SCREENING BRINJAL FOR JASSID, *Amrasca biguttula biguttula* (Ishida) TOLERANCE.

By

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THESIS

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DECLARATION

I hereby declare that the thesis entitled **"Screening brinjal for jassid, *Amrasca biguttula biguttula* (Ishida) tolerance"** is a bonafide record of research work done by me during the course of research and the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

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CERTIFICATE

Certified that the thesis entitled **"Screening brinjal for jassid, *Amrasca biguttula biguttula* (Ishida) tolerance"** is a record of research work done independently by **Miss Malini.C.D** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, associateship or fellowship to her.

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Introduction

INTRODUCTION

Vegetables occupy a major role in the predominantly vegetarian diet of Indian people. The productivity of vegetables in India is only 15 tonnes per hectare. Augmenting the production of vegetables in the country is a matter which should be given top priority. To meet the increasing demand of vegetables, productivity should be raised to a minimum of 25 tonnes per hectare by 2020, which is possible only through the popularization of multiple resistant varieties and adoption of scientific cultural practices. (Shanmugasundaram, 2005)

Brinjal (egg plant or aubergine) (*Solanum melongena* L.) is one of the most popular vegetable crops of India which occupy 9.4 per cent of total cropped area under vegetables in the country. India ranks second in the production of brinjal, next to China. In the country, the crop is grown in an area of 5.02 lakh hectares producing 83.47 lakh tonnes with an average productivity of 16.63 tonnes per hectare (NHB, 2005). The crop is widely grown in states like Orissa, Bihar, West Bengal, Gujarat, Madhya Pradesh and Tamil Nadu. In Kerala, the cultivation of brinjal is more in homestead farms and the intensive cultivation as seen in other states is rather limited. Here the crop is mainly grown as a rainfed crop during May to December in selected villages scattered throughout the state.

Brinjal has been considered as a staple vegetable in our diet since ancient times. Contrary to the common belief, it is not low in nutritive value. In every 100g, it contains 1.4g protein, 0.3g fat, 0.3g minerals, 4.0g carbohydrates and 1.3g fibre. The medicinal properties of egg plant fruit are also well known. White and small fruited brinjal is good for diabetic patients (Chaudhary, 1976). In Ayurvedic treatments, it is used as an appetizer, aphrodisiac and cardio tonic.

Being a highly productive and long duration vegetable, brinjal finds its place in every homestead prevalent in Kerala. But its commercial cultivation is limited by the occurrence of several pests like jassids, shoot and fruit borer, and whiteflies and diseases like bacterial wilt, phomopsis blight and little leaf. Further more, the market preference of fruits varies with colour, size and shape from region to region. So the cultivation can be made more remunerative by the popularization of high yielding, multiple disease and pest resistant varieties with attractive fruits suitable to specific locations.

Since brinjal is believed to be originated in India, the crop here is endowed with wide variability in characters. The basis of any crop improvement programme is the availability of variability in the existing germplasm and its utilization for the development of high yielding and multiple resistant varieties. Earliness, erect and self staked plant habit, less branching nature, uniform fruit size and colour, thick flesh, resistance to diseases and pests and above all higher yield are a few breeding objectives in brinjal (Peter, 1998).

Identification of sources of resistance by screening the germplasm and related species, and working out the mechanisms of resistance are essential steps to develop genotypes with desired levels of resistance. The crop improvement attempts till now in brinjal has resulted in the release of many bacterial wilt resistant, high yielding and attractive fruited varieties suitable to specific markets. Still, a high yielding variety resistant to jassid attack, which is one of the limiting factor in the economic cultivation of brinjal during summer months, is not available. In order to realize the production potential of superior varieties of brinjal which are recommended for commercial cultivation, a rational strategy of pest management is indispensable. Hence, alternative low cost insect control strategies that are effective and safe are very much needed.

Jassids or leaf hoppers (*Amrasca biguttula biguttula* (Ishida)) are causing severe yield reduction in brinjal during summer months. Both nymphs and adults suck the sap from the lower surface of leaves and inject their toxic saliva into the plant tissues. The infested leaves curl upward along the margin, which may turn yellowish, and show burnt up patches called "hopper burn". They also transmit mycoplasma disease like little leaf and virus disease like mosaic. Fruit setting is also adversely affected by the attack. Chemical control measures have proven to be not fully effective since jassids are highly mobile and they concentrate more on the ventral surface of leaves. Further more, development of insecticide resistance and the consequential residue hazards are of much concern. It is therefore imperative to think of developing jassid resistant / tolerant varieties as part of an integrated approach for combating the pest. The research carried out on identifying the sources of resistance to jassid attack in brinjal is meagre.

The utilization of host resistance for the population management of crop pests is one of the well known approaches in crop protection research. The potential benefits to be derived from the use of host plant resistance in comparison with other methods are enormous. Even a low level of resistance can be effective by way of reducing the viability of the pests and favouring the activity of natural enemies to the extent of effective natural control.

With these views in mind the present study was undertaken with the following objectives.

- Evaluation of brinjal accessions for horticultural traits and estimation of genetic parameters.
- Screening of brinjal accessions for jassid resistance.
- Studying the mechanisms of resistance against jassid attack in brinjal.

Review of Literature

REVIEW OF LITERATURE

Brinjal (*Solanum melongena* L.) is an important vegetable crop grown through out the warmer regions of the world. The crop has been reported to be originated in India (Vavilov, 1928). Despite its wide genetic variability, very little work has been done on the development of multiple resistant varieties. Insect pests are limiting factors in profitable cultivation of brinjal crop. Among the insect pests, jassid (*Amrasca biguttula biguttula* (Ishida) is very important, as it affects the yield and quality of brinjal considerably, especially during summer season. The present study was undertaken to screen the available brinjal accessions for yield and jassid resistance.

The available literature related to the topic are reviewed under the following headings.

1.Evaluation of brinjal accessions for yield components and estimation of genetic parameters .

2.Screening of brinjal accessions for jassid resistance.

2.1. SCREENING OF BRINJAL FOR YIELD AND YIELD COMPONENTS

India being the centre of diversity for brinjal, considerable variation exists here, which provide ample scope for its genetic improvement (Ganabus, 1964). Three main botanical varieties have been reported under the species *melongena*. The round or egg shaped cultivars are grouped under var. *esculentum*, the long slender types were included under var. *serpentinum* and the dwarfs were under var. *depressum* (Chaudhary, 1976).

2.1.1.Growth and yield characters

Crop yield is a complex character determined by various yield components

(Singh, 1983). Krishnamoorthy and Subramoniam (1953) classified the flower types of brinjal into four groups *viz.*, short styled, pseudo short styled, medium styled and long styled. They opined that under natural conditions 27 per cent of flowers set fruits and 93 per cent of these fruits came from long styled flowers. They also observed developing fruits reduced the pistil growth in flowers formed later on the same plant. Nothmann and Rylski (1983) also reported that basal fruits were the heaviest and its presence affected the development of other fruits produced further

Anserwadekar *et al.* (1979) compared growth and yield of five cultivated varieties of brinjal and found significant difference in plant height among varieties. Cultivated variety Gongegaon produced maximum leaves.

Sankar (1984) evaluated eleven genetic groups of brinjal line SM-6 for two cycles and reported that SM 6-4 had the highest yield of 1.71 kg per plant in the first cycle and SM 6-7 (1.9 kg/plant) during the second cycle. Jessykutty (1985) evaluated eleven genetic groups of brinjal line SM 6 for third and fourth cycles and SM 6-2 has recorded the highest yield of 1.11 and 1.28 kg per plant for the two cycles respectively.

Vadivel and Bapu (1989) reported that on evaluation of ten promising accessions, EP 65 and Annamalai were the most stable giving high fruit yields over all environments. They observed wide variation for plant height, secondary branches and number of fruits per plant.

Varghese (1991) conducted a study for identifying high yielding bacterial wilt resistant brinjal lines. Significant difference was noticed for fruits per plant, average fruit weight, plant height, total yield per plant and fruiting period in all the four seasons she studied. SM 6-6 was the earliest variety and highest mean yield was given by the hybrid SM 6-2 X PPL.

2.1.2. Variability, heritability, genetic advance and genetic gain in brinjal

The efficiency of selection in crop improvement programmes largely depends on the extent of genetic variability present in the population. The variation present in the plant population is of three types, viz., phenotypic, genotypic and environmental (Singh, 1983). Coefficient of variation gives an idea about the magnitude of variability present in the population.

Heritability and genetic advance are important selection parameters for crop improvement. The ratio of genotypic variance to phenotypic variance is known as heritability. Heritability (%) was categorized into low (0-30%), moderate (30-60%) and high (above 60%) by Singh (1983). Higher heritability indicates the least environmental influence on the character.

The difference between the mean phenotypic value of the progeny of selected plants and the parental population is called as the genetic advance. The genetic advance was categorized into low (<20%) and high (>20%) by Singh (1983). Genetic advance expressed in percentage of mean is called genetic gain. The genetic gain has been classified in to low (1-10 %), moderate (11-20 %) and high (>20 %).

Dhesi *et al.* (1964) reported that the heritability values for yield in brinjal were low. The heritabilities obtained for fruit weight was 44.4 per cent and for fruit length was 50.8 per cent.

Singh *et al.* (1974) studied genetic variability, heritability and genetic advance in brinjal. High value of genetic variability was observed for fruit weight, fruit length and yield per plant. High genetic advance was observed for fruit weight, fruit length, fruit girth and yield per plant.

Bhutani *et al.* (1977) studied 17 varieties of brinjal and found that characters like marketable fruits per plant and total fruits per plant had high estimates of genetic co efficient of variation, heritability and genetic advance.

Dharmegowda *et al.* (1979) revealed a narrow sense heritability estimates of 63.48 per cent for number of fruits per plant and 67.48 per cent for number of seeds per fruit in a 9 x 9 diallele analysis conducted in brinjal.

Sidhu *et al.* (1980) reported that heritability estimates varied from 20.9 per cent for yield to 98.8 per cent for fruit length. Borikar *et al.* (1981) observed that heritability was moderate for yield per plant but high for plant height and branches per plant. But Singh and Singh (1981) reported high heritability estimates for plant height, fruit length, fruit girth, fruits per plant, and yield.

Salehuzzaman and Alam (1983) reported high narrow sense heritability for fruit number. They reported moderate heritability values for fruit weight and low heritability estimates for fruit yield.

Chadha and Paul (1984) investigated genetic variability in brinjal and observed the highest genetic co efficient of variation for fruits per plant. In a genetic variability study conducted in 27 brinjal varieties, Gopimony *et al.* (1984) reported that the phenotypic co-efficient of variation was highest for yield per plant (98.85 %) while genotypic co-efficient of variation was maximum for single fruit weight (98.2%).

Dixit *et al.* (1984) observed that the heritability values for plant height and yield per plant were less than 50 per cent. Singh and Singh (1985) reported that heritability was high for fruit length, girth, shape index and fruits per plant.

In a variability study conducted by Varma (1995) 23 green fruited brinjal genotypes showed considerable variation for plant height, plant spread, primary branches per plant, days to flowering, fruiting period, flowers per cluster, per cent of productive flowers and fruit yield per plant. The genotypic coefficient of variation was of high magnitude for fruit yield per plant, total number of fruits per plant, average fruit weight and number of productive flowers. She reported high heritability coupled with high genetic advance for characters like yield per plant, fruits per plant average fruit weight and per cent of productive flowers.

Patel *et al.* (1999) evaluated 41 genotypes of brinjal and they observed highest genotypic coefficient of variation for fruit volume followed by seed to pulp ratio.

Behera *et al.* (1999) evaluated eight eggplant genotypes and four related *Solanum* spp., *viz., S. gilo, S. anomalum, S. incanum,* and *S. indicum.* They observed high genotypic and phenotypic coefficient of variation for length and diameter of fruits and fruit yield per plant

Rajyalakshmi *et al.* (1999) reported high heritability values for fruit weight, fruit diameter, plant height and number of fruits per plant. Heritability and genetic advance were high for fruits per plant and fruit weight.

Seventy eight brinjal accessions were studied by Singh and Gopalakrishnan (1999). They observed high heritability for fruit weight and days to last harvest. Yield per plant had high values of heritability and genetic advance both in terms of number and weight of fruits, indicating scope for improvement through selection. Genetic advance was very low for days to flower and fruit set. They also reported maximum phenotypic coefficient of variation for number of fruits per plant (60.09 %) followed by yield per plant (57.12 %). Genotypic variation was also maximum for the above two characters (54.8 % and 52.67 % respectively). All characters other than yield per plant gave a coefficient of variation below 50 per cent.

Sharma and Swaroop (2000) evaluated 27 brinjal accessions and found that genotypic coefficient of variation for number of fruits per plant, mean fruit weight and yield per plant were higher. Heritability estimates were higher for length of fruit, number of fruits per plant, mean fruit weight and yield per plant.

High heritability coupled with high genetic advance was observed for number of fruits per plant, number of harvests and yield per plant. High genotypic and phenotypic coefficients of variation were observed for these characters (Daliya, 2001).

2.1.3. Correlation studies

Yield is a complex character and it is manifested by the multiplicative interaction of several component characters. Improvement in yield is possible only through selection for the desired component characters. Hence the knowledge of association between yield and its component characters, and among component characters is essential for yield improvement through selection programme.

Srivastava and Sachan (1973) conducted correlation and path analysis studies in brinjal and observed that yield per plant had a significant positive correlation with fruits per plant and a negative correlation with weight of 10 fruits. Path coefficient analysis revealed that fruits per plant had maximum positive direct effect on yield.

Hiremath and Rao (1974) observed that yield per plant had significant positive correlation with number of fruits per plant, but it had a negative correlation with fruit weight and girth of fruit.

Vijay *et al.* (1978) showed significant positive correlation of yield per plant with size and weight of fruit, and negative correlation with days to flower.

Kalyanasundaram (1979) reported that yield per plant was positively correlated with flower diameter, fruit volume and fruit diameter but negatively correlated with fruit length. In a path analysis study in brinjal conducted by Singh and Singh (1981) yield was found to be positively correlated with length, weight and number of fruits and negatively correlated with days to flower, plant height and fruit girth. Fruit girth had the greatest direct effect on yield per plant followed by fruit length and fruit weight.

Sidhu *et al.* (1980) evaluated 39 accessions and found that total yield per plant was highly correlated with plant height, number of branches, weight of fruit, marketable yield, unmarketable yield and insect incidence.

Sinha (1983) had done path analysis in brinjal and reported that yield was positively correlated with fruits per plant, plant height, branches per plant and length to circumference ratio of fruits. Fruits per plant and fruit length to circumference ratio had the maximum direct effect on yield. Chadha and Paul (1984) observed that yield was positively correlated with fruits per plant and plant height.

Krusteva (1985) studied the effects of different yield components on yield of brinjal and found that fruits per plant and mean fruit weight had the highest correlation with yield. Khurana *et al.* (1988) also reported high positive correlation of yield with fruit diameter and mean fruit weight. These two characters showed high positive correlation with number of branches, stem weight, leaf weight, leaf area and number of leaves. But the above characters showed negative correlation with fruit length. Number of fruits had a negative correlation with fruit diameter, stem weight and leaf width.

Randhawa *et al.* (1989) studied yield component characters in 22 long fruited brinjal varieties and reported high positive correlation between fruit yield and number of fruits per plant and negative association between fruit yield and short styled flowers. Plant height expressed a significant correlation with branches per plant.

Mishra and Mishra (1990) studied yield-influencing characters in 30 genotypes. Yield per plant was positively correlated with fruit length, fruit girth and fruit weight. Positive correlation was observed with plant height, girth of main stem, number of branches, flowers and fruits per plant and average fruit weight.

Nainar *et al.* (1990) conducted correlation studies and found that number of fruits per plant had the highest and most significant positive correlation with yield. Gautham and Srinivas (1992) found plant spread and number of fruits per plant showing significant positive correlation with yield.

Ponnuswami and Irulappan (1994) evaluated 17 brinjal genotypes and reported that yield per plant was positively correlated with plant height, number of branches per plant, fruit weight, fruit length, and number of fruits per plant. The inter correlation among fruits per plant, fruit length and branches per plant were all positive and significant revealing that fruit weight and plant height are the important yield components.

Varma (1995) conducted correlation studies in 23 brinjal genotypes and revealed that yield was positively and significantly correlated with total fruits per plant, fruiting period, average fruit weight, and number of flowers per cluster, while yield was negatively and significantly correlated with days to first flowering, fruit set and harvest. Total number of fruits per plant had the maximum direct positive effect on yield.

Narendrakumar (1995) conducted correlation analysis in 21 genotypes and found that yield per plant was showing significant and positive association with primary branches per plant, fruit length and fruits per plant. However correlation with fruit diameter was non significant.

Sharma and Swaroop (2000) evaluated 27 brinjal accessions and reported that number of fruits per plant, mean fruit weight and diameter of fruits were positively correlated with yield. So selection of high yielding plants based on fruit number per plant, average fruit weight and fruit diameter would be successful. Days to 50 per cent flowering showed no correlation with yield.

Prasath *et al.* (2001) observed that yield was positively correlated with plant height, branches per plant, long styled flowers, fruit girth, fruit weight and fruits per plant. Number of fruits and fruit weight had the maximum direct effect on yield.

2.2. SCREENING OF BRINJAL FOR JASSID RESISTANCE

2.2.1. About the pest

Cotton jassid (*Amrasca biguttula biguttula* (Ishida) = *Sundapteryx biguttula biguttula* (Ishida) = *Empoasca devastans* (Distant) = *Amrasca devastans* (Dist.)), a polyphagous insect, is an important pest of brinjal during summer months in Kerala (Singh, 1996). It is a green coloured leaf hopper .A description of the adult insect was given by Distant (1918) as the adults can be recognized in the field by the presence of a prominent black spot on either side of head. Adult insects are very active and they move diagonally when disturbed. It is a polyphagous insect feeding on different crops like brinjal, okra, bitter gourd,cotton, potato, sunflower, mesta and so on.

Jassids, like other sucking insects, cause injury to their hosts by sucking and de sapping the plant. This injury is probably insignificant as compared to the damage which they cause by injecting toxic saliva into the plant tissues which are killed in the process, resulting in the yellowing, browning, crumpling and withering of the leaf. This characteristic symptom is known as 'hopper burn' and subsequently it will lead to the death of the plants. Threshold level of jassids on okra crop is found to be two nymphs per leaf (Sharma *et al.*, 2001). This suggests that the jassid population is immaterial in causing damage.

2.2.2 Distribution

Infestation of brinjal by jassids has been reported from many places in the country. Brinjal was reported to be attacked by the jassid (*Amrasca biguttula biguttula* (Ishida)) in New Delhi (Subbaratnam *et al.*, 1983), Kerala (Singh, 1996), Banglore (Reddy and Srinivasa, 2001), Tamil Nadu (Raja *et al.*, 2001), West Bengal (Ghosh and Senapati, 2001), Andra Pradesh (Sudhakar *et al.*, 1998), Gujarat (Jyani *et al.*, 1997), Bihar (Mandal *et al.*, 2000) and Rajasthan (Kumar *et al.*, 2002)

Bhindi (*Abelmoschus esculentus* L.) was seen attacked by the jassid, *Amrasca biguttula biguttula,* in Punjab (Sidhu and Simwat, 1973), Rajasthan (Dadheech *et al.*, 1977), Bhuvaneswar (Senapati and Khan, 1978), Gujarat (Chari *et al.*, 1987) Kerala (Reghunath *et al.*, 1987), Madhya Pradesh (Dhamdhere *et al.*, 1995), Haryana (Hooda *et al.*, 1999) and Assam (Gogoi and Dutta, 2000).

A. biguttula biguttula was reported as an important pest of cotton and desi cotton in Bhuvaneswar (Senapati and Mohanty, 1980), Faridkot (Singh *et al.*, 1982), Gujarat (Rao *et al.*, 1983), Punjab (Dhawan *et al.*, 1988) and New Delhi (Sharma and chander, 1998)

Balasubramanian and Chelliah (1985) reported the cicadellid *A. biguttula biguttula* as the most injurious pest of sunflower. Cherian and Kylasam (1938) have reported sunflower as one of the hosts of *Amrasca biguttula biguttula* in the Madras area. Men and Kandalkar (1999) reported jassid attack on sunflower in Maharashtra.

Husain and Lal (1940) reported cotton jassid attack on castor plant (*Ricinus communis*), *Hibiscus cannabinus* and also on some cucurbit plants at Delhi.

Hiranand *et al.* (1981) in Haryana observed jassid infestation in Guar (*Cyamopsis tetragonaloba*) during *Kharif* season. Rao *et al.* (1983) observed the incidence of jassids on mesta (*Hibiscus subdariffa* L.)

2.2.3 Seasonal distribution

Husain and Lal (1940) noticed that in Punjab, the jassid passes the winter season on brinjal crop.

Patel and Thanki (1987) studied the infestation of jassid *A. biguttula biguttula* on brinjal and found that the infestation of jassid on January transplanted crop was maximum during March to June, where as the July crop was attacked during September to February. The crops transplanted in September and November were found infested from October to April and January to May respectively. The crop transplanted in January was attacked for shorter duration.

Dhamdhere *et al.* (1995) reported that the jassids remain active during summer as well as kharif seasons on brinjal, but summer was the most favorable condition for pest build up. Singh (1996) reported heavy incidence of jassids as a serious problem of brinjal during summer months in Kerala.

Prasad and Logiswaran (1997) noticed peak incidence of *A. biguttula biguttula* during September to October in winter and from April onwards in summer on brinjal at Tamil Nadu. Mahmood *et al.* (2002) reported serious activity of jassids on brinjal from 21st May to 6th August.

Sidhu and Simwat (1973) observed that okra was attacked by jassids during summer months in Punjab. Senapaty and Khan (1978) recorded high population of jassids on okra from November to February with its peak in December.

Gogoi and Dutta (2000) revealed that the jassid population on okra was maximum (37-53 nymphs/leaf) in the last week of May in 1998 and middle of April in 1999 (30 nymphs/leaf).

Husain and Lal (1940) observed that in Punjab, towards the end of June cotton seedlings were attacked by jassids. Singh *et al.* (1982) reported jassid as a serious pest on American cotton from the end of July to the end of August and population level declined after mid September.

2.2.4 Preferred stage of the crop

Subbaratnam *et al.* (1983) studied the jassid population on brinjal from 20 and 50 days after transplanting to 90 and 175 days after transplanting in rainy and winter season respectively. He found that jassid infestation was high at 70 days after transplanting in both the seasons.

Patel and Thanki (1987) studied the infestation of jassid on brinjal and found that infestation started on six to seven weeks old crop, which continued until 13 to 30 weeks after transplanting.

Lit *et al.* (2000) observed that during summer the leaf hopper population on brinjal started to build at 45 days after transplanting, peaked at 60 days after transplanting and gradually declined as the plant matured during the summer season.

For screening brinjal varieties against leaf hopper, Reddy and Srinivasa (2001) recorded leaf hopper population between 30 and 90 days after planting. According to Mahmood *et al.* (2002) leaf hopper starts the activity soon after transplanting the brinjal crop.

Rawat and Sahu (1973) studied jassid population on five, eight and 11 weeks old okra plants and recorded the highest population on the eight weeks old plants.

Senapati and Khan (1978) observed that okra plants at the age of seven to 11 weeks were more succumbed to jassid attack and they also noticed the highest population on eight weeks old plants. Uthamasamy (1985) also recorded maximum hopper burn on okra at 60 days after sowing.

Faleiro and Rai (1988) observed that leaf hopper population during peak fruiting stage (45 to 75 days after germination) affected the yield of okra. Misra and Senapati (2003) observed jassids on okra appearing from 11th day of crop germination, remaining active for another 49 days and continued on the crop till maturity.

Usually cotton in the pre-flowering stage is most susceptible to jassid attack and in Punjab this period coincides when the plant is eight to 10 weeks old (Husain and Lal, 1940). Maximum population of leaf hopper (*Amrasca devastans*) on cotton was observed at 50 to 60 days after sowing (Reghupathy and Subramaniam, 1980).

Sivanandan (2003) observed that the time required to develop characteristic symptoms of damage on cotton plants by *A. biguttula biguttula* was positively correlated with the age of plants. Younger plants were more susceptible.

Rao *et al.* (1983) observed the incidence of jassid *Sundapteryx biguttula biguttula* on mesta and reported that jassid preferred the young crop aged 45 to 60 days.

2.2.5 Distribution on plant parts

Spatial distribution pattern of insects characterizes the insect species and is determined by their interaction with the biotic and abiotic environment. According to the spatial distribution pattern the sampling method of plant part is fixed for ascertaining the intensity of pest incidence. It accurately transforms population counts for statistical analysis. Spatial distribution is studied to understand and predict the distribution, abundance and interaction of population with the host crop.

On brinjal leaves jassids oviposit along the midrib (Subbaratnam *et al.*, 1983). So nymphs are found aggregated along the sides of midrib. Lit *et al.* (1999) observed more leaf hoppers infesting the fifth leaf from the growing tip of brinjal plants.

Sharma and Singh (2002) were of the opinion that the lateral veins of eggplant received more eggs of leaf hoppers in comparison with main and sub veins

On okra Jaganmohan (1985) observed maximum leaf hopper population on second, third, and fourth leaves from the top. Faleiro and Rai (1988) opined that the wingless nymphal stage of the leaf hopper was the most reliable measure of its population and he recorded the population of jassids from the three leaves below the crown leaf of bhindi.

Sharma and Singh (2002) observed the subveins of okra receiving the highest number of eggs followed by lateral and main veins.

On cotton plants Cheriyan and Kylasam (1938) observed the older jassid nymphs developing a tendency to become gregarious and crowded on the underside of the semi dry leaves. Husain and Lal (1940) also observed the nymphs of the first and second instars preferring to feed near the base of the leaf veins of cotton and during the later instars they got distributed all over the leaf but fed chiefly on the under surface.

Sharma and Chander (1998) studied spatial distribution of *A. biguttula biguttula* on cotton plants and found that the pest was following either aggregated or regular distribution on the crop. Sharma and Singh (2002) opined that the jassids prefer lateral veins of cotton plants for egg laying to main and sub veins.

2.2.6 Influence of weather parameters on jassid incidence

Patel and Thanki (1987) reported that the maximum temperature of 20^0C with less than 15^0C variation between maximum and minimum temperatures, favored the population build up of jassid *S. biguttula biguttula* on brinjal.

Shukla (1989) and Prasad and Logiswaran (1997) were of the view that the population of *Amrasca biguttula biguttula* showed a significant positive correlation with maximum temperature and a negative correlation with rainfall.

Ratnapara *et al.* (1994) reported that the minimum temperature and vapour pressure were negatively associated with the population build up of jassids. Sunshine hours had a positive association with increasing number of the pest on brinjal.

Bernice (2000) recorded that an increase of 10^0C in maximum temperature and 1mm in rainfall would lead to an increase of 2.10 nymphs and adults per three leaves and a decrease of 1.44 nymphs and adults per three leaves respectively in brinjal.

Mahmood *et al.* (2002) studied the population dynamic of leaf hopper, *A. biguttula biguttula* on brinjal crop and effects of abiotic factors on its dynamic. Mean maximum and minimum temperatures were found as positively and significantly correlated with population change. Relative humidity and rainfall were found as negatively and non-significantly correlated with population fluctuation. Sunshine was also a positively but non-significantly correlated factor.

Srinivasan *et al.* (1981) found that rainfall reduced the mean density and aggregation of the jassid *S. biguttula biguttula* on okra. The absolute maximum temperature caused an increase in aggregation.

But Singh and Sekhon (1998) reported a weak negative correlation of leaf hopper population with sun shine. Leaf hopper population increased on okra plants, when ever the mean temperature was near 30^0C, coupled with 5 - 8 hours of sunshine per day. Rainfall tended to reduce leaf hopper population on okra plants.

In a study conducted by Gogoi and Dutta (2000) on okra, they found that high temperature (30^0C -36^0C) and evening relative humidity (below 80%) and low rainfall period coupled with bright sunshine hours favored the development of jassid population.

2.2.7 Varietal preferance of leaf hopper on brinjal

Field studies conducted in Maharashtra by Gaikwad *et al.* (1991) revealed two brinjal varieties, Manjari Gota and Vaishali as resistant to the cicadellid, *A. biguttula biguttula*.

Singh (1996) reported two varieties of brinjal BB-7 and Pusa Kranti as resistant to jassid attack. Pusa Kranti wedge grafted on *Solanum torvum* rootstocks over came jassid infestation (Anon, 2004)

Study conducted by Jyani *et al.* (1997) for evaluating some brinjal varieties for insect pest resistance, revealed that all the cultivars they tested *viz.*, Suphal, Punjab Barsati, GB-6, Ravedi, Round-14, Gujarat Brinjal Hybrid 1 'and Chaklasi Doli were equally susceptible to *A. biguttula biguttula.*

Raja *et al.* (2001) screened a total of 153 aubergine genotypes against *A. biguttula biguttula* and found that none of them were either immune or resistant. Twenty three entries *viz.*, EP-1, 5, 9, 11, 21, 40, 1, 74, 79, 81, 119, 130, 138, 139, 140, 147, 154, 155, 156, 157, 160 and 173 were graded as moderately resistant. Among these 144, 150, 157 and 160 were wild types namely *Solanum macrocarpum* (BE – 046), *Solanum macrocarpum* (TO – 147), Ghana wild type and *Solanum macrocarpum* (GH – 303) respectively.

Reddy and Srinivasa (2001) found abundant leaf hoppers on brinjal varieties, Green long, Arka Neelakant and Arka Sheel during *kharif* season in Bangloore. Leaf hoppers were less on MHB-10, Pusa Purple Round, Pusa Purple Long and Arka Shirish.

Lit *et al.* (2000) screened ninety-nine egg plant genotypes for field resistance to the leaf hopper at vegetative and reproductive stages. Accession 658 had the highest count followed by 356, 483, 544 white, Mars, Dumaguete Long Purple and Claveria Long Purple.Leaf hoppers were absent on NBPGR accessions 566, 651, 671, 672, 682 and Phl 9405. Abar was resistant to leaf hopper and 544 white was the most susceptible.

Kumar *et al.* (2002) conducted field experiments to study the varietal preference of jassids on brinjal at Rajasthan. Among the 12 varieties, F_1 Hybrid was least preffered while local variety was most preferred by jassids. The preference in ascending order was F_1 Hybrid, Chyamla, Egg lester, Pusa Purple Long, Jhumka, MHB-2, Brinjal F-2, Kanahya, MHB-3, Navchetan, Pusa Purple Round and Local variety.

2.2.8 Host plant resistance

Host plant resistance may be defined as the collective heritable characters by which, a plant species, race, clone or individual may reduce the possibility of successful utilization of that plant as a host by a pest species, race, biotype or individual. (Beck, 1965). Reaction of host plant to insect pest may vary from high level of resistance to extreme susceptibility.

Painter (1951) had categorized plant resistance phenomenon into non-preference, antibiosis, and tolerance. Antibiosis is the mechanism of interfering or destructing the life cycle of insects. It is manifested by the presence of some allelochemicals present in the plant body (Singh, 1986). Kogan and Ortman (1978) suggested the term 'antixenosis' to replace non-preference. It is the avoidance of plants by the insects in search of food, shelter, or ovipositional site (Singh, 1986). Tolerance is the term used when resistant plant is capable of supporting a population of insects with out loss of vigor.

Ananthakrishnan (1992) reported that there can be morphological, anatomical or genetic factors determining pest resistance reactions.

2.2.9 Mechanism of leaf hopper resistance in brinjal

Non-preference and antibiosis are the two important mechanisms of leaf hopper resistance. Ruzzel (1978) emphasized the role of morphological and biochemical factors in deciding non-preference in brinjal.

According to Lit and Bernardo (1990) the important mechanisms of resistance to the jassids in the brinjal varieties were antixenosis and antibiosis. Bernardo and Taylo (1990) suggested the potential use of okra as a trap crop to prevent severe jassid attack on brinjal. The effect of intercropping okra with cotton was studied by Ali and Karim (1989) and it was found that okra was 3 - 10 times preferred to cotton and about 5 per cent of the cicadellids were diverted from cotton .

The jassid resistant varieties of okra affected the biology of the jassid adversely, i.e., they reduced the survival and prolonged the developmental period of the nymphs and also the females laid fewer eggs on resistant varieties (Bindra and Mahal, 1979).

Mahal and Singh (1982) opined that an increased level of antibiosis was exhibited in the segregates of various crosses of okra, which was evident from lower nymphal survival and prolonged nymphal duration on the segregates. Screen house studies conducted by them revealed that the days for nymphal development on susceptible and resistant okra parents were 6.74 and 7.69 respectively. On F1 hybrid between susceptible and resistant parents the nymphs took 8.26 days for development and on F1 hybrid between two resistant parents the days for nymphal development was 9.92.The nymphal survival per cent was 70.88 on susceptible parent and 37.57 on resistant parent. High nymphal mortality, prolonged nymphal period and reduction in size and weight of the adults are some of the antibiotic effects of okra against jassids. The insect takes only fewer days to complete life cycle in susceptible varieties, which means a quicker multiplication and a greater number of generations in a given period than on the resistant variety (Uthamasamy and Subramaniam, 1985).

There are contradictory reports regarding the antibiotic effects of cotton varieties towards jassids. It was reported by Husain and Lal (1940) that nymphs of all instars of jassid could feed and reach normal maturity on all cotton equally well regardless of resistance or susceptibility of the strain. On the other hand Krishnananda (1972) found in a few American cotton strains that, resistant strains had adverse effects on the biology of jassids. Husain and Lal (1940) found marked reduction in egg laying (or possibly hatching of nymphs) on resistant varieties. But nymphs reared on resistant varieties developed in to fertile adults just as those reared on susceptible ones. That is, once hatched nymphs found no difficulty in normal survival on resistant plants.

In *Gossypium arborium* species of cotton tolerance type of resistance appeared to be operating against *Empoasca devastans* (Bhut *et al.*,1985).

2.2.10 Leaf pubescence and jassid resistance

Lit (1989) reported a highly significant and negative linear association between the trichome characters like number of branches of leaf trichomes, length and density of trichomes, and adult oviposition or nymphal feeding of the leaf hopper on brinjal. Lit and Bernardo (1990) and Gaikwad *et al.* (1991) also had same opinion.

Subbaratnam *et al.* (1983) observed that the angle of insertion of midrib hairs has significant influence on egg laying preference of jassids on brinjal.

The works of Uthamasamy (1985) on okra crop revealed that leaf hopper population had highly significant negative correlation with all facets of hairiness, i.e., hair density and hair length. The density and length of hair on the midvein of leaves increased with increasing crop age up to the fifth week. There after only hair density showed a pronounced increase, which simultaneously matched the field resistance response to *Amrasca biguttula biguttula*. He also added that lamina hair of inadequate length or long hair with out adequate density is not effective in imparting resistance.

Experiments conducted by Husain and Lal (1940) in cotton revealed that even though practically all jassid resistant varieties are hairy all hairy varieties are not necessarily resistant. Bhut *et al.* (1985) also had the same opinion that the relationship of hairiness and jassid resistance was not absolute since all hairy varieties were not always resistant to jassids.

2.2.11 Leaf thickness and jassid resistance

Subbaratnam *et al.* (1983) observed that the thickness of the lamina and midrib were positively correlated with jassid infestation in brinjal. He also noted that thickness of lateral veins had no correlation with jassid infestation.

Gaikwad *et al.* (1991) reported that leaf thickness, midrib thickness and leaf area were positively correlated with infestation levels of jassids on brinjal.

In a varietal screening trial conducted by Kumar *et al.* (2002), they found that F_1 hybrid of brinjal with tough surface and thin and hard midrib was resistant to jassid attack.

Sharma and Singh (2002) observed that the leaf vein thickness and length were positively correlated with jassid resistance in cotton.

Works on cotton by Yadava *et al.* (1966) revealed that high and positive correlations were found between nymphal population of jassids and diameter of midribs and leaf veins.

2.2.12. *Anatomical characters associated with jassid resistance*

Host plant characters including morphological or structural qualities interfere with insect behavior such as mating, ovipositing, feeding and food ingestion. Various mechanical resistance factors in plants such as solidness of stem, thickness of tissues, anatomical adaptations, and protective structures affect the use of a plant as a host by phytophagous insects. Pubescence and tissue hardness limit insect mobility acting as structural barriers (Anandakrishnan, 1992).

Studies conducted by Afzal and Abbas (1945) revealed that there was no significant difference in the cuticle thickness, extent of intercellular spaces and secondary thickening of cell walls between the jassid susceptible and resistant varieties of cotton. But Yadava *et al.* (1966) opined that thickness of leaf cortex is having influence on imparting jassid resistance. Singh and Tanega (1989) also suggested the positive correlation of thickness of epicuticular wax and leaf cuticle with jassid resistance in some malvaceous plants.

In pegion pea it was found that the leaf cuticle and epidermal cell wall of mite (*Aceria cajani*) resistant lines, were 50-100 % thicker than in susceptible lines. Cuticle thickness was 3.79 µm and 1.89 µm in resistant and susceptible varieties respectively (Reddy *et al.*, 1995).

Hossain *et al.* (2002) studied anatomical characters of brinjal in relation to resistance against shoot and fruit borer. Compact vascular bundles in a thick layer with lignified cells and less area of pith in the shoot provided some resistance to *Leucinodes orbonalis*.

2.2.13. Other plant characters associated with jassid resistance

In an effort to find out the association between various plant characters and jassid resistance, Afzal and Abbas (1945) observed that the moisture content of the leaf veins, the toughness of leaf cuticle and the p^H value of the cell sap have no significant influence on jassid resistance. But Jayaraj (1967) reported that jassid resistant okra varieties are characterized by low organic acid content.

Uthamasamy (1985) revealed that the leaf hopper resistant varieties of okra contain more total chlorophyll, xanthophylls and carotene than susceptible varieties.

According to Singh and Tanega (1989) moisture content, protein and total sugar contents of the leaves were positively correlated and leaf phosphorus and total phenols were negatively correlated with survival and oviposition of jassids on malvaceous plants. Total level of sugars, free amino acids and polyphenols in the leaves of egg plant are negatively correlated with the number of *A. biguttula biguttula* infesting the plant (Lit and Bernardo, 1990). Gaikwad *et al.* (1991) also were of the same opinion. In addition, they suggested that the fat content of leaves were negatively correlated with oviposition and feeding preference of jassids on brinjal.

Ahmad (1986) studied the relationship of population of the cicadellid *A. bigutula biguttula* with different plant characters in brinjal.The number of insects occurring on the crop was negatively correlated with plant height, number of leaves, number of flowers and fruit yield.

Materials and Methods

MATERIALS AND METHODS

The present study was conducted in the department of Olericulture, College of Horticulture, Vellanikkara, during 2003 – 2005. The field experiments were laid out in the vegetable research field of Department of Olericulture. The field was located at an altitude of 22.5 m above MSL and 10^0 30" N latitude and 76^0 17" E longitude. The studies were conducted under the following heads:

1. Evaluation of brinjal accessions for horticultural traits and estimation of genetic parameters
2. Screening of brinjal accessions for jassid resistance
3. Studying the mechanisms of resistance against jassids in brinjal

3.1. EVALUATION OF BRINJAL ACCESSIONS FOR HORTICULTURAL TRAITS AND ESTIMATION OF GENETIC PARAMETERS

3.1.1. Experimental materials

The brinjal accessions collected by survey and postal correspondence from Kerala and outside and those maintained in the Department of Olericulture, College of Horticulture, Vellanikkara were utilized for the study. The .source details of the accessions are given in Table 1. Twenty nine accessions were grown in a randomised block design with two replications during November 2004 to April 2005 (*rabi* season) and 36 accessions were grown during February 2005 to July 2005 (summer season). Meteorological data during the cropping season are given in Appendix 1.The plants were grown in channels at a spacing of 90 X 60 cm. There were 10 plants per accession per replication. The crop was raised as per Package of Practices Recommendations (KAU, 2002). Prophylactic measures were taken against bacterial wilt incidence.

Table.1 Source of the brinjal accessions used in the study

Sl. No:	Variety/ Accessions	Source	Remarks
1	Neelima	Dept. of Olericulture, COH, Vellanikkara	
2	Surya	Dept. of Olericulture, COH, Vellanikkara	
3	Swetha	Dept. of Olericulture, COH, Vellanikkara	
4	Haritha	Dept. of Olericulture, COH, Vellanikkara	
5	SM 337	Local collection from Thrissur	
6	SM 339	Local collection from Thrissur	
7	SM 343	NBPGR, Regional station, Thrissur	
8	SM 344	Local collection from Thrissur	
9	SM 345	Local collection from Thrissur	
10	SM 347	NBPGR, Regional station, Thrissur	
11	SM 348	NBPGR, Regional station, Thrissur	
12	SM 350	NBPGR, Regional station, Hyderabad	IC 333519
13	SM 351	NBPGR, Regional station, Hyderabad	IC 10675
14	SM 353	NBPGR, Regional station, Hyderabad	IC 383101
15	SM 354	NBPGR, Regional station, Hyderabad	IC 382115
16	SM 355	NBPGR, Regional station, Hyderabad	IC 383106
17	SM 356	NBPGR, Regional station, Hyderabad	IC 383195
18	SM 359	NBPGR, Regional station, Hyderabad	IC 345326
19	SM 360	NBPGR, Regional station, Hyderabad	IC 382107
20	SM 361	NBPGR, Regional station, Hyderabad	IC 345323
21	SM 362	NBPGR, Regional station, Hyderabad	IC 383175
22	SM 363	NBPGR, Regional station, Hyderabad	IC 316248
23	SM 364	NBPGR, Regional station, Hyderabad	IC 316283
24	SM 365	NBPGR, Regional station, Hyderabad	EC 384556
25	SM 366	NBPGR, Regional station, Hyderabad	IC 36323
26	SM 369	NBPGR, Regional station, Hyderabad	EC 329327
27	SM 371	NBPGR, Regional station, Hyderabad	EC 305039
28	SM 378	NBPGR, Regional station, Hyderabad	IC 310886
29	SM 379	NBPGR, Regional station, Hyderabad	IC 373823
30	SM 384	NBPGR, Regional station, Hyderabad	EC 48462
31	SM 385	Dept. of Olericulture, COH, Vellanikkara	
32	SM 386	Dept. of Olericulture, COH, Vellanikkara	
33	SM 387	Local collection from Thrissur	
34	SM 388	Local collection from Thrissur	
35	Swetha x Haritha	Dept. of Olericulture, COH, Vellanikkara	
36	*Solanum macrocarpum*	Dept. of Olericulture, COH, Vellanikkara	

3.1.2. Observations recorded

Five plants per accession per replication were selected randomly to observe the qualitative and quantitative characters. Descriptions were made as per the minimal descriptor list of NBPGR (Srivastava *et al.*, 2001).

3.1.2.1. Qualitative characters

i) Leaf and petiole colour – Green / Purple

ii) Presence of prickles on leaves, stem, and calyx – Prickly / Nonprickly

iii) Flower colour – Violet / Light violet / Dark violet /White

iv) Fruit colour – Green / White / Violet / Striated

v) Fruit shape – Round / Oval / Oblong / Long

Leaf characters were observed at full foliage stage.

Fruit characters were noted at marketable stage of fruits.

3.1.2.2. Quantitative characters

i) Plant height (cm) - Recorded at peak fruiting stage. Height was measured from ground level up to the level of topmost young flushes in its natural standing stature.

ii) Plant spread (cm) - Recorded at peak fruiting stage. Spread was measured from the widest portion of plant canopy.

iii) Number of primary branches – Recorded at peak fruiting stage.

iv) Leaf length (cm) - Length of lamina along with petiole was recorded on fifth leaf from top at full foliage stage.

v) Leaf width (cm) - The width of leaf blade was measured on fifth leaf from top at full foliage stage. Width was taken from the widest area of leaf.

vi) Days to first flowering - Recorded as number of days from sowing to the anthesis of first flower in the plot.

vii) Days to 50 per cent flowering - Recorded as number of days from sowing to date when flowers opened in 50 per cent plants of the accession

viii) Days to first harvest - Recorded as number of days from sowing to date when first formed fruits were harvested at marketable stage.

ix) Days to peak harvest - Recorded as the number of days from sowing to peak harvest of the accession.

x) Days to last harvest - Recorded as the number of days from sowing to the last harvest of the plot.

xi) Number of economic harvests – Recorded as the number of harvests where yield was more than 100g per plant.

xii) Total number of harvests

xiii) Fruit length (cm) - Recorded as average of five fruits at marketable stage excluding stalk.

xiv) Fruit girth (cm) - Recorded as average of same five fruits at marketable stage at the widest region of fruit.

xv) Average fruit weight (g) - Recorded as average of same five fruits at marketable stage

xvi) Number of fruits per plant – Number of fruits per plant was recorded as cumulative number of fruits from five plants and the average was calculated.

xvii) Yield per plant (kg) - Recorded as average of cumulative yield of all pickings from five plants.

xviii) Yield per plot (kg) - Recorded as cumulative yield of the plot.

3.1.3. Statistical analysis

The average of the values obtained from five randomly selected plants in each replication were used for statistical analysis.

The data were subjected to analysis of variance as described by Panse and Sukhatme (1978) with the help of the statistical package MSTAT -C.

3.2. Estimation of genetic parameters

The variance components were estimated by the method suggested by Singh and Chaudhary (1985) as given below.

Phenotypic variance (Vp)

Vp = Vg + Ve where Vg = Genotypic variance

Ve = Environmental variance

Genotypic variance (Vg)

$$Vg = \frac{VT - VE}{N}$$

where VT = Mean sum of squares due to treatments

V E = Mean sum of square due to error

N = Number of replication

Environmental Variance (Ve)

Ve = VE where VE = Mean sum of square due to error

Phenotypic and genotypic coefficients of variation

The phenotypic and genotypic co efficients of variation were calculated by the formula suggested by Burton (1952) with the help of the statistical package SPAR 1.

Phenotypic coefficient of variation (PCV)

$$PCV = \frac{\sqrt{Vp}}{\bar{x}} \times 100$$

where Vp = Phenotypic variance

$\bar{x}$ = Mean of the character under study

Genotypic coefficient of variation (GCV)

$$GCV = \frac{\sqrt{Vg}}{\bar{x}} \times 100$$

where Vg = Genotypic variance

Heritability (H)

Heritability in the broad sense was estimated by following the formula suggested by Burton and Devane (1953) with the help of the statistical package SPAR 1.

$$H = \frac{Vg}{Vp} \times 100$$

where Vg = Genotypic variance

Vp = Phenotypic variance

Genetic Advance (GA)

The expected genetic advance of the accession was measured by the formula suggested by Lush (1949) and Johnson *et al.* (1955) at 5 per cent selection intensity using the constant K as 2.06 as given by Allard (1960).

$$GA = \frac{Vg}{\sqrt{Vp}} \times K$$

where K = Selection differential

Genetic gain (GG)

Genetic advance calculated by the above method was used for estimating genetic gain.

$$GG = \frac{GA}{\bar{X}} \times 100$$

Phenotypic and Genotypic Correlation Coefficients

The phenotypic and genotypic correlation coefficients were worked out to study the extent of association between the characters. The correlation estimates were calculated by the method suggested by Fisher (1954) by using the statistical package QUICKBASIC

Phenotypic covariance between two characters 1 and 2 is given by the formula

$$CoVp12 = CoVg\ 12 + CoVe\ 12$$

Where, CoVp12 = Phenotypic covariance between characters 1 and 2,

CoVg12 = Genotypic covariance between characters 1 and 2 and

CoVe12 = Environmental covariance between characters 1 and 2

$$CoVg12 = \frac{Mt12 - Me12}{N}$$

Where, Mt12 = Mean sum of product due to treatment between characters 1 and 2

Me12 = Mean sum of product due to error between characters 1 and 2

N = Number of replications

The phenotypic and genotypic correlation coefficients among the various characters were worked out in all possible combinations according to the formula suggested by Johnson *et al.* (1955).

Phenotypic correlation coefficient between two characters 1 and 2 is given as,

$$(r_p\ 12) = \frac{CoVp12}{\sqrt{Vp1\ Vp2}}$$

Where, CoVp12 = Phenotypic covariance between characters 1 and 2

Vp1 = Phenotypic variance of character 1

Vp2 = Phenotypic variance of character 2

Genotypic correlation coefficient between two characters 1 and 2 is given as,

$$(r_g\ 12) = \frac{CoVg12}{\sqrt{Vg1\ Vg2}}$$

Where, CoVg12 = Genotypic covariance between characters 1 and 2

Vg1 = Genotypic variance of character 1

Vg2 = Genotypic variance of character 2

3.2. SCREENING OF COLLECTED BRINJAL ACCESSIONS FOR JASSID TOLERANCE/ RESISTANCE

Field screening for jassid tolerance/ resistance was carried out for two seasons namely *rabi* (2004) and summer (2005). For *rabi* crop 29 accessions were evaluated during November 2004 to April 2005. For summer season crop (February 2005 – July 2005) an additional number of seven accessions were included in the screening, totaling to 36. For field screening a total of 20 plants were maintained per accession during each season.

3.2.1. Screening during *rabi* season

Jassid population on plants was assessed by noting the number of nymphs on top, middle and lower leaves of five plants each, at weekly intervals from the starting of pest infestation. Since the adult leaf hoppers are highly mobile their count on individual leaves will not give a reliable estimation of intensity of pest infestation. So adult insects were excluded from observations. Nymphal counting was continued weekly until there was a sharp decrease in number of nymphs.

During the final stage of *rabi* crop brinjal accessions were categorized in to different resistant/susceptibility classes based on the intensity of hopper burn symptoms on leaves. The visual assessment of hopper burn intensity was converted into numerical values by calculating the per cent intensity of infestation by adopting the formula given below.

$$\%\ \text{intensity} = \frac{\text{Sum of all numerical ratings}}{\text{Total number of leaves assessed}} \times \frac{100}{\text{Maximum grade}}$$

Scoring of plants for hopper burn symptom on the leaves was done using 0 - 4 scale as suggested by Singh and Rai (1995) and the grades are given below.

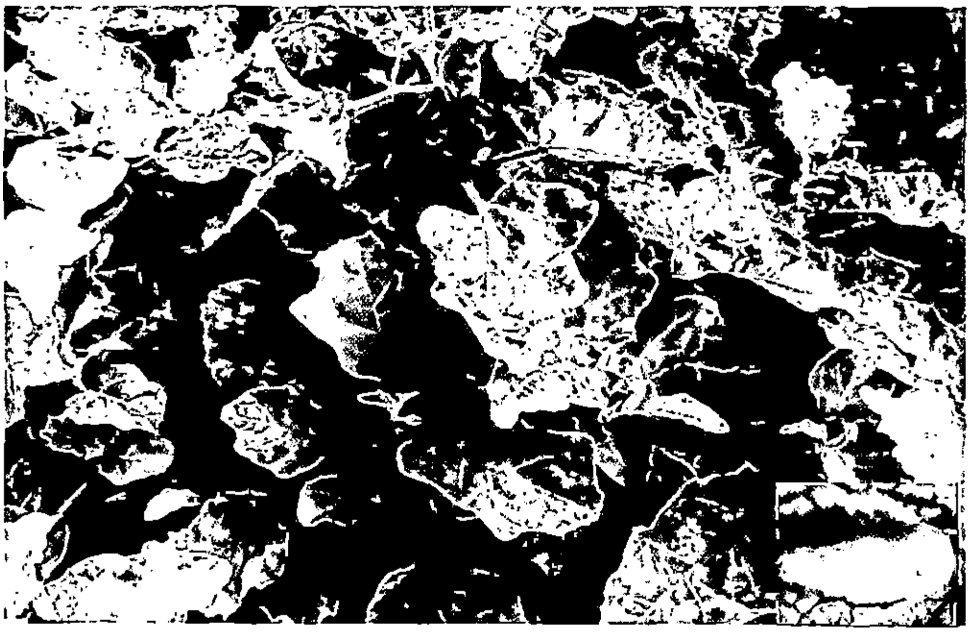


Plate 1. Hopper burn symptom caused by jassid attack in brinjal

Grade	Intensity of infection
0	Healthy green leaves
1	Slight yellowing of leaf margin
2	Yellowing and necrosis of leaf margin
3	Intensive yellowing and necrosis of leaves
4	Complete necrosis of leaves

Based on the per cent of intensity, the accessions were grouped in to five categories as suggested by Singh (1996).

Per cent Intensity	Category
0	Immune
1-10	Highly resistant
10.1-25	Moderately resistant
25.1-50	Moderately susceptible
Above 50	Highly susceptible

3.2.2. Screening during summer season

The brinjal lines were subjected to field screening for jassid resistance during the summer season also. Jassid population was assessed by the same method followed in the first season.

3.2.3. Artificial infestation of plants under cages

The brinjal lines, identified as resistant to jassid infestation in the field trials on the basis of hopper burn symptoms and nymphal population, were subjected to artificial infestation under cages during summer (2005). One plant each was maintained in a pot covered with an insect proof cage. Cages were made by stitching transparent light penetrable cloth on iron frames. A closable window was cut on the cloth for taking observations (Plate 2). When plants reached at eight to 10 leaf stage,

Plate 2. The resistant brinjal accessions subjected to artificial infestation by jassids under insect proof cages

10 nymphs of medium size were released on each caged plant. Nymphs of same size were collected and carefully released on to the leaves of caged plants by means of a paint brush. Survival and reproductive ability of the nymphs were noted by recording the number of surviving nymphs after four days, and number of adults and newly emerged nymphs after 10 days and 16 days respectively. The frequency of observations was fixed based on the report that leaf hoppers take duration of eight days for nymphal development (Mahal and Singh, 1982). Insect release was repeated three times on the same plants for confirmation.

3.3. STUDYING THE MECHANISMS OF RESISTANCE AGAINST JASSIDS IN BRINJAL

Morphological parameters like leaf thickness, midrib thickness, density and length of midrib hairs and anatomical parameters like cuticle thickness and epidermal cell wall thickness of mid rib were observed for unraveling the mechanisms of jassid resistance.

3.3.1. Morphological traits

i) Leaf thickness (mm) – The leaf lamina thickness of fifth leaf from top was measured using a screw guage. Laminar portion excluding veins was separated from the middle portion of leaf. After inserting the separated lamina piece in to the screw guage, the head scale and pitch scale readings were noted.

The lamina thickness was measured using the formula,

Leaf thickness = Pitch scale reading + (Head scale reading x Least count)

Least count is the distance through which the screw advances when it is rotated through one division of the head scale. It is taken as 0.01mm

ii) Midrib thickness (mm) – The midrib thickness at middle portion of fifth leaf from top was measured using a screw guage by adopting the same method as above.

iii) Density of midrib hairs – Number of trichome hairs present per unit area of midrib was counted using a stereomicroscope. Midrib peels from ventral surface of top, middle and basal portions of leaf were stained by acetocarmine stain and observed under a stereo microscope, whose eye piece was marked with a rectangle of 25 mm^2 area. The number of hairs on peels from top, middle and basal portion of midrib were counted in an area of 25 mm^2 each and its average was calculated.

iv) Length of midrib hairs (μm) – The midrib hair length of the susceptible and resistant accessions were compared. Hair length was measured using a calibrated compound microscope.

3.3.2. Anatomical parameters

Cuticle thickness and cell wall thickness of the jassid resistant accessions were studied by viewing the midrib sections of leaves with the help of an image analyzer. Thin horizontal sections of midrib were taken using sharp razor blade. These sections were stained with acetocarmine and images were viewed at 4X and 40X magnifications, using image analyzer stereoscopic microscope, equipped with a computerized micrometer. Measurement of cuticle and cell wall thickness were conducted using the software 'labomed Digipro-2' at 40X magnification. For every field, 10 counts were taken randomly and mean was worked out to know the cuticle and cell wall thickness and expressed in microns.

3.4. Organoleptic test

Acceptability traits of fruits of the jassid resistant brinjal accessions were conducted. Four quality attributes like appearance, taste, flavour, and non-bitterness were included in the organoleptic evaluation. Each of the above mentioned qualities were assessed by a five point hedonic scale.

Results

RESULTS

The results of the present study are presented under the following heads.

1. Evaluation of brinjal accessions for horticultural traits and estimation of genetic parameters
2. Screening of brinjal accessions for jassid tolerance
3. Studying the mechanisms of resistance in brinjal against jassids

4.1. EVALUATION OF BRINJAL ACCESSIONS FOR HORTICULTURAL TRAITS AND ESTIMATION OF GENETIC PARAMETERS.

A total of 42 accessions of *Solanum melongena* and one accession of related species *Solanum macrocarpum* collected were utilized for the field experimentation. During *rabi* season, out of 35 *Solanum melongena* and one *Solanum macrocarpum* evaluated, seven were lost by bacterial wilt even at the seedling stage itself. Hence only 29 accessions were evaluated during *rabi* (2004) season. During summer (2005) crop seven more accessions were included totaling to 36. The accessions were catalogued as per the NBPGR descriptor list (Table 2).

4.1.1. Evaluation of brinjal accessions for horticultural traits

The collected accessions were evaluated for six qualitative characters and 18 quantitative yield components.

The brinjal accessions exhibited three types of growth habit *viz.*, spreading, semi spreading and upright. Most of the accessions had an upright or semi spreading growth habit, except five *viz.*, SM 361, SM 366, SM 384, SM 385 and SM 387 which had a spreading habit, with six to eight primary branches per plant. Sixteen accessions *viz.*, SM 339, SM 344, SM 345, SM 348, SM 350, SM 353, SM 356, SM 359, SM 363, SM 364, SM 371, SM 378, SM 379, SM 385, SM 386 and SM 388 had

Table.2. Morphological characters of brinjal accesions evaluated

Accession	Growth habit	Leaf&petiole colour	Prickliness	Flower colour	Fruit colour	Fruit shape
	1	2	3	4	5	6
Neelima	Sreading	Green with purple veins	Nonprickly	Dark violet	Purple	Oval
Surya	Semispreading	Green with purple veins	Nonprickly	Dark violet	Purple	Oval
Swetha	Upright	Green with purple veins	Nonprickly	Light violet	White	long
Haritha	Semispreading	Green	Nonprickly	white	Light green	Long
SM 337	Semispreding	Green	Nonprickly	white	White	Round
SM 339	Upright	Green with purple veins	prickly	violet	Light green	long
SM 343	Semispreading	Green with purple veins	Nonprickly	violet	Light green	Oval
SM 344	Upright	Green with purple veins	prickly	Dark violet	Green	Long
SM 345	Upright	Green with purple veins	prickly	Dark violet	Green with light green striations	Oval
SM 347	Semispreading	Green with purple veins	Nonprickly	violet	Light green	Oblong
SM 348	Upright	Green with purple veins	Nonprickly	Dark violet	Green with light green striations	Oblong
SM 350	Upright	purple veins	Nonprickly	violet	Light green	Oval
SM 351	Semispreading	Green	prickly	violet	Green	long
SM 353	Upright	Green with purple veins	Nonprickly	violet	Green with light violet striations	long
SM 354	Semispreading	Green	Nonprickly	Light violet	Green with light green striations	Round
SM 355	Semispreading	Green with purple veins	Nonprickly	violet	purple	Oval
SM 356	Upright	Green	Nonprickly	violet	Green with light green striations	Round
SM 359*	Upright	Green	Nonprickly	violet	light green	long

	1	2	3	4	5	6
SM 360	Semispreading	Green with purple veins	Nonprickly	violet	Green with violet striations	Oval
SM 361	Spreading	Green with purple veins	prickly	violet	Green with light green striations	Oval
SM 362	Semispreading	Green with purple veins	Nonprickly	violet	Green with light green striations	Oblong
SM 363	Upright	Green with purple veins	Nonprickly	violet	Green with purple striations	Oblong
SM 364	Upright	Green with purple veins	prickly	violet	Green with light green striations	Oval
SM 365	Semispreading	Green with purple veins	Nonprickly	violet	Green with light green striations	Oblong
SM 366	Spreading	Green with purple veins	Nonprickly	Dark violet	Purple	Oblong
SM 369	Semispreading	Green with purple veins	prickly	violet	Purple	Oval
SM 371*	Upright	Green	Nonprickly	violet	Green with light violet striations	long
SM 378*	Upright	Green	prickly	white	White	Round
SM 379*	Upright	Green	Nonprickly	white	White	Round
SM 384	Spreading	Green	Nonprickly	violet	Green with light green striations	Oval
SM 385	Spreading	Green	Nonprickly	violet	Violet with white striations	Round
SM 386*	Upright	Green with purple veins	prickly	violet	Light purple	long
SM 387*	Spreading	Green with purple veins	Nonprickly	violet	Green with light violet striations	Oval
SM 388*	Upright	Green with purple veins	Nonprickly	violet	Purple with green striations	Oval
S X H	Upright	Green with purple veins	Nonprickly	violet	Light green	long
S.m.	Upright	Green with purple veins	Nonprickly	violet	White	Round

S X H - Swetha X Haritha

S.m. - *Solanum macrocarpum*

* Additional lines included during summer season

an upright growth habit. Swetha and the F_1 hybrid of Swetha X Haritha had upright and bushy growth habit. All the remaining 13 accessions were semi spreading in nature.

The accessions varied in their foliage colour. Accessions like SM 337, SM 351, SM 354, SM 356, SM 359, SM 371, SM 378, SM 379, SM 384 and SM 385 had uniformly green lamina and veins. All the remaining accessions had green leaves with purple tinged midrib, veins and petiole.

Based on the presence of prickles on any of the plant parts like stem, leaves or calyx, brinjal accessions were classified as prickly and nonprickly types. The released varieties Surya, Swetha, Haritha and F_1 hybrids Neelima and Swetha X Haritha and 20 other accessions had prickleless stem, petiole, leaves and calyx. All the remaining accessions were prickly.

Brinjal flowers were basically two colored, either white or violet. Only four accessions *viz.*, SM 337, SM 378, SM 379 and Haritha had white flowers and all others had violet flowers. In violet colour itself there were different gradations. Swetha, Swetha X Haritha and SM 354 were with light violet flowers. Neelima, Surya, SM 344, 345, 348 and SM 366 produced dark violet flowers.

Accessions varied greatly in their fruit characteristics also. There were purple, white, green and violet colored fruits. Some fruits were striated like, purple fruits with light green or violet striations or green fruits with light green, violet or purple striations. Swetha, SM 337, 378, 379 and *S. macrocarpum* had white coloured fruits. Six accessions viz., Neelima, Surya, SM 356, SM 366, SM 369 and SM 388 were purple fruited. All the remaining accessions had variegated or striated fruits. Shape of the fruits ranged from round to long with other intermediate shapes like oval, oblong and medium long. SM 337, SM 378 and SM 379 produced white, round fruits. *S. macrocarpum* also produced white flat and round fruits. Twelve lines were with oval fruits and 16 lines with oblong to long fruits.

Plate 3. Variability in brinjal fruits

The mean values of quantitative characters observed during *rabi* and summer seasons are given in Table 3 and Table 4 respectively. The analysis of variance indicated significant differences among the 36 accessions for all the 18 quantitative characters studied during the *rabi* (Appendix 2) and summer (Appendix 3) seasons.

Plant height

There was significant difference for plant height among the brinjal accessions during both the seasons ($P<0.05$). During *rabi* season, the plant height ranged from 39.85 cm to 81.15 cm and SM 339 was the tallest plant (81.15 cm), which was significantly taller than all other accessions. This was followed by SM 353, SM 385 and SM 384 which were at par. SM 361 was the shortest plant (39.85 cm) which was on par with SM 366 and SM 360. The plant height values ranged from 40.5 cm to 101.5 cm during summer. During that season also SM 339 was the tallest plant (101.5 cm). But the shortest plant was SM 366 (40.5 cm) and it was on par with SM 351, SM 360 and SM 361. SM 385 and SM 388 were significantly taller than the rest of the accessions (91.88 and 83.75 cm respectively) but significantly shorter than SM 339.

Plant spread

This character also showed significant difference among the accessions during *rabi* and summer seasons. During *rabi* season the plant spread ranged between 51 cm and 134.3 cm. Accession SM 366 recorded maximum spread, which was significantly more spreading than all other accessions evaluated. SM 385, SM 384 and Neelima had significantly more plant spread (115, 110 and 107.5 cm respectively) than the rest of the accessions, but only next to SM 366. SM 337 had minimum spread, but it was on par with accessions SM 344, SM 360, SM 363, SM 364 and F_1 hybrid Swetha X Haritha. During summer the values ranged from 52.75 cm in SM 344 to 128.5 cm in

Table 3. Mean performance of yield contributing characters, yield and duration of 29 brinjal accesssions (rabi ,2004)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Accession No	Plant height (cm)	Plant spread (cm)	No: of primary branches	Leaf length (cm)	Leaf width (cm)	Days to1st flowering	Days to 50% flowering	Days to 1st harvest	Days to peak harvest	Days to last harvest	No: of economic harvests	No: of total harvests	fruit length (cm)	fruit girth (cm)	fruit weight. (g)	fruits/. plant	yeild/ plant (kg)	Yield/ plot (kg)
Neelima	67.20	107.50	4.70	19.45	10.71	59.50	67.50	80.00	142.50	179.50	11.50	14.00	11.02	4.83	112.50	16.38	1.19	11.93
Surya	60.30	70.60	4.75	14.60	8.95	57.50	67.00	77.00	137.50	176.50	6.00	10.00	11.00	4.33	63.75	10.43	0.64	6.37
Swetha	57.00	66.80	5.75	17.35	8.05	46.50	53.50	64.00	128.00	179.00	5.00	11.00	11.60	3.60	55.00	17.44	0.84	8.42
Haritha	69.00	78.50	5.00	21.65	13.60	51.00	57.50	71.50	135.50	181.50	9.50	12.50	18.25	4.43	103.60	9.65	1.00	9.93
SM 337	49.60	51.00	6.30	21.85	14.15	66.00	75.50	87.00	146.50	188.50	6.00	6.50	10.10	6.74	98.63	7.38	0.70	7.02
SM 339	81:15	65.50	4.50	20.95	11.15	59.50	69.50	81.00	143.50	192.50	6.50	7.50	17:21	4.13	128.10	8.45	0.95	9.50
SM 343	46.00	72.50	5.25	17.73	9.32	61.00	70.50	79.50	139.50	179.00	3.00	10.00	9:45	3.68	49.88	9.75	0.48	4.85
SM 344	67.85	56.50	3.88	21.63	9.82	59.50	70.50	82.50	154.00	186.00	6.50	6.50	34.50	3.53	109.40	7.13	0.74	7.40
SM 345	65.00	61.80	6.70	18.85	8.80	69.00	78.50	86.50	162.00	192.50	1.00	5.00	12.32	4.07	47.38	4.50	0.25	2.50
SM 347	57.00	72.75	5.00	14.00	9.00	59.00	66.50	77.00	137.50	172.50	7.50	11.00	11.88	4.15	60.00	15.50	0.83	8.30
SM 348	62.88	70.50	5.28	12.75	8.94	66.50	73.50	87.50	146.00	172.50	3.50	8.50	14.50	4.53	51.25	11.20	0.57	5.70
SM 350	48.90	67.36	4.38	13.38	7.25	70.50	78.00	93.50	161.00	178.50	2.00	5.50	8.94	3.75	49.38	9.50	0.41	4.05
SM 351	46.95	74.54	3.75	13.44	9.88	64.50	70.50	84.50	145.50	171.50	3.00	5.50	15.03	3.61	82.50	6.38	0.49	4.90
SM 353	74.50	76.68	4.80	18.40	8.79	67.00	73.50	85.50	152.50	177.50	6.00	6.50	21.59	4.63	91.88	5.90	0.54	5.40

Contd..

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
SM 354	55.88	66.88	7.25	15.74	9.00	66.50	74.00	90.00	151.00	177.00	4.00	6.50	14.94	6.13	150.60	4.93	0.45	4.45
SM 355	54.60	67.98	8.00	17.56	9.57	69.00	77.00	93.50	166.50	169.00	4.00	6.00	14.32	6.15	100.80	6.90	0.47	4.70
SM 356	60.15	65.68	6.50	21.80	13.45	73.50	81.00	93.50	158.50	170.00	4.00	6.00	14.19	6.72	104.80	7.20	0.80	7.95
SM 360	41.45	54.45	6.75	14.50	6.63	66.00	72.50	86.50	163.00	167.50	6.00	7.50	12.57	4.83	86.50	7.25	0.44	4.40
SM 361	39.85	87.92	6.00	14.75	8.50	68.00	74.50	89.00	149.00	164.00	4.50	5.50	10.63	4.40	70.38	5.88	0.43	4.25
SM 362	58.65	65.65	5.50	16.50	7.24	65.50	74.50	88.00	150.50	171.00	3.00	5.00	8.23	4.44	64.38	10.25	0.43	4.30
SM 363	57.90	57.00	5.90	17.65	10.60	76.00	86.00	97.00	165.50	186.00	5.50	5.50	15.90	6.33	120.60	6.00	0.61	6.05
SM 364	65.38	59.75	5.75	20.88	11.88	67.00	76.50	87.50	153.50	181.50	7.00	7.50	15.69	6.48	103.13	5.60	0.60	5.90
SM 365	66.90	81.88	5.60	20.95	11.45	69.50	79.00	91.00	164.00	180.00	7.00	7.50	15.15	5.51	104.10	5.30	0.57	5.65
SM 366	40.50	134.30	9.00	19.85	9.57	66.50	78.00	88.50	157.50	168.50	5.00	6.00	14.13	4.54	75.80	4.38	0.33	3.30
SM 369	54.85	62.00	3.85	12.75	8.14	70.00	80.00	91.00	165.50	161.00	4.00	4.00	17.44	5.81	100.60	5.10	0.51	5.15
SM 384	71.25	110.00	8.15	14.20	10.20	62.50	70.00	82.00	134.00	189.50	5.50	5.50	12.31	4.92	92.50	10.50	0.96	9.50
SM 385	72.50	115.00	8.00	14.85	9.90	63.50	70.00	83.00	161.00	185.00	5.00	5.00	11.37	7.17	128.10	5.00	0.64	6.40
* S X H	66.70	59.50	4.90	17.90	8.35	51.50	57.00	68.00	116.50	169.50	7.50	10.00	17.25	3.26	53.75	19.15	0.90	8.95
** *S.m.*	72.00	53.38	4.25	29.00	14.75	67.00	74.50	90.50	153.00	162.50	2.00	5.00	5.25	6.29	94.00	6.25	0.58	5.85
CD	4.48	9.14	0.97	1.95	0.70	1.43	1.91	1.73	3.03	4.98	1.71	1.58	2.52	0.85	13.59	2.85	0.12	1.21
CV	3.66	6.07	8.29	5.36	3.43	1.11	1.31	1.01	0.99	1.37	16.08	10.55	8.77	8.45	7.54	16.20	9.55	9.36

* Swetha X Haritha

** *Solanum macrocarpum*

Table 4. Mean values of yield contributing characters, yield and duration in 36 brinjal accessions (summer ,2005)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Accession No	Plant height (cm)	Plant spread (cm)	No: of primary branches	Leaf length (cm)	Leaf width (cm)	Days to1st flowering	Days to 50% flowering	Days to 1st harvest	Days to peak harvest	Days to last harvest	No: of economic harvests	No: of total harvests	Fruit length (cm)	Fruit girth (cm)	Fruit weight. (g)	Fruits/ plant	yeild/ plant (kg)	Yield/ Plot (kg)
Neelima	71.5	107.50	5.00	21.60	11.45	62.50	71.50	82.50	146.50	186.00	9.50	10.50	11.75	5.00	102.90	14.90	1.06	10.55
Surya	65.50	71.63	5.10	14.31	10.18	61.00	73.00	81.50	141.00	183.50	6.50	9.50	10.25	4.45	68.10	9.95	0.63	6.30
Swetha	58.60	68.50	5.25	17.80	8.05	50.50	63.50	70.50	131.50	185.50	6.50	8.50	11.90	3.80	59.70	16.70	0.73	7.30
Haritha	69.50	80.38	5.13	21.15	12.56	62.50	76.50	83.00	147.50	188.50	8.50	10.50	15.25	4.30	103.10	9.40	0.93	9.25
SM 337	53.50	60.00	5.75	25.05	16.65	69.50	81.00	92.50	151.50	196.50	6.00	6.00	11.65	6.70	103.10	8.55	0.72	7.15
SM 339	102	84.50	6.60	20.70	10.90	63.50	78.50	84.00	144.00	198.00	6.50	7.00	18.30	4.50	128.30	11.20	0.97	9.70
SM 343	67.3	76.38	5.13	18.56	10.18	68.50	78.50	89.50	151.50	185.50	8.00	8.00	9.65	3.85	57.75	11.90	0.59	5.85
SM 344	64.50	52.75	4.25	24.94	10.93	62.00	73.50	89.00	152.50	194.00	7.50	7.50	36.25	3.25	110.40	7.15	0.70	7.10
SM 345	66.3	61.88	5.75	21.13	9.37	71.00	81.50	94.50	158.50	197.00	2.00	4.00	13.05	4.35	50.05	5.70	0.34	3.35
SM 347	59.8	70.63	4.75	17.55	11.90	62.00	73.00	85.00	147.50	177.00	6.50	9.50	12.05	4.45	66.15	13.75	0.87	8.65
SM 348	66.50	71.75	5.15	15.75	11.20	70.50	85.50	90.50	154.50	183.00	7.50	9.50	14.90	4.75	54.45	10.15	0.54	5.40
SM 350	50.1	61.63	4.63	18.05	11.95	72.50	88.50	96.50	167.00	193.50	2.50	5.00	9.25	3.85	53.75	10.85	0.54	5.40
SM 351	41.40	67.50	4.20	13.60	7.15	65.00	74.50	85.00	148.50	178.50	4.50	5.50	15.95	3.75	89.95	6.05	0.49	5.00
SM 353	68.40	79.00	4.50	21.85	11.25	68.00	82.00	91.00	158.50	184.50	6.00	6.00	22.80	4.50	99.45	5.90	0.52	5.20
SM 354	57.90	64.60	6.50	24.05	15.50	70.00	86.00	93.00	151.50	185.50	5.50	5.50	15.15	6.30	151.80	4.50	0.42	4.20
SM 355	69.9	76.50	4.13	21.10	10.10	60.50	77.00	87.50	147.50	177.50	4.50	5.50	13.75	5.80	98.20	6.55	0.50	5.00
SM 356	62.30	66.90	6.50	26.30	14.20	79.00	92.00	101.00	162.00	181.50	5.00	5.00	14.90	6.75	106.10	7.85	0.85	8.45
SM 359	64.75	77.13	4.13	25.30	14.40	63.00	73.00	84.00	141.00	180.50	5.50	6.50	15.50	6.70	77.75	7.90	0.55	5.45

Contd..

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
SM 361	42.9	71.88	5.75	18.75	9.55	68.00	77.00	89.00	149.00	171.50	5.00	6.00	10.65	4.55	72.15	4.55	0.37	3.70
SM 362	65.4	70.50	5.88	21.75	12.10	66.50	80.50	91.00	152.00	181.50	2.50	5.50	9.05	4.65	67.75	9.20	0.39	3.85
SM 363	66.3	61.00	6.35	25.00	12.20	79.00	90.50	105.00	168.50	193.50	5.50	5.50	16.05	6.65	127.50	6.55	0.65	6.50
SM 364	66.9	75.63	5.38	20.50	12.03	67.00	82.00	92.00	155.00	190.50	5.50	7.00	15.90	6.55	103.40	6.05	0.70	7.00
SM 365	77.00	90.50	6.20	22.55	11.85	72.50	87.00	96.50	157.50	189.50	4.50	5.50	15.25	6.00	109.40	5.25	0.54	5.40
SM 366	40.50	128.50	8.10	22.80	11.70	86.50	98.00	105.00	156.50	175.50	4.00	5.50	15.20	4.55	79.55	5.25	0.43	4.30
SM 369	54.70	66.00	3.90	17.00	10.35	71.50	84.50	92.00	154.50	179.50	3.50	4.50	17.60	6.05	102.00	5.70	0.54	5.35
SM 371	76.90	61.95	5.20	16.60	9.35	72.50	80.50	102.50	151.50	182.00	3.50	4.00	15.75	3.75	81.00	6.65	0.60	5.95
SM 378	59.00	63.50	5.20	22.60	12.50	75.50	87.50	104.50	167.50	199.00	4.00	6.00	13.40	7.25	122.70	5.05	0.58	5.75
SM 379	70.13	58.50	4.88	26.05	16.75	79.00	91.50	105.50	170.50	203.50	3.50	5.50	11.00	6.00	82.90	3.65	0.30	3.00
SM 384	71.88	105.00	7.88	14.74	10.62	64.50	74.50	84.50	148.50	192.50	10.00	12.50	13.35	5.10	97.55	14.05	1.30	12.95
SM 385	83.75	103.10	7.63	16.44	10.43	64.50	79.00	84.50	145.00	197.50	4.00	4.00	12.20	8.00	133.00	4.40	0.67	6.65
SM 386	63.45	54.70	4.00	20.20	9.70	79.00	87.50	103.50	162.50	198.00	3.50	4.50	24.25	3.20	98.05	4.15	0.46	4.55
SM 387	63.63	103.10	7.95	22.25	14.25	60.00	68.50	83.50	146.00	186.50	9.00	10.50	12.35	6.15	95.70	12.45	1.04	10.35
SM 388	91.88	68.63	5.63	23.95	15.60	68.50	77.00	96.50	156.50	187.50	5.50	5.50	11.35	5.90	103.20	6.10	0.57	5.65
* S X H	69.40	60.90	5.50	18.40	8.35	56.50	71.00	76.50	135.50	186.50	6.50	9.50	18.75	3.25	59.55	11.00	0.81	8.10
** *S.m.*	72.50	48.00	4.00	26.65	14.40	46.50	62.50	69.00	139.00	169.00	2.50	4.50	5.25	6.60	97.95	5.10	0.50	4.95
CD	3.04	3.42	0.33	1.21	0.59	1.62	2.15	3.06	1.68	2.68	0.97	1.03	1.05	0.29	5.67	0.94	0.04	0.45
CV	3.26	3.24	4.25	4.12	3.53	1.67	1.87	2.36	0.77	1.00	12.45	10.67	5.06	3.94	4.31	8.10	4.79	4.94

* swetha X Haritha

** *Solanum macrocarpum*

SM 366. Thus, during both the seasons SM 366 recorded maximum plant spread (134.3 cm and 128.5 cm during rabi and summer seasons respectively).

Number of primary branches per plant

Brinjal accessions varied significantly in their number of primary branches also. During both the seasons SM 366 was the accession with maximum spread and more number of primary branches. The branch number varied from 3.75 to 9 during *rabi* season and from 3.9 to 8.1 during summer season. SM 354, SM 385 and SM 384 had significantly higher number of branches during both the seasons (7.25, 8.00 and 8.15 during first season and 6.5, 7.63 and 7.87 during second season). SM 351 was with minimum number of primary branches (3.75) during *rabi* season. During summer, SM 369 got the minimum number of branches (3.9).

Leaf length

Leaf length showed significant difference among accessions during both the seasons. *S. macrocarpum* recorded more leaf length (29 cm during *rabi* and 26.65 cm during summer) than all *S. melongena* accessions. During rabi SM 337 had the longest leaves (21.85 cm) among *S. melongena* accessions followed by SM 356, SM 359 and SM 379 with on par values. During summer also SM 337 had the maximum leaf length of 25.05 cm. SM 351 had minimum leaf length (13.6 cm) during summer season. During *rabi* season also this accession had smaller leaves and was on par with other three lines *viz.*, SM 369, SM 348 and SM 350.

Leaf width

Leaf width of brinjal accessions ranged from 6.63 cm to 14.75 cm during *rabi* and from 7.15 cm to 16.75 cm during summer. During *rabi*, SM 337 (14.15 cm) recorded a significantly higher leaf width than the rest of the lines with Haritha and SM 356 closely following it (13.6 cm and 13.45 cm respectively). SM 362, SM 360 and SM 350 had narrow leaves with a significantly lower leaf width than all other accessions (6.63 cm, 7.24 cm and 7.25 cm, respectively). During summer season SM 379 recorded maximum leaf width value of 16.75 cm. The widest leaved line of *rabi* season, SM 337, closely followed it (16.65 cm) which had no significant difference from the former and SM 351 recorded a significantly lower leaf width value (7.15 cm) than the rest of the lines. Swetha, Swetha X Haritha, SM 371 and SM 345 were also having narrow leaves.

Days to first flowering

During *rabi* and summer Swetha was the earliest to flower taking 46.5 days and 50.5 days respectively. Swetha X Haritha followed this. SM 363 was the last to flower during first season (76 days). But during summer season SM 366 was the last, which took 86 days to flower, followed by SM 363 with 79 days to flower.

Days to 50 per cent flowering

Accessions varied significantly for days to 50 per cent flowering. During both the seasons this character followed the same trend as in the case of days to first flowering. During the two seasons Swetha took significantly less number of days to attain 50 per cent flowering than other accessions (53.5 days and 63.5 days during *rabi* and summer respectively). Swetha X Haritha followed this with 57 days during *rabi* and 71 days during summer. Neelima, Surya, Haritha, SM 344, SM 347, SM 359 and SM 387 also had attained 50 per cent flowering significantly earlier than other accessions. SM 350, SM 356, SM 364, SM 365 and SM 366 were late to attain 50 per cent flowering during both the seasons. As compared to *S. melongena* accessions, *S. macrocarpum* attained 50 per cent flowering much earlier (62.5 days) during summer season.

Days to first harvest

This character also followed the same pattern as that of days to first flowering. Days to first harvest varied from 64 days to 97 days during first season and 69 days to 105.5 days during second season. Among *S. melongena* accessions Swetha and Swetha X Haritha showed significantly less number of days to first harvest (64 and 68 days during *rabi* and 70.5 and 76.5 days during summer). Swetha was the first to harvest during *rabi* (64 days) and *S. macrocarpum* during summer (69 days). SM 363 was significantly late to attain first harvest during the two seasons.

Days to peak harvest

The accessions varied significantly for days to peak harvest ($p<0.05$). Swetha X Haritha and Swetha attained peak harvesting stage significantly earlier than all other accessions (116.5 and 128 days during *rabi*, 135.5 and 131.5 days during summer). Some of the additional accessions planted during summer seasons *viz.*, SM 379, SM 378 and SM 386 were late to attain peak harvesting stage (170.5, 167.5 and 162.5 days respectively). SM 363 took significantly more number of days to attain peak harvesting stage during both the seasons (165.5 days during *rabi* and 168.5 days during summer).

Days to last harvest

There was significant variation for fruiting period of different accessions. During the *rabi* season days to last harvest was extended up to 192.5 days in SM 339 and SM 345. In SM 369 and *S. macrocarpum* harvesting was completed with in 161 and 162 days respectively, which was significantly lower than all other lines. During summer season *S. macrocarpum* recorded lowest value (169 days) than all *S. melongena accessions.* Among *S. melongena* accessions SM 361 took significantly less number of days to last harvest (171.5 days) and SM 379 took significantly more number of days (203.50). Some of the additional lines included during summer season *viz.*, SM 378, SM 379 and SM 386 recorded significantly longer duration.

Number of economic harvests

Harvest was considered as economic when yield per plant was more than 100g. This character showed significant variation among the accessions. The value ranged from one to 11.5 during first season and from two to 10 during second season. During first season, released hybrid Neelima performed best with a significantly higher number of economic harvests than the rest of the lines (11.5). Haritha, Swetha X Haritha and SM 347 closely followed this with values 9.5, 7.5 and 7.5 respectively. But during summer SM 384 recorded maximum number of economic harvests (10) followed by Neelima (9.5), which were at par. During both the seasons SM 345 had minimum number of economic harvests (1 and 2 respectively).

Number of total harvests

Brinjal lines showed a noteworthy variation for this character also. During *rabi*, Neelima and Haritha recorded maximum number of harvests which were significantly higher than all other accessions (14 and 12.5 respectively). SM 347 and Swetha followed this; both recording a total number of 11 each. SM 369 recorded least number of harvests (4), which was significantly lower than the rest of the accessions. During summer, SM 384 was having significantly higher number of harvests than all other accessions (12.5). Neelima, SM 387 and Haritha performed just lower to this with a total harvest of 10.5 each. SM 345, 371 and 385 recorded the minimum number of harvest of four.

Fruit length

During both *rabi* and summer SM 344 produced significantly longer fruits than all other accessions (34.50 cm during rabi and 36.25 cm during summer). SM 339, SM 353, Haritha and Swetha X Haritha also had higher fruit length values. SM

339, SM 353, Haritha and Swetha X Haritha also had higher fruit length values. SM 362 recorded minimum fruit length during both the seasons (8.23 cm and 9.05 cm respectively). During the two seasons, *S. macrocarpum* recorded a significantly lower value (5.25 cm in both seasons) for fruit length as compared to *S. melongena* accessions.

Fruit girth

The accessions varied significantly among themselves in their fruit girth. During both the seasons SM 385 recorded maximum fruit girth, which was significantly higher than others (8 cm and 7.165 cm during *rabi* and summer respectively). Swetha X Haritha recorded a significantly lower fruit girth value of 3.26 cm and 3.25 cm during *rabi* and summer respectively. During summer, SM 386 and SM 344 also had lower fruit girth, which were on par with Swetha X Haritha.

Fruit weight

The average fruit weight ranged from 47.38 g in SM 345 to 150.6 g in SM 354 during *rabi* season. SM 339 and SM 385 also had heavier fruits with a weight of 128.1g each. SM 343 and SM 350 had significantly lower fruit weight (49.88 g and 49.38 g respectively), but next to SM 345. During summer the average fruit weight ranged from 50.05 g to 151.80 g and SM 354 itself produced the heaviest fruits and SM 345 produced the lightest.

Number of fruits per plant

The observations recorded that the accessions varied significantly in the number of fruits per plant. During *rabi*, Swetha X Haritha recorded maximum number of fruits per plant (19.15). Swetha and Neelima followed this with on par values. SM 366 recorded the minimum number of fruits per plant (4.38). During summer, Swetha recorded maximum number of fruits per plant (16.70) closely followed by Neelima (14.90). During summer season also SM 366 recorded minimum number of fruits (5.25). This was followed by SM 345, SM 354 and SM 385 (4.5, 4.93 and 5.0 respectively), which were on par with SM 366. This character had moderately high genotypic and phenotypic coefficients of variation.

Yield per plant

In general the performance of the crop was better during *rabi* season as indicated by the mean yield per plant during *rabi* season (0.83 kg/ plant) compared to summer (0.63 kg/ plant). It also had a wide range during both the seasons (from 1.19 to 0.25 during *rabi* and from 1.30 to 0.30 during summer). During *rabi* yield per plant was maximum in Neelima (1.19 kg) followed by Haritha, whereas during summer Neelima ranked second in yield (1.06 kg) next to SM 384 (1.30 kg) which were at par. SM 387 was also on par with them. Yield per plant was minimum in SM 345 (0.25 kg) during *rabi* and in SM 379 (0.3 kg) during summer. It had a moderate value of genotypic and phenotypic coefficients of variation as indicated by the values 34.74 and 36.03 during *rabi* and 35.06 and 35.38 during summer respectively.

Yield per plot

Yield from a plot area of 4.5 m^2 varied significantly among accessions. The values ranged from 2.50 to 11.93 kg per plot during *rabi* and from 3.00 to 12.95 kg per plot during summer. During *rabi* the released F_1 hybrid Neelima yielded better than all other accessions. (11.93 kg per plot). During summer Neelima was the second high yielding accession (10.55 kg per plot) with SM 384 occupying the first position (12.95 kg per plot). SM 345 had the lowest yield (2.5 kg per plot) during rabi, where as during summer SM 379 recorded the lowest yield of 3 kg per plot, which was significantly lower than all other accessions except SM 345 (3.35 kg per plot).

4.1.2. Estimation of genetic parameters

4.1.2.1. Genetic variability and heritability

Genetic parameters like genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), heritability, genetic advance and genetic gain were estimated for 21 quantitative characters. Genetic parameters of characters during *rabi* and summer seasons are given in Table 5 and 6 respectively.

GCV and PCV estimated for two seasons revealed that during both the seasons PCV values were greater than GCV values for all the 21 quantitative characters studied. However PCV values were following the same trend as that of GCV values during both the seasons. During *rabi* and summer, density of midrib hairs recorded highest GCV and PCV values (66.17 and 66.78 during *rabi* and 62.41 and 63.66 during summer respectively). Number of fruits per plant, total harvests and economic harvests, fruit length and yield per plant were the other traits having moderate GCV and PCV values. Days to last harvest recorded the lowest GCV and PCV values (4.84 and 5.03 during *rabi* and 4.31 and 4.43 during summer respectively). Other characters like midrib thickness, days to first flowering, first harvest, and peak harvest also recorded lower GCV and PCV values.

During both the seasons all the 21 quantitative characters recorded high heritability values of more than 87 per cent. Characters *viz*., days to first flowering, first harvest, 50 per cent flowering and peak harvest and density of mid rib hairs recorded relatively higher heritability values than all other traits during *rabi* season (99.4, 99.1, 99.0, 98.6 and 98.2 respectively). During summer, plant spread, days to first flowering and peak harvest, fruit length and yield per plant expressed high heritability with significantly higher values than other characters (98.4, 98.2, 98.2, 98.1 and 98.1 respectively).

The genetic advance values of the characters followed the same trend during both the seasons. Density of midrib hairs recorded the highest genetic gain (135.05

Table 5. Range, mean, GCV, PCV, heritability, genetic advance and genetic gain as percentage of mean for 21 characters in brinjal (rabi, 2004)

CHARACTER	MEAN + SE	Range	GCV	PCV	HERITABILITY	GENETIC ADVANCE	GENETIC GAIN
Plant height (cm)	59.72 ± 1.55	39.85 - 81.15	17.87	18.24	96.00	21.54	36.06
Plant spread (cm)	73.58 ± 3.16	51.00 - 134.30	26.68	27.36	95.10	39.43	53.58
No of branches	5.7 ± 0.33	3.75 - 9.00	23.57	24.98	89.00	2.61	45.78
Leaf length	17.76 ± 0.24	12.75 - 29.00	20.60	21.29	93.70	7.29	41.05
Leaf width (cm)	9.92 ± 0.01	6.63 - 14.75	20.66	20.94	97.30	4.16	41.94
Leaf thickness (mm)	0.35 ± 0.04	0.24 - 0.44	14.77	15.47	91.10	0.10	28.57
Midrib thickness (mm)	2.17 ± 0.49	1.47 - 2.63	12.17	12.50	94.80	0.53	24.42
Midrib hair density	14.38 ± 0.66	0.23 - 44.40	66.17	66.78	98.20	19.42	135.05
Days to 1st flowering	64.1 ± 0.59	46.5 - 76.00	14.33	14.37	99.40	18.50	28.86
Days to 50%flowering	72.29 ± 1.04	14.38 - 53.50 - 86.00	13.23	13.30	9.00	19.28	26.67
Days to 1st harvest	84.69 ± 1.72	64.00 - 97.00	10.39	10.44	99.10	17.83	21.05
Days to peak harvest	149.67 ± 0.59	116.50 - 166.50	8.27	8.33	98.60	25.31	16.91
Days to last harvest	176.88 ± 0.55	161.00 - 192.50	4.84	5.03	92.50	16.96	9.58
No of economic harvest	5.21 ± 0.86	1.00 - 11.50	41.93	44.90	87.20	4.20	80.60
Total no: of harvest	7.33 ± 0.29	4.00 - 14.00	33.65	35.27	91.10	4.85	66.16
Fruit length (cm)	14.03 ± 4.69	5.25 - 34.50	36.73	37.76	94.60	10.32	73.55
Fruit girth (cm)	4.93 ± 0.98	3.26 - 7.17	22.37	23.91	87.50	2.12	43.00
AverageFruit weight (g)	88.04 ± 0.42	47.38 - 150.60	30.95	31.86	94.40	54.55	61.96
Fruits/ plant	8.59 ± 0.45	4.38 - 19.15	45.36	48.17	88.70	7.56	88.00
Yield/ plant (kg)	0.83 ± 0.03	0.25 - 1.19	34.74	36.03	93.00	0.44	53.01

Table 6. Coefficients of variation, Heritability genetic advance and genetic gainfor 21 quatitative characters (summer, 2005)

CHARACTER	Mean± SE	Range	GCV	PCV	HERITABILITY	GENETIC ADVANCE	GENETIC GAIN
Plant height	64.92±1.49	40.5 - 101.50	19.64	19.91	97.39	25.91	39.90
Plant spread	73.57±1.68	48.00 - 128.50	23.6	23.82	98.20	35.43	48.15
No of branches	5.51±0.16	3.90 - 8.10	20.68	21.11	96.06	2.30	41.74
Leaf length	20.71± 0.59	13.6 - 26.65	16.96	17.45	94.58	6.93	33.46
Leaf width	11.68±0.29	7.15 - 16.75	19.68	20.00	96.97	4.66	39.89
Leaf thickness	0.31± 0.52	0.18 - 0.44	21.79	22.08	97.48	0.14	45.16
Midrib thickness	2.24± 0.02	1.47 - 2.73	10.06	10.23	96.76	0.46	20.53
Midrib hair density	13.3± 1.18	0.20 - 40.75	62.41	63.66	96.23	16.76	126.00
Days to 1st flowering	67.46± 0.79	46.5 - 86.5	11.84	11.95	98.10	16.29	24.15
Days to 50%flowering	79.85± 1.05	62.50 - 98.00	9.94	10.11	96.67	16.06	20.10
Days to 1st harvest	90.57± 1.50	69.00 - 105.50	10.11	10.38	94.99	18.38	20.29
Days to peak harvest	152.15± 0.82	131.50 - 170.5	5.96	6.01	98.41	18.52	12.17
Days to last harvest	186.79± 1.32	169.00 - 203.50	4.31	4.43	95.02	16.16	8.65
No of economic harvest	5.46± 0.48	2.00 - 10.00	35.93	38.02	89.57	3.82	69.96
Total no: of harvest	6.72± 0.50	4.00 - 12.50	32.03	33.76	90.28	4.21	62.64
Fruit length	14.51± 0.53	5.25 - 36.25	35.89	36.24	98.10	10.62	73.19
Fruit girth	5.17± 0.14	3.20 - 8.00	24.38	24.70	97.53	2.56	49.52
AverageFruit weight	91.8± 2.79	50.05 - 151.80	26.65	26.99	97.53	49.74	54.18
Fruits/ plant	8.08± 0.46	3.65 - 16.70	41.68	42.46	96.46	6.81	84.28
Yield/ plant	0.63± 0.02	0.30 - 1.30	35.06	35.38	98.22	0.45	71.42

during *rabi* and 126.0 during summer) and days to last harvest recorded the lowest (9.58 during *rabi* and 8.65 during summer).

4.1.2.2. Correlation studies

The phenotypic and genotypic correlation coefficients of different yield contributing characters with yield, were worked out for *rabi* (Table 7) and summer (Table 8) seasons separately. The characters which had significant association with yield were days to first flowering, days to 50 per cent flowering, days to first harvest days to peak harvest, number of fruits per plant, number of economic harvests and total number of harvests. Out of these characters, number of fruits per plant, economic harvests and total harvests were significantly and positively correlated with yield. Four characters *viz.*, days to first flowering, 50 per cent flowering, first harvest and peak harvest were having a significant negative association with yield.

During both the seasons the character having highest positive correlation with yield was number of economic harvests (r_p = .73, r_g = .78 during rabi and r_p = .74, r_g = .80 during summer). This was followed by total number of harvests with a genotypic correlation value of 0.67 and 0.77 during *rabi* and summer respectively. During *rabi* the attribute with highest negative correlation with yield was days to peak harvest (r_p =-.59, r_g = -.62). During summer, days to first harvest recorded highest negative correlation with yield. For all the yield component characters studied, genotypic correlation coefficient values were higher than phenotypic correlation coefficient values suggesting less influence of environment.

4.1.2.3. Inter correlations among different characters

The inter relationship among different characters were found out by working out phenotypic and genotypic correlation values. There was significant positive association between plant spread and number of primary branches (r_g = 0.52 and 0.63 during *rabi* and summer respectively). Leaf length and leaf width were significantly

Table 7. Genotypic (upper diagonal) and phenotypic (lower diagonal) correlation coefficients between yield and yield characters in brinjal accessions (*rabi* season)

Characters	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}	X_{14}	X_{15}	X_{16}	X_{17}	X_{18}
(X_1)	1.000	-.024	-.224	.394*	.379*	-.339*	-.328	-.34*	-.183	.480**	.327	.149	.287	.106	.355*	.143	.552**	.553**
(X_2)	-.007	1.000	.517**	-.189	-.051	.089	.078	.051	-.039	.037	.242	.089	-.139	-.016	.078	-.018	.131	.127
(X_3)	-.191	.482**	1.000	-.074	-.028	.320	.308	.315	.241	.113	-.105	-.264	-.255	.410*	.172	-.277	-.222	-.228
(X_4)	.382*	-.162	-.073	1.000	.794**	-.457**	-.376*	-.327	.040	.152	.158	.055	.089	.270	.303	-.166	.222	.223
(X_5)	.351*	-.553**	-.025	.747*	1.000	-.285	-.243	-.183	-.002	.217	.236	.055	-.016	.546**	.461**	-.209	.400*	.400*
(X_6)	-.332	.086	.301	-.447*	-.281	1.000	.988**	.955**	.580**	.128	-.148	-.408*	-.157	.243	.135	-.458**	-.411*	-.412**
(X_7)	-.317	.080	.294	-.371	-.239	.984**	1.000	.560**	.519**	.166	-.152	-.433*	.182	.253	.155	-.501**	-.424**	-.426**
(X_8)	-.318	.041	.295	-.326	-.179	.953**	.953**	1.000	.733**	.037	-.245	-.546**	.122	.378*	.251	-.608**	-.497**	-.497**
(X_9)	-.177	-.051	.225	.034	-.257	.577**	.612**	.727**	1.000	-.093	-.385*	-.668**	.055	.553**	.342*	-.814**	-.617**	-.613**
(X_{10})	.447**	-.039	.108	.138	.211	.128	.166	.041	-.085	1.000	.196	.106	.232	-.023	.245	-.030	.321	.320
(X_{11})	.293	.229	-.116	.161	.222	-.141	-.148	-.228	-.359*	.208	1.000	.723**	.327	-.03	.346*	.436**	.782**	.781**
(X_{12})	.119	.083	-.231	.063	.063	-.395*	-.409*	-.522**	-.636**	.100	.683**	1.000	.004	-.394*	-.167	.762**	.668**	.668**
(X_{13})	.299	-.112	-.202	.096	-.023	.148	.172	.113	.049	.209	.313	-.007	1.000	-.224	.328	-.132	.173	.172
(X_{14})	.123	.0056	.412*	.261	.492**	.227	.237	.342*	.509**	-.011	-.021	-.361*	-.162	1.000	.657	-.544**	-.070	-.069
(X_{15})	.355*	.076	.159	.286	.434	.132	.148	.238	.335*	.228	.328	-.169	.318	.627**	1.000	-.444**	.258	.260
(X_{16})	.113	-.022	-.268	-.133	-.196	-.436*	-.478**	-.568**	-.772**	-.019	.409**	.718**	-.134	-.465**	-.411*	1.000	.642**	.642**
(X_{17})	.526**	.116	-.227	.225	.375*	-.400*	-.416*	-.478**	-.596**	.276	.727**	.628**	.165	-.059	.257	.640**	1.000	.999**
(X_{18})	.527**	.133	-.023	.225	.376*	-.402*	-.418*	-.479**	-.595**	.274	.726**	.628**	.164	-.058	.260	.639**	.99**	1.000

*- Significant at 5% level
**- Significant at 1% level

(X_1)- Plant height
(X2)- Plant spread
(X3)- No: of primary branches
(X4)- Leaf length
(X5)- Leaf width
(X6)- Days to 1st flowering
(X7)- Days to 50 % flowering
(X8)- Days to 1st harvest
(X9)- Days to peak harvest
(X10)- Days to last harvest
(X11)- No: of economic harvest
(X12)- Total No: of harvest
(X13)- Fruit length
(X14)- Fruit girth
(X15)-Average fruit weight
(X16)- Fruits per plant
(X17)- Yield per plant
(X18)- Yield per plot

Table 8. Genotypic (upper diagonal) and phenotypic (lower diagonal) correlation coefficients between yield and yield characters in brinjal accessions (summer season)

Characters	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}	X_{14}	X_{15}	X_{16}	X_{17}
(X_1)	1.000	.102	.079	.063	.144	-.239	-.230	-.182	-.179	.348*	.164	.077	.052	.171	.301	.100	.334*
(X_2)	.110	1.000	.628*	-.0531	-.057	.081	.026	-.093	-.199	-.083	.414**	.375*	-.121	.136	.111	.268	.425**
(X_3)	.075	.617**	1.000	.124	.137	.235	.227	.147	.015	.170	.240	.184	-.197	.272	.249	.105	.348*
(X_4)	.060	-.048	.128	1.000	.668**	.413**	.407**	.501**	.446**	.319*	-.032	-.233	.239	.357*	.370*	-.279	-.119
(X_5)	.139	-.055	.138	.649**	1.000	.195	.218	.246	.303	.171	-.051	-.101	-.239	.622**	.354*	-.202	-.020
(X_6)	-.235	.080	.230	.395*	.183	1.000	.949**	.959**	.847**	.309*	-.329*	-.432**	.145	.108	.134	-.481**	-.351*
(X_7)	-.227	.031	.225	.391*	.212	.943**	1.000	.917**	.851**	.312*	-.404**	-.482**	.121	.172	.183	-.521**	-.409**
(X_8)	-.172	-.088	.146	.443**	.239	.932**	.886**	1.000	.912**	.358*	-.403**	-.507**	.172	.138	.186	-.554**	-.419**
(X_9)	-.169	-.191	.017	.425**	.296	.834**	.829**	.894**	1.000	.428**	-.377*	-.446**	.119	.171	.169	-.499**	-.374*
(X_{10})	.343*	-.080	.169	.309*	.157	.299	.288	.343*	.425**	1.000	.046	-.018	.253	.102	.287	-.050	.144
(X_{11})	.149	.389*	.233	-.045	-.005	-.316*	-.383*	-.369*	-.358*	.024	1.000	.906**	.167	-.152	.079	.683**	.802**
(X_{12})	.066	.357*	.177	-.221	-.088	-.409**	-.448**	-.472**	-.417**	-.022	.878**	1.000	-.014	-.268	-.197	.797**	.768**
(X_{13})	.047	-.117	-.182	.237	-.231	.146	.119	.163	.117	.253	.159	-.006	1.000	-.337*	.285	-.187	.071
(X_{14})	.163	.135	.273	.353*	.613**	.109	.174	.134	.170	.104	-.131	-.243	-.324*	1.000	.577**	-.349*	.008
(X_{15})	.292	.115	.244	.364*	.348*	.128	.179	.169	.161	.272	.078	-.193	.273	.563**	1.000	-.382**	.193
(X_{16})	.097	.263	.114	-.268	-.198	-.473**	-.511**	-.527**	-.488**	-.049	.643**	.749**	-.176	-.338*	-.368*	1.000	.722**
(X_{17})	.332	.421**	.333	-.119	-.018	-.346*	-.398*	-.396*	-.366*	.139	.739**	.715**	.067	.007	.194	.699	1.000

*- Significant at 5% level

**- Significant at 1% level

(X_1)- Plant height

(X2)- Plant spread

(X3)- No: of primary branches

(X4)- Leaf length

(X5)- Leaf width

(X6)- Days to 1st flowering

(X7)- Days to 50 % flowering

(X8)- Days to 1st harvest

(X9)- Days to peak harvest

(X10)- Days to last harvest

(X11)- No: of economic harvest

(X12)- Total No: of harvest

(X13)- Fruit length

(X14)- Fruit girth

(X15)-Average fruit weight

(X16)- Fruits per plant

(X17)- Yield per plant

(X18)- Yield per plot

and positively correlated, which is evident from the genotypic correlation values of 0.79 and 0.67 during *rabi* and summer respectively. Days to peak harvest had significant positive association with days to first flowering, 50 percent flowering, and first harvest. But this character had a significant negative association with number of economic harvests and total number of harvests. Total number of harvests had a significant and negative association with days to first flowering, 50 per cent flowering, first harvest, and peak harvest. Fruit girth is significantly and positively associated with fruit weight (r_g *rabi* =0.66 r_g summer = 0.58) and fruit weight is positively associated with number of economic harvests, which is in turn contributing positively towards yield. Number of fruits per plant is contributing significantly and positively towards the number of economic harvests and total number of harvests.

4.2. SCREENING OF BRINJAL ACCESSIONS FOR JASSID RESISTANCE

The collected brinjal accessions were screened for resistance/tolerance to jassid infestation during *rabi* (2004) and summer (2005).

4.2.1. Screening during *rabi* season

During the rabi season (2004), 28 *S. melongena* accessions along with one *S. macrocarpum* were exposed to natural infestation to jassids in a preliminary field evaluation. There was no jassid infestation in the nursery stage. The infestation was noticed from about 45th day after transplanting and hence observations on jassid count started from 48th day. Weekly observations were recorded up to 90 DAT. The mean values of nymphal count per leaf of the accessions taken on 48 DAT, 55 DAT, 64 DAT, 72 DAT, 80 DAT and 90 DAT are given in Table 9. The statistical analysis of the data showed significant variation in jassid infestation on different accessions.

At 48 DAT the nymphal count per leaf on *S. melongena* accessions ranged from 0.85 in SM 384 to 2.43 in SM 343. Accessions SM 343, SM 339 and SM 344 recorded significantly higher nymphal population on leaves. (2.43, 2.23, and 2.21

Table 9. Number of jassid nymphs per leaf observed at different stages of crop (*rabi* ,2004)

Accessions	48DAT	56DAT	64DAT	72DAT	80DAT	90DAT
Neelima	1.33	1.29	2.37	2.75	3.13	2.13
Surya	1.79	2.14	2.85	4.20	4.65	2.29
Swetha	1.67	2.17	2.73	4.88	6.37	2.20
Haritha	1.79	2.43	3.59	4.03	6.78	3.40
SM 337	1.93	2.30	2.83	3.39	4.86	2.16
SM 339	2.23	2.17	3.45	4.09	6.78	3.03
SM 343	2.43	2.85	3.50	4.07	7.16	2.93
SM 344	2.21	2.55	3.29	4.30	7.03	2.60
SM 345	1.87	2.23	2.95	4.08	4.73	2.13
SM 347	1.69	1.95	2.40	3.07	4.08	2.26
SM 348	1.20	1.77	2.33	2.73	3.50	2.00
SM 350	1.15	2.02	2.59	3.05	3.99	1.79
SM 351	1.68	1.70	1.95	2.86	3.69	1.58
SM 353	1.80	2.18	3.18	3.73	4.99	1.78
SM 354	1.75	2.28	3.33	4.16	6.30	1.83
SM 355	1.95	2.40	3.65	4.25	5.40	3.10
SM 356	1.85	2.40	3.15	4.10	5.90	3.25
SM 360	2.05	2.80	3.25	4.00	6.10	3.00
SM 361	2.10	2.90	3.40	4.50	6.10	3.10
SM 362	2.15	2.75	3.70	4.95	7.00	3.95
SM 363	1.25	1.40	2.70	2.50	2.70	0.70
SM 364	1.30	1.75	2.13	2.40	2.09	0.90
SM 365	0.95	1.45	2.03	2.30	2.08	0.95
SM 366	1.90	1.65	1.55	2.50	2.16	1.00
SM 369	1.60	1.50	2.11	2.70	4.00	1.95
SM 384	0.85	1.08	1.60	1.80	2.11	0.90
SM 385	0.95	1.07	1.78	2.02	2.54	0.65
* S X H	2.10	2.30	3.10	3.48	4.75	2.10
** *S.m.*	0.80	1.50	1.70	1.60	1.85	0.60
CD	0.28	0.46	0.37	0.35	0.47	0.56
CV	8.29	11.16	6.54	5.06	4.98	13.18

* swetha X Haritha

** *Solanum macrocarpum*

nymphs per leaf respectively). SM 365, SM 385 and SM 384 recorded a significantly lower nymphal count than all other accessions (0.95, 0.95 and 0.85 nymphs/ leaf respectively). *S. macrocarpum* recorded the least infestation (0.8 nymphs/ leaf).

Observation of nymphal count per leaf taken on 56 DAT also showed significant variation. At this stage, SM 361 recorded the maximum number of nymphs per leaf (2.9) closely followed by SM 343 (2.85), which were at par. Other accessions with higher nymphal count were SM 344, SM 355, SM 356 and Haritha. The lowest nymphal population was recorded on SM 385 (1.07) and SM 384 (1.08) which were significantly lower than all other accessions.

At 64 DAT the number of nymphs per leaf ranged from 1.55 in SM 366 to 3.7 in SM 362. As in the previous observations Haritha, SM 343, SM 361, SM 344, SM 360, SM 356 and SM 345 recorded comparatively higher number of nymphs per leaf (3.59, 3.50, 3.40, 3.29, 3.25, 3.15 and 2.95 nymphs/ leaf respectively).

The nymphal count was again increased to 4.95 per leaf in SM 362 at 72 DAT followed by Swetha (4.88), which were at par. At this stage lowest nymphal count was recorded in SM 384 with 1.8 nymphs per leaf. The nymphal count of *S. macrocarpum* was lower than all *S. melongena* lines (1.6)

At 80 DAT the jassid infestation reached its peak. The number of nymphs per leaf reached as high as 7.16 in SM 343. SM 344 and SM 362 followed this with on par values (7.03 and 7.00 respectively). Some of the accessions like SM 364, SM 365, SM 366 and SM 384 had recorded a significantly lower jassid population than all other accessions. *S. macrocarpum* recorded minimum number of jassids per leaf (1.85).

At 90 DAT the intensity of jassid infestation came down to 3.95 nymphs per leaf in SM 362, which had the highest count at this stage. SM 363, SM 364, SM 365, SM 366, SM 384 and SM 385 recorded a significantly lower jassid count than the rest of the lines except *S. macrocarpum*, which recorded the lowest jassid count per leaf (0.6) through out the study.

4.2.2. Screening during summer season

During summer season, 36 brinjal accessions were subjected to an intensive screening against jassid infestation. The nymphal count recorded at different stages starting from the stage of infestation is given in Table10. The statistical analysis of data revealed significant variation among the accessions. Observations were recorded from 20 DAT i.e., the day on which jassids were first appeared, to 62 DAT when there was a significant reduction in jassid count.

At 20 DAT highest jassid infestation was recorded on SM 354 and SM 362 (3.85 nymphs per leaf on each). Number of jassids were minimum on SM 363 (1.25) followed by SM 384 (1.55). On *S. macrocarpum*, nymphal count was significantly lower (0.85) than *S. melongena* lines.

Observations at 28 DAT showed highest nymphal population in SM 362 itself (5.4) followed by SM 339 (5.25). At this stage also SM 363 recorded significantly lower number of jassids (1.95) than all other *S. melongena* accessions. This was followed by SM 364, 365, 366, 384 and 385, which do not differ significantly among themselves.

Jassid infestation reached its peak at 35- 40 DAT. Observations recorded on 36 DAT revealed a jassid infestation rate as high as 9.85 nymphs per leaf in SM 389 and SM 343. As in the previous observation, SM 363, SM 364, SM 365, SM 366, SM 384 and SM 385 recorded comparatively lower nymphal count at the peak infestation stage also (3.35, 3.75, 3.45, 3.75, 3.45 and 3.9 respectively).

The jassid population came down drastically by about 40 DAT. Observation at 44 DAT revealed a range of 2 - 6.1 nymphs per leaf. *S. macrocarpum* recorded the lowest jassid count followed by SM 363, SM 365 and SM 366 with values 2.2, 2.65 and 2.65 respectively.

The nymphal count at 56 DAT had still come down and ranged from 4.45 nymphs per leaf in SM 362, to 1.25 nymphs per leaf in SM 363.

Table 10. Number of jassid nymphs per leaf observed at different stage of crop (summer ,2005)

Accessions	20DAT	28DAT	36DAT	44DAT	52DAT	62DAT
Neelima	2.07	3.60	5.50	2.98	2.20	2.30
Surya	2.25	3.75	5.40	2.86	2.30	2.00
Swetha	3.05	4.70	8.30	2.80	2.55	2.30
Haritha	3.20	4.55	8.75	3.15	2.50	2.30
SM 337	2.35	3.40	6.50	3.55	2.60	2.05
SM 339	3.35	5.25	9.85	5.45	4.25	3.10
SM 343	3.50	4.75	9.85	6.10	4.40	3.35
SM 344	3.70	5.00	9.65	5.35	4.15	3.90
SM 345	2.75	3.80	6.30	3.95	3.35	2.25
SM 347	2.95	3.70	6.40	3.25	2.50	2.50
SM 348	2.40	3.65	5.75	3.30	2.15	2.20
SM 350	2.45	3.75	5.95	3.60	2.40	3.00
SM 351	2.80	3.90	6.15	4.95	3.00	3.75
SM 353	3.05	4.05	6.45	3.95	2.20	2.95
SM 354	3.85	5.05	8.40	4.60	3.55	3.15
SM 355	3.20	4.25	7.55	4.25	3.50	3.15
SM 356	3.15	4.65	7.55	5.05	3.80	3.15
SM 359	3.30	4.15	6.15	4.50	3.75	3.05
SM 360	3.15	4.40	8.10	5.50	4.10	3.10
SM 361	3.45	4.80	8.00	4.85	4.10	3.35
SM 362	3.85	5.40	9.15	5.95	4.45	3.90
SM 363	1.25	1.95	3.35	2.20	1.25	1.60
SM 364	1.70	2.60	3.75	2.90	2.20	1.00
SM 365	1.80	2.75	3.45	2.65	2.30	1.50
SM 366	1.90	2.75	3.75	2.65	2.35	1.75
SM 369	2.70	4.15	6.05	4.10	3.35	3.10
SM 371	3.15	4.45	7.15	4.65	3.95	3.55
SM 378	3.75	4.55	6.30	4.85	3.65	3.35
SM 379	3.25	4.55	6.10	4.45	3.60	3.25
SM 384	1.55	2.70	3.45	2.90	2.15	1.40
SM 385	1.90	2.75	3.90	2.85	2.60	2.05
SM 386	3.15	4.65	6.70	4.70	3.40	3.20
SM 387	2.75	3.70	5.75	3.40	2.75	2.25
SM 388	3.05	3.65	5.85	3.75	2.70	2.25
* S X H	3.15	4.75	6.90	3.70	3.10	2.40
** *S.m.*	0.85	1.05	1.60	0.20	0.50	0.20
CD	0.30	0.31	0.39	0.52	0.36	0.31
CV	7.61	5.46	4.24	9.45	8.34	8.33

* swetha X Haritha

** *Solanum macrocarpum*

Last observation on nymphal count taken at 62 DAT also followed a similar trend. SM 364 and SM 384 recorded the lowest value of nymphal count per leaf among *S. melongena* accessions (1 and 1.4). Least count was recorded by *S. macrocarpum* (0.2nymphs/leaf). SM 344 and SM 362 recorded the maximum count of 3.9 each.

4.2.3. Categorization of brinjal accessions based on per cent intensity of infestation.

The brinjal accessions were categorized into resistant/susceptibility classes based on the intensity of hopper burn symptoms (Table 11).

Out of the 29 accessions, six *S. melongena* lines *viz.*, SM 363, SM 364, SM 365, SM 366, SM 384 and SM 385 and *S. macrocarpum* were categorized as immune. Even though immunity is a generic or species-specific character and not a varietal character, since the above *S. melongena* accessions recorded a percentage intensity value of zero, they were included under the immune class. SM 343 showed an intense hopper burn symptom with a percentage intensity of 62.5, which is significantly higher than the rest of the accessions. Released varieties Neelima and Surya were moderately resistant (16.66 and 16.25) and Swetha and Haritha were highly susceptible (55 and 50.1). SM 348, 350 and 351 were categorized as moderately resistant. Most of the lines *viz.*, SM 337, SM 345, SM 347, SM 354, SM 355, SM 356, SM 360, SM 361, SM 369 and Swetha X Haritha were classified as moderately susceptible. SM 339, SM 343, SM 344, SM 362, Swetha and Haritha were highly susceptible to jassid attack with an intensity value of above 50 per cent.

4.2.4. Artificial infestation of plants under cages

Six *S. melongena* accessions *viz.*, SM 363, SM 364, SM 365, SM 366, SM 384 and SM 385, which were rated as immune to jassid attack during field trials, were further subjected to confirmation test under protected environment along with a

Table. 11.Categorization of brinjal accessions based on % intensity of jassid infestation (*rabi*, 2004)

Accession	% intensity	category	nymphs/leaf
Neelima	16.66	MR	3.13
Surya	16.25	MR	4.65
Swetha	55.00	HS	6.37
Haritha	50.10	HS	6.78
SM 337	41.66	MS	4.86
SM 339	58.33	HS	6.78
SM 343	62.50	HS	7.16
SM 344	56.25	HS	7.03
SM 345	33.33	MS	4.73
SM 347	30.00	MS	4.08
SM 348	18.75	MR	3.50
SM 350	25.00	MR	3.99
SM 351	20.00	MR	3.69
SM 353	37.50	MS	4.99
SM 354	50.00	MS	6.30
SM 355	45.00	MS	5.40
SM 356	43.75	MS	5.90
SM 360	31.25	MS	6.10
SM 361	37.50	MS	6.10
SM 362	58.30	HS	7.00
SM 363	0.00	I	2.70
SM 364	0.00	I	2.09
SM 365	0.00	I	2.08
SM 366	0.00	I	2.16
SM 369	31.25	MS	4.00
SM 384	0.00	I	2.11
SM 385	0.00	I	2.54
Swetha X Haritha	25.10	MS	4.75
Solanum macrocarpum	0.00	I	1.85

I - Immune
HS - Highly susceptible
MR - Moderately resistant
MS - Moderately susceptible
HS - Highly susceptible

susceptible accession SM 343. In order to assess the susceptibility or resistance of the accessions to infestation by specified population levels of jassid, ten jassid nymphs of medium size were released on each caged plant at 8-10 leaf stage. The observations taken on 4, 10 and 16 days after release are given in Table12.

. The nymphal count at four days after release were 9, 10, 10, 8, 8, 7 on the resistant accessions SM 363, SM 364, SM 365, SM 366, SM 384 and SM 385 respectively and 10 on the susceptible accession SM 343. On the 10^{th} day of release the number of surviving nymphs was found to be less on resistant lines (6, 5, 4, 5 and 5 on SM 363, SM 364, SM 366, SM 384 and SM 385 respectively) compared to the susceptible accession (9 on SM 343). However SM 365, which was rated as immune in the previous field trials, gave a better support to jassids in the cage (8 adults per plant at 10^{th} day of release) indicating its susceptibility in the confirmation test. After 16 days of release the number of surviving adults and newly emerged nymphs were recorded on each plant. SM 363, SM 364, SM 366, SM 384 and SM 385 retained only 4, 2, 3, 3 and 2 adults respectively per plant. On SM 365 comparatively higher adult survival was observed (6 adults per plant). SM 343, which was a susceptible accession during field trials, retained 7 adults up to 16^{th} day of release. The number of emerged nymphs were 1, 0, 4, 1, 2 and 2 on resistant accessions SM 363, SM 364, SM 365, SM 366, SM 384 and SM 385 respectively and 6 on susceptible accession SM 343.

None of the accessions that were rated as immune during field trial, except SM 365 developed hopper burn symptoms (Plate 4). But SM 365 exhibited slight yellowing along margin (Plate 5). The susceptible accession SM 343 showed a reduced plant growth.

Table. 12. Count of nymphs per plant at different intervals during cage tests of resistant accessions

Accession	No: of nymphs released in cages	count of jassids on whole plant under cages		
		after 4 days	after 10 days	after 15 days
SM 363	10	9 nymphs	6adults	3 adults +1nymph
SM 364	10	10 nymphs	5adults	2 adults + 0 nymph
SM 365	10	10 nymphs	8adults	5 adults + 4nymphs
SM 366	10	8 nymphs	4adults	3 adults +1 nmyph
SM 384	10	8 nymphs	5adults	3 adults + 2 nymphs
SM 385	10	7 nymphs	5adults	2 adults + 1nymph
SM 343	10	10 nymphs	9 adults	7 adults + 6 nymphs

Plate 4. Jassid resistant brinjal accessions after 30 days of release of insects in cages

SM 363

SM 364

SM 366

SM 384

SM 385

Plate 5. The susceptible accession SM 365 developing hopper burn symptom after 30 days of release of insects in cages

SM 365 SM 365

4.3. MECHANISMS OF RESISTANCE AGAINST JASSID ATTACK IN BRINJAL

In order to understand the mechanisms of resistance against jassids morphological and anatomical characters of leaves were studied.

4.3.1. Morphological characters

The observations on leaf thickness, midrib thickness and density of midrib hairs of the accessions during *rabi* and summer seasons are given in Table 13 and 14 respectively.

Leaf thickness

Brinjal accessions showed significant difference for leaf thickness. During the first season the value ranged from 0.24 mm in SM 353 and SM 365 to 0.44 mm in SM 384. During the second season the range was from 0.18 mm in SM 378 to 0.44 mm in SM 350.

Midrib thickness

Brinjal accessions varied significantly in their midrib thickness. During *rabi* season, midrib thickness ranged from 1.47 mm in SM 360 to 2.63 mm in SM 337. During summer season the value ranged from 1.47 mm in SM 351 to 2.73 mm in SM 379. During both the seasons Surya, SM 337, SM 353 and SM 369 recorded significantly higher midrib thickness. During the two seasons SM 351, SM 354, SM 360, SM 361 and SM 363 recorded a significantly lower midrib thickness compared to other accessions (1.64, 1.67, 1.47, 1.96 and 2.03 mm in rabi and 1.47, 2.04, 1.82, 1.96 and 2.06 mm during summer respectively).

Table 13. Morphological characters observed for studying jassid resistance in brinjal accessions (*rabi*, 2004)

Accessions	Leaf thickness(mm)	Midrib thickness(mm)	Midrib hair no:/25mm2
Neelima	0.43	2.25	13.66
Surya	0.39	2.45	4.63
Swetha	0.32	2.29	5.19
Haritha	0.36	2.42	5.65
SM 337	0.31	2.63	12.21
SM 339	0.37	2.15	12.85
SM 343	0.34	2.27	10.66
SM 344	0.38	2.38	2.13
SM 345	0.36	2.12	3.75
SM 347	0.37	2.34	19.30
SM 348	0.35	2.14	20.25
SM 350	0.34	2.24	19.50
SM 351	0.39	1.64	12.10
SM 353	0.24	2.58	10.56
SM 354	0.29	1.67	10.75
SM 355	0.38	2.43	12.25
SM 356	0.29	1.87	8.01
SM 360	0.32	1.47	14.90
SM 361	0.34	1.96	13.35
SM 362	0.38	2.06	15.32
SM 363	0.41	2.04	44.40
SM 364	0.39	2.06	34.22
SM 365	0.24	2.13	30.50
SM 366	0.37	2.14	18.20
SM 369	0.33	2.42	22.38
SM 384	0.44	2.24	14.25
SM 385	0.29	2.25	15.45
* S X H	0.43	2.14	10.25
** *S.m.*	0.26	2.11	0.22
CD	0.03	0.13	2.64
CV	4.62	2.86	9.00

* Swetha X Haritha

** *Solanum macrocarpum*

Table 14. Morphological characters observed for studying jassid resistance in brinjal accessions (summer ,2005)

Accession No	Leaf thickness (mm)	midrib thickness (mm)	Density of midrib hairs/25mm^2
Neelima	0.43	2.26	14.25
Surya	0.36	2.42	6.08
Swetha	0.31	2.31	6.25
Haritha	0.38	2.28	8.50
SM 337	0.30	2.63	14.50
SM 339	0.38	2.21	12.35
SM 343	0.34	2.40	9.30
SM 344	0.38	2.37	3.55
SM 345	0.33	2.20	5.05
SM 347	0.33	2.42	16.55
SM 348	0.37	2.10	18.95
SM 350	0.44	2.27	17.25
SM 351	0.24	1.47	12.65
SM 353	0.26	2.57	12.85
SM 354	0.22	2.04	10.55
SM 355	0.30	2.39	11.70
SM 356	0.26	2.07	8.45
SM 359	0.35	2.35	11.75
SM 360	0.36	1.82	10.75
SM 361	0.29	1.96	12.40
SM 362	0.22	2.15	13.80
SM 363	0.27	2.06	40.75
SM 364	0.38	2.07	33.90
SM 365	0.24	2.22	26.28
SM 366	0.33	2.17	26.85
SM 369	0.25	2.45	21.05
SM 371	0.21	2.25	3.05
SM 378	0.18	2.20	3.75
SM 379	0.30	2.73	7.45
SM 384	0.41	2.22	15.10
SM 385	0.30	2.28	13.95
SM 386	0.20	2.45	6.45
SM 387	0.39	2.31	15.40
SM 388	0.26	2.15	14.45
* S X H	0.32	2.15	12.55
** *S.m.*	0.37	2.44	0.20
CD	0.11	0.06	2.39
CV	12.27	1.87	12.53

* swetha X Haritha

** *Solanum macrocarpum*

Density of midrib hairs

Midrib hair density varied significantly from as high as 44.4 hairs per 25 mm^2 during first season and 40.75 hairs per 25 mm^2 during second season to as low as 2.13 hairs per 25 mm^2 and 3.05 hairs per 25 mm^2 during *rabi* and summer seasons respectively. *S. macrocarpum* was having glabrous leaves with negligible number of midrib hairs (0.22 and 0.20/25 mm^2 during *rabi* and summer respectively). During both the seasons, SM 363 showed significantly higher density of midrib hairs than the rest of the accessions (44.4 and 40.75/25mm^2 during *rabi* and summer respectively).

4.3.2. Anatomical characters

The cell wall thickness and cuticle thickness of the resistant *S. melongena* accessions along with two susceptible accessions were observed for a comparison study.

The cuticle thickness of the resistant accessions *viz*., SM 363, SM 364, SM 366, SM 384 and SM 385 were 2.89, 3.40, 3.13, 3.46 and 3.47 microns respectively while the susceptible accessions SM 343 and SM 344 recorded a lesser cuticle thickness of 2.3 and 2.63 microns respectively (Table 15)

Significant difference could not be observed between the cell wall thickness of all the resistant and susceptible accessions. The cell wall thicknesses of resistant lines SM 363, SM 366 and SM 385 were comparatively higher (1.74, 1.70 and 1.76 microns respectively). The susceptible accessions SM 343 and SM 344 recorded a cell wall thickness of 1.31 and 1.56 microns respectively.

4.4. Organoleptic test

The organoleptic evaluation of jassid resistant accessions SM 363, SM 364, SM 366, SM 384 and SM 385 was conducted for acceptability. The external appearance of the fruits of these lines was not appreciable since the fruits were striated except in SM 366 which had purple fruits. Four attributes *viz*., appearance,

Table 15.Cuticle thickness and cell wall thickness of resistant and susceptible accessions

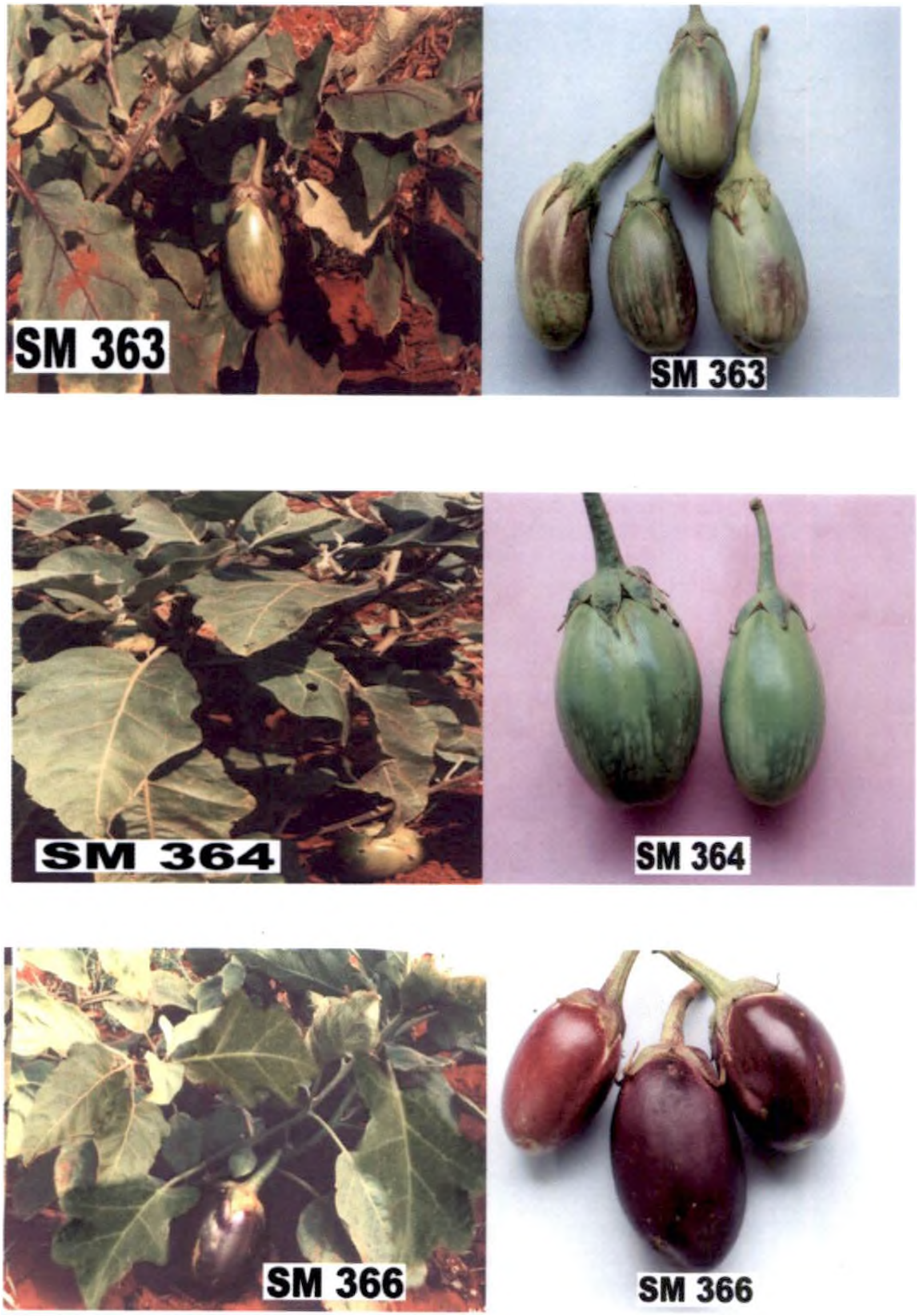
Accession	category	cuticle thickness (Microns)	cell wall thickness (Microns)
SM 363	Immune	2.89	1.74
SM 364	Immune	3.40	1.43
SM 366	Immune	3.13	1.70
SM 384	Immune	3.46	1.26
SM 385	Immune	3.47	1.76
SM 343	Highly susceptible	2.30	1.31
SM 344	Highly suscep'ible	2.63	1.56

taste, flavour and non bitterness of cooked fruits were evaluated during the organoleptic study (Table 16). The total score for all the accessions were moderately high. (> 14 out of 20). SM 366 was more appealing in appearance with a score of 4.08 out of 5. SM 385 was relished most (4.33 out of 5), while SM 363 scored the highest for flavour. The over all score was the highest for SM 364 closely followed by SM 366 (15.58 and 15.49 out of 20 respectively).

Table 16. Organoleptic evaluation of fruits of the jassid resistant brinjal accessions

Accession	Appearance (out of 5)	Taste (out of 5)	Flavour (out of 5)	non-bitterness (out of 5)	Total (out of 20)
SM 363	3.25	2.92	3.50	3.50	13.17
SM 364	3.92	4.08	3.33	4.25	15.58
SM 366	4.08	4.08	3.33	4.00	15.49
SM 384	3.42	3.83	3.42	3.16	13.83
SM 385	2.83	4.33	3.33	4.33	14.82

Plate 6. Jassid resistant brinjal accessions




SM 384

SM 384

SM 385

SM 385

Discussion

DISCUSSION

Brinjal is a popular and widely cultivated vegetable crop in India. India ranks second, next to China in the area and production of brinjal in the world. The crop is grown in an area of 5.02 lakh hectares producing 83.47 lakh tonnes with an average productivity of 16.63 tonnes per hectare (NHB data base, 2003)

The crop is grown in many states through out India. It has been a staple vegetable in our diet since ancient times. A variety of dishes are prepared out of the tender fruits. The medicinal properties of brinjal fruits are also well known.

Brinjal is mainly grown as a rainfed crop during May to December in selected villages of Kerala. Cultivation of the crop during summer season is limited primarily due to the heavy incidence of leaf hopper symptoms caused by *Amrasca biguttula biguttula.* The green coloured hoppers appearing in large numbers suck the sap by feeding on the under surface of leaves and causes characterized yellowing, and drying up of leaves. Since the hoppers are highly mobile and seen in large numbers, the chemical control is practically ineffective. Hence the only viable solution for growing summer brinjal in Kerala is the cultivation of resistant/ tolerant hybrids. None of the varieties available in the state are resistant to this dreadful pest. Hence the present investigation was carried out with the objective of identifying hopper resistant/ tolerant lines having desirable horticultural traits

An effort was made to investigate the mechanism of resistance in wild brinjal accessions with special reference to some morphological and anatomical characteristics. An attempt was also made to generate information on genetic parameters and to ›vok out the correlation between yield and its component characters.

5.1. EVALUATION OF BRINJAL ACCESSIONS FOR HORTICULTURAL AND GENETIC PARAMETERS

The experimental material consisted of 36 brinjal accesssions evaluated during *rabi* (2004) and summer (2005). The performance of the crop with respect to vegetative characters were better during summer while the productivity was better during *rabi*.

5.1.1 Horticultural parameters in brinjal

Thirty six brinjal accessions were evaluated for six quanlitative characters and 18 quantitative yield components. There was significant difference among these 36 genotypes for all the quantitative characters studied. The general analysis of variance conducted for *rabi* and summer seasons revealed considerable variation existing for these characters indicating the scope for further improvement of population. The accessions were varying greatly in their morphological traits also. Anserwadekar *et al.* (1979), Varghese (1991) and Varma (1995) also reported high variability for most of the characters studied in brinjal accessions.

It was observed that out of the 36 accessions only six accessions had spreading growth habit, while 15 had upright and 12 had semi spreading habit. This suggests the need for varying spacings for different genotypes in accordance with their growth habit. SM 339 was the tallest plant (81.15 cm and 101.5 cm) and SM 366 was the most spreading plant (134.3 cm and 128.5 cm) with maximum number of primary branches (9 and 8.1).

Foliage colour is having a prime róle in species characterization and insect resistance (Ananthakrishnan, 2002). Only nine accessions were with entirely green foliage and the remaining lines had green coloured lamina with purple tinged venation. During both rabi and summer, SM 337 recorded highest leaf area with maximum leaf length and leaf width.

Prickliness is considered as a wild and undesirable horticultural character in brinjal, which hinder intercultural operations and harvesting. Out of the 36 accessions evaluated, 25 were nonprickly and 11 had prickles either on stems, leaves, calyx, or all these parts.

The colour and shape of fruits determine the market preference of aubergines in different localities. Six accessions including Neelima and Surya were purple fruited. Only four genotypes were white fruited and majority were with striated fruits, which do not have consumer preference in Kerala. Four lines had round shaped fruits and sixteen were having oblong to long fruits.

Size of the fruits as indicated by its length, girth and weight in general was more during summer. During both the seasons fruit length was maximum in SM 344 (34.5 cm and 36.25 cm during *rabi* and summer respectively). During *rabi* SM 344 was closely followed by SM 353, Haritha and SM 339 in length of fruits (21.59cm, 18.25cm and 17.21cm respectively). Similarly in girth of fruits SM 337, SM 364 and SM 363 followed SM 385. During both the seasons SM 354 produced the heaviest fruits (150.6 g and 151.8 g) and SM 345 produced the lightest fruits (47.38 g and 50.05 g).

During *rabi,* Swetha x Haritha produced maximum number of fruits per plant (19.15) followed by Swetha, Neelima and SM 384. During summer, Swetha produced more number of fruits (16.7) than all others. More number of economic harvests was recorded in Neelima (11.5) during *rabi,* and in SM 384 (10) during summer. Number of total harvests also was highest for Neelima (14) in *rabi* season and for SM 384 (12.5) in summer season.

Swetha was the earliest genotype with minimum number of days to first flowering (46.5 and 50.5 days), 50 per cent flowering (53.5 and 63.5 days) and days to first harvest (64 and 70.5 days). The hybrid of Swetha and Haritha reached the peak harvesting stage significantly earlier than all other accessions.

Duration of the crop was more in February planted crop. Reception of summer rain during the fag end of the crop resulted in the production of more flushes and prolonged the growth of plants. Brinjal being a crop with perennial tendency, such variations are quite common. Crop duration was extended up to 192.5 days in SM 339 and SM 345 during *rabi*, and up to 203.5 days in SM 379 during summer. Crop duration was the shortest for SM 369 (161 days) during *rabi* and for SM 361 (171.5 days) during summer.

5.1.2. Estimation of Genetic parameters

Studies on genetic parameters of a crop is the basic requirement for its further genetic improvement. The critical assessment of nature and magnitude of genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), heritability and genetic advance of different characters and their association with yield are important prerequisite in formulating effective breeding strategies. Further, the effectiveness of selection depends on whether the variability is heritable or nonheritable in nature, and this is more so in a crop like brinjal where high degree of divergence is known to exist among different genotypes (Kalloo, 1988).

5.1.2.1.Variability and heritability parameters in brinjal

Information on vriability helps the plant breeder for effective selection of characters for crop improvement. In the present study, significant difference was observed among the accessions for all the characters studied. The characters like density of midrib hairs, fruit length, fruit weight, number of fruits per plant, number of economic harvests and total harvests and yield per plant recorded comparatively high GCV than all other characters. The existence of high variability for these indicated a great scope for further improvement through selection of these characters. Chadha and Paul (1984) and Gopimony *et al.* (1984) recorded a high GCV for fruit weight and fruits per plant. Earlier workers like Vadivel and Bapu

(1989), Varghese (1991), Varma (1995), Behera *et al.* (1999) and Singh and Gopalakrishnan (1999) also reported high variability in brinjal for yield contributing characters. The results of the present study are in accordance with these earlier findings. GCV values were low for midrib thickness, days to first flowering, 50 per cent flowering, first harvest, peak harvest and last harvest.

High heritability was estimated for all the quantitative traits studied.. A high heritability coupled with high GCV would indicate less environmental influence on the character and high transmission index; while a low heritability, even with a high GCV is not of much use for the improvement of the character by selection. Heritability estimates along with genetic advance would be more rewarding than heritability alone in predicting the consequential effects of selection to choose the best individual (Johnson *et al.*, 1955). High heritability in conjunction with high genetic gain was obtained for characters like density of midrib hairs, fruit length, average fruit weight number of fruits per plant, yield per plant, total number of harvests and number of economic harvests indicating that these characters are least affected by environment. This is indicative of additive gene action and consequently a high genetic improvement is expected through selection based on these traits. These results are in agreement with the reports of Singh *et al.*, (1974) who also recorded a high genetic advance coupled with high heritability for the above traits. High heritability with moderate genetic gain was recorded for characters like midrib thickness, days to first flowering, 50 per cent flowering, first harvest and last harvest. This reveals the possibility of non additive gene action governing these characters. Some of the morphological characters *viz.*, leaf thickness, midrib thickness and number of branches recorded a high heritability with low genetic gain values. Low genetic gain for these characters may be due to non additive gene action which was earlier reported by Peter and Singh (1974) for number of branches per plant. This signifies that high heritability is not always an indication of high genetic advance. This result suggested that plant selection based on above characters will not be effective as it is by non additive gene action and genotype X environment (G X E) interaction may have played a significant role in the expression of these traits.

5.1.2.2.Correlation studies

Selection for yield alone need not be effective or rather not possible since there may not be any gene or genes for yield alone, and it is a consequence of multiplicative interaction of several component characters (Singh, 1983). Simultaneous increase of yield and its component characters is possible only with a thorough knowledge of the direction of interaction of these component traits with yield. In the present study it was revealed that genotypic correlation coefficient was higher than phenotypic correlation coefficient for all characters. This indicates the presence of inherent association among these characters. Yield was found to be significantly and positively correlated with number of economic harvests, total number of harvests and number fruits per plant. This is in confirmation with the findings of Srivastava and Sachan (1973), Hiremath and Rao (1974) and Prasath *et al.* (2001). There was significant and negative association of yield with days to first flowering, 50 per cent flowering, first harvest and peak harvest. This proves that early flowering and fruit set results in increased yield in brinjal. This is in agreement with the observations of Varma (1995) who also opined that yield was negatively associated with days to 50 per cent flowering, fruit set and harvest. The earliness had a significant and positive contribution towards number of economic harvest and total harvest. There was significant positive association of fruit girth and fruit weight with number of economic harvests. Krusteva (1985), Khurana (1988), Mishra and Mishra (1990) and Sharma and Swaroop (2000) also obtained similar results.

5.2. SCREENING OF BRINJAL ACCESSIONS FOR JASSID RESISTANCE

Cultivation of brinjal during summer in the state is limited mainly due to severe incidence of jassids. Jassids cause debilitatory effects even at early stage of crop growth. In addition, it disrupts transportation in conducting vessels and apparently introduces a toxin that impairs photosynthesis in proportion to the amount of feeding (Sharma and Chander, 1998). The feeding results in characteristic yellowing and drying up of the leaves starting from the margin. In severe cases the infestation leads to severe stunting of plants and poor yield.

During the *rabi* season (2004), 29 brinjal accessions were subjected to a preliminary evaluation against jassids by exposing to natural infestation. Nursery stage was free of jassid attack. Infestation was noticed at 40 – 45 DAT (30th Dec., 2004 to 4th Jan., 2005). During the initial stage of infestation an average of 1.5-2.0 jassids were recorded per leaf. There after, the population increased gradually and peaked at 80 - 90 DAT (19th to 29 th Feb., 2005) with a nymphal count of 6 - 7 nymphs per leaf on some accessions like SM 339, SM 343, SM 344, SM 354, SM 360, SM 361, SM 362, Swetha and Haritha.. Jassids were more on middle leaves compared to the lower leaves and top young flushes.

The infestation started with more or less same population density on all the accessions. Later the population started to concentrate on some accessions only, recording a comparatively greater number of nymphs on these lines and lesser number on the remaining accessions.

On SM 339, SM 343, SM 344, SM 362 and Swetha, the population was significantly higher than the other lines during the peak infestation days (6.8, 7.2, 7.0, 7.0 and 6.37 nymphs/ leaf respectively). Significantly lesser number of jassids were noticed on six *S. melongena* accessions *viz.*, SM 363, SM 364, SM 365, SM 366, SM 384 and SM 385 (2.7, 2.09, 2.08, 2.16, 2.11 and 2.54 nymphs/leaf respectively at 80 DAT) (Fig. 1).

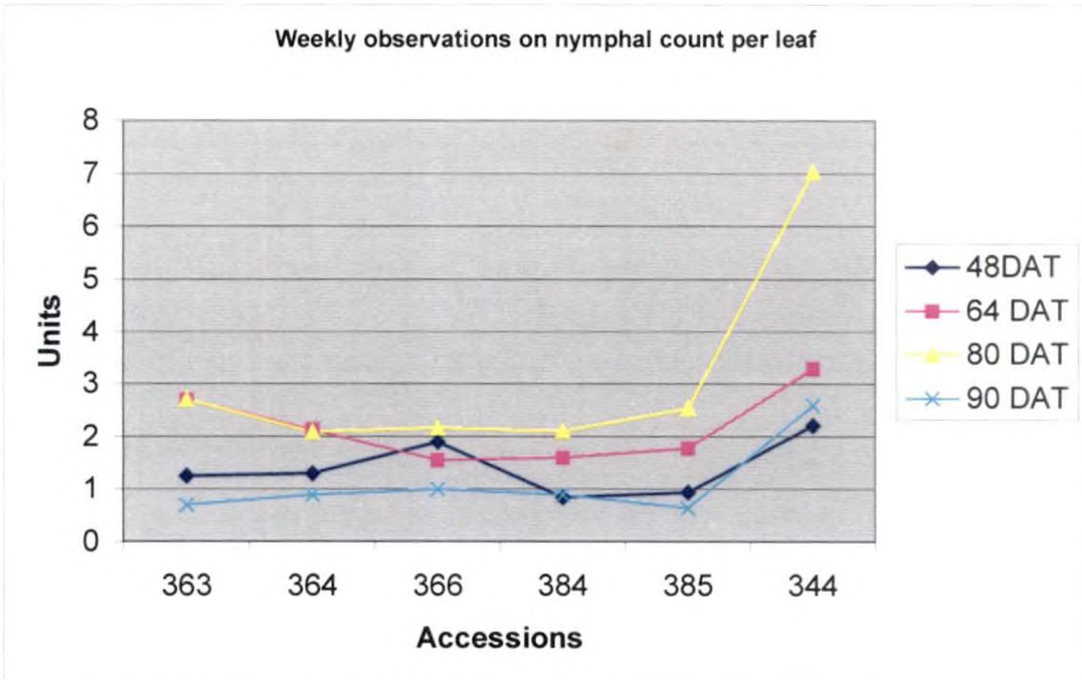


Figure 1. Weekly observations on number of nymphs per leaf on jassid resistant (SM 363, SM 364, SM 366, SM 384, SM 385) and susceptible (SM 344) accessions

The accessions were categorized into resistant or susceptible groups according to their relative resistance or susceptibility to jassid attack. The classification was based on the degree of hopper burn symptoms exhibited by the accessions. The visual assessment of hopper burn intensity was converted into numerical terms by calculating the per cent intensity which made the classification and comparison much easier.

Thus out of 29 lines screened against jassids, seven were rated as immune (SM 363, SM364, SM 365. SM 366, SM 384, SM 385 and *S. macrocarpum*), five were moderately resistant (SM 348, SM 350, SM 351, Neelima and Surya), 11 were moderately susceptible and six highly susceptible (Table 11).

The range of infestation revealed that the tested accessions possessed high variability in respect of their relative susceptibility to jassid attack. *S. macrocarpum* did not show any infestation by jassids. This species was found to be an unacceptable host for oviposition as evidenced by its lowest nymphal count (1.85 at 80 DAT) and zero per cent intensity of infestation . This finding confirms with the report of Raja *et al.* (2001) who also observed more resistance in *S. macrocarpum* than *S. melongena* lines.

During summer (2005) also, all the 29 accessions along with seven additional lines were subjected to screening for jassid tolerance. Jassid infestation was substantially higher during summer months compared to the *rabi* season. How ever the mean values of jassid infestation on different accessions followed the same trend during *rabi* and summer seasons. Dhamdhere *et al.* (1995), Singh (1996) and Mahmood *et al.* (2002) also reported that summer was the most favourable condition for the build up of leaf hopper population on brinjal. The relatively high level of infestation during summer months may be due to high temperature, more sunshine hours and low relative humidity prevailed during February 2004 to middle of May (Appendix 1). Several studies conducted earlier by Shukla (1989), Prasad and Logiswaran (1997), Ratnapara *et al.* (1994), Bernice (2000) and Mahmood *et al.*

(2002) revealed that the population build up of jassids was positively correlated with day degrees and sunshine hours and negatively correlated with atmospheric relative humidity. The present study also revealed the same relation existing between jassid population dynamics and weather parameters.

The *S. melongena* accessions which were rated as immune to jassid attack during *rabi* season were further proceeded for confirmation test under protected environment during the summer season. In order to assess the susceptibility or resistance of the accessions a specified population of jassids, (10 nymphs) were released on each caged potted plant. The observation taken at 16th day after release revealed substantial reduction in jassid number on resistant plants (from 10 to 7 and 2 in susceptible and resistant accessions respectively).

During intensive screening under cages, none of the accessions except SM 365 developed hopper burn symptoms. SM 365, which was considered as resistant to jassid attack in initial field screening, developed slight yellowing along leaf margin during the confirmation test. On this accession, the nymphal survival and reproduction was comparatively better than other resistant accessions. It seems that this accession might had a chance escape from jassid attack during field screening. In cages; the survival ability of the jassids might have improved due to mechanical exclusion from natural enemies and the unavailability of other susceptible accessions. The resistant accessions may have some inherent defence mechanisms against the insects compared to those in the susceptible group. The results of studies conducted under confinement were more or less in agreement with the data generated in the field screening trial, except for SM 365.

5.3. Mechanisms of jassid resistance in brinjal

Mechanisms of varietal resistance to insect pests has been classified into antibiosis, antixenosis and tolerance (Painter, 1951). During the present field screening and cage studies non preference and antibiosis were observed as the resistance mechanisms acting in brinjal against jassids. Tolerance has not much significance since jassid attack will reduce the vigour and photosynthetic efficiency of plants and consequently the yield will be suffered.

The aggregation of jassid population on susceptible varieties and consequently a lower jassid infestation on resistant plants during the field trials of *rabi* and summer seasons hints that a type of non-preference or antixenosis mechanism may be acting against jassids. Nonpreferance or antixenosis is the avoidance of plants by the insects in search of food, shelter or ovopisitonal site (Painter, 1951). The non preference can be attributed to some morphological or anatomical factors present in resistant plants about which will be discussed later.

Intensive screening of plants under cages revealed that the survival ability and reproduction capacity of nymphs were reduced on resistant plants. This indicated a strict antibiosis mechanism functioning against jassids. Antibiosis is the mechanism of interfering or destructing the life cycle of insects, which is manifested by reduced nymphal size and their survival ability, increased nymphal duration and reduced fecundity (Painter, 1951). Ruzzel (1978) and Lit and Bernardo (1990) also had reported that nonpreferance and antibiosis were together working to resist jassid attack in brinjal, in tune with the present result.

5.3.1.Morphological traits associated with jassid resistance

The morphological features of plants interfere physically with locomotor mechanism and more specifically with the mechanism of host selection, feeding, ingestion, digestion, mating and ovipisotion of insects. Such physical barriers are mediated by the presence of trichomes, surface waxes, silication or sclerotization of tissues. In addition, allomones affecting insect behaviour and metabolic processes may occur in plant morphological structures like trichomes (Anandakrishnan, 2002).

The morphological characters like leaf thickness, midrib thickness density and length of midrib hairs were assumed as the possible traits associated with jassid resistance in brinjal. Subbaratnam *et al.* (1983), Gaikwad *et al.* (1991) and Singh and Sharma (2002) reported a positive correlation of jassid infestation with leaf and midrib thickness. During the present study varietal variation for these characters were observed. Moderately susceptible accessions like SM 353, SM 355 and SM 369 and highly susceptible accessions like SM 337, SM 344 and Haritha were having thicker midrib than other accessions. Some of the highly resistant lines, *viz.*, SM 363, SM 366 and SM 384 and moderately resistant lines like SM 348 and SM 351 had thin midrib and is in agreement with the earlier reports. However, SM 363 and SM 384 which showed resistant reaction towards jassids, were with thick midribs. This shows that a generalization on the relation of jassid infestation with leaf lamina thickness mid rib thickness is not possible in a crop like brinjal.

It is natural to think that leaf thickness, which is a measure of leaf succulance, would be favourable for sucking insects like jassids, which feed on plant sap. Another fact is that jassids oviposit along the midrib of brinjal and so a thicker midrib can be a hindrance to jassids during egg laying. But the present study revealed that there might not be a strict association between the intensity of jassid infestation and leaf and midrib thickness. A group of different mechanisms like trichome density, cuticle thickness etc may be contributing for resistance in such cases. Four resistant accessions had thin midrib but two accessions turned out to be exceptions. Likewise, even though majority of the susceptible accession had thicker midrib, three moderately susceptible accessions *viz.*, SM 360, SM 354 and SM 356 had very thin midribs (1.47, 1.67 and 1.87 mm respectively). As a result of these exceptional cases simple correlations worked out between jassid intensity and leaf thickness and between jassid intensity and midrib thickness revealed a negative but non significant association (Table17 and 18). This result indicated that apart from leaf and midrib

Table.17.Correlation of jassid infestation with leaf thicknesss, midrib thickness and density of midrib hairs (*rabi*, 2004)

	Average leaf thickness of brinjal lines(mm) 0.35	Average midrib thickness of brinjal lines(mm) 2.17	Average midrib hair density of brinjal lines 14.38
Average number of jassids per leaf on peak infestation stage 4.58	Correlation coefficient = - 0.041	Correlation coefficient = - 0.020	Correlation coefficient = -.0.491

Table. 18.Correlation of jassid infestation with leaf thicknesss, midrib thickness and density of midrib hairs(sumer, 2005)

	Average leaf thickness of brinjal lines(mm) 0.31	Average midrib thickness of brinjal lines(mm) 2.24	Average midrib hair density of brinjal lines 13.3
Average number of jassids per leaf on peak infestation stage 6.38	Correlation coefficient = - 0.021	Correlation coefficient = - 0.041	Correlation coefficient = - 0.434

thickness there may be some other biochemical or anatomical features of plants, which determine jassid resistance in brinjal.

Simple correlation was worked out between nymphal population on plants with the number of midrib hairs present in 25 mm^2 area on ventral surface of leaf. The correlation coefficient of –0.491 revealed a significant and positive association of jassid resistance with leaf pubescence (Table 17 and 18). The resistant accessions SM 363 and SM 364 had highly pubescent leaves and veins. The density of midrib hairs per 25 mm^2 area was 44.4 and 34.22 respectively for these accessions. Other resistant accessions *viz.*, SM 366, SM 384 and SM 385 recorded a comparatively lesser trichome density of 18.2, 14.25 and 15.45 per 25 mm^2 respectively, but significantly higher than those of susceptible lines. All the susceptible accessions were having significantly low density of midrib hairs. For most of them the hair density was below 10 per 25mm^2 area. Thus the study revealed that leaf pubescence had a major role in determining jassid resistance.

According to Arnold (1986) plant hairs may serve as structural features, which will alter the reflectance of the leaves and the microclimate of its surface and can act as barriers to herbivores or the hairs may be glandular and secrete substances that can cover the surrounding surface. According to him resin secretions from the clavate hairs of solanaceous plants will be retained as a droplet on plant surface and such secretions will provide defence against herbivores. As jassids oviposit along the ventral surface of midrib, high density of glandular hairs on midrib can offer a substantial hindrance to egg laying. Earlier works by Lit (1989), Lit and Bernardo (1990) and Gaikwad *et al.* (1991) revealed a highly significant linear association of leaf trichome density and its branching, with adult oviposition and nymphal feeding of leaf hoppers on brinjal. The present study also revealed the same correlation.

The association if any, between jassid population and length of midrib hairs was studied by measuring the midrib hair length of selected plants from different resistance category (Table 19). A negative association was revealed to exist between

Table.19.Comparison of midrib hair length and hair density with jassid population on selected brinjal accessions

variety/ accession	Hair length (mm)	Midrib hair no:/25mm2	Jassid no:at 80 DAT	Pest resistance category
SM 363	0.416	44.40	2.70	I
SM 364	0.463	34.22	2.09	I
SM 365	0.286	30.50	2.08	I
SM 366	0.540	18.20	2.16	I
SM 384	0.619	14.25	2.11	I
SM 385	0.543	15.45	2.54	I
Neelima	0.370	13.66	3.13	MR
SM 347	0.303	19.30	4.08	MS
SM 348	0.240	20.25	3.50	MS
SM 353	0.280	10.56	4.99	MS
SM 355	0.183	12.25	5.40	MS
SM 337	0.302	12.21	4.86	MS
SM 339	0.311	12.85	6.78	HS
SM 343	0.096	10.66	7.16	HS
SM 344	0.272	2.13	7.03	HS

I - Immune
MS - Moderately resistant
HS - Highly susceptible

the length of midrib hair and jassid infestation. All the susceptible accessions were with less number of midrib hairs and the hairs were comparatively shorter whereas the resistant accessions had more number of hairs and they were comparatively longer also. The hair length ranged from 0.096 mm in the susceptible line SM 343 to 0.619 mm in the resistant accession SM 384.

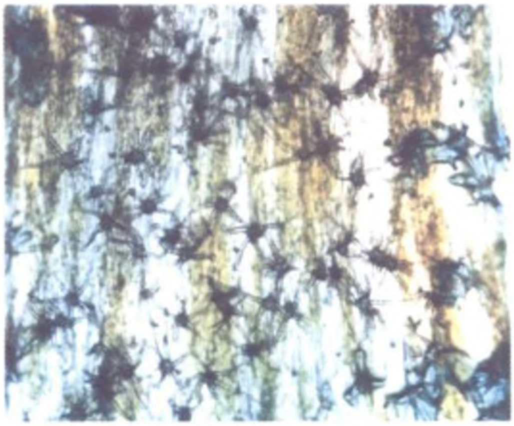
The resistant accessions SM 366, SM 384 and SM 385 had comparatively less midrib hair density than the remaining resistant accessions. But their hair length was strikingly higher than all other accessions. This may be the reason for imparting better resistance to jassids in these accessions. SM 365, which turned out to be susceptible to jassids under protected conditon, was with a higher midrib hair density. But its midrib hairs were shorter (0.29 mm). So the susceptibility of this accession under confinement can be explained on the basis of less pubescence of leaves which allowed the jassids to oviposit successfully on the midrib. So a greater rate of nymphal emergence was observed. During the field trials presence of more glabrous plants like SM 343, SM 344, SM 362 etc. in the population, might have prompted the jassids to avoid this line for oviposition, which made the plant unaffected by jassids.

Pubescence of leaf is a multitude of both hair length and hair density. More number of lengthy hairs will result in higher pubescence and consequently a better resistance towards jassids (Fig. 2 & 3). Thus it is evident from this study that midrib hair of inadequate length or long hairs with out adequate density is not fully effective in imparting resistance against oviposition by jassids (Plate 7). Uthamasamy (1985) was also of the same opinion.

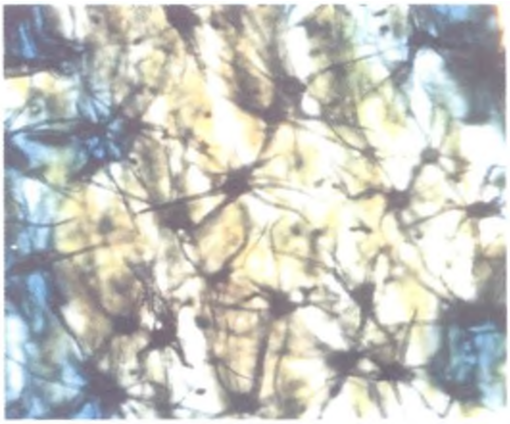
5.3.2. Anatomical features associated with jassid rtesistance

Epidermis of plants is considered as the first line of defence against insect attack, which offers a mechanical barrier to the penetrating stylets during feeding, or creates mechanical obstruction during oviposition. Jassids are phloem feeders and

Plate 7. Enlarged view of ventral surface of midrib showing trichome length and density ($25mm^2$) in resistant (SM 363 and SM 364) and susceptible (SM 344) accessions



SM 363



SM 364

SM 344

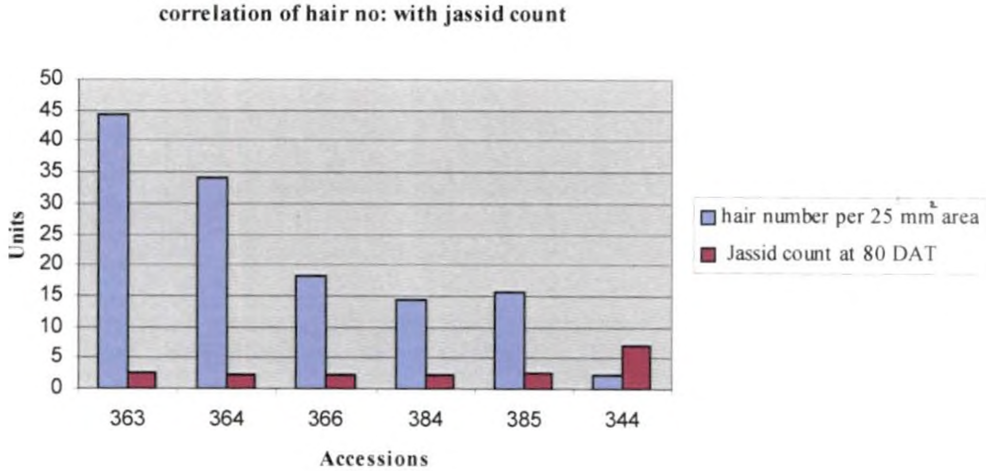


Figure 2. Association of midrib hair density (25mm^2) with jassid count in resistant (SM 363, SM 364, SM 366, SM 384 SM 385) and susceptible (SM 344) accessions

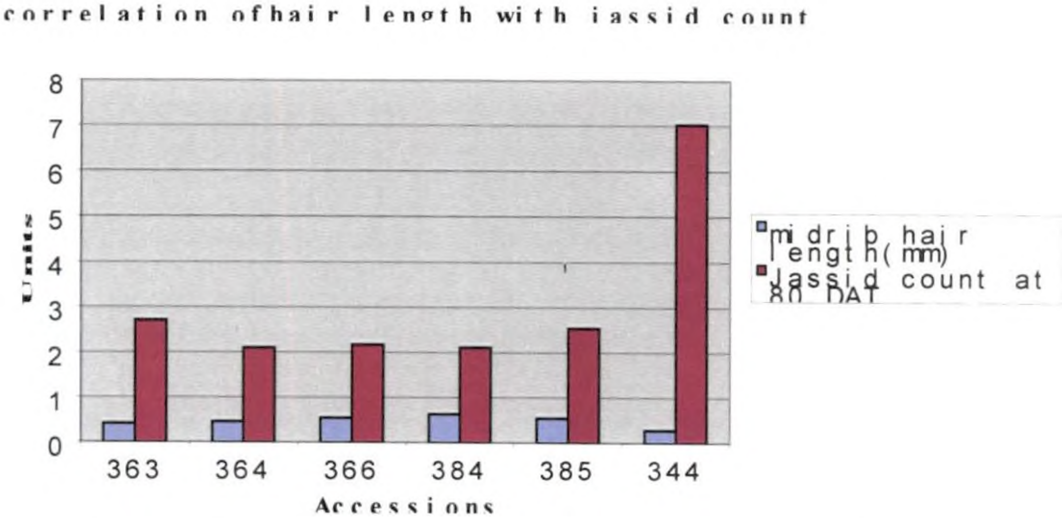


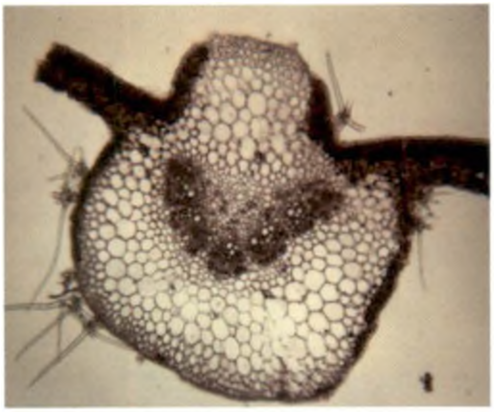
Figure 3. Association of midrib hair length with jassid count in resistant (SM 363, SM 364, SM 366, SM 384 SM 385) and susceptible (SM 344) accessions

they suck the plant sap along the midrib portion. More over jassids oviposit by penetrating and inserting the eggs in to the epidermal layer of midrib. The outer wall of epidermis is impregnated with some fatty substances collectively called as cutin and this layer is called cuticle, which constitutes the skin of plants (Martin and Janiper, 1970). So any resistance offered by the cuticle or epidermal layer of midrib, can hinder the feeding and oviposition of jassids.

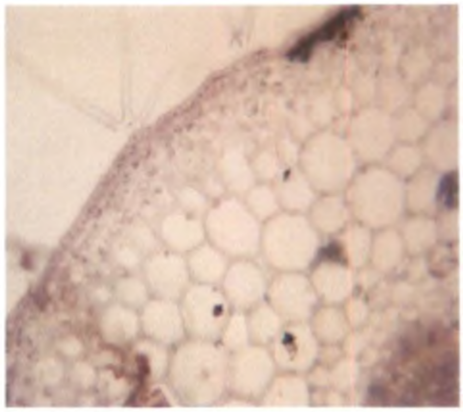
In order to unravel the anatomical basis of jassid resistance the cuticle and cell wall thickness of epidermal cells in resistant and susceptible accessions were measured with an image analyzer. The cuticle of resistant accessions *viz.*, SM 363, SM 364, SM 366, SM 384, and SM 385 were comparatively thicker than the cuticle of susceptible lines *viz.*, SM 343 and SM 344 (Plate 8 & 9).

The wall thickness of epidermal cells also showed difference among the accessions. The hypodermal cells were more compactly arranged in the resistant lines where as inter cellular space was more in susceptible lines. The cuticle of resistant lines SM 363 and SM 366 were comparatively thinner (2.89 and 3.13 microns) than other resistant lines. But their epidermal cells were more compactly packed with very less inter cellular space and they had comparatively thicker cell wall (1.74 and 1.70 microns respectively). So this compactly packed cells and thick cell wall may be the mechanical barriers preventing the penetration by jassids. In other resistant accessions SM 364, SM 384 and SM 385, inter cellular space in the hypodermis was more. But their cuticle of mid rib was markedly thicker. In this case a thick cuticle of mid rib may be the prime mechanical barrier to jassids. In the susceptible lines like SM 343 and SM 344, all the three factors *viz.*, cuticle thickness, cell wall thickness of epidermal cells and intercellular space of hypodermis were on the adverse side. The cuticle and cell wall were thinner and the hypodermal cells were very loosely packed. So the jassids might have successfully oviposited and fed on them.

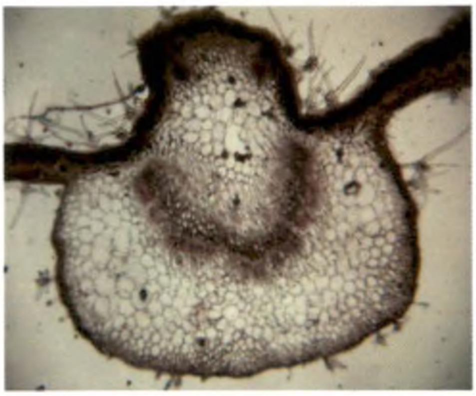
Plate 8. Cross sectional view of midrib of jassid resistant (SM 363, SM 364) and susceptible (SM 344) brinjal accessions



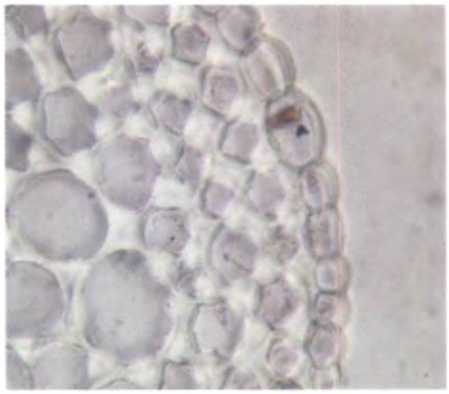
SM 363 (4X)



SM 363 (40 X)

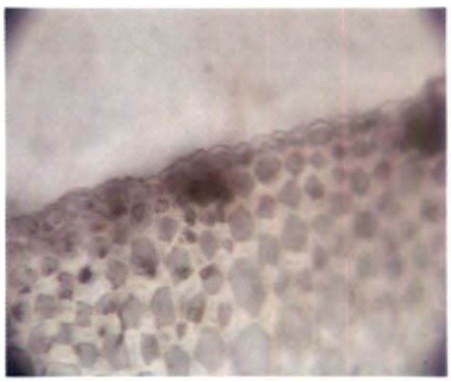


SM 364 (4X)



SM 364 (40X)

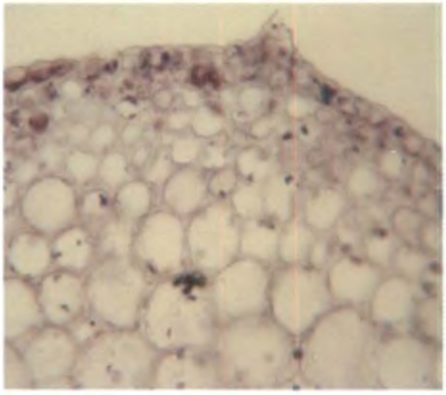
SM 344 (4X)



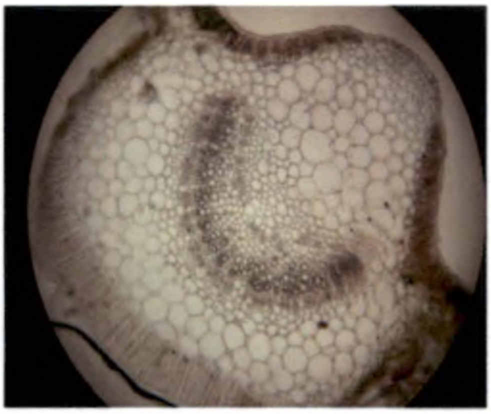
SM 344 (40X)

Plate 9. Cross sectional view of midrib of jassid resistant (SM 366, SM 384, SM 385) and susceptible (SM 343) brinjal accessions

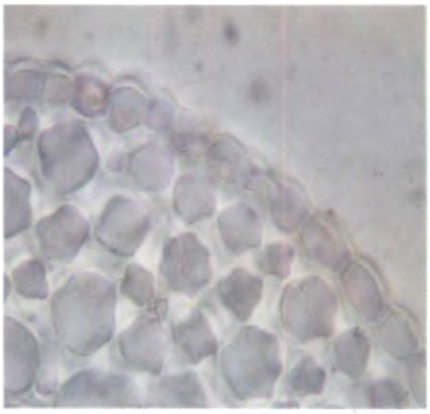
SM 366 (4X)



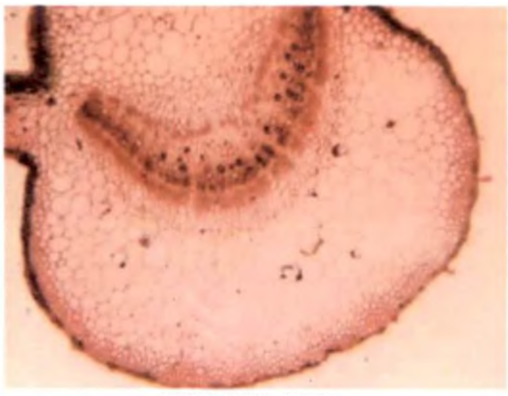
SM 366 (40X)



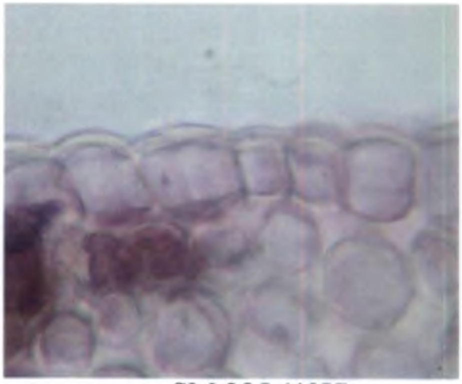
SM 384 (4X)



SM 384 (40X)

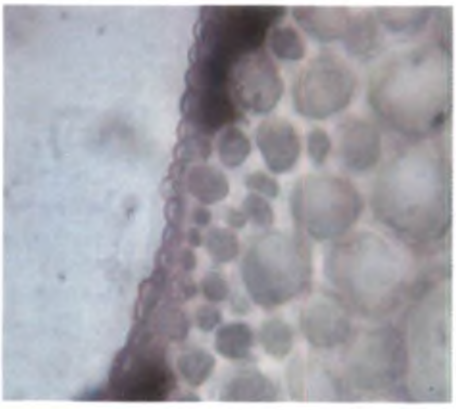


SM 385 (4X)



SM 385 (40X)

SM 343 (4X)



SM 343 (40X)

5.4. Organoleptic test

Appearance and cooking quality of vegetables are prime factors in crop improvement programmes. A high yielding and pest resistant variety, if not having good cooking quality, will not have consumer preference. So the organoleptic acceptability of the resistant accessions should be confirmed. The jassid resistant accessions *viz.,* SM 363, SM 364, SM 384 and SM 385 produced striated fruits, which do not have consumer preference in Kerala. The organoleptic test revealed that all the accessions were moderately good in taste after cooking except SM 363 and SM 384, which were relatively bitter in taste.

Even though the cooking quality of resistant accessions like SM 364, SM 366 and SM 385 were good, SM 364 and SM 385 were with striated fruits. Since this nature is not preferred in Kerala, these resistant lines can be utilized in the hybridization programme to develop a jassid resistant variety with attractive fruit characters.

Summary

SUMMARY

The present study on 'Screening brinjal for jassid, *Amrasca biguttula biguttula* (Ishida) tolerance' was conducted in the Department of Olericulture, College of Horticulture, from November 2004 to August 2005 to evaluate brinjal accessions for yield and yield attributes, to estimate various components of variation, to screen the accessions for jassid resistance and to unravel the mechanisms of jassid resistance operating in resistant /tolerant accessions.

The salient findings of the study are summarized below:

1. The accessions exhibited different growth patterns like spreading, semi spreading and upright stature. Accessions varied in their leaf and petiole colour also. Flower colour varied from white to violet with a range of different intensity of these colors. There were non prickly as well as prickly plants with spines on different plant parts like leaves, stem and calyx. Fruits of different accessions varied in size, shape and colour.

2. The accessions showed significant variation in vegetative as well as fruit characters. Among the different accessions SM 339 was the tallest and SM 366 the most spreading. SM 337 had the largest leaves. SM 344 had longest fruits and SM 385 produced largest fruits with maximum fruit girth. Maximum fruit weight was observed in SM 354. Neelima and SM 384 were identified as better ones with more number of harvests and higher yield.

3. Swetha and Swetha x Haritha were the earliest with minimum days for flowering, fruit set and harvest. Accessions SM 339, SM 345 and SM 379 had longer crop duration of more than 190 days.

4. The genetic parameters like GCV, PCV, heritability, genetic advance and genetic gain were estimated for the 21 characters. Heritability was high for all the 21 characters observed. Characters like fruit length, fruit weight, number of fruits per plant, number of economic harvests, total number of harvests and yield per plant recorded high heritability coupled with high GCV. High heritability along with high genetic advance (%) was observed for characters like fruit length, number of fruits per plant, number of economic harvests, number of total harvests, and yield per plant indicating their possibility of improvement through selection.

5. In the present study the yield was positively and significantly correlated with number of economic harvests, total number of harvests and number of fruits per plant suggesting yield improvement by straight selection based on these characters. Mean while characters like days to first flowering, 50 per cent flowering, first harvest and peak harvest had a significant negative association with yield showing that early flowering and fruiting is associated with better yield.

6. During *rabi* and summer nursery stage was free of jassid attack. During *rabi* season the infestation started on 45 days after transplanting, with an average of 1.5 - 2 nymphs per leaf, then increased gradually and peaked at 80 DAT with a jassid count of 2.08 – 7.16 nymphs per leaf, and then started declining. Accessions SM 365, SM 364, SM 384, SM 366, SM 385 and SM 363 showed lesser jassid infestation with a jassid count of 2.08, 2.09, 2.11, 2.16, 2.54 and 2.70 per leaf respectively. During summer season the infestation started from 20 DAT and peaked at 35 DAT. Jassid population ranged from 3.35 to 9.85 nymphs per leaf on *S. melongena* accessions at peak infestation stage. The nymphal count on a related species *S. macrocarpum* was found to be lesser than all *S. melongena* accessions.

7. Based on the intensity of hopper burn symptoms, six *S. melongena* accessions namely SM 363, SM 364, SM 365, SM 366, SM 384 and SM 385 along with *S. macrocarpum* were grouped under immune class (0 % intensity). The accessions SM 348, SM 350, SM 351, Neelima and Surya were categorized as moderately resistant (10.1 - 25 % intensity).

SM 337, SM 345, SM 347, SM 354, SM 355, SM 356, SM 360, SM 361, SM 369 and Swetha x Haritha were classified as moderately susceptible (25 – 50 % intensity) and SM 339, SM 343, SM 344, SM 362, Swetha and Haritha were highly susceptible (> 50 % intensity). The accessions grouped under immune class recorded significantly less nymphal count as compared to other accessions.

8. The evaluation of immune accessions in insect proof cages showed that the survival ability of jassids were reduced on SM 363, SM 364, SM 366, SM 384,and SM 385 as compared to the susceptible ones. The resistance reaction of all the accessions were confirmed except SM 365 which became susceptible under artificial inoculation.

9. The reaction of brinjal plants towards jassids during field trials and under confinement revealed that antibiosis and antixenosis (non preference) might be the possible mechanisms of resistance existing in brinjal against jassids.

10. The morphological study of leaves revealed that long mid rib hairs and high hair density could be the possible causes of jassid resistance in brinjal. This was confirmed by a significant and negative correlation (-0.491) existing between mid rib hair density and jassid population. The resistant accessions SM 363 and SM 364 had highly pubescent leaves and veins. Other resistant accessions *viz.*, SM 366, SM 384 and SM 385 recorded a comparatively lesser trichome density but significantly higher than those of susceptible accessions. The hair length of these three resistant accessions was strikingly higher than all others. This may be the reason for imparting better resistance to jassids in these accessions. Hence leaf pubescence can be taken as an index for jassid resistance in brinjal.

11. Anatomical studies revealed that the resistant accessions SM 364, SM 384 and SM 385 had a comparatively thicker cuticle. The other resistant accessions, SM 363 and SM 366 had thick cell wall for their epidermal cells. The hypodermal cells of SM 363 and SM 366 were compactly arranged with out intercellular space. These factors may have contributed for imparting resistance in these accessions.

12. Organoleptic test revealed that resistant accessions SM 364, SM 366 and SM 385 had medium acceptability. SM 363 and SM 384 were relatively bitter in taste.

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* Originals not seen

Appendices

APPENDIX 1

Weather data during the period of study May 2004 to June 2005							
	Temperature (^0C)		Relative humidity (%)	Total rainfall (mm)	Total sunshine hours	Rainy days
	Maximum	Minimum				
May-04	34.40	22.00	84.00	578.30	104.30	21
Jun-04	31.30	21.60	85.00	786.00	98.90	24
Jul-04	31.80	21.60	85.00	369.60	66.40	24
Aug-04	31.30	21.50	83.00	386.90	137.10	14
Sep-04	32.80	22.60	80.00	208.80	154.00	10
Oct-04	33.80	20.80	73.00	493.20	185.30	11
Nov-04	32.80	21.40	65.00	71.70	211.90	3
Dec-04	33.60	18.60	55.00	0.00	279.90	0
Jan-05	35.00	19.80	56.00	7.60	264.00	1
Feb-05	37.60	17.40	53.00	00.00	280.70	0
Mar-05	38.20	22.00	42.00	00.00	193.20	0
Apr-05	36.70	22.80	74.00	171.40	208.20	10
May-05	35.50	21.50	72.00	89.20	217.50	5
Jun-05	33.20	21.80	86.00	711.40	94.30	23

Appendix 2.

General analysis of variance for the quantitative characters during *rabi* season

	Mean Sum Of Squares		
Character	**Replication**	**Genotype**	**Error**
Plant height	5.933	232.59*	4.79
Plant spread	9.46	790.52*	19.94
No: of primary branches	0.631	3.84*	0.22
Leaf length	0.59	7.67*	0.90
Leaf width	0.24	8.51*	0.12
Leaf thickness	0.003	0.005*	0.00
Midrib thickness	0.003	0.143*	0.004
Density of midrib hairs	0.53	182.65*	1.67
Days to first flowering	30.41	162.75*	0.49
Days to 50% flowering	52.16	177.79*	0.87
Days to first harvest	68.43	151.98*	.717
Days to 50% harvest	197.40	308.37*	2.18
Days to last harvest	28.98	152.49*	5.91
No: of economic harvest	3.38	10.23*	0.70
Total No: of harvests	10.78	12.76*	0.60
Fruit length	1.59	54.59*	1.51
Fruit girth	0.108	2.61*	0.17
Average fruit weight	32.79	1529.*61	44.03
Fruits per plant	1.00	32.33*	1.94
Yield per plant	0.002	0.100*	0.004
Yield per plant	0.17	9.92*	0.35

* Significant at 5% level

APPENDIX 3.

General analysis of varience for the quantitative characters during summer season

	Mean sum of squares		
Character	**Replication**	**Genotype**	**Error**
Plant height	30.81	329.51*	4.47
Plant spread	6.91	608.42*	5.68
No: of primary branches	0.001	2.65*	0.06
Leaf length	0.65	24.69*	0.71
Leaf width	0.65	10.74*	0.17
Leaf thickness	0.12	6.28*	0.01
Midrib thickness	0.00	0.104*	0.002
Density of midrib hairs	7.93	140.49*	2.78
Days to first flowering	36.125	128.78*	1.27
Days to 50% flowering	82.35	128.14*	2.23
Days to first harvest	36.13	172.35*	4.55
Days to 50% harvest	86.68	165.74*	1.37
Days to last harvest	10.13	133.24*	3.50
No: of economic harvest	0.347	8.154*	0.46
Total No: of harvests	2.00	9.78*	0.51
Fruit length	0.04	54.77*	0.54
Fruit girth	0.27	3.22*	0.041
Average fruit weight	57.96	1212.21*	15.62
Fruits per plant	0.05	23.12*	0.43
Yield per plant	0.003	0.099*	0.001
Yield per plant	0.26	9.91*	0.10

* Significant at 5% level

SCREENING BRINJAL FOR JASSID, *Amrasca biguttula biguttula* (Ishida) TOLERANCE.

By

MALINI. C. D.

ABSTRACT OF THE THESIS

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ABSTRACT

The present investigation entitled " Screening brinjal for jassid *Amrasca biguttula biguttula* (Ishida) tolerance" was conducted in the Department of Olericulture, College of Horticulture, Kerala Agricultural University, Vellanikkara during *rabi* (2004) and summer (2005).

Thirty six brinjal accessions collected from different parts of the country were characterized for different qualitative and quantitative characters. The evaluated accessions exhibited considerable variation for growth habit, prickliness of plant parts, colour, shape and size of fruits and colour of petiole, leaves, stem and flowers.

Fruit yield was maximum in F_1 hybrid, Neelima and SM 384. Swethe and Swetha X Haritha were early and produced maximum number of fruits per plant. Longest fruits were produced by SM 344. Fruits of SM 385 recorded maximum girth and SM 354 had heaviest fruits.

The study revealed high heritability coupled with high genetic advance for characters like fruit length, number of fruits per plant, days to last harvest and number of economic harvests. Yield was positively associated with number of fruits per plant, number of economic harvests and total harvests.

The accessions SM 363, SM 364, SM 366, SM 384 and SM 385 were found resistant to jassid infestation in the field screening and under cage studies.

The morphological and anatomical bases of resistance was also studied. High midrib hair density and longer midrib hairs were found to impart resistance in

resistant/ tolerant accessions. The anatomical studies of midrib of resistant and susceptible accessions revealed variation in cuticle thickness, cell wall thickness of epidermal cells and inter cellular space of hypodermal cells. These characters either alone or in combination may be contributing resistance to oviposition and feeding of jassids in brinjal.