent of new growth were considered as indications of mortality and survival, respectively. Very few gaps filling was done by transplanting uniform, healthy and well developed seedling of same age in each plot with same line and sufficient care was taken for their proper establishment. However, plants transplanted later in the gaps were not included for detailed study.

Tagging of plants for studies :

For the sake of recording the data, 5 plants were randomly selected in each plot excluding the border in each replication and they were tagged and numbered. Altogether 540 plants were tagged out of total plant population.Observations were recorded at different intervals for the investigation.

Observations recorded:

Observations were recorded on five randomly selected plants from each genotype in every replication, summed up and divided by five to get mean value. The procedure is described under the respective sub-heads. Observations for morphological documentation of the genotypes were recorded as per documented descriptors.

Quantitative data:

Plant height (*cm*):

The plant height was measured in centimeter from the base to the top of plant at time of last picking of the fruits by a meter scale.

Number of primary branches/ plant:

The number of primary branches was counted during peak fruiting stage of the tagged plant and the average recorded.

Days to first flowering :

Days to first flowering was considered as a number of days from the date of transplanting to the opening of first flower on any plant of the plot.

Days to 50 per cent flowering:

Days to 50 per cent flowering was considered as a number of days from the date of transplanting to the opening of first flower on the 50 per cent of the plants per plot.

Days to first fruit set:

Days to first fruit set was considered as number of days taken to attain first fruit setting on any plant of the plot from transplanting.

Fruit length (cm):

At second picking, fourth picking and sixth picking 5 randomly selected fruits were taken from the harvested fruits in each replication when it reached at edible maturity. The fruits were cut longitudinally and length was measured with the help of a measuring tape.

Fruit diameter (cm):

At second picking, fourth picking and sixth picking 5 randomly selected fruits were taken from the harvested fruits in each replication when it reached edible maturity and girth was measured with the help of slide calliper.

Average fruit weight (g):

At second picking, fourth picking and sixth picking 5 randomly selected fruits were taken from the harvested fruits in each replication and weighed on a digital balance. The total weight was divided by number of fruits and their weight was recorded in gram, which was averaged to get the average fruit weight.

Number of fruits per plant :

The total number of fruits from five randomly selected plants upto last picking was recorded and divided by five to get the number of fruits per plant.

Fruit yield per plant (kg):

The fruits of selected plants were harvested at the edible maturity stage at weekly intervals. Treatment and replication wise weight of fruits were taken with pan balance (Total number of pickings was 14). The total weight of fruits of the five plants after all the harvests was recorded and average was calculated.

Trichome density:

The third expanded leaves from the randomly selected plants were plucked at 60DAT and leaf trichomes were counted from lower $25mm^{-2}$ areas of the same leaves under stereo binocular microscope.

Shoot diameter:

The diameter of the shoot at 1" below the axillary tip of each of the five randomly selected plant of each replication from each genotype was measured with slide calliper at 30, 60, 90 and 120 DAT and averaged.

Shoot borer incidence (%):

The number of plants affected with shoot borer was recorded at 30, 60, 90 and 120 DAT, their percentage calculated and the pooled data was used.

Fruit borer incidence by number:

The number of fruits infested by fruit borer was counted and their percentage estimated to get percentage fruit borer incidence by number.

Fruit borer incidence by weight (%):

The weight of the fruit borer affected fruits of all the harvests was recorded and their percentage calculated to determine the per cent fruit borer infestation by weight.

Visual data for morphological characterization of the genotypes :

- *Leaf blade colour*: Light green/ Green/ Dark green/ Greenish violet/ Violet.
- *Leaf pubescence :* Dense/ sparse.
- *Number of prickles in upper surface*: None/ Few/ Many**.**
- *Corolla colour* :White/ Greenish white/ Pale violet/ Light violet/ Bluish violet.
- *Calyx colour:* Green/ Light purple/ Dark purple.
- *Calyx spininess*: Smooth/ Medium thorny/ Highly thorny.
- *Plant growth habit:* Intermediate/ Spreading/ Erect.
- *Fruit pedicel prickles*: None/ Few/ Many.
- *Fruit shape*: Round/ Oblong/ Long/ Oval.
- *Fruit colour*: Dark purple/ Purple/ Light purple/ Light green/ Dark green/ White.

Biochemical data:

Total ascorbic acid content:

Composite flesh with peel of 3 randomly sampled fruits per replication at edible maturity were used to estimate ascorbic acid content in the fresh fruits by volumetric method as suggested by AOAC (2001).

Materials:

- Metaphosphoric acid 3 per cent
- *Dye solution*: 42mg sodium bicarbonate was taken

into a small volume of distilled water and 50mg of 2, 6-dichlorophenol indophenol was dissolved in it. Volume was made upto 200 ml with distilled water.

– *Stock standard solution*: 100mg ascorbic acid was dissolved in 100ml of 3 per cent metaphosphoric acid solution in a standard flask (1mg/m1)

– *Working standard*: 10ml of the stock solution was diluted to 100ml with 3 per cent metaphosphoric acid.

Procedure:

10 ml metaphosphoric acid was added in it and titrated against the dye solution (Vim1). End point was the appearance of pink colour which persists for a few minutes. The amount of the dye consumed was equivalent to the amount of ascorbic acid. (ii) 2g of fruit sample was crushed and extracted in 3 per cent metaphosphoric acid. Volume was made upto 100m1 and centrifuged for 20 minutes. (iii) 5ml of this supernatant was pipetted out and added into the 10 ml of 3 per cent metaphosphoric acid. (iv) It was titrated against the dye (V2 ml).

Calculation:

$$\text{Amount of ascorbic acid mg /100 g sample} = \frac{1}{\text{V1ml}} \times \frac{\text{V2}}{\text{Aliquot volume}} \times \frac{\text{Valume made up}}{\text{Weight of the sample}} \times 100$$

Total sugar content:

The total sugar content of the pulp was determined by Fehling's method.

Materials required:

Fehling's-A and Fehling's-B solution (b) Concentrated HCl (c) Methylene blue indicator (1g of methylene blue dissolved in 100ml distilled water).

Procedure:

5g crushed sample or 5m1 of juice taken in a conical flask t 3-4 drops of HC1 added Heated till hydrolysis occurs, colour changes a bit and a burnt sugary smell is perceived cooled 1 (N) NaOH solution added to make the sample alkaline, tested by litmus paper volume made upto 50 ml by adding distilled water Filled in burette and kept for heat titration Meanwhile, 2m1 Fehling solution A and 2m1 Fehling's solution B taken in a conical flask and 16m1 distilled water added This conical flask is heated When boiling starts methylene blue indicator 2-3 drops added Heat titration with the sample in burette is done till end point End point brick red colour precipitate Titre value noted.

Total chlorophyll content:

Total chlorophyll was estimated as per Arnon (1949).

Materials:

Diluted and pre-chilled analytical grade 80 per cent acetone.

Procedure:

1g of sample was taken and well mixed with 10m1 of 80 per cent acetone. (ii) It was kept under the cold condition for 2 days in dark. (iii) The sample was strained with fine muslin cloth. (iv) The mixture was centrifuged (5000rpm for 5min) and the supernatant was collected in volumetric flask. (v) The supernatant (lml) was taken in a test tube. (vi) The volume was made upto 10 times by adding 9m1 of 80 per cent acetone. (vii) From this l ml was taken and diluted with 80 per cent acetone to make volume upto 5m1. (viii) The optical density of the sample was recorded with the help of spectrophotometer with wave length of 663nm and 645nm.

Formula for estimation of total chlorophyll:

Total chlorophyll (mg /100g) = [{(20.2 x A645) + (8.02 x A663)} x D1/100 where, A663= optical density at 663nm, A645= optical density at 645nm D= dilution.

Total anthocyanin content:

Total anthocyanin was estimated as per Ranganna (1977).

Procedure:

lg of sample + 10ml of Methanolic HC1 (85ml ethanol +15ml (1N) HC1 for 100ml Methanolic HC1) Crushed and taken into test-tube and kept in cool for 3 days. Sample strained: lml of strained sample taken. Read in spectrophotometer at 535nm using 85 per cent of Methanolic HC1 as blank.

Polyphenol oxidase activity:

5g of the sample was homogenized by mixing 10ml of 0.2M potassium phosphate buffer (pH 7.0). Homogenates were centrifuged for 10 min at 7.244 x g under cold conditions. PPO activity was measured as per the methods of Haplin and Lee. McIlvaine buffer [0.2M Na_2HPO_4/0.1 M potassium citrate monohydrate

in a proportion of (2.3:1) was adjusted to pH 6.5 for the substrate preparation and 1.37g catechol was dissolved in 25ml McIlvaine buffer. The prepared substrate solution was added to 250ml McIlvaine buffer (0+10) and stirred for 30 mi to equilibrium. 200µl of enzyme extract was added to 2.8ml of substrate solution in the test tube and mixed thoroughly, after which the changes in absorbance at 420nm were measured overtime using a spectrophotometer. One unit of PPO activity was expressed as the change in absorbance of 0.1 per minute per ml of the enzyme extract.

Preparation of sample for total phenol, total antioxidant capacity:

1 gram composite sample from randomly selected three fruits from each replication at edible maturity was crushed with 10 ml of 80 per cent methanol in mortar pestle. Prepared sample was centrifuged at 10000 rpm at 4°C. Supernatant was taken for further estimation.

Total phenol content:

Total phenolics were estimated spectrophotometrically using Folin-Ciocalteau reagent (FCR) (Singleton *et al.*,1999). To the100ul of the sample extract (80% methanol), 2.9ml of deionized water, 0.5 ml of Folin—Ciocalteu reagent and 2.0 ml of 20 per cent Na_2CO_3 solution were added. The mixture was allowed to stand for 60 min and absorption was measured at 765 nm against a reagent blank in UV*viz.*, spectrophotometer (Varian Cary 50).Calibration curve was built with standard catechol and results were expressed as catechol equivalent (mg CE/100g fw).

Total antioxidant capacity:

The cupric ion reducing antioxidant capacity of eggplant was determined according to the method of Apak *et al.* (2004). Briefly, according to the protocol 0.1 ml of sample extract was mixed with 1 ml each of CuC12 solution (1.0 x 10-2 mol/L), neocuproine alcoholic solution (7.5 x 10-3 mol/L) and NH4Ac (1 mol/L, pH 7.0) buffer solution and 1 ml of water to make the final volume 4.1 ml. After 30 min, the absorbance was recorded at 450 nm against the reagent blank. The results were expressed as t mol TE/g, using molar absorptivity of Trolox as 1.67 x 104 L/mol/cm.

Correlation co-efficient analysis:

Correlation co-efficient is the mutual association between variables without implying any cause and effect relationship. Single correlation co-efficients were computed at genotypic and phenotypic levels between pair of characters adopting following formula given by Johnson *et al.* (1955) and Al-Jibouri *et al.* (1958).

Heritability:

Heritability in broad sense is the ratio of genotypic variance to the total variance and is calculated by the formula given by Lush (1940).

Genetic advance:

Genetic advance is the improvement in mean genotypic value of selected plants over the parental population. The estimates of genetic advance were obtained by the formula given by Lush (1949) and Johnson *et al.* (1955).

Path co-efficient analysis:

The path co-efficient analysis is simply the standardized partial regression co-efficient, which splits the correlation co-efficient into the measures of direct and indirect effects of independent variables on the dependent variables. The concept of path analysis was originally developed by Wright (1921), but this technique was firstly used for plant selection by Dewey and Lu (1959). Path analysis was worked out by using the estimates of correlation co-efficient in all possible combinations among the dependent variables.

Genetic diversity analysis:

The concept of D^2 statistics for a measure of group distance based on multiple characters was developed by P.C. Mahalanobis in 1928.

Cluster diagram:

With the help of D^2 values between (inter-cluster distance) and within (intra-cluster distance) clusters, a diagram showing the relationship between different genotypes can be drawn. Such a diagram is not exactly to the scale.

Contribution of individual characters towards total divergence:

In all the combination of genotypes, $^{n(n}2\ ^{1})$, each character is ranked on the basis of mean difference, *i.e.*, *di* = Yi Yi2 value, rank 1 is given to the highest mean difference and rank p to the lowest mean difference where p is the total number of characters. Using these

ranks, the following table was prepared to work out the percent contribution of each character to the total divergence.

RESULTS AND DISCUSSION

The materials utilized and methods involved in studying different plant characters and genetic parameters have been described in the preceding chapter. The result of the experiment carried out have been presented and discussed here under.

Variability for morpho-biochemical characters and fruit and shoot infestation in the genotypes under study :

Analysis of variance:

Analysis of variance was performed for 25 characters for RBD. The mean sum of squares due to genotypes for morphological and biochemical characters from ANOVA are presented in Table 1 and 2, respectively. They were significant for different characters suggesting that there is ample variability among the genotypes for the traits under study.

Table 1 : Mean sum of squares for 15 morphological characters under study

Characters	Mean sum of square		
	Replication (df=2)	Genotypes (df=35)	Error (df=70)
Plant height (cm)	515.83	668.25**	183.12
Primary branches/plant	0.38	1.57**	0.39
Days to first flowering	1.37	101.57**	5.19
Days to 50% flowering	2.49	38.65**	4.37
Days to 1st fruit set	4.36	129.58**	10.32
Shoot diameter (mm)	0.01	0.27**	0.04
Trichome density	5.36	566.96**	49.56
Fruit length (cm)	1.38	5.84**	1.54
Fruit diameter (cm)	0.25	2.07**	0.73
Fruit weight (g)	8.13	535.60**	3.35
Fruit/plant	0.01	40.81**	0.15
Fruit yield/plant	7.13	192127.84**	532.04
Shoot borer infestation	1.01	76.58**	1.36
Fruit borer infestation% by number	2.31	109.69**	1.17
Fruit borer infestation by weight	2.50	103.17**	1.15

* and ** indicate significance of values at P=0.01 and 0.05, respectively

Table 2 : Mean sum of squares for 10 biochemical characters under study

Characters	Mean sum of square		
	Replication (df=2)	Genotypes (df=35)	Error (df=70)
Leaf phenol	3.22	131.23**	5.50
Fruit phenol	7.48	197.42**	4.63
Antioxidant	0.65	41.53**	1.27
Leaf chlorophyll	0.61	3.34**	0.28
Fruit chlorophyll	0.003	1.37**	0.02
Leaf anthocyanin	0.01	241.19**	1.95
Fruit anthocyanin	0.05	241.99**	0.38
Ascorbic acid	0.14	3.28**	0.35
Total sugar	0.08	2.84**	0.10
Polyphenol oxidase activity	0.36	1024.38	3.01

*and ** indicate significance of values at P=0.01 and 0.05, respectively

Morphological and biophysical traits influencing FSB in brinjal:

The mean performances of genotypes for the morphological and biochemical characters under study have been presented in Table 3 and 4, respectively. In general a wide range of mean values within the genotypes have been found for the respective characters. Character wise mean performances of the genotypes are being discussed here.

Growth characters:

Plant height (*cm*):

Data pertaining to plant height has been presented in Table 3. It would be evident from the data that the maximum plant height was recorded in IC 89837 which showed statistical parity with BRBR-01, Muktakeshi, Swarna Shree and Pusa Purple Long. However, the minimum plant height was recorded in BRBL-08 which was at par with IC 215020, BRBL-01and BRBL-05.

Number of primary branches per plant:

From the data regarding the number of primary branches per plant presented in Table 3, it was found that the genotypes which gave significantly higher number of primary branches per plant were Punjab brinjal 67 which was at par with BRBR-01, Arka Neelkanth, IC 89837 and RCMBL-04, while, the lowest number of primary branches per plant was (3.00) recorded in genotype BRBL-08 which was statistically at par of BRBL-05 and BRBL-06 followed by BSB-31, EC

Table 3 : GCV, PCV, heritability, genetic advance and genetic advancement as percentage of mean for biophysical

Characters	GCV	PCV	h^2(bs)	GA	GA % of mean
Plant height (cm)	12.68	18.51	0.47	17.94	17.88
Primary branches/plant	15.15	21.44	0.50	0.91	22.07
Days to first flowering	12.89	13.90	0.86	10.83	24.64
Days to 50% flowering	6.00	7.06	0.72	5.92	10.51
Days to 1st fruit set	9.53	10.70	0.79	11.57	7.50
Shoot diameter (mm)	5.82	7.04	0.68	0.47	19.91
Trichome density	14.42	16.37	0.78	23.84	26.19
Fruit length (cm)	12.58	18.12	0.48	1.71	17.99
Fruit diameter (cm)	13.48	21.81	0.38	0.85	17.16
Average fruit weight	18.18	18.35	0.98	27.18	37.11
Fruit/plant	57.92	58.24	0.99	7.54	118.68
Fruit yield/plant	55.42	55.65	0.99	518.44	113.68
Shoot borer infestation	23.83	24.46	0.95	10.05	47.81
Fruit borer infestation% by number	14.81	15.05	0.97	12.19	30.03
Fruit borer infestation by weight	14.28	14.52	0.97	11.81	28.92

Table 4: GCV, PCV, heritability, genetic advance and Genetic advance as percentage of mean for biochemical characters

Characters	GCV	PCV	h^2(bs)	GA	GA % of mean
Leaf phenol	24.70	26.27	0.88	12.53	47.83
Fruit phenol	31.63	32.75	0.93	15.95	62.92
Antioxidant	35.67	37.31	0.91	7.21	70.23
Leaf chlorophyll	23.07	26.00	0.79	1.85	42.15
Fruit chlorophyll	68.43	69.89	0.96	1.36	138.01
Leaf anthocyanin	96.70	97.88	0.98	18.18	196.81
Fruit anthocyanin	68.16	68.32	1.00	18.44	140.07
Ascorbic acid	23.49	27.33	0.74	1.75	41.59
Total sugar	38.69	40.76	0.90	1.87	75.66
Polyphenol oxidase activity	93.42	93.83	0.99	37.84	191.60

382524, BRBL-01.

Reproductive characters:

Days to first flowering :

Data pertaining days to first flowering is given in Table 3. It is evident that the number of days taken from transplanting to first flowering was minimum in the genotype IC 90148, which showed statistical parity with genotypes IC 90087, IC 215020, EC 384606 and Pant Rituraj, while, the genotype BRBL-01 took the maximum number of days from flowering, and was statistically at par with BRBL-07 and BRBR-01.

Days to 50 per cent flowering:

It is clear from perusal of the data regarding days to 50 per cent flowering presented in Table 3 that the number of days taken to 50 per cent flowering from the day of transplanting was found maximum in the two genotypes IC 545920 and BRBL-07 followed by in BRBR-01, BRBL-01 and DRNKV-03-26, and in genotypes IC 261802 and Muktakeshi while, the genotype EC 169084 took minimum days to 50 per cent flowering from day of transplanting which was at par with EC 382524 and IC 215020 followed by BRBL-06, BSB-31 and IC 90087.

Days to first fruiting:

It is obvious from the data pertaining to days to 1st fruiting presented in Table 3 that Pusa Purple Long took minimum days to set fruit which was found statistically at par with genotype IIHR 562 followed by BRBL-04, Arka Neelkanth, Punjab Brinjal 67, Pusa Purple Cluster and BRBL-01,while, the genotype IIHR 586 and IC 545920 took maximum number of days to first fruit setting from days to transplanting.

Shoot diameter (mm):

Data regarding shoot diameter which is provided in Table 3 exhibited that the maximum shoot diameter at 1" below the tip was produced by genotype Muktakeshi which showed statistically parity with Swami Mani, IC 261802, IC 89837 and Swarna Manjari. However, the minimum shoot diameter was recorded in genotype IC 90121 which was statistically at par with BRBL-06, BRBL-06, Pusa Purple Long, Punjab Brinjal 67 and BRBL-08.

Trichome density (per sq.cm):

It would be evident from the data pertaining to trichome density presented in Table 3 that a wide range of variation in respect of trichome density was presented. The maximum trichome density was obtained in genotype IC 89933 which exhibited statistical parity with BRBL-07 followed by Muktakeshi, BRBL-04, Pusa Purple Cluster and BRBL-05. However, the genotype Swarna Shree had least number of trichomes and it was at par with Swarna Manjari, Arka Neelkanth and IIHR 562.

Fruit length (cm):

The fruit length of different genotypes has been presented in Table 3 and depicts that there was a distinct variation in fruit length of different genotypes. The long genotypes IIHR 563 produced significantly highest fruit length which was statistically at par with IIHR 586 followed by Swarna Shyamli, Pusa Purple Long, RCMBL-04 and IIHR 562. The lowest fruit length was recorded in round genotype Pant Rituraj which was statistically comparable to BRBL-07, BRBL-08, Swarna Mani and BRBL-01.

Fruit diameter (cm):

Data pertaining to fruit diameter have been provided in Table 3 and indicates that the maximum fruit diameter was noted in round genotype Swarna Shree which was statistically at par with Swarna Mani and BRBL -01 producing fruit diameter of and, respectively and followed by Arka Neelkanth, IC 89837, EC 384606B.

Fruit weight (g):

From the Table 3 concerning fruit weight, it is evident that the long genotype Punjab brinjal 67 produced significantly the heaviest fruit having weight 114.32g which was statistically at par with Muktakeshi, Swarna Mani and Pant Rituraj. The minimum fruit weight was observed in genotype EC 384606 and proved inferior to the remaining genotypes in respect of average fruit weight. However, it was at par with IC 107769, IC 90121 and BRBL-04.

Number of fruits per plant:

It would be evident from the data pertaining to number of fruits per plant presented in Table 3 that a wide range of variation in respect of number of fruits/ plant was present. The maximum number of fruits per

plant was found in genotype Pusa Purple long, whereas the genotype Punjab brinjal 67 produced least number of fruits per plant and it was at par with IC 107769, DRNKV-03-26, IC 545920, BRBL-07, IC 90148, Arka Neelkanth, IC 215020 and EC 384606.

Fruit yield per plant (g):

From the data presented in Table 3, it is apparent that the genotype Pusa Purple Long produced significantly the highest fruit yield per plant while, the lowest yield per plant was obtained in genotype IC 107769 which was at par with DRNKV-03-26, EC 384606, Punjab brinjal 67, IC 90148, Arka Neelkanth and IC 545920.

Biochemical characters influencing FSB in brinjal:

Total sugar content (*%*):

From the data pertaining to total sugar content presented in Table 4, it was revealed that the genotype BRBL-06 contained the maximum amount of total sugar which was followed by BSB-31, Swarna Manjari, IC 89933 and Swarna Shree. However, the minimum amount of total sugar was observed in BRBL-02 and BRBL-04 which showed statistical parity with IIHR 562, IIHR 586, Punjab brinjal 67, BRBL-07 and RCMBL-04.

Total phenol content of leaf (mg/100g FW):

From the data regarding the total phenol content of leaf presented in Table 4, it was found that the genotype with significantly the maximum amount of total phenol content of leaf was in BRBL-05 which was almost statistically similar to IC 261802. However, the lowest amount of leaf phenol was observed in IC 90087 which was comparable to genotype IIHR 563, Pant Rituraj and BRBL-04.

Total phenol content of fruit (mg/100g FW):

From the Table 4, it was observed that the total phenol content of fruit was minimum in the genotype BRBL-04 which was almost at par with BSB-31, BRBL-08, BRBL-05 and Pusa Purple Long. However, the maximum amount of total phenol was found in Pant Rituraj which had statistically parity with Muktakeshi followed by Swarna Manjari, Swarna Mani.

Total antioxidant (p mol trolox equivalent/g FW):

From the data regarding the total antioxidant capacity it is evident that the genotype IIHR 586 contained significantly the highest amount of total antioxidant followed by IC 545920. The minimum amount of total antioxidant was extracted from IC 90087 which was statistically at par with RCMBL-04, BRBL-04, and Pant Rituraj.

Total chlorophyll content of leaf (mg /100g FW):

It can be concluded from the table that the total chlorophyll content of leaf was minimum in dark purple genotype IC 90148 which was at par with EC 169084. On the other hand, maximum amount of leaf chlorophyll was extracted from the genotype BRBL-02, followed by Swarna Manjari.

Total chlorophyll content of fruit (mg/100g FW):

From the table it was observed that the whitish green genotype IC 215020 had minimum amount of fruit chlorophyll which was at par with IIHR 562 while maximum fruit chlorophyll was found in IC 90148 which was at par with IC 89933.

Total anthocyanin content of leaf (mg /100g FW):

The Table 4 reveals that the maximum amount of leaf anthocyanin was found in IIHR 562 which was statistically comparable with Muktakeshi, BRBL-07, while minimum leaf anthocyanin was extracted from EC 169084 which was at par with Arka Neelkanth, IC 261802 and Swarna Shree.

Total anthocyanin content of fruit (mg /100g FW):

It can be concluded from Table 4 that the white genotype BRBL-05 had minimum amount of fruit anthocyanin which was at par with Swarna Shree, IC 215020 while, maximum fruit anthocyanin extracted from RCMBL-04 which was statistically comparable with Swarna Mani.

Total ascorbic acid content (mg /100g FW):

From the data pertaining to ascorbic acid content presented in Table 4, it is apparent that the genotype IC 261802 with dark purple colour fruit had maximum ascorbic acid followed by IC 89837 and Swarna Mani. However, the minimum ascorbic acid content was found in genotype BRBL-07 which was at par with BRBL-01, IC 90148, IIHR 586.

Polyphenol oxidase activity:

It is obvious from the Table 4 that polyphenol

oxidase activity was maximum in EC 169084 which was at par with BRBL-01, EC 382524 whereas, minimum amount of activity was observed in DRNKV-03-26, followed by Muktakeshi.

FSB infestation on the genotype:

Per cent shoot borer infestation (*%*):

From the Table 3 concerning per cent shoots borer infestation, it is evident that genotype EC 382524 was found to be highly infested by shoot borer which was at par with BSB-31 and EC 384606. However, the least infestation was observed in Pusa Purple Cluster and it was at par with BRBR-01, IC 545920, BRBL-07 and BRBL-04.

Per cent fruit borer infestation by number (%):

The per cent fruit borer infestation by number in different genotypes has been presented in Table 3 and depicts that the maximum infestation of fruit borer was noticed in genotype IC 107769 which showed statistical parity with BRBL-08 followed by BRBL-05, Swarna Shree and IC 261802, while, the lowest fruit infestation was recorded in genotype BRBL-01 which was comparable to IC 545920, Pusa Purple Cluster, Muktakeshi and BRBL-04.

Fruit borer infestation by weight (%):

From the Table 3 concerning to fruit borer infestation by weight, it was apparent that the genotype BRBL-08 was the most infested by fruit borer by weight followed by Swarna Shree, IC 215020, EC 384606 and BRBL-05.

Studies on component of variability of morphological characters:

The data pertaining to the different variability components, *viz.*, phenotypic co-efficient of variation, genotypic co-efficient of variation, heritability and genetic advance for different morphological and biochemical characters have been represented in Table 5 and 6, respectively.

Phenotypic co-efficient of variation (PCV):

A wide range of PCV was observed ranging from 7.04 per cent to 58.24 per cent. Of the morpho-physical traits, highest magnitude of PCV was recorded for fruits/plant followed by fruit yield/plant; shoot borer infestation, fruit diameter and primary branches/plant. The trait shoot diameter exhibited lowest PCV followed by days to 50 per cent flowering. While the other traits exhibited moderate PCV. All the biochemical traits showed high PCV.

Table 5 : Composition of clusters based on Ward's minimum variance of 36 genotypes

Clusters	Members
Cluster I	BRBL-05, BRBL-08, BRBL-04, IC 90087, Swarna Shree
Cluster II	BSB-31, IC 261802, IC 107769, DRNKV-03-26, Swarna Manjari, IC 89933
Cluster III	BRBL-01
Cluster IV	BRBL-06, IC 215020, EC 382524, IC 545920, BRBL-07, IC 90148, EC 384606
Cluster V	BRBR-01, Swarna Shyamli, Arka Neelkanth, IC 89837, Swarna Mani, Pant Rituraj, EC 169084, RCMBL-04
Cluster VI	Muktakeshi, Punjab Brinjal 67
Cluster VII	IIHR 562, IIHR 563, IC 90121, IIHR 586, BRBL-02, PPC, PPL

Table 6 : Average of intra (diagonal) and inter cluster distance

Euclidean 2 : Cluster distances : Ward

	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5	Cluster 6	Cluster 7
Cluster 1	1260.42	2599.37	62220.01	4855.70	4263.76	8424.09	3286.64
Cluster 2		1874.00	6516.05	4524.92	3024.87	6357.33	4577.27
Cluster 3			0	9928.31	6905.79	8029.12	6744.15
Cluster 4				3180.79	4734.99	8091.23	5737.07
Cluster 5					1739.39	3865.91	3391.55
Cluster 6						2123.25	5578.54
Cluster 7							1944.44

Genotypic co-efficient of variation (GCV):

The analysed data concerning genotypic co-efficient of variation revealed that among the morpho-physical traits under study fruits/plant showed the highest genotypic co-efficient of variation and high GCV was observed in fruit yield/plant. In the present study, the GCV was high for per cent shoot borer infestation, moderate for average fruit weight, number of primary branches per plant, per cent fruit borer infestation by number, trichome density and per cent fruit borer infestation by weight, fruit diameter and fruit length. The rest of characters under study exerted low amount of GCV. GCV for all biochemical traits was high.

Heritability:

Heritability has been usually adopted as a reliable indicator for making effective improvement in the character for which selection is practiced. A perusal of data in Table 5 and 6 reveals that heritability estimated for 15 quantitative traits ranged from 38 per cent to 99 per cent. High estimates of heritability were noticed for fruits/plant and fruit yield/plant, average fruit weight/plant, per cent fruit borer infestation both by number and weight. Data pertaining to heritability of morphological traits presented in Table 5 revealed that a number of traits were highly heritable in nature and the highest estimate of heritability was found in number of fruits/plant and fruit yield/plant followed by average fruit weight, fruit borer infestation both by number and weight and shoot borer infestation, days to first flowering, days to first fruiting, trichome density, days to 50 per cent flowering, shoot diameter while it was moderate in number of primary branches/plant, fruit length and low for fruit diameter. Heritability studies of biochemical traits depicted in Table 6 revealed that highest estimates were obtained for fruit anthocyanin followed by polyphenol oxidase, leaf anthocyanin, fruit chlorophyll, fruit phenol, antioxidant, total sugar, leaf phenol, leaf chlorophyll and ascorbic acid.

Genetic advance:

The data with respect to genetic advance among the different characters under investigation presented in Table 5 and 6 indicated that the high genetic advance was noted in yield per plant, preceded by fruit weight, trichome density while, days to first flowering, shoot borer infestation, showed moderate genetic advance. The lowest genetic advance was noticed in shoot diameter. For the biochemical traits highest estimate of genetic advance was obtained for polyphenol oxidase activity followed by fruit anthocyanin and leaf anthocyanin while lowest estimates were obtained for ascorbic acid followed by leaf chlorophyll and total sugar content.

Genetic advance as percentage of mean:

Since the genetic advance as percentage of mean gives a better picture of genetic gain among the traits under study than genetic advance, therefore, a perusal of genetic advance as per cent of mean was calculated and depicted in Table 5 and 6 which revealed that it ranged between 9.91 per cent to 118.68 per cent. The highest genetic advance as percentage of mean was observed for number of fruits/plant followed by fruit yield/plant. However, the characters *viz.*, fruit length, days to first fruiting, days to 50 per cent flowering had moderate while, very low amount of genetic advance as percentage of mean for shoot diameter. B Among biochemical traits, genetic advance as percentage of mean ranged from 41.59 per cent to 196.81 per cent. The highest genetic advance as percentage of mean was obtained for total anthocyanin content of leaf followed by polyphenol oxidase, fruit anthocyanin and total chlorophyll content of fruit.

Influence of biophysical traits on FSB infestation in brinjal:

The influence of different biophysical traits on FSB infestation was worked out by estimation of phenotypic and genotypic correlation as well as phenotypic and genotypic path analysis studies.

Correlation studies:

Phenotypic correlation studies:

The statistical data relating to phenotypic correlation co-efficient has been presented in Table 7. Correlation studies revealed a highly significant negative correlation for per cent shoot borer infestation with number of primary branches per plant, days to 1st flowering and 50 per cent flowering. Per cent fruit borer infestation by weight showed significant negative correlation with number of primary branches per plant, days to 1st flowering and 50 per cent flowering. Trichome density showed highly significant negative correlation with per cent shoot borer infestation and per cent fruit borer

infestation by weight while, fruit diameter had non-significant positive correlation with per cent fruit borer infestation by weight. Average fruit weight had significant negative association with per cent shoot borer infestation and per cent fruit borer infestation by weight. Number of fruits per plant showed highly significant positive correlation with fruit yield per plant and there was significant negative correlation between yield per plant and per cent fruit borer infestation on weight basis.

Genotypic correlation studies:

Genotypic correlation between FSB infestation and biophysical traits under study were worked out which has been presented in Table 8. It was found that the plant height and number of primary branches/plant had highly significant negative correlation with shoot borer infestation and fruit borer infestation by weight. Days to first flowering and days to 50 per cent flowering had significant negative correlation with per cent shoot borer infestation and per cent fruit borer infestation by weight. Days to first fruiting had significant positive correlation with per cent fruit borer infestation both by weight and number. Shoot diameter had positive correlation with average fruit weight and significant negative correlation with per cent shoot borer infestation and per cent fruit borer infestation by weight. Trichome density had

Table 7 : Mean values of seven clusters for 15 morphological characters under study

Characters	Clusters						
	Clusters I	Clusters II	Clusters III	Clusters IV	Clusters V	Clusters VI	Clusters VII
PH	94.79	95.72	73.28	95.09	107.57	115.83	104.61
PB	3.84	3.96	3.33	3.68	4.69	5.33	4.13
DFF	44.87	42.67	51.67	41.29	43.29	47.00	45.90
D50%F	56.33	56.39	59.33	55.57	55.79	58.83	56.57
DFFr	66.87	68.61	56.67	68.67	66.67	64.00	62.33
SD	4.71	4.82	4.91	4.68	4.99	4.99	4.64
TD	537.5	587.812	649	574.312	553.25	649.25	554
FL	9.01	9.35	9.65	8.80	9.35	9.84	10.83
FD	5.18	4.94	6.61	4.68	5.33	4.16	4.75
FW	69.61	69.65	76.89	69.26	76.93	106.02	68.86
FP	8.53	4.02	13.62	3.50	5.11	3.58	10.85
YP	583.42	290.13	1046.38	235.59	392.47	362.34	742.77
SBI	20.32	22.05	22.95	23.07	18.22	21.03	21.48
FBIN	46.40	44.78	29.63	36.96	42.81	34.74	37.25
FBIW	47.34	41.90	28.40	41.53	40.86	31.57	39.04

Note: Plant height, Number of primary branches/plant, Days to first flowering

Table 8 : Mean values of seven clusters for 10 biochemical characters under study

Characters	Clusters						
	Clusters I	Clusters II	Clusters III	Clusters IV	Clusters V	Clusters VI	Clusters VII
LP	23.971	24.458	21.127	26.460	28.461	25.782	27.356
FrP	19.677	24.815	34.153	21.725	29.509	30.417	26.011
Aox	7.915	10.666	9.610	12.414	8.325	6.038	13.003
L Chl	4.542	4.007	4.707	3.571	4.428	5.615	4.932
Fr Chl	1.319	1.163	0.877	1.227	0.785	0.382	0.753
L Anth	3.313	3.376	2.370	7.982	7.532	23.218	18.669
Fr Anth	2.317	4.503	4.687	11.565	21.684	21.855	18.943
AA	4.438	4.127	3.000	3.580	4.650	5.000	4.175
TS	2.153	3.121	1.747	2.971	2.551	1.645	1.893
PPO	10.829	15.309	68.150	28.140	26.134	8.522	10.541

Note: Total sugar content, Ascorbic acid content, Total chlorophyll content

significant negative correlation with per cent shoot borer infestation, per cent fruit borer infestation by weight and by number. Fruit length had significant negative correlation with fruit diameter, per cent fruit borer infestation by weight and by number while, highly significant positive correlation with fruit yield/plant.

Path analysis studies:

Correlation studies depicts the linear relationship between the traits only, hence, to estimate the direct and indirect effects path analysis studies was conducted.

Phenotypic path analysis:

The data pertaining to the path analysis representing direct and indirect contribution towards per cent fruit borer infestation by number have been presented in Table 9 along with residual effect and perusal of the data indicates that fruit borer infestation by weight expressed very high direct positive effect and yield per plant showed direct positive effect towards per cent fruit borer infestation by number. Its maximum indirect effect was negative *via*. fruit weight followed by number of primary branches. It had negligible negative indirect effect *via* plant height, days to first flowering, trichome density, fruit length, total antioxidant capacity. It also exhibited negligible positive indirect effect *via* leaf phenol, total anthocyanin content of leaf and fruit, polyphenol oxidase. Plant height, days to 1st flowering, 50 per cent flowering, trichome density, fruit length, fruit diameter exerted negligible direct on per cent fruit borer infestation by number but it had moderate negative direct effect *via* fruit per plant, total antioxidant capacity, total chlorophyll content of fruit.

Genotypic path studies :

The data pertaining to the path co-efficient analysis representing direct and indirect contribution of different biophysical traits towards per cent fruit borer infestation by number along with residual effect. Perusal of the data indicates that fruit yield per plant expressed very high direct positive effect towards per cent fruit borer infestation by number. Its maximum indirect effect was positive *via* days to first fruiting. It had negligible negative indirect effect *via* days to first flowering, days to first fruiting, fruit diameter, plant height and days to first flowering, average fruit weight and number of primary branches/plant. It also exhibited negligible positive indirect effect *via* days to 50 per cent flowering, plant height, number of primary branches/plant, yield per plant, fruit length, number of fruits/plant. Per cent fruit borer infestation by weight had positive direct effect but had high negative indirect effect *via* trichome density, number of primary branches/plant, average fruit weight, plant height, shoot diameter, days to first flowering, days to 50 per cent flowering. It exerted oderate positive indirect effect *via* fruit diameter, per cent shoot borer infestation.Number of fruits per plant exerted high significant negative direct effect on per cent fruit borer infestation by number also it had high negative indirect effect *via* fruit yield per plant, fruit length, days to first flowering. It had less positive indirect effect *via* plant height, number of primary branches/plant, fruit borer infestation by weight. It also exhibited negligible negative indirect effect *via* shoot borer infestation, days to 50 per cent flowering, fruit diameter. Trichome density had significant positive direct effect but had moderate negative indirect effect *via* per cent shoot borer infestation, per cent fruit borer infestation by weight. It

Table 9: Percentage contribution of each character towards total genetic divergence in 36 genotypes

Characters	Contribution %	Characters	Contribution %	Characters	Contribution %
Plant height (cm)	0.00	Primary branches/ plant	0.00	Days to first flowering	0.00
Days to 50% flowering	0.00	Days to first fruit set	0.00	Shoot diameter (mm)	0.00
Trichome density/cm^2	0.00	Fruit length (cm)	0.00	Fruit diameter (cm)	0.00
Average fruit weight (g)	0.00	Fruits/ plant	4.13	Fruit yield/ plant	6.03
Shoot borer infestation	0.16	Fruit borer infestation % by number	18.41	Leaf phenol (mg/100g FW)	0.00
Total sugar (%)	0.32	Fruit borer infestation by weight	20.95	Fruit phenol (mg/100g FW)	0.16
Polyphenol oxidase activity	14.60	Leaf chlorophyll (mg/100g FW)	0.00	Antioxidant (mg/100gFW)	0.16
Ascorbic acid (mg/100g FW)	0.00	Fruit chlorophyll (mg/100 FW)	0.48	Fruit anthocyanin mg/100FW)	26.51
Leaf anthocyanin (mg/100g FW)			8.10		

showed negligible positive indirect effect *via* shoot diameter days to first flowering, average fruit weight, number of primary branches per plant, fruit yield per plant, number of fruits per plant. Fruit length exhibited significant positive direct effect but had negligible negative indirect effect *via* days to 50 per cent flowering, trichome density, fruit diameter, average fruit weight and plant height. It exerted less positive indirect effect *via* number of fruits per plant, yield per plant and shoot borer infestation, primary branches/plant.

Influence of biochemical traits on FSB infestation in brinjal :

The influence of different biochemical traits on FSB infestation was worked out by estimation of phenotypic and genotypic correlation as well as phenotypic and genotypic path analysis studies.

Correlation studies:

Phenotypic correlation studies:

There was a highly significant negative correlation of per cent fruit borer infestation by weight with total phenol content of fruit and non-significant negative association with polyphenol oxidase activity. It had showed high significant negative correlation with total anthocyanin content of both leaf and fruit while, non-significant positive correlation with total sugar and per cent shoot borer infestation. Total anthocyanin content of fruit exhibited significant negative correlation with per cent fruit borer infestation by number and total antioxidant capacity showed non-significant negative correlation with per cent fruit borer infestation by number. Polyphenol oxidase activity showed negative correlation with per cent fruit borer infestation by number.

Genotypic correlation studies:

Correlation studies revealed that there was significant negative correlation between total phenol content of fruit and per cent fruit borer infestation by weight and per cent fruit borer infestation by number. There was negative but non-significant correlation between total anthocyanin content of leaf and per cent shoot borer infestation. However, anthocyanin content of leaf exhibited significant negative correlation with per cent fruit borer infestation by weight and per cent fruit borer infestation by number. Similarly, total anthocyanin content of fruit had significant negative correlation with per cent shoot borer infestation and per cent fruit borer infestation by weight and per cent fruit borer infestation by number. Total sugar had positive but non-significant correlation with per cent shoot borer infestation, per cent fruit borer infestation by weight and per cent fruit borer infestation by number. Polyphenol oxidase was negatively correlated with per cent fruit borer infestation by weight and significantly negatively correlated with per cent fruit borer infestation by number.

Path analysis studies:

Path analysis studies were conducted to estimate the direct and indirect effects of different biochemical traits on per cent fruit borer infestation by number.

Phenotypic path analysis:

The perusal of the data indicates that per cent fruit borer infestation by weight had highly significant positive direct effect towards per cent fruit borer infestation by number. Its maximum indirect effect *via* total anthocyanin content of leaf. It had negligible negative indirect effect *via* total phenol content of fruit, total antioxidant capacity, total chlorophyll content of fruit and polyphenol oxidase activity. Total phenol content of leaf and fruit exerted negligible direct positive effect on per cent fruit borer infestation on number basis but total anthocyanin content of leaf, total antioxidant capacity, total chlorophyll content of leaf had moderate direct negative effect.

Genotypic path studies:

The data pertaining to the path co-efficient analysis representing direct and indirect contribution towards per cent fruit borer infestation by number along with residual effect and perusal of the data indicates that the fruit borer infestation by weight had highly significant positive direct effect but exerted moderate negative indirect effect *via* leaf anthocyanin, fruit anthocyanin, fruit phenol, leaf chlorophyll, polyphenol oxidase. It had less positive indirect effect *via* total antioxidant capacity, leaf phenol and total sugar. Ascorbic acid had moderate direct positive effect on per cent fruit borer infestation by number but it exerted negligible negative indirect effect *via* fruit phenol, total antioxidant capacity, fruit chlorophyll and polyphenol oxidase activity. It had also less positive indirect effect *via* leaf phenol, fruit anthocyanin and total sugar. Fruit phenol showed moderate positive direct effect but had negligible negative indirect effect *via* leaf phenol, antioxidant, ascorbic acid, polyphenol oxidase. It exhibited less positive indirect effect *via* leaf chlorophyll,

fruit anthocyanin, total sugar and shoot borer infestation.

Influence of inter-relationship between biophysical and biochemical traits on FSB infestation in brinjal:

On the basis of estimation of the correlation studies the inter relationship between the 25 different biophysical and biochemical has been has been determined and their influence on the per cent infestation of fruit borer by number estimated based on which selection can be emphasized for yield and FSB resistance. The phentopic and genotypic correlation studies have been presented in Tables 15 and 16. In general, the effects of genotypic correlation co-efficient are higher than the respective phenotypic correlation co-efficient.

Correlation studies:

Phenotypic correlation studies:

It reveals that the per cent fruit borer infestation on weight basis exerted highly significant positive correlation with per cent fruit borer infestation on number basis and significant positive association with per cent shoot borer infestation, total chlorophyll content of fruit. Per cent fruit borer infestation by number had highly significant negative correlation with total anthocyanin content of both leaf and fruit and it had significant negative association with polyphenol oxidase. There was high and significant positive correlation between phenol content of fruit and total chlorophyll content of leaf. Ascorbic acid was highly significantly and positively correlated with total chlorophyll content of leaf while, exerted significant negative correlation with shoot borer infestation.

Genotypic correlation studies:

Correlation studies revealed that plant height showed negative but non-significant correlation with per cent fruit borer infestation by number and had significant negative correlation with per cent shoot borer infestation and per cent fruit borer infestation by weight. Days to first flowering had highly significant positive correlation with days to 50 per cent flowering, shoot diameter, trichome density, fruit yield/plant while, significant negative correlation with per cent SBI followed by per cent fruit borer infestation by weight, total sugar but exhibited non-significant negative correlation with per cent fruit borer infestation by number and polyphenol oxidase. Days to 50 per cent flowering showed significant positive correlation with trichome density and fruit phenol. However, it was significantly negatively correlated with per cent shoot borer infestation, per cent fruit borer infestation by weight, total sugar and polyphenol oxidase. There was high significant positive correlation between shoot diameter and trichome density, average fruit weight, fruit phenol and ascorbic acid. It had high significant negative correlation with per cent shoot borer infestation, per cent fruit borer infestation by weight. Trichome density exhibited significant positive correlation with average fruit weight, but non-significant positive correlation with fruit yield/plant and polyphenol oxidase. It showed highly significant negative correlation with per cent shoot borer infestation, per cent fruit borer infestation by number and per cent fruit borer infestation by weight, and, respectively. Fruit length showed high significant positive correlation with number of fruits/plant, fruit yield/plant and non-significant positive correlation with fruit phenol, antioxidant. However, it had significant negative correlation with per cent fruit borer infestation by number and by weight. Fruit diameter had high significant positive correlation with per cent fruit infestation by number and by weight but non-significantly positively correlated with total sugar and fruit yield/plant. There was non-significant positive correlation between average fruit weight and fruit yield/plant, total sugar while, significant positive correlation with fruit phenol, leaf chlorophyll. However, it had negative correlation with per cent fruit borer infestation by number, highly significantly correlated with per cent shoot borer infestation, fruit borer infestation by weight. Fruit borer infestation by weight was significantly negatively correlated with fruit phenol, leaf and fruit anthocyanin and non-significant negative correlation with polyphenol oxidase. Fruit phenol had significant positive correlation with days to 50 per cent flowering, days to first fruit set, average fruit weight while, significant negative correlation with per cent fruit borer infestation by number and by weight. Leaf chlorophyll content showed highly significant positive correlation with days to 50 per cent flowering, shoot diameter, average fruit weight, number of fruits/plant, fruit yield/plant, fruit borer infestation by weight, total antioxidant capacity. However, it had significant positive correlation with fruit phenol. Fruit anthocyanin showed non-significant negative correlation with antioxidant while, significant positive correlation with fruit length, average fruit weight.

Diversity study in the genotypes under study:

In order to select right parents for crossing and exploiting maximum variability and heterosis, we need

to know about genetic divergence. The 36 genotypes varied significantly with regard to the traits under study and showed divergence. D^2 cluster analysis of genotypes was performed using Ward's minimum variance method and then groups were compared.

Clustering pattern:

Through cluster analysis the 36 genotypes have been grouped into seven clusters. Among these clusters, cluster III contained only one genotype whereas, cluster V consisted maximum number of genotypes (8) followed by cluster IV and VII, cluster II, cluster I and cluster VI contained 2 genotypes. The clustering pattern clearly reflects the presence of ample extent of genetic diversity in the genotypes under study.

Cluster distance :

The intra and inter cluster average distances among seven clusters were variable and has been presented. The highest intra cluster distance was in cluster IV (3180.79) followed by cluster VI (2123.256).

The maximum inter cluster distance was recorded between the members of cluster III and cluster IV followed by cluster VI and cluster I, cluster IV and cluster VI. The inter cluster distance ranged from 2599.375 to 9928.319 indicating wider genetic diversity among the members between distantly located clusters.

Cluster mean for biophysical and morphological traits:

A comparison of the mean values of different clusters for 15 biophysical and morphological traits has been presented. It was observed that a considerable difference in cluster mean values were evident for all the characters under study.

Days to 50 per cent flowering, days to first fruiting, shoot diameter, trichome density/cm^2, fruit length, fruit girth, average fruit weight, number of fruit/plant, yield/plant, shoot borer infestation, fruit borer infestation per cent by number and fruit borer infestation by weight. The present study revealed that cluster VI showed highest mean values for most of the characters like plant height, number of primary branches, shoot diameter, trichome density and average fruit weight. Cluster III showed highest mean values for days to first flowering, days to 50 per cent flowering and yield/plant. Cluster III showed lowest mean value for per cent fruit borer infestation by number and weight while, cluster IV showing lowest mean value for days to first flowering, fruit length, fruit weight, number of fruits per plant and yield/plant and cluster V showed lowest per cent of shoot borer infestation.

Cluster mean for biochemical traits:

The mean table of 7 different clusters for the ten biochemical characters under study has been presented. leaf, Total chlorophyll content fruit, total anthocyanin content leaf, total anthocyanin content fruit, total phenol content leaf, total phenol content fruit, total antioxidant capacity and polyphenol oxidase activity. It revealed that cluster VI showed highest mean value for total chlorophyll content of leaf, total anthocyanin content of leaf and fruit and ascorbic acid content. However, cluster I had lowest total phenol content of fruit, fruit total anthocyanin content. Cluster III had highest mean value for total phenol content of fruit, total polyphenol oxidase activity but minimum mean value for ascorbic acid, total phenol content of leaf. Cluster II showed maximum mean value for total sugar.

Percentage contribution of each character towards divergence:

Diversity of the genotypes is always due to the characters inculcating within them. The percentage contribution of each character towards total genetic divergence has been shown. The table clearly reveals that the morphological/biophysical characters like per cent fruit borer infestation by weight followed by per cent fruit borer infestation by number, fruit yield per plant and number of fruits per plant showed maximum contribution towards divergence and plant height, number of primary branches, days to 1^{st} flowering, 50 per cent flowering, 1^{st} fruit set, shoot diameter, trichome density, fruit length, diameter, weight did not show any contribution towards divergence.

High yield combined with good quality as well as resistance to shoot and fruit borer is the ultimate aim in most of the brinjal breeding programmes. Varieties that are often inherent to fruit and shoot borer resistance have the potential to improve the marketable yield and enhance economic returns of the poor farmers. The major bottleneck in the resistance breeding programme for shoot and fruit borer is the lack of resistant source in the cultivated germplasm. This has necessitated brinjal

breeders to search resistance for genes in wild species that are taxonomically related and compatible with brinjal. Genotypes possessing some specific morphological bases may provide resistance or tolerance of the brinjal plant against BSFB. Improvement in yield and quality is normally achieved by selecting genotypes with desirable character combinations existing in the nature or by hybridization.

Variability :

The selection of desirable genotype is primarily based on mean performance. However, before launching any breeding programme, it is necessary to have a thorough knowledge of variability present in population. In the present investigation, significant differences were observed among the genotypes for all the characters thus providing substantial scope for improvement in brinjal. The variation among the genotypes might have occurred due to differences in genes carried by different lines, differences in the environmental factors to which these lines were exposed to and by interaction between genotypes and environment. Genotypic co-efficient of variation helps in measuring the range of diversity in character and provides a means to compare the genetic variability in the quantitative characters. However, it is not possible to estimate heritable variations with the help of GCV alone. The high estimates of GCV and PCV was observed for number of fruits per plant, fruits yield per plant and per cent shoot borer infestation. The estimates for GCV and PCV for all the biochemical traits under study were high. PCV was slightly higher than GCV for all the characters indicating lesser role of environment on the expression of these traits.

Heritability:

Heritability in broad sense may be defined as it is the ratio of genotypic variance by phenotypic variance. Heritability is an important genetical parameter since it provides a measure of overall importance of hereditary determination of a character and permits the prediction of progress in a selection scheme for a given character. Heritability in conjugation with genetic advance provide better picture for predicting the genetic progress in selection. The magnitude of heritability estimates in broad sense revealed that all the biochemical traits and most of the morphological characters except plant height, number of primary branches per plant, fruit length and fruit diameter and exhibited high estimates of heritability and were highly heritable in nature. The characters like number of fruits per plant, fruit yield per plant and shoot borer infestation had high GCV along with high heritability while trichome density, average fruit weight, per cent fruit borer infestation both by number and weight showed moderate GCV coupled with high heritability suggesting that selection will be more effective for these characters.

Genetic advance and genetic advance as percent of mean:

Heritability estimates in conjunction with genetic advance are more useful than the heritability alone in predicting the resultant effects for selecting the best individuals. Thus, it is clear that a character with higher GCV and moderate heritability will have high genetic gain. On the other hand, characters with low GCV and high heritability estimates may have low genetic gain. Therefore, it has been observed that high heritability does not necessarily mean that character will show high genetic progress. Hence, high heritability with genetic advance is obtained probably due to additive gene effects. The higher genotypic variation of these characters is probably due to additive gene effects. Therefore, the selection based on phenotypic performance of these characters would be useful for achieving desired results. Shoot diameter showed moderate heritability and low genetic advance indicating predominant role of non-additive gene action for these traits. Moderate genetic advance as percentage of mean and high heritability for suggests that individual plant selection will be more effective. High heritability along with high genetic advance was reported for all the biochemical characters under study. Hence, selection will be effective for all these characters due to preponderance of additive gene effect.

Correlation studies:

The adequate knowledge about the magnitude and direction of association of different plant characters with yield and its component traits is essential for selection process, in effective breeding. The present study revealed that in general, genotypic correlation co-efficients were higher than their phenotypic ones. This could be attributed to the masking effect of environment which modifies the expression of a character thereby reducing the phenotypic expression. Also inter-relations of characters at genotypic level were quite different from those at

phenotypic level. This might be due to different interaction of genotypes with the environment. In the present investigation separate correlation studies were conducted for the biophysical traits and BFSB infestation, biochemical traits and the BSFB infestation and all the morpho-biochemical traits under study. At genotypic level, the correlation co-efficient studies revealed that yield per plant had significant positive correlation with number of fruits per plant, fruit length and total ascorbic acid content. Total antioxidant capacity had positive correlation with chlorophyll content of fruit. Significant negative correlation was observed between total phenol content of fruit and ascorbic acid content.

Path co-efficient analysis:

The estimation of correlation co-efficient indicated only the association of characters with FSB infestation and relative inter-relationships, but did not furnish information on causal relationship. In the present investigation separate path analysis studies were conducted for the biophysical traits and BFSB infestation, biochemical traits and the BSFB infestation with per cent fruit borer infestation by number being the dependent variable. In the present study, the path co-efficients analysis indicated that fruit yield per plant, plant height, number of primary branches per plant, days to 1st flowering, trichome density, fruit length, fruit diameter, shoot borer infestation and FBI by weight exhibited positive direct effect on per cent infestation of fruit borer by number. While, the characters like fruits per plant, fruit weight, shoot diameter, days to 50 per cent flowering, days to 1st fruit set exerted negative direct effect. The qualitative characters like fruit phenol, ascorbic acid and also FBI by weight had positive direct influence in relation to per cent FBI by number whereas, antioxidant, chlorophyll content, anthocyanin content, total sugar, polyphenol oxidase and shoot borer infestation exerted indirect effect.

Genetic divergence:

For selecting right parents for hybridization and exploiting maximum heterosis the knowledge of genetic divergence becomes essential. The clustering pattern reflects the presence of considerable extent of genetic diversity in the genotypes under study. There were seven clusters and cluster III contained only one genotype whereas, cluster V consisted maximum number of genotypes followed by cluster IV and VII, cluster II, cluster I and cluster VI contained 2 genotypes. Results indicated that the highest inter-cluster distance was observed between cluster III and cluster IV followed by cluster I and cluster VI and cluster IV and cluster VI indicating wide spectrum of variability of population. However, the highest intra-cluster distance was observed within cluster IV, indicated the genotypes in these clusters were more diverged than those of other clusters. The lowest inter-cluster distance was observed between cluster I and cluster II suggesting a close relationship among the genotypes included within these clusters. The intra-cluster distance varied from 0 to 3180.79, the maximum being for cluster IV that was composed of 7 genotypes of diverse origin, while the minimum distance was found in cluster III that was composed of only one genotype. The present study revealed that cluster VI showed highest mean values for most of the characters like plant height, number of primary branches, shoot diameter, trichome density and average fruit weight. Cluster III showed highest mean values for days to first flowering, days to 50 per cent flowering and yield/plant. Cluster III showed lowest mean value for per cent fruit borer infestation by number and weight while, cluster IV showing lowest mean value for days to first flowering, fruit length, fruit weight, number of fruits per plant and yield/plant and cluster V showed lowest per cent of shoot borer infestation. It revealed that cluster VI showed highest mean value for total chlorophyll content of leaf, total anthocyanin content of leaf and fruit and ascorbic acid content and lowest values for total sugar. However, cluster I had lowest total phenol content of fruit, fruit total anthocyanin content. Cluster III had highest mean value for total phenol content of fruit, total polyphenol oxidase activity but minimum mean value for ascorbic acid, total phenol content of leaf. Cluster II showed maximum mean value for total sugar. The genotypes of these clusters with high mean values for yield attributing traits and low mean values for BFSB infestation may be directly used for adaptation or may be used as parents' in future breeding programme. The desirable values for traits for per cent fruit borer infestation by number and weight both have been exhibited by cluster III followed by cluster VI, while the desirable value for per cent of shoot borer infestation was found in cluster V.

Conclusion :

On the basis of results obtained in the present investigation it was concluded that sufficient genetic variability was present among the genotypes taken under study, thus, there is ample scope for selection of promising lines for future breeding programme. The ovipositional preference of adult of BFSB could possibly be determined by secondary plant metabolites or allelochemicals. Expression of resistance to BFSB was also associated with low total sugars content and high total phenolic content. High total anthocyanin content of leaves and fruits also marked lesser incidence of BFSB. Also, the genotypes with high polyphenol oxidase activity showed lesser infestation of the noxious pest. Besides, it has been found that round fruits having higher fruit girth were more prone to infestation compared to long fruits with more fruit length and less fruit girth. Trichome density of the leaves also determined the ovipositional preference of the adults and leaves with higher trichome density exhibited lower infestation of the insect. However, it is evident that resistance is not conferred by any single character alone. The combination of biophysical and biochemical traits can be used as effective and reliable selection criteria for resistance. It may be suggested that the brinjal genotypes higher trichome density with long fruits having lesser fruit girth, with high anthocyanin content in leaves and fruits, high total phenols, low total sugar content may be used in hybridization programme to develop cultivars with resistance to BFSB. Variability among 36 brinjal genotypes for the traits like number of fruits per plant, total anthocyanin content, polyphenol oxidase activity, fruit borer infestation both by number and weight were higher hence, genetic improvement through selection for these traits will be rewarding.

REFERENCES

Al- Jibouri, H.A. Millar, P.A. and Robinson, H.F. (1958). Genotypic and environmental variances and co-variance in an upland cotton cross of interspecific origin. *Agron. J.,* **50**: 633-637.

Amin, S.M.R., Alam, M.Z., Rahman, M.M., Hossain, M.M. and Mian, I.H. (2014). Study on morphological characteristics of leaves, shoots and fruits of selected brinjal varieties/lines influencing brinjal shoot and fruit borer infestation. *Internat. J. Econ. Plants,* **1**(1): 1-8.

Apak, R., Güçlü, K., Özyürek, M. and Karademir, S.E. (2004). Novel total antioxidant capacity index for dietary polyphenols and vitamins C and E, using their cupric ion reducing capability in the presence of neocuproine: CUPRAC Method. *J. Agric. & Food Chem.,* **52** (26) : 7970-7981.DOI: PMid: 15612784 .

Ardez, K.P., Sumalde, A.C. and Taylo, L.D. (2008). Ovipositional preference, host range and life history of eggplant fruit and shoot borer, *Leucinodes orbonalis* Guenee (Lepidoptera: Pyralidae). *Philippine Entomologist.,* **22**(2): 173-183.

Arnon, D. I. (1949). Copper enzymes in isolated chloroplast polyphenol oxidase in Beta vulgaris. *Pl. Physiol.,* **24** : 115.

Bharadiya, A.M. and Patel, B.R. (2005). Study on the efficacy of certain insecticides against brinjal shoot and fruit borer, *Leucinodes orbonalis* Guenee. *J. Plant Protec. & Environ.,* **2** : 113-115.

Chandrashekhar, C.H., Malik, V.S. and Singh, R. (2009). Morphological and biochemical factors of resistance in eggplant against *Leucinodes orbonalis* (Lepidoptera: Pyralididae). *Entomologia Generalis,* **31**: 337-345.

Dewey, D.R. and Lu, K.H. (1959). A correlation and path co-efficient analysis of components of crested wheat grass production. Agron. J., **51**: 515-518.

Dhaka, S.K. and Soni, A.K. (2012). Genetic variability in brinjal (*Solanum melongena* L.). *Asian J. Hort.,* **7**(2): 537-540.

Dhruve, J.J., Shah, R., Gandhi, S. and Talati, J.G. (2014). Biochemical and morphological traits of different cultivars of brinjal fruits growing in Anand (Gujarat). *Indian J. Agric. Biochem.,* **27**(2): 211-214.

Elanchezhyan, K., Muralibaskaran, R.K. and Rajavel, D.S. (2008). Field screening of brinjal varieties on major pests and their natural enemies. *J. Bio Pesticides,* **1**(2):113- 120.

Elanchezhyan, K., Muralibaskaran, R.K. and Rajavel, D.S. (2009). Biochemical basis of resistance in brinjal genotypes to shoot and fruit borer, *Leucinodes orbonalis* Guen. *J. Entomological Res.,* **33**: 101-114.

Gupta, Y.C. and Kauntey, R.P.S. (2008). Studies on fruit characters in relation to infestation of shoot and fruit borer, *Leucinodes orbonalis* Guen.in brinjal, *Solanum melongena* L. *J. Entomological Res.,* **32** (2) : 119-123.

Johnson, H.W., Robinson, H.F. and Comstock, R.E. (1955). Estimates of genetic and environmental variability in soybean. *Agron. J.*, **47**: 274-318.

Khorsheduzzaman, A.K.M., Alam, M.Z. and Rahman, M.M. (2010). Biochemical basis of resistance in eggplant (*Solanum melongena* L.) to *Leucinodes orbonalis* Guenee and their

correlation with shoot and fruit infestation. *Bangladesh J. Agric. Res.,* **35**(1): 149-155.

Kumar, S.R., Arumugam, T. and Balakrishan, S. (2013). Studies on evaluation and mean performance associated with yield, quality and pest and disease incidence in eggplant (*Solanum melongena* L.) *Internat. J. Hort.,* **13**(3): 70-79.

Kushwah, S. and Bandhyopadhya, B.B. (2005). Variability and Correlation studies in brinjal lndian. *J. Hort.,* **62**(2): 210-212.

Lush, J.L. (1940). Intra-sire correlations or regressions of offspring on dam as a method of estimating heritability of characteristics. *Proc. Amer. Soc. Anim. Prod.*, 293.

Lush, J.L. (1949). Heritability of quantitative characters in farm animals. Heriditas (suppl.). **35** : 256-261.

Miller, Daniel (2007). *Genetically engineered eggplant*. Span, 41.

Naliyadhara, M.V., Mehta, D.R., Pandya, H.M. and Purohit, V.L. (2007). A study on genetic diversity and genetic variability in brinjal (*Solanum melongena* L.). *Agric. Sci. Digest.,* **27** (1): 22-25.

Naqvi, A.R., Pareek, B.L., Nanda, U.S. and Mitharwal, B.S. (2008). Leaf morphology and biochemical studies on different varieties of brinjal in relation to major sucking insect pests. *Indian J. Plant Protec.,* **36** (2) : 245-248.

Naqvi, A.R., Pareek, B.L., Nanda, U.S. and Mitharwal, B.S. (2009). Biophysical characters of brinjal plant governing resistance to shoot and fruit borer, *L. orbonalis. Indian J. Plant Protec.,* **37**(1/2): 1-6.

Padgilwar, T., Deshmukh, M. and Mahorkar, V.K. (2009). Correlation and path analysis for biochemical constituents and fruit infestation in brinjal. *Plant Archiv.,* **9**(1): 307-308.

Pareek, B.L. and Bhargava, M.C. (2009). Estimation of avoidable losses in vegetable crops caused by borers under semi-arid conditions of Rajasthan. *Insect Environment.*, **9**: 59-60.

Prabakaran, S. (2010). Evaluation of local types of brinjal (*Solanum melongena* L.). M.Sc., (Hort.) Thesis, Agricultural College and Research Institute, Tmil Nadu Agricultural University, Madurai, T.N. (INDIA).

Prabhu, M., Natarajan, S. and Pugalendhi, L. (2007). Biochemical basis of shoot and fruit borer (*Leucinodes orbonalis* Guen.) resistance in brinjal (*Solanum melongena* L). In: Keshavachandran, R., Nazeem, P.A., Girija, D., John, P.S. and Peter, K.V. (Ed.), Recent trends in Horticultural Biotechnology, New India Publishing Agency, New Delhi, India, pp. 829-837.

Prabhu, M., Natarajan, S., Veeraragavathatham, D. and Pugalendhi, L. (2009). The biochemical basis of shoot and fruit borer resistance in interspecific progenies of brinjal (*Solanum melongena*). *Eur. Asian J. BioSci.,* **3**: 50-57.

Prasad, T.V., Bhardwaj, R., Gangopadhyay, K.K., Arivalagan, M., Bag, M.K., Meena, B.L. and Dutta, M. (2014). Biophysical and biochemical basis of resistance to fruit and shoot borer (*Leucinodes orbonalis* Guennee) in eggplant. *Indian J. Hort.,* **71** (1): 67-71.

Ranganna, S. (1977). Plant pigments. In: S. Ranganna (Ed.): *Manual of analysis of fruit and vegetable products.* Tata McGraw-Hill Publishing Co., Ltd. New Delhi. pp. 72-93.

Roychowdhury, R., Datta, S. Gupta, P. and Tah, J. (2012). Analysis of genetic parameters on mutant populations of mungbean (*Vigna radiata* L.) after ethyl methyl sulphonate treatment. *Notulae Scientia Biologicae.,* **4** (1): 137-143.

Samadia, D.K., Aswani, R.C. and Dhandar, G. (2006). Genetic analysis for yield components in tomato land races. *Haryana J. Hort. Sci.,* **35** (1&2): 116-119.

Senapati, N., Mishra, H.N., Bhoi, M.K., Dash, S.K. and Prasad, G. (2009). Genetic variability and divergence studies in brinjal (*Solanum melongena* L.). *Veg. Sci.,* **36** (2): 150-154.

Shinde, K.G., Birajdar, U.M., Bhalekar, M.N. and Patil, B.T. (2012). Correlation and path analysis in eggplant (*Solanum melongena* L.). *Veg. Sci.,* **39**(1): 108-110.

Singh, A.K., Ahmed, N. and Narayan, S. (2006). Genetic divergence studies in brinjal under temperate condition. *Indian J. Hort.,* **63** (4) : 407-409.

Singleton, V.L., Orthofer, R., Lamuela-Raventos, R.M. (1999). Analysis of total phenols and other oxidation substrates and antioxidants by means of Folin-Ciocalteu reagent. *Methods Enzymol.,* **299** : 152-178.

Soundararajan, R. and Baskaran, P. (2005). Effects of antibiosis components of eggplant on the developmental biology of whitefly parasitoids, *Encarsia transvena* T. and *Eretmocerus mundus* M. (Aphelinidae: Hymenoptera). *In:* National seminar on sustainable insect pest management (Ignacimuthu, S. and Jayaraj, S. Ed.), Loyola College, Chennai. pp. 298.

Thamburaj, S. and Singh, N. (2013). *Vegetables, tubercrops and spices*. Indian Council of Agricultural Research, NEW DELHI, INDIA.

Thangamani, C. and Jansirani, P. (2012). Correlation and path co-efficient analysis studies on yield and attributing characters in brinjal (*Solanum melongena* L.). *Electronic J. Plant Breed.,* **3** (3): 939-944.

Wagh, S.S., Pawar, D.B., Chandele, A.G. and Ukey, N.S. (2012). Biophysical mechanisms of resistance to brinjal shoot and

fruit borer, *Leucinodes orbonalis* Guenee in brinjal. *Pest Mgmt. Hort. Ecosyst.*, **18** (1) : 54-59.

Warade, S.D., Shinde, K.G. and Kadam, J.H. (2008). Association of characters in relation to shoot and fruit borer infestation in brinjal (*Solanum melongena* L.). *Asian J. Hort.*, **3** : 304-306.

Wright, S. (1921). Correlation and causation. *J. Agirc.Res.*, **20**: 557 - 585.

Yadav, D.S. and Sharma, M.M. (2005). Evaluation of brinjal varieties for their resistance against fruit and shoot borer, *Leucinodes orbonalis* Guenne. *Indian J. Entomol.*, **67**(2): 129-132.