PHYSICO-CHEMICAL MECHANISMS OF RESISTANCE TO *Leucinodes orbonalis* Guenee IN BRINJAL

By

SHRIRANG SHARAD WAGH

(Reg. No. 09/38)

A thesis submitted to the

MAHATMA PHULE KRISHI VIDYAPEETH,
RAHURI-413722, DIST. AHMEDNAGAR, MAHARASHTRA STATE (INDIA)

in partial fulfilment of the requirements for the degree

of

DOCTOR OF PHILOSOPHY (AGRICULTURE)

in

AGRICULTURAL ENTOMOLOGY

DEPARTMENT OF AGRICULTURAL ENTOMOLOGY,
POST GRADUATE INSTITUTE,
MAHATMA PHULE KRISHI VIDYAPEETH, RAHURI - 413 722,
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2012

CANDIDATE'S DECLARATION

I hereby declare that this thesis or part thereof

has not been submitted by me or any other

person to any other University

or Institute for a Degree

or Diploma.

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This is to certify that the thesis entitled, **"Physico-chemical mechanisms of resistance to *Leucinodes orbonalis* Guenee in brinjal"** submitted to the Faculty of Agriculture, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist-Ahmednagar, Maharashtra, India, in partial fulfillment of the requirement for the degree of **DOCTOR OF PHILOSOPHY** in **AGRICULTURAL ENTOMOLOGY** embodies the results of a piece of bona fide research work carried out by Shri. **SHRIRANG SHARAD WAGH**, under my guidance and supervision and no part of the thesis has been submitted for any other degree or diploma in any other form. The assistance and help received during the course of this investigation has been duly acknowledged.

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Place: MPKV, Rahuri
Dated: / /2012

(**R. S. Patil**)

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Place : MPKV, Rahuri
Date :   /   /2012   *(Shrirang. S. Wagh)*

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LIST OF ABBREVIATIONS

Abbreviation	**Description**
Agric.	Agriculture
Ann.	Annals
Annu.	Annual
App.	Applied
C.D.	Critical difference
cm	Centimeter
Cm^2	Square centimeter
Conc.	Concentration
C.R.D.	Completely Randomized Design
^0C	Degree Celsius
DAT	Days after transplanting
etc	Etcetera
et al.	et alli (and others)
Fig.	Figure
g	Gram
hrs	Hours
ha	Hectare (s)
i.e.	Id est (That is)
kg	Kilogram
Ltd.	Limited
ml	Millimeter

Abbreviation	**Description**
min	Minute
No.	Number
O.D.	Optical density
PO	Peroxidase
PPO	Polyphenol oxidase
R.B.D.	Randomized Block Design
RPM	Revolution per minute
S.E.	Standard error
Sr.	Serial
viz.	Videlicet (Namely)
v/v	Volume by volume
w/v	Weight by volume
/	Per
%	Per cent
>	More than

ABSTRACT

Physico-chemical mechanisms of resistance to *Leucinodes orbonalis* Guenee in brinjal

by

Mr. WAGH SHRIRANG SHARAD

A candidate for the degree of

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POST GRADUATE INSTITUTE,
MAHATMA PHULE KRISHI VIDYAPEETH,
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2012

Research Guide	:	Dr. D. B. Pawar
Department	:	Agricultural Entomology

The present investigations were conducted during 2010 to 2012 at All India Co-ordinated Vegetable Improvement Project, Department of Agricultural Entomology and Department of Biochemistry, Mahatma Phule Krishi Vidhyapeeth, Rahuri (M.S.) to study the biophysical and biochemical mechanisms of resistance to brinjal shoot and fruit borer, *Leucinodes orbonalis* Guen. Twenty brinjal genotypes with diverse morphological characters were selected and statistically laid out field trials were conduced to study their reaction to brinjal shoot and fruit borer.

The studies on field screening of different brinjal genotypes revealed that none of the genotypes had complete resistance to shoot and fruit borer. Significantly minimum (1.38 %) shoot infestation was registered in genotype RHRB-60 while, brinjal genotype RHRB-73 recorded maximum (9.96 %) shoot infestation. In case of fruit infestation genotypes RHRB-20 and RHRB-28 were observed to be highly resistant to the attack of *L. orbonalis* recorded less than 10 per cent fruit infestation. The genotypes RHRB-20, RHRB-28, RHRB-60, RHRB-79, RHRB-21, RHRB-37 and RHRB-70 were found promising in resistance to pest and high yielders.

Highly resistant genotype RHRB-28 showed considerable antibiosis effect on larvae of brinjal shoot and fruit borer when fed on diet fortified with fruit powder of the genotype. Higher larval and pupal period with lower pupal weight, per cent pupation, moth emergence, growth index, fecundity and adult longevity were observed when larvae fed with diet of highly resistant genotype RHRB-28. Whereas, reverse trend was noticed when larvae of *L. orbonalis* were reared on diet fortified with fruit powder of susceptible genotype RHRB-42.

The biophysical characters of brinjal genotypes exercised great influence on infestation of the pest. The characters influencing shoot infestation *viz.*, trichome density and shoot thickness have strong association with resistance and susceptibility to *L. orbonalis*. Trichome density exhibited significantly negative correlation (r = - 0.621) with respect to shoot infestation however, significantly positive correlation (r = 0.632) was found between shoot thickness and per cent shoot infestation.

In the present investigation the fruit characters *viz.*, length of fruit, diameter of fruit, thickness of pericarp, colour and shape of fruit did not found associated with borer infestation. However, the length of pedicel and length of calyx showed positive and highly significant correlation with fruit infestation (r = 0.474 and 0.616, respectively).

The biochemical factors in brinjal genotypes imparted resistance and exercised great influence on infestation of the pest. Fruits as well as shoots of resistant genotypes had high amount of ash, crude fibre and polyphenols content with low moisture, sugar, proteins and fats. Susceptible genotypes were found to contain high moisture, sugar, protein and fats with low ash, crude fibre and polyphenols.

Higher activities of oxidative enzymes *viz.* polyphenol oxidase and peroxidase were observed in resistant genotypes. Highly significant and negative correlation (r = - 0.798) was found between PPO activity and fruit infestation while, PO activity showed significant and positive correlation (r = 0.536) with per cent fruit infestation.

Path coefficient analysis studies indicated that, the characters trichome density, shoot thickness, protein content and polyphenol oxidase activity in case of shoot and length of pedicel, length of fruit, ash, crude fibre and polyphenol oxidase activity in case of fruits are directly associated with resistance indicating these characters have direct relation with shoot and fruit infestation. So, while seeking improvement regarding host plant resistance these characters should get priority.

Pages: 1 to 175

1. INTRODUCTION

Brinjal (*Solanum melongena* L.) is widely grown fruit vegetable of tropical and subtropical parts of the world. In India it is an important commercial vegetable grown in almost all parts of the country, except high altitudes. It is one of the most important commercial vegetable crops of Maharashtra occupying considerable area and grown almost throughout the year usually under irrigated conditions.

Brinjal has been cultivated in India for the last 4,000 years, as its centre of origin is Indo-burma region (Vavilov, 1928). The global area under brinjal cultivation has been estimated at 1.66 million hectares with total production of brinjal fruit of about 41.84 million tonnes (FAOSTAT, 2012). India is the second largest country after china in the world and accounts for about 11.89 million tonnes with an area of 0.68 million hectares under cultivation having productivity 17.5 tonnes /ha. In India, brinjal occupies 8.0 % of total vegetable area with 8.1 % share in production. Among the major brinjal producing states in India, Maharashtra accounts 35 thousand hectare area and produces about 490 thousand tonnes of fruits annually with productivity of 14.00 tonnes/ha. (Anonymous, 2012).

Brinjal fruits are primarily consumed as cooked vegetable in various ways and dried shoots are used as fuel in rural areas. It is often described as a poor man's vegetable because it is popular amongst small scale farmers and low income consumers. A poor man's crop it might be, but brinjal is also called as the 'King of vegetables'. It is featured in the dishes of virtually every household in India, regardless of food preferences, income levels and social status. In India, it is consumed in a variety of ways depending upon the eating habits of the different parts of the country. It is used as cooked vegetable in various ways or in the form of oven dried pieces in '*Sambhar*' in south India. It is also used for frying, roasting, stuffing. The preference for brinjal varieties changes for every 100 km distance as per the eating habits, in West Bengal white fruited varieties are preferred; in North India non-spiny, purple coloured fruits are popular. In Maharashtra, however, majority of the consumers prefer brinjal varieties with spines, small to medium fruits having purple colour intermixed with white stripes and oval to round shape. In short, brinjal has embedded itself deeply into the Indian culture.

Brinjal is low in calories and fats, contains mostly water, some protein, fibre and carbohydrates. It is a good source of minerals and vitamins and is rich in total sugars and proteins among other nutrients. Brinjal is known to have ayurvedic medicinal properties and is good for diabetic patients. It has also been recommended as an excellent remedy for those suffering from liver complaints (Shukla and Naik, 1993). Therefore, brinjal has wide spectrum of use for maintaining the human health essentially a source of building economic trading for farmers.

In spite of its popularity among small and resource poor farmers, and having importance in nutrition and health of human being, brinjal cultivators facing many problems, especially related to pest management. Among the major constrains in brinjal cultivation, pest damage is the most important one, causing heavy losses. The crop is attacked by about 140 species of insect and non-insect pests (Frepong, 1979). In Maharashtra, the crop mainly suffers heavily due to infestation of shoot and fruit borer (*Leucinodes orbonalis* Guen.), whitefly (*Bemisia tabaci* Genn.), jassids (*Amarasca biguttula biguttula* Ishida), aphids (*Aphis gossypii* Glover), brinjal mite (*Tetranychus cinnabarinus* Biosd) and nematodes. However, shoot and fruit borer is the most limiting factor distributed all over the India, causing heavy yield losses upto 70 per cent (Jat and Pareek, 2003).

At early stage of the crop growth, the adult female moth lays eggs mostly on the lower side of the young leaves near midrib, at the top of shoot or sometimes even on tender shoots itself. After hatching, the young larvae bore into the young leaves near the midrib or tender shoot and close the opening with frass and feed within the shoot or midrib of the leaves. Drooping, wilting or withering of shoots is the typical symptoms of shoot damage during the early stage of crop growth. After fruit formation, larvae generally enter from the underside of the calyx or bud or fruit. The entry hole is closed with frass. Infestation to the buds results in flower drop. The holes seen on the fruits are actually the exit holes of the larvae. Such infested fruits are partially unfit for human consumption and fetch fewer prices in the market (Singh and Singh, 2002). The magnitude of losses due to this pest varies from season to season, year to year and location to location.

The brinjal cultivators spray frequently, at times daily, to kill the larvae before they enter into the fruits. The indiscriminate use of pesticides creates problem of pest resistance, pest resurgence, pesticide residue in harvested produce and adversely affect the non-target species (Jat and Pareek, 2003). Pesticide resistance is emerging as one of the key constraints to successful crop protection and public health problems worldwide. Although the resistance is a natural mechanism for survival, its development has been accelerated in recent year due to excessive dependence upon chemical pesticides. Insecticides resistance in BSFB especially to pyrethroids and carbametes is now widespread in many brinjal producing countries (Rahman and Rahman, 2009), therefore chemical control practices are not sustainable and economical.

Instead of this, the use of host plant resistance against the pest is one of the effective and eco-friendly alternative methods for combating the pest problems. Use of resistant varieties recognized as an important tool in the biointensive pest management system and also it is environmentally safe and economically sound method for pest management. Insect resistant varieties provide pest control at essentially no cost to farmers (Prem Kishore, 2001).

Plant resistance would be useful either as complete control or as a part of an integrated programmes with other methods as resistant and tolerant varieties form the basic component of Integrated Pest Management (IPM) over which other components are to be built up. Resistant varieties contribute IPM in two ways; by reducing the use of insecticides and improving the performance of natural enemies. Even a low level of tolerance in plants has a dramatic effect of efficacy of natural enemies in killing their hosts, which in fact reduces the need of insecticides (Srivastava, 1993). Considering the losses caused by the pest, it is an urgent need to find out tolerant or resistant cultivars, which could be used in breeding programme. Breeder generally considers the varietal development for yield and consumer's preference, however many such varieties proved to be highly susceptible to the pest attack. In view to find out tolerant or resistant variety, screening of the plant material is very basic requirement. Therefore, the different genotypes of brinjal need to be screened to find out their reaction to the shoot and fruit borer.

Plant morphological characters as well as chemical composition play a significant role in resistance to insect by providing non-preferable plant to an insect, as these characters interfere in the movement, feeding, oviposition and development etc. These factors may directly cause nutritional imbalance, either through restrictive feeding or by limiting the digestibility and utilization of food by insects (Kasting and Mc Ginnis, 1961). These characters of different brinjal cultivars need to be studied thoroughly for the development of resistance to the pest. Therefore, it was felt necessary to study different morphological characters and biochemical attributes of different brinjal cultivars in relation to varying degree of infestation by the shoot and fruit borer.

Taking into consideration the importance of host plant resistance, it was proposed to conduct the present investigations which will be useful in formulating the IPM modules against brinjal shoot and fruit borer and for breeders to develop resistance crosses by using the source of resistance. Biophysical and biochemical studies of different brinjal varieties will be helpful to judge the resistant, tolerant and susceptible cultivars and their deployment in pest management.

The present investigation was therefore undertaken to locate the source of resistance and to study the biophysical and biochemical bases of resistance in brinjal responsible for resistance to shoot and fruit borer with following objectives;

i. Field screening of selected brinjal genotypes to study their resistance or susceptibility to brinjal shoot and fruit borer.

ii. To study larval and post-larval development of *L. orbonalis* on selected brinjal genotypes in order to find out possible antibiotic principles responsible for resistance.

iii. To study the biophysical characters of brinjal genotypes to know their correlation with infestation of shoot and fruit borer.

iv. To study the biochemicals responsible for resistance.

2. REVIEW OF LITERATURE

The brinjal shoot and fruit borer, *Leucinodes orbonalis* Guenee is the major limiting factor in brinjal production. The management of this destructive pest is done by using different control methods and most often by using chemicals. In case of vegetable and fruit crops including brinjal use of pesticides is not desirable due to the fear of toxic residue. Also chemicals recommended for the control of brinjal shoot and fruit borer have been found unpopular among brinjal growers. The only alternative left in such cases is to grow pest resistant varieties. It eliminates the use of pesticides and its ill effects on agro-ecosystem. Thus the deployment of host plant resistance in brinjal is one of the ideal and cheapest ways of managing shoot and fruit borer, *L. orbonalis.* Since absence of complete resistance against the pest, even the less susceptible varieties need to be promoted to minimize the pesticidal load on the environment. In recent years, host plant resistance is receiving attention of entomologist all over the world therefore the literature on resistance in crop plants is increasing by leaps of bounds. However, keeping in view the review of literature has been restricted to the work on resistance in brinjal to shoot and fruit borer, *L. orbonalis.* Review of published research work related to specific aspects presented hereunder with the respective headings and subheadings;

2.1 Sources of resistance

2.2 Field screening of brinjal genotypes

2.2.1 Mean per cent shoot infestation

2.2.2 Mean per cent fruit infestation

2.2.3 Yield of marketable fruits

2.1 Sources of resistance

Resistant cultivars against *L. orbonalis* were reported by many scientists such as in Haryana, PCC-2 and Aushey (Dhankar *et al.,* 1977); Anamalai and S-6 (Dhooria and Chadha, 1981); in Assam, Kuchia (Isahaque and Choudhary, 1984a); in Bangladesh, Singnath Long (Ahmed *et al.,* 1985); in Andhra Pradesh SM-204 (Raju *et al.,* 1987); in Orissa Pusa Purple Cluster (Das and Singh, 1990); in Maharashtra, PBR-120-5 (Darekar *et al.,* 1991); in Bihar, MHR, Kachbachia and Anpurna (Shah *et al.,* 1995); in Gujarat, PPL, PPC, Pusa Kranti (Patel *et al.,* 1995a); in Delhi Annamalai, Aushey and PPC (Singh and Kalda, 1997); in Pantnagar, PPC and BB-3 (Kumar and Ram, 1998). Yadav *et al.* (2003) reported that the PPC, Pusa Kranti, PPL, Neelam Long, Black Beauty and BR-112 were least susceptible cultivars to this pest. However though number of cultivars tolerant to shoot and fruit borer have been reported, there was no consistency.

2.2 Field screening of brinjal genotypes

2.2.1 Mean per cent shoot infestation

Lall and Ahmad (1965) reported shoot infestation from 5.93 to 21.46 per cent on eight different brinjal varieties. The brinjal variety Aushey recorded least shoot infestation of 5.93 per cent however; maximum shoot infestation of 21.46 per cent was recorded in local variety.

To study the reaction to *L. orbonalis* Panda *et al.* (1971) screened 19 brinjal varieties during winter and rainy season. The lowest shoot infestation with 1 to 3 per cent damage was noticed on eight brinjal varieties while susceptible varieties were found with 8 to 15 per cent shoot infestation.

Dhankar *et al.* (1977) screened 39 brinjal genotypes against *L. orbonalis* and reported shoot infestation of 1.67 to 21.69 % for resistance and susceptible varieties, respectively.

Incidence of *L. orbonalis* on 22 brinjal varieties were studied by Gill and Chadha (1979) and found shoot infestation in the range of 5.06 to 14.6 per cent in tolerant and susceptible genotypes, respectively.

Thirteen cultivated varieties of brinjal were screened by Raut and Sonone (1980) under field conditions for judging their tolerance and susceptibility. They observed the mean per cent shoot infestation in the range of 1.12 to 9.84 per cent. Significantly lower shoot infestation (1.12%) was recorded on variety Pusa Kranti followed by S.M. 41 (2.98%) while maximum shoot infestation was recorded on Manjri Gota (9.84%) and Dorli (8.54%).

Incidence of brinjal shoot and fruit borer on different varieties of brinjal under Punjab conditions was studied by Dhooria and Chadha (1981) and observed least shoot infestation on varieties Annamalai and S-6. Also the varieties PPC, PPL, Pusa Anmol and Pusa Kranti were found to be moderately susceptible.

Subbaratnam and Butani (1981) reported variety PPL most tolerant to shoot infestation (0.91%), followed by Arka Kusumakar (1.92%). PPC (2.42%) found moderately tolerant while Indo American hybrid (7.91%) showed highly susceptible reaction.

Nathani (1983) tested 36 varieties of *Solanum melongena* and reported Ringan Giant, Pusa Purple Cluster and SM 62 as a resistant varieties against shoot infestation of *L. orbonalis.*

According to Kale *et al.* (1986a) the wild species *Solanum incanum, S. xanthocarpum, S. khasianum* and *S. sisymbrifolium* were immune as they shown no infestation on shoots during rainy season of 1981 at Department of Horticulture, Dr. PDKV, Akola (M.S.).

Malik *et al.* (1986) studied variability and correlation among certain characters in relation to shoot and fruit borer infestation in brinjal where among the 39 lines tested, the most tolerant was infested with 9.09 shoots per plant, while the most susceptible was infested with 19.64 shoots per plant.

Thanki and Patel (1991) observed the varietal resistance in 12 egg plant strains against different pests and recorded shoot infestation up to 45.09 per cent as maximum in variety GB_1 and minimum shoot infestation was found to be 25.51 in variety PPC.

Tejavathu *et al.* (1991) recorded the relative resistance to shoot and fruit borer in egg plant where among the 38 genotypes tested the relative incidence of pest on shoots was ranged from 3.5 per cent as least on genotype *Solanum gilo* to 42.5 per cent on genotype PB as maximum.

Mukhopadhyay and Mandal (1994) studied relative incidence of insect pests on 41 brinjal varieties and observed variety Nakiran as tolerant with 0.98 shoots damage per five plants. However, the susceptible cultivar brinjal long green had 5.02 infested shoots per plant.

Twenty eight varieties of brinjal were screened by Patel *et al.* (1995a) against *L. orbonalis* of which Pusa Purple Long had recorded minimum of 11.29 per cent shoot infestation. However, maximum per cent shoot infestation of 20.47% was recorded in Junagadh Ravaiya.

To find out the source of resistance Singh and Kalda (1997) screened egg plant cultivars and solanum species against shoot borer at IARI, New Delhi. The varieties Annamalai, Aushey and Pusa Purple Cluster were found to be resistant at seedling stage. Among the wild species, *S. gilo* and *S. anomalum* showed high degree of resistant to borer.

Behara *et al.* (1999) screened brinjal cultivars and wild species against brinjal shoot and fruit borer and recorded the shoot infestation in the range of 2.92 to 13.67 per cent. Least shoot infestation of 2.92 per cent was recorded by wild species *S. indicum* while, among the cultivars minimum infestation of 6.78 per cent was recorded by Nurki. However, Nurki, PPC, PK, Aushey and all wild species were found resistant at vegetative phase.

Awasti (2000) conducted screening of brinjal genotypes for brinjal shoot and fruit borer infestation during *Kharif* season in Raigarh (M.P.) and recorded shoot infestation in the range from 9.81 per cent (Rajendra Annapurna) to 21.93 per cent (AB-1).

Ghosh and Senapati (2001) evaluated brinjal varieties against dead hearts caused by *L. orbonalis* and observed hybrid variety Sufal as least susceptible (0.08 dead hearts per plant). According to them presence of semi hard wood might be the reason for less susceptibility in hybrids.

Extent of losses caused by brinjal shoot and fruit borer was studied by Muralikrishna *et al.* (2001) at IARI, New Delhi for two years. The study revealed that minimum shoot infestation was recorded in Pusa Purple Long (9.57 per cent), while the maximum shoot infestation was recorded in H-12 (14.86 per cent).

Lit *et al.* (2002) evaluated 21 egg plant accessions against shoot borer infestation and recorded shoot borer infestation in the range of 0.4 to 10.9 per cent.

Jat and Pareek (2003) evaluated 10 aubergine cultivars for resistance to brinjal shoot and fruit borer. The shoot infestations varied from 3.28 to 12.71 per cent lowest being in Arka Kusumakar (3.28%) followed by Neelam long (5.27%), Pusa Purple Long (6.28%), Pusa Kranti (6.21%) and Pant Rituraj (7.42%) and were moderately resistant to shoot borer.

Senapati (2003) conducted a field trial in West Bengal, India to investigate the susceptibility of 12 aubergine cultivars to *L. orbonalis* and recorded lowest percentage of shoot infestation (4.0%) in Pusa Purple Long.

Elanchezhyan *et al.* (2008) conducted a field experiment to study the response of cultivar/hybrids/germplasm of brinjal to *L. orbonalis* and recorded the shoot infestation in the range of 8.0 to 41.7 per cent. The hybrid Sweta performed best and recorded shoot damage of 8.0 per cent followed by Ravaiya (9.8%).

Naqui *et al.* (2009) registered shoot infestation in the range of 6.7 to 16.3 per cent. Pusa Purple Long emerged as most resistance variety recording shoot damage 6.7 per cent while Pusa Purple Round recorded maximum shoot infestation of 16.3 per cent.

Studies at National Agriculture Research Centre, Islamabad recorded maximum shoot infestation by *L. orbonalis* in cv. Naeelam (43.15 and 33.75%) followed by cv. Kanha-091 (37.72 and 28.73 %) and cv. Nirala was found to be least attacked by the pest showing 19.27 and 15.81% shoot infestation during 2007-08 and 2008-09, respectively (Javed *et al.*, 2011).

2.2.2 Mean per cent fruit infestation

Several varieties of brinjal have been evaluated for resistance against fruit infestation by *L. orbonalis*. Panda *et al.* (1971) screened 19 varieties of brinjal to the attack of *L. orbonalis* and found that the varieties *viz.*, Black pendy, H-165 and H-407 were resistant, placed in 10 to 20 per cent damage scale. The varieties with 21 to 40 per cent damage were categorized as susceptible, while those showing more than 40 per cent damage were considered as highly susceptible.

In an attempt to locate the source of resistance to *L. orbonalis*, Krishnaiah and Vijay (1975) studied varietal resistance in brinjal to shoot and fruit borer. Out of 37 cultivars tested, only two cultivars *viz.*, Ex-Beckwai from Ghana and Musk brinjal from banglore were found to possess moderate degree of resistance recording 15.80 and 20.00 per cent damaged fruits, respectively while commercially cultivated varieties showed susceptible reaction recording 60 to 80 per cent fruit damage.

Lal *et al.* (1976) tested 69 cultivars and 6 *Solanum* species under field conditions for their reaction to shoot and fruit borer in the Upper Kulu Valley and found that wild species *viz.*, *Solanum sisymbriofolium L., S. xanthacarpum, S. nigrum* and *S. khaslanum* were always free from infestation, while *S. incarum* had 5 to 8 per cent infested fruits. They considered only one cultivated type *viz.*, S-519 as an immune. The varieties *viz.*, S-520, S-502, S-493, S-497, S-521, Solan 11, S.M. 145 and S-519 were found to be highly resistant.

Nawale and Sonane (1977) found that fruits of Dorly, Long Green Mysore, H-4 and S.M. 41 were least infested by *L. orbanalis* amongst 15 egg plant selections and cultivars tested. The infestation on fruits of resistant strain was 9.41 per cent (Dorly) while in susceptible variety the infestation was upto 43.33 per cent (Nimbkar Green Round).

Mote (1979) tested 10 brinjal varieties to the attack of fruit borer in the field as well as laboratory and reported that varieties *viz.*, Arka Kusumakar, A.C. 3698, Long Green Mysore, S.M. 2 and A-61 were resistant, while Manjri Gota and S.M. 313 were highly susceptible.

Resistance studies in brinjal were carried out by Gill and Chadha (1979) on 22 cultivars. The mean percentage of infested fruits was 10.09 in Pusa Purple Cluster as lowest, while the susceptible variety Punjab Bahar showed the highest fruit infestation of 48.98 per cent.

Mote (1981) screened 50 varieties to the attack of *L. orbonalis* in Maharashtra and found that varieties *viz.*, Brinjal Kranti, Muktakeshi and S.M. 213 had significantly less number of infested fruits as compared to rest of the varieties.

Assessment of comparative susceptibility of different brinjal cultivars against shoot and fruit borer in brinjal was done by Mehto and Lall (1981). The variety Long Purple was graded as resistance than other cultivars due to minimum fruit infestation of 6.77 per cent.

Subbaratnam and Butani (1981) screened brinjal varieties for resistance to shoot and fruit borer and found that varieties *viz.* Arka Kusumakar, Pusa Kranti, H-4 and A-61 were resistance to brinjal shoot and fruit borer on the basis of fruit infestantion.

Baksha and Ali (1982) studied 13 aubergine cultivars for resistance to *L. orbonalis* and reported that none was resistant to the pest. However, the varieties *viz.,* Noyankajal, Signatu, Japani, Jhumki, Indian and Baromashi found moderately tolerant to fruit infestation.

Working in Assam, Isahaque and Chaudhari (1984a) screened 10 brinjal varieties against brinjal shoot and fruit borer and found that "Bhola Bengana" was most susceptible recorded 98.88 borers/10 plants and "Kuchia" was emerged as least susceptible recording 48.81 borers/10 plants.

Yein and Rathaiah (1984) studied the incidence of the Pyralid, *L. orbonalis* in 13 promising cultivars of brinjal over 3 consecutive years (1979-81) and reported that Pusa Purple Cluster and Azad Kranti were least susceptible to the pest.

Tewari and Moorthy (1985) evaluated the resistance of 26 varieties of brinjal to *L. orbonalis* in the field and found that the varieties *viz.*, S.M. 17-4, PBR-129-5 and Musk Brinjal were the most resistant, while varieties *viz.*, Punjab chamkila, black beauty, Arka shital and Pusa purple round were the most susceptible. They found 25.88 to 30.33 per cent fruit borer damage in less susceptible strains and 58.19 to 61.57 per cent fruit infestation in most susceptible types.

Dhankar and Sharma (1986) registered 43.33 per cent mean infested fruits per plant with a maximum of 56.43 per cent in variety Sel. 1 and a minimum of 27.08 per cent in variety PPC_2.

Kale *et al.* (1986a) reported that wild brinjal species *viz. Solanum incanum, S. xanthocarpum, S. khasianum* and *S. sisymbrifolim* were immune to *L. orbonalis* and cultivated varieties Nurki, PPC and Gulabi Dorla showed highly resistant reactions as regards to fruit infestation on number basis.

To determine the resistance in 150 aubergine cultivars to *L. orbonalis* (Singh and Sidhu, 1986) carried out field trials in Punjab. They reported Punjab Chamkila as most susceptible cultivar while SM-17-4 was the most resistant followed by PPC and PRB-12905.

Pawar *et al.* (1987) screened 32 varieties of brinjal and 22 local accessions for resistance to *L. orbonalis* in the field and observed that the varieties *viz.*, Giant, S-345, S-258, PB-8, S.M.-2, S-2070 and Six Seer were the most resistant. Among the local accessions Malkapuri, Shirpur Khandala, Khanpur, Ranjangaon and Sungaon Kagal were resistant to fruit borer.

Mishra *et al.* (1988) tested 46 varieties of brinjal for their relative response to *L. orbonalis* in Uttar Pradesh. They reported that none of the varieties was found immune and the fruit damage ranged from 1.74 to 53.24 per cent in tolerant to susceptible cultivar, respectively.

Pusa Purple Long and Pusa Kranti were reported as less susceptible varieties to *L. orbonalis* by Reddy *et al.* (1988) at the Regional Research Station, Raichur, Karnataka.

Shelke (1989) studied 14 brinjal genotypes for their response to *L. orbonalis* in Maharashtra. The lowest fruit damage of 3.81 per cent was recorded in variety Vaishali and Aruna while Manjari Gota (28.53%) was observed as most susceptible to the attack of *L. orbonalis*.

Das and Singh (1990) reported that none of the cultivars of brinjal was free from attack by *L. orbonalis* out of 9 aubergine cultivars tested for susceptibility to the pest. Pusa Purple Cluster was the least susceptible with 18.76 per cent infested fruits. The cultivar Muktakeshi had the highest mean number of holes per fruit.

Darekar *et al.* (1991) screened nine varieties of brinjal under field conditions in Maharashtra for resistance to *L. orbonalis* and found that the tolerant variety PBR-129-5 was attacked by *L. orbonalis* with 7.93 per cent fruit infestation while the most susceptible cultivar Manjari Gota recorded 33.00 per cent fruit infestation.

Lal (1991) screened one hybrid and 21 cultivars of aubergine under field conditions in Himachal Pradesh against *L. orbonalis* and reported the fruit infestation in the range of 9.00 to 66.33 per cent on number basis and 9.5 to 87.41 per cent on weight basis. He also recorded SM-202 as highly resistant cultivar followed by PPC, SM 17-4, PBR-129-5 and SM-202 x PPI (F_1).

Tejavathu *et al.* (1991) evaluated 38 lines of *Solanum spp.* against relative incidence of *L. orbonalis*. The minimum fruit infestation of 4.4 and 4.6 per cent was noticed in *S. gilo* on number and weight basis, respectively.

Thanki and Patel (1991) tested 12 varieties of brinjal for resistance to *L. orbonalis* and observed that the incidence of pest was highest in GB-1, Selection 1, GB-6 and Selection 4.

Patil and Ajri (1993) reported that out of 18 varieties tested, PBR129-5 recorded least fruit infestation (21.29%), however the most susceptible variety was S-258 recording 53.14 per cent fruit infestation.

Mukhopadhyay and Mandal (1994) evaluated 41 varieties of brinjal for resistance to fruit borer and observed that none of the variety was resistant to the pest. However, the varieties *viz.*, Nishchindipur local, Muktajhuri, Shyamla Dhepa, Navkrian, Kala Dhepa and Banaras long purple were tolerant to the fruit borer, while variety R-14 was highly susceptible.

Patel *et al.* (1995a) screened 28 varieties of brinjal for the resistance to insect pests. They observed that Pusa purple long, Pusa purple cluster, Junagadh long, Pusa Kranti, S-71-5-39-9, S-71-21-4-22 and Arka Kusumakar were comparatively resistant to *L. orbonalis.*

Patel *et al.* (1995b) reported that the brinjal varieties *viz.,* Chaklasi Doli, Doli-5 and Pusa purple cluster were resistant to shoot and fruit borer out of eight varieties screened against the pest.

Srinivas and Peter (1995) found that out of 18 brinjal cultivars, Arka Kusumakar, Arka Shirish and Neelam were significantly less infested by *L. orbanalis* than Early Long fellow and Nagpur Round.

Gangopadhyay *et al.* (1996) tested 27 germplasm and two wild species of brinjal for resistance against *L. orbonalis*. The S*olanum melongena* L. cultivars *viz.*, Arka Kusumakar, Nischintapur, Brinjal Long Green, Attapati, Arka Shirish, Manipur, Makra and Chikan Long were relatively resistant to the pest. Whereas, Green brinjal round, Suphal, Gourkahji, Brinjal No. 3 and Light purple round were highly susceptible. The wild type *S. macrocarpon* completely resisted shoot infestation, performing better than *S. incanum* which was known to be pest resistant.

Kumar and Sadashiva (1996) reported the incidence of *L. orbonalis* on cultivated aubergine (*S. melongena*) varieties ranged from 10 to 50 per cent.

Lowest incidence of 12.5 per cent in brinjal entry BB 49 was reported by Mishra and Mishra (1996).

Kumar *et al.* (1997) reported that out of 40 brinjal accessions, Pusa purple cluster and BB-13 were resistant to fruit borer, while Plant Samrat, KT-4, BB-26, PB-29, PB-34, Composite-2, NDBH-7, NDB-25, Pusa hybrid-5, PB-38, PB-39, PB-41, PB-42, PB-44 and ARBH-527 were tolerant to the pest.

Sharma *et al.* (1998) evaluated eight cultivars of brinjal for response to *L. orbonalis*. None of the cultivars was absolutely tolerant to the pest, based on fruit infestation on number and weight basis, the cultivars *viz.*, Arka Kusumakar and Pusa purple cluster were ranked as tolerant, while cultivars Muktakeshi and

BR-112 were susceptible. Pusa Kranti, Pusa purple long, Pusa purple round and Neelam round were highly susceptible.

Mathur and Upadhyay (1999) suggested preferring varieties viz. Pusa Kranti, PPC, H-4, A-11 and Arka Kusumakar as these varieties proved resistant to brinjal shoot and fruiting borer.

Panda (1999) screened 174 cultivars of brinjal for resistance to *L. orbonalis* under field condition. He reported that none of the brinjal entries was immune to larval attack. The maximum fruit damage recorded between 76-121 and 99-114 DAT in susceptible and resistant cultivars, respectively. Thus, early fruiting varieties were found to be more liable to fruit attack by *L. orbonalis*.

Chaudhary and Sharma (2000) evaluated nine genotypes of brinjal *viz*., Arka Keshav, Arka Neelakanth, Hisar Shyamal, Pusa Purple Cluster, Pusa Purple Long, SM 6-6, SM 6-7, Arka Nidhi and Punjab Barsati. They reported that the incidence of fruit borer in these varieties varied from 2.88 (Arka Keshav) to 5.64 (SM 6-6) per cent.

Awasthi (2000) screened 12 brinjal genotypes against *L. orbonalis*. The brinjal genotype Nurki and CH-150-16-4-1 recorded significantly lowest fruit damage.

Krishna *et al.* (2001) reported the maximum fruit infestation in cv. Ramy Round Purple (39.5 to 42.82%), while the minimum infestation in cv. SM-202 (22.15 to 22.78%) on number basis.

Sridhar *et al.* (2001) conducted trial at IIHR Research Centre, Aiginia, Bhubaneswar (Orissa). None of the cultivated or wild species of brinjal was found immune to the pest. Three wild species of brinjal *viz. Solanum khasianum, S. viarum* and *S. incanum* were found to be resistant with fruit infestation ranging from 0.5 to 10.00 per cent.

Naresh *et al.* (2001) studied performance of nine local aubergine lines (Selection-1 to 9). Among the lines, Selection-6 was the most susceptible to fruit borer (26.97% damage), whereas, Selection-9 was resistant (12.12% damage).

Kumar and Shukla (2002) studied the varietal preference of *L. orbonalis* on 12 aubergine cultivars. They found that the average percentage of infestation from all pickings ranged from 33.65 to 53.02 per cent among cultivars. Pusa purple round showed the lowest per cent of infestation (33.65) which was on par with 6 other cultivars, *viz.*, MHB-2 (36.53%), Pusa purple long (37.7%), Eggolester (37.46%), Jhumka (41.04%), F-1 hybrid (41.15%) and MHB-3 (41.85%). The local cultivar recorded the highest per cent of infestation (53.02 %).

Doshi *et al.* (2002) reported that varieties Aruna and Manjari Gota had 18.66 and 18.80 per cent borer infestation respectively, showing fairly resistant reaction against *L. orbonalis*.

Jat and Pareek (2003) evaluated 10 aubergine cultivars for resistance to *L. orbonalis*. Arka Kusumakar (18.33%) and SM-10 (20.23%) showed lowest fruit infestation and were found to be resistant to shoot and fruit infestation while Neelam long (30.72%) and Pusa Purple Long (31.60%) were moderately susceptible to fruit borer. Greatest fruit infestation of 46.51per cent was reported in Pusa Purple Round.

Yadav *et al.* (2003) screened 10 aubergine cultivars for their resistance against the shoot and fruit borer and observed that the cultivars, Pusa Purple Cluster, Pusa Kranti, Pusa Purple Long, Neelum Long, Black Beauty and BR-112 were least susceptible, Pusa purple round was susceptible and the local variety Krishna and Kanahya were highly susceptible.

Senapati (2003) conducted a field trial in West Bengal, India to investigate the susceptibility of 12 aubugine cultivars to

L. orbonalis. The lowest percentages of fruit infestation (16.24%) on weight basis and (27.4%) on number basis were recorded in Shyamal and Milky white, respectively. The highest percentage of fruit infestation by weight (45.67%) and number (40.13%) was recorded in KB-13.

Mandal *et al.* (2005) screened 31 brinjal cultivars to the attack of *L. orbonalis*. They found that none of the cultivars was resistant. Only three cultivars *viz.*, BBS-103, BB-112 and Pusa Purple Cluster were detected as moderately resistant, recording 11.28, 12.98 and 13.33 per cent fruit damage on number basis and 12.3, 13.36 and 13.86 per cent on weight basis, respectively.

Yadav and Sharma (2005) evaluated 11 aubergine cultivars for their resistance to fruit borer. Brinjal green long, Selection Puja and Pusa purple long were found relatively less susceptible (<25% infestation), followed by Pusa hybrid-5, Pusa kranti, Koikila, Pusa Upkar and Aarti as moderately susceptible (25-35% infestation), Nakiran, Pusa uttam and Pusa hybrid-6 were susceptible (>35% infestation).

Elanchezhyan *et al.* (2008) conducted a field experiment to study the response of cultivar/hybrids/germplasm of brinjal to *L. orbonalis* and recorded the lowest per cent fruit damage in hybrid Sweta 8.7 and 7.2 per cent on number and weight basis, respectively. However, Bejo Sheetal was found most susceptible variety recording fruit infestation 48.4 % (on number basis) and 45.5 % (on weight basis).

Gupta and Kauntey (2008) reported the per cent fruit infestation in the range of 24.38 to 65.05 per cent. The variety PPC recorded minimum per cent fruit infestation of 24.38 per cent while maximum infested fruits 65.05 per cent were recorded in variety Punjab Chamkila.

Naqvi *et al.* (2009) registered per cent fruit infestation in the range of 14.3 to 45.8 per cent. Out of Thirteen cultivars of brinjal Arka Kesar recorded minimum fruit damage of 14.3 per cent while Udaipur Local emerged as most susceptibe having 45.8 per cent fruit damage.

According to Chandrashekhar *et al.* (2009) the resistant genotype HLB-12 exhibited significantly ($p \leq 0.05$) less fruit damage (29%) by shoot and fruit borer than the highly susceptible genotypes (42.00 to 61.50%).

Javed *et al.* (2011) evaluated different aubergine cultivars against brinjal shoot and fruit borer (*L. orbonalis*) at National Agriculture Research Centre, Islamabad during 2007-08 and 2008-09. The results reflected different levels of infestation in all cultivars by the pest. Cultivar Neelam showed maximum fruit infestation (58.60 and 48.09%) followed by Black long (47.93 and 33.31%), while minimum was observed in Nirala with 24.75 and 21.57% fruit infestation during 2007-08 and 2008-09, respectively.

2.2.3 Yield of marketable fruits

Among the various pests infesting brinjal *Leucinodes orbonalis* Guenee is most destructive one and the yield losses by this pest have been reported to the extent of 20.70 % in Delhi (Peswani and Lal, 1964), 70% in Andhra Pradesh (Krishnaiah and Vijay, 1975), 43% in Himachal Pradesh (Lal *et al.*, 1976) 48% and 56% in Maharashtra (Mote, 1981; Datar and Ashtaputre, 1984), 13.28 to 88.89 % in Haryana (Naresh, *et al.,* 1986; Malik *et al.*, 1986), 67 % in Bangladesh (Islam and Karim, 1991), and 20.70 % to 88.70 % in various parts of India (Raju *et al.,* 2007).

Sharma *et al.* (1985) studied inter relationship and path analysis for yield and susceptibility to shoot and fruit borer in brinjal. They found negative correlation between infestation of the pest and yield of fruits per plant.

The performance of 39 brinjal entries in relation to *L. orbonalis* infestation was assessed by Dhankar and Sharma (1986) and recorded a mean total yield of 1.26 kg per plant, of which 45.69 per cent was infested due to the pest. The total yield per plant ranged from 0.450 to 1.97 kg and the level of infestation was in the range of 29.58 to 60.90 per cent of total yield.

Raju *et al.* (1987) found that susceptible cultivar among eight varieties yielded only 6.28 tonnes per hectare while tolerant cultivar (SM-204) yielded 18.40 tonnes per hectare.

Negative correlation of fruit yield with level of infestation was reported by Shelke (1989) during evaluation of 14 aubergine varieties against *L. orbonalis*.

Least susceptible varieties *viz.* Pusa Kranti and Aruna yielded high 326.94 and 257.50 q/ha, respectively whereas susceptible variety Manjari Gota recorded less yield of marketable fruits 207.22 q/ha (More, 1991).

Twelve brinjal varieties were studied by Thanki and Patel (1991) for the infestation of *L. orbonalis*. It was observed that most tolerant variety to shoot and fruit borer attack was Selection-4 and yielded highest (328.60 q/ha), while the susceptible variety was noticed to yield 124.30 q/ha.

Patil and Ajri (1993) studied the performance of 18 brinjal entries in relation to shoot and fruit borer. It was found that the level of incidence of shoot and fruit borer and yield per plant had a strong negative correlation. The highest yield of 2.92 kg per plant was noticed in tolerant variety as against 0.71 kg per plant in susceptible cultivar.

According to Ghosh and Senapati (2001) the F1 hybrids PK-123 and Pant yielded high (33.54 and 32.64 tonnes/ha, respectively) along with least susceptibility to *L.orbonalis*.

Doshi *et al.* (2002) reported the variety Aruna and Manjari Gota had yield of 2.03 and 2.06 kg plant^{-1}, respectively.

Prabhu *et al.* (2009) studied the performance of interspecific progenies of brinjal (*S. melongena*). They reported that the cross EP 65 x *S. viarum* showed less fruit borer infestation (8.87%) with high yield (2.49 kg plant^{-1}) however, the cross CO2 x *S. viarum* showed more fruit borer infestation (19.05%) with low yield (1.89 kg plant^{-1}). Among the parents, MDU recorded highest marketable yield (2.13 kg plant^{-1}) and low level of infestation (22.20%) as compared to CO2 recording low yield (1.90 kg marketable fruits plant^{-1}) and high level of infestation (32.20%).

Haseeb *et al.* (2009) estimated the losses caused by brinjal shoot and fruit borer, *L. orbonalis* and results revealed that the yield losses by this pest ranged 0.74 to 8.14 q/ha.

2.3 Effect of brinjal entries on larval and post-larval development of *L. orbonalis*

In order to understand the suitability of the host plant to the pest and to know whether any antibiosis is involved, it is necessary to rear the pest and study its larval and post-larval development.

Panda and Das (1975) studied the effect of ten brinjal varieties on the larval and post-larval development of brinjal shoot and fruit borer. The survival of the borer larvae and the weight gained by them on both shoots and fruits were significantly lower in resistance varieties as compared to susceptible ones. The growth index in general was higher in susceptible than the resistant varieties. Similarly, the pupal weights and pupal periods were significantly lower in resistant varieties than those in the susceptible ones. Even the emergence of moth was higher in susceptible varieties than in the resistant ones.

Isahaque and Chaudhari (1984b) studied the larval development of brinjal shoot and fruit borer on 10 varieties of brinjal. They recorded fastest larval growth and development on Bhola Bengena, Bobengena and Powal Bengena and slowest on Kuchia and Pusa Purple Cluster. The larval period was shortest and larval weight was greatest on varieties with higher protein content.

Raju *et al.* (1987) studied the effect of eight brinjal varieties and found that and more larval and pupal period accompanied by less larval and pupal weight was noticed in moderately resistance variety SM-206 as compared to the susceptible varieties. No mortality of either larvae or pupae was noticed on any variety.

Patil (1990) developed a technique for mass rearing of brinjal shoot and fruit borer on natural as well as semi-synthetic diet. For effective rearing of the pest the basal semi-synthetic diet consisting of Kabuli gram flour, yeast, ascorbic acid, sorbic acid, methyl parahydroxybenzoate, formaldehyde, agar and water was modified by using black gram floor instead of Kabuli gram floor, fortified with Wesson's salt mixture, vitamins of B group and offered in rectangular cut pieces for the rearing of *L. orbonalis* larvae.

To overcome the seasonal barriers and accelerate the rate progress of research Talekar *et al.* (1999) from AVRDC, Taiwan developed a procedure for rearing *Leucinodes* in laboratory throughout the year. They fortified an artificial diet used for rearing *Helicoverpa* with 10 per cent brinjal fruit powder. To rear the pest successfully the fraction of fruit powder always maintain at the level of 10 per cent.

Singh and Singh (2001) studied the biology of brinjal shoot and fruit borer and reported that the weight of full grown larva ranged from 0.0415 to 0.0827 g and weight of pupa 0.0290 to 0.0566 g.

Srinivasan *et al.* (2005) studied eggplant shoot and fruit borer larval development on artificial diet fortified with egg plant powder from resistant and susceptible varieties. They found that the pupation was significantly less in insects fed on the diet fortified with shoots of the resistance accessions and conclude that shoots in the resistance accessions may have certain antibiotic principles, which adversely affect feeding and development of *L. orbonalis*.

From the foregoing literature, it could be seen that not much work on the larval and post-larval development of *L. orbonalis* on artificial diet fortified with brinjal shoot and fruit powder has been carried out. Potential exists for further use of this technique in greater understanding of mechanism of resistance hence the present investigation was proposed and conducted.

2.4 Association of biophysical attributes with resistance to *L. orbonalis*

Biophysical attributes are known to provide resistance against the pest and vast literature is available on this aspect of host plant resistance. However, published work related to present investigation is presented here.

2.4.1 Studies on characters influencing shoot infestation

2.4.1a Trichome density

Panda and Das (1974) studied ovipositional preference of shoot and fruit borer and observed that dense hairs (980 to 1503/cm^2) on lower surface of leaf were unsuitable for oviposition and for newly hatched larvae to reach the boring site.

Importance of leaf hairs in host plant resistance is affirmed by many workers; according to Mote (1981) resistant varieties of brinjal has large number of hairs on lower surface of leaf. Isahque and Choudhari (1984a) also confirmed that less susceptible varieties had more number of hairs on plant. According to Duffey (1986), leaf hairs in *Solanum spp.* play important role in defense against insects.

Kale *et al.* (1986a) reported that wild types and resistant varieties were of dense pubescent type, having comparatively more number of trichomes.

Shelke (1989) observed that high density of leaf hairs (44.80 per microscopic field) present on resistant variety Vaishali than ABV_4 which had fewer hairs (32.00 per microscopic field) and showed a greater susceptibility. He found negative correlation between infestation and number of hairs on leaf surface.

More hairyness of leaf in resistant variety *viz.* Doli-5 (406.73), PPC (345.94) and Junagarh Long (331.43) were reported by (Jyani *et al.*, 1995)

Naqvi *et al.* (2008) studied leaf morphology of different brinjal varieties and recorded trichome density in the range of 1068.5 to 550.8 per cm^2. The maximum trichome density (1068.5/ cm^2) was found in Pusa Purple Round, followed by Arka Sheel (1019.6/ cm^2), Bikaner Local (990.4/ cm^2) and Arka Nidhi (954.9/ cm^2). The minimum trichome density (550.8/ cm^2) was recorded on Arka Kesar, followed by Udaypur Local (740.7/ cm^2) and IC-112358 (760.3/ cm^2). They also found that trichome density was negatively correlated with leafhopper population while results did not exhibit any relationship between trichome density and whitefly incidence.

2.4.1b Shoot thickness

Among the various characters studied Panda *et al.* (1971) found that shoot thickness was positively correlated with the infestation of pest.

Isahaque and Chaudhary (1984a) reported that resistant variety 'Kuchia' had more lignified and compact shoots with less diameter and plant height 89.3 cm as compared to susceptible variety 'Bhola Bengana' which had less lignified and compact shoots with more diameter and average plant height of 76.8 cm.

According to Malik *et al.* (1986) varieties with thin shoots were more tolerant to the pest. The thickness of shoot ranged from 0.29 to 0.57 cm in tolerant to susceptible types respectively. A positive correlation was found with shoot thickness and pest attack.

Patil and Ajri (1993) reported more shoot thickness (0.59 cm) in susceptible brinjal entry S-258 than that in least susceptible entry PBR-129-5 (0.28 cm).

Jat and Pareek (2003) reported that the shoot of less susceptible cultivars had more lignified hypodermis with compact vascular bundles and narrow shoot pith.

Positive correlation of shoot thickness with fruit infestation was reported by Hazra *et al.*, (2004) and Ahmad *et al.*, (2009).

Naqvi *et al.* (2009) conducted studies to see the effect of biophysical and anatomical characters of plants on the infestation by shoot and fruit borer on different Brinjal cultivars. They observed that plant height had no effect on shoot borer infestation, while diameter of shoot pith had positive significant correlation. Anatomical characters of shoots in different varieties of brinjal showed that less susceptible varieties like Pusa Purple Long and Pusa Purple Cluster had more lignified tissues with compact vascular bundles.

Javed *et al.* (2011) found very strong and negative correlation between fruit infestation and leaf trichomes, stem thickness and stem hair density with $r = -0.821$, $r = -0.819$ and $r = -0.807$, respectively.

2.4.2 Studies on pedicel and calyx characters of brinjal entries associated with infestation of *L. orbonalis*

Since the moths of fruit borer prefer to lay eggs on the calyx of the fruit, varieties with more calyx length and girth would be expected to provide more space for egg laying and thus prove susceptible to fruit borer.

Panda *et al.* (1971) reported that loose calyx helped the young borer to get easily into the fruit through the soft tissue below the calyx.

Kale *et al.* (1986a) reported that wild genotypes and resistant cultivars had compact and short calyx. According to Malik *et al.* (1986) less susceptible lines had comparatively less calyx length and diameter.

Patil and Ajri (1993) observed that the entries with longer calyx and with more calyx girth were susceptible to attack of *L. orbonalis*. They found positive and weak correlation of calyx length with susceptibility (r = 0.506) but calyx girth and susceptibility had strong and positive correlation (r = 0.775). They recorded pedicel length in the range of 3.57 to 5.96 cm and found strong and positive correlation of pedicel length (r = 0.888) with susceptibility.

Panda (1999) found that varieties having fruits with loose calyx were more susceptible to fruit borer than those having fruits with tight calyx.

Asati *et al.* (2004) found that infestation was positively correlated with calyx diameter, number of holes per plant/fruit and number of larvae per fruit. Larvae number per fruit was positively correlated with calyx diameter and number of holes per fruit.

2.4.3 Studies on fruit characters of brinjal entries associated with infestation of *L. orbonalis*

Pradhan (1969) reported that varieties having long narrow fruits were less susceptible to fruit borer infestation.

Lal *et al.* (1976) reported that the fruit colour had no impact on the degree of infestation.

Dooria and Chadha (1981) found that brinjal varieties bearing long fruits were less attacked by fruit borer than round fruited variety.

Subbaratanam (1982) evaluated 18 common cultivars of brinjal for resistance to the shoot and fruit borer. He observed that the diameter of pericarp (r = 0.535) and mesocarp (r = 0.538) were positively correlated with degree of fruit borer damage. The varieties with less diameter of pericarp (0.67 to 0.28 cm) and mesocarp (1.73 to 3.17 cm) were less infested (12.2 to 21.1 per cent damaged fruits), while the varieties with wider pericarp (1.41 to 1.72 cm) and mesocarp (3.38 to 5.74 cm) showed higher fruit borer damage. The author also reported that varieties with long fruits had less infestation of fruit borer. The varieties with round fruit were found to be more susceptible. However, varieties with oblong fruits did not show clear indication.

Tambe (1984) observed that there was a positive correlation between girth of fruit and borer infestation.

Isahaque and Chaudhari (1984a) observed that out of 10 brinjal varieties screened against fruit borer, the varieties having round, oblong and oval fruits were more susceptible.

Sharma *et al.* (1985) studied interrelationship and path analysis for susceptibility to *L. orbonalis* incidence and found a positive correlation between infestation and fruit diameter however negative correlation was found between fruit length and infestation.

Malik *et al.* (1986) observed negative correlation of fruit length with *L. orbonalis* incidence. Among 39 varieties tested, a less prone variety to borer had fruit length of 9.48 cm and the susceptible had 18.45 cm. However diameter of fruit was positively correlated with infestation of the pest. They also found that fruit colour had no role in plant resistance against the pest.

Mishra *et al.* (1988) tested 49 varieties of brinjal for resistance to *L. orbonalis* and found that the fruit damage ranged from 1.74 per cent in the long fruited Katrain-4 to 53.24 per cent in the round fruited variety T-3. The tightly arranged seeds in the mesocarp, thick skin of the fruit and closely packed vascular bundles in the pulp were found to be the possible causes of resistance in long fruited varieties. They further reported that the long fruited varieties *viz.*, S-5 and PSL were susceptible despite of having the same characters.

Shelke (1989) concluded that long fruited varieties were more tolerant to the attack of shoot and fruit borer than the varieties with lower fruit length. However, varieties with higher fruit diameter like Manjari Gota and ABV_4 were more susceptible to *L. orbonalis* attack than varieties with less fruit diameter as in Aruna and Vaishali. Shoot and fruit borer damage was negatively correlated with the fruit length and positively correlated with diameter of fruit.

Patil and Ajri (1993) worked out relationship of certain biophysical characters in 18 brinjal entries to incidence of shoot and fruit borer. They observed that length of fruit showed non significant negative correlation indicating longer fruits as susceptible to the pest at lesser extent. The diameter of fruit showed good positive correlation with susceptibility to shoot and fruit borer indicating long narrow fruits less infested by the pest.

Grewal *et al.* (1995) attributed resistance of cv. SM 17-4, PPC and Brinjal Green Long to oblong or extra longer fruits with narrow pericarp. The least susceptible varieties had narrow pericarp and 'oblong' or 'extra longish' fruits with green, purple or light purple colour, in additional to long peripheral seed-ring and less seedless area. The other characters studied like fruit length, diameter, shape index, size index, thickness of mesocarp had no significant effect in imparting resistance to the borer.

Gangopadhyay *et al.* (1996) screened 27 germplasms and two wild species of brinjal and reported that resistance was not conferred by any single character like spinyness, shape and size of fruits or arrangement of seeds.

Kumar *et al.* (1997) evaluated 40 brinjal accessions for resistance to *L. orbonalis*. Based on simple correlations assuming non-damaged fruit number (%) and non-damaged fruit weight (%) as the dependent variables, fruit diameter, fruit weight and fruit volume were effective for selection for resistance/tolerance. The size of fruit was negatively correlated to borer resistance, it is suggested to select for fruit number rather than size to simultaneously increase yield and resistance.

Behera *et al.* (1998) observed that the diameter of fruit was positively correlated with infested fruit yield, number of holes and larvae per fruit at genotypic level which indicated that round/oblong fruits were more affected by borer attack. The positive correlation of infested yield and infested fruits per plant with total yield was mainly due to its direct effect via diameter of fruit.

According to Panda (1999) long fruits increased the resistance of fruits to attack by *L. orbonalis*.

Ghosh and Senapati (2001) concluded that the PK-123 and pant cultivars of brinjal were least susceptible to *L. orbonalis* due to their relatively tough skin, hard to semi hard pulp and tight to semi tight arrangement of seeds, whereas pusa purple long and pundiburi were most susceptible cultivars due to there narrow, long fruits, soft fruit skin and pulp and loosely arranged seeds.

Shukla *et al.* (2001) reported that the plant characters like fruit length, fruit diameter, plant height and number of exit holes per fruit were insignificant to establish any relationship. However, path analysis established their direct and indirect effect on fruit damage. Among them fruit diameter showed maximum direct and number of fruits maximum indirect effect via calyx diameter with values of 1.977 and 0.383, respectively, whereas, via fruit diameter had maximum indirect negative effect (-1.638).

Sridhar *et al.* (2001) observed that the genotypes with relatively long fruits and tightly arranged seeds were less attacked by *L. orbonalis*.

Jat and Pareek (2003) reported that the light green coloured fruits were not preferred by the borer. The cultivars having narrow pericarp and mesocarp with compact seedlings and closely arranged seeds in mesocarp were less infested.

Yadav and Sharma (2005) screened 11 varieties of brinjal for their resistance against shoot and fruit borer. They found that the varieties exhibited differential response of damage by the pest. The possible reasons of higher susceptibility in Navkiran, Pusa Uttam and Pusa Hybrid-6 might be due to the round shape of the fruit, less number of seeds and smooth fruit surface. The variety Brinjal Green long was less susceptible perhaps due to its green colour, long shape of fruits and hard fruit surface. The varieties Selection Puja and Pusa Purple Long were comparatively less susceptible might be due to their hard fruit surface, long shape of fruits and more number of seeds.

Gupta and Kauntey (2008) studied fruit characters in relation to brinjal shoot and fruit borer, *L. orbonalis* revealed that the thickness of pericarp of fruit varied from 4.18 to 9.56 mm. The varieties with broader pericarp included Gulabi Dorla (9.56 mm) and PBR 91-2 (8.56 mm). The varieties PPL, Green Long, PPC and SM 17-4 fell in narrow pericarp range (6.0 mm). It was observed that varieties with narrow pericarp were less susceptible to the pest (damage 34.00 per cent). There was no linear correlation found between length and diameter of fruit and degree of infestation however, they reported that varieties with round fruits were more susceptible to the infestation of borers.

According to Chandrashekhar *et al.* (2009) correlation of thickness of pericarp (r=0.80) and mesocarp (r=0.70) with resistance were positive and significant, while the effect of fruit length was non-significant with the incidence of shoot and fruit borer.

Naqvi *et al.* (2009) conducted studies to know the effect of biophysical and anatomical characters of plants on the infestation by shoot and fruit borer on different Brinjal cultivars. They revealed that the shape and colour had no clear cut impact on the preference of fruit borer, whereas, length of fruit had significant negative correlation with fruit borer infestation. They also found that the fruit diameter had significant positive correlation with fruit borer infestation. Significant positive correlation was also found between per cent fruit infestation and thickness of pericarp and mesocarp. The increase in size of pericarp and mesocarp enhanced the fruit infestation. The varieties having compact seed rings with closely arranged seeds in mesocarp had low degree of fruit infestation, whereas, highly susceptible varieties neither had compact seed rings nor closely arranged seeds in the mesoarp.

2.5 Association of biochemical attributes with resistance to *L. orbonalis*

Biochemical constituents of the plant are known to confer in built resistance against the pests and diseases and there is voluminous literature available on this aspect of host plant resistance. However, the literature related to important biochemical attributes studied during present investigation presented here.

Panda and Das (1975) observed that higher silica and crude fiber in the shoots of resistant varieties. They also observed that higher ash and less sugar in resistant varieties. Resistant varieties had about 20 per cent ash in fruits while susceptible varieties recorded 11.8 per cent.

Ishaque and Chaudhari (1984b) reported that out of 10 varieties of brinjal screened against *L. orbonalis*, varieties having high amount of sugar and protein were the most susceptible. They found only 3.00 per cent proteins and 3.04 per cent total sugars in resistant variety 'Kuchia' and 4.27 per cent proteins and 5.62 per cent total sugars in susceptible variety 'Bhola Bengana'.

Kale *et al.* (1986b) reported that the moisture, crude protein and ascorbic acid content of the shoots were not associated with the resistance. Whereas immune wild type highly resistant varieties have high silica and crude fibre contents in the shoots as compared to others.

Chadha and Sidhu (1987) observed that Sada Bahar Baigan variety was more tolerant of boring insects and had a high DM content (8.67%) with low phenol and anthocyanin contents. They also found that Punjab Barsati variety of brinjal exhibited 14.4 per cent damage due to fruit borer and had a low concentration of anthocyanin, total phenols and glycoalkalloids.

Raju *et al.* (1987) found less protein content, determined in the form of total nitrogen in fruits of moderately resistant variety

SM-204 than that in the susceptible check SM-82. He also estimated contents of P, K, Ca, Mg, Fe, Zn, Mn and copper in fruits of different brinjal varieties. There was positive correlation (r = 0.725) between Zn content and fruit damage, but the relationship between other mineral constituents of fruits and the fruit damage was not significant. He further observed a strong and negative correlation (r = -0.939) between total phenol content of fruits and damage by fruit borer. The moderately resistant variety SM-204 recorded higher amount of total phenols (0.056%) than the susceptible variety SM-66 (0.025%).

Bajaj *et al.* (1989) analyzed eighteen varieties of egg plant. On an average, the long types were having higher dry matter, crude protein, chlorophyll and phenolic content, while round types had higher polyphenol oxidase activity and glycoalkaloids content. It was suggested that glycoalkaloids in association with phenolic compounds in SM-17-4 might be responsible for resistance to attack by *L. orbonalis*.

Darekar *et al.* (1991) screened the egg plant cultivars for resistance to shoot and fruit borer. Studies were also carried out regarding chemical constituents in the fruits in relation to the percentage fruit infestation due to fruit borer, *L. orbonalis*. The biochemical characters such as total sugars and free amino acids were positively correlated with fruit infestation while polyphenols were negatively correlated with fruit borer infestation.

Biochemical analysis of 18 brinjal entries was carried out by Patil *et al.* (1994). A significant variation in moisture, ash, crude protein, crude fibre, silica, crude fat and sugars was observed in fruits and shoots of brinjal cultivars. Among the cultivars studied, the fruits of susceptible S-258 contained the maximum amount of moistuer (89.80%), crude protein (22.35%) and sugars (42.83%). However, the same cultivar showed minimum amount of crude fibre (11.16%) and ash (5.89%). He found that, among the biochemical attributes moisture (r= 0.878), crude protein (r= 0.796) and total sugar (r= 0.891) have strong and positive correlation while polyphenols (r= - 0.706), crude fat (r= - 0.813), crude fibre (r= - 0.722), ash (r= - 0.889) and silica (r= - 0.912) content observed negatively correlated with infestation of *L. orbonalis*. A wide variation in some of the proximate composition indicates further scope for breeding of brinjal cultivars with improved nutritional composition.

Dighe *et al.* (1997) analyzed mature fruits of 57 promising brinjal genotypes for various chemical constituents. Different brinjal genotypes recorded wide variation in chemical composition. Dry matter ranged from 6.6 to 8.8 %, crude protein6.6 to 8.8 %, crude fibre 6.8 to 16.2 %, total sugars 7.2 to 27.1 %, ash 3.8 to 9.6 %, and total phenolics 0.4 to 2.0 % on dry weight basis.

Panda (1999) reported that fruit borer infestation was restricted by low percentages of moisture, nitrogen and potassium and high phosphorus content.

Girish *et al.* (2001) observed that the susceptible species had higher protein content in the epicarp and proteinoplasts present in the mescorp cells, whereas the resistant species had low protein content in the epicarp and proteinoplasts were not detected in the mesocarp.

Ranjan and Chakrabarti (2002) reported that PPL, Pusa Kranti and PPC had 43.35, 51.65 and 60.95 mg total phenol contents, respectively on 20 days after fruit set.

Jat and Pareek (2003) found that the biochemical characters such as total sugars, free amino acids and crude protein were positively correlated with fruit infestation, while total phenols had negative correlation.

Asati *et al.* (2004) noticed that borer infestation percentage was negatively correlated with total phenol content.

Hazra *et al.* (2004) reported that the total phenol content of fruit was markedly and negatively correlated with susceptibility to borer attack. He also found that lower moisture, sugar and protein contents in the fruits associated with less susceptibility to the infestation by shoot and fruit borer.

Chandrashekhar *et al.* (2009) revealed that among phytochemicals in fruits, moisture (r = 0.84), crude protein (r = 0.68) and nitrogen (r = 0.69) contents manifested positive and significant correlation, while total sugars (r = -0.67), fibre (r = -0.76), tannin (r = -0.85) and phenol (r = -0.80) contents showed significantly negative correlation with per cent fruit infestation. Among mineral constituents potassium and magnesium showed negative effects on the incidence of shoot and fruit borer.

Elanchezhyan *et al.* (2009) estimated biochemical constituents from leaf samples of five genotypes and reported that genotype Sweta (resistant) recorded highest ash content (12.3 %) and total phenols (7.6 mg/g) and lowest moisture content (78.4 %) and total sugars (5.8 mg/g) while Bejo Sheetal (highly susceptible), recorded the lowest ash content (10.1 %) and total phenols (1.9 mg/g) and highest moisture content (89.2 %) and total sugars (18 mg/g).

Seven cultivars of eggplant were sampled for peroxidase (PO), polyphenoloxidase (PPO) activity and phenol content by Bhattacharya *et al.* (2009). Stepwise multiple regression analysis revealed that there was a lack of correlation between fruit infestation and PO activity. However, a correlation between fruit infestation, PPO activity and phenol content was observed. Principal components analysis indicated that BCB-38 was the best performing cultivar and can likely be used as improved genetic material in future breeding programs.

Prabhu *et al.*, (2009) observed the different levels of biochemical constituents namely peroxidase, polyphenoloxidase, total phenols, and solasodine contents in genotypes derived from inter-specific crosses and their parents. A higher level of polyphenoloxidase activity was observed in interspecific cross F6 EP65 x *S. viarum*. There was a clear correlation between the levels of biochemical constituents and shoot and fruit borer incidence. The study showed that biochemical parameters responsible for the resistance but showed as well the development of superior genotypes with resistance to shoot and fruit borer.

Khorsheduzzaman *et al.* (2010) observed that the shoot and fruit of less susceptible varieties had the higher amount of poly phenol oxidase (PPO), Phenylalanine ammonium lyase (PAL) and lignin and lower amount of reducing sugar. Significant negative correlation was found between per cent infestation with PPO, PAL and lignin content, whereas it was positively correlated with reducing sugar content. Among biochemical constituents, PPO, PAL and lignin contents were negatively correlated with reducing sugar, but PPO was positively correlated with PAL and lignin content and vice versa.

2.6 Path coefficient analysis

Pest infestation is a complex phenomenon as different physico-chemical attributes of host plant influence on pest infestation during host finding, host recognition and host suitablility by the pest. Correlation coefficient provides measure of association between any pair of character. The direct and indirect effect of the different mechanisms of host plant resistant are however, not revealed by this study. Path coefficient analysis developed by Wright (1921) helps in partitioning the correlation coefficient into direct and indirect effects, thereby providing relative importance of each of the causal factors. This will provide precise information for the selection of important physico-chemical traits which may contribute more towards resistance to shoot and fruit borer.

Kumar and Ram (1998) studied path analysis for shoot and fruit borer resistance in brinjal and reported that fruit size components; namely, fruit diameter, fruit weight and fruit volume were effective indirect negative selection criteria for improving resistance to shoot and fruit borer.

Association of different biochemical characters and direct as well as indirect effects of these characters on shoot and fruit bore infestation were studied by Doshi *et al.* (1999). The estimates of direct and indirect effects of biochemical traits on shoot and fruit borer infestation revealed that the total soluble sugar, reducing sugars and anthocyanin content had high positive and direct effect except anthocyanin content which had high indirect effect *via* total soluble sugars. On the other hand, total phenols, polyphenol oxidase activity and glycoalkaloids content had a high negative direct effect on shoot and fruit borer infestation. They suggested that the genotypes having high phenols, glycoalkaloids and polyphenol oxidase activity and lower in total soluble sugars and anthocyanin contents should be utilized in breeding programme for the development of shoot and fruit borer resistant variety.

Hossain *et al.* (2002) studied path coefficient analysis of plant characters influencing brinjal shoot and fruit borer infestation and reported that stem diameter has high positive direct effect (0.9385) on brinjal shoot and fruit borer infestation and also its indirect effects *via* other characters was also high it indicated that stem diameter should be considered while correlating with other characters like plant height, number of leaf per plant, 3rd leaf length and width.

Prabhu (2008) studies path coefficient analysis and reported that the characters like branches per plant, earliness, fruit girth, fruit number per plant and mean fruit weight exerted positive direct effect on marketable yield per plant. The characters like plant height, fruit length and fruit borer infestation exerted negative direct effect. Study on correlations and path coefficient analysis in general revealed that characters like branches per plant, fruit girth, number of fruits per plant and mean fruit weight are of great importance and must be considered in selection programme with the present set of materials for improvement of yield potential in eggplant.

The field experiment was conducted to identify shoot and leaf characteristics of brinjal plants for their susceptibility/resistance against brinjal shoot and fruit borer infestation (Ahmed *et al.*, 2009). The estimated correlation coefficients among shoot infestation caused by BSFB and tested leaf and shoot characters were partitioned into direct and indirect effects by path coefficient analysis. The direct effect of plant height and stem diameter, number of leaves plant^{-1} and third leaf width against shoot infestation caused by BSFB were positive (0.396,0.248, 0.059 and 0.393 respectively) and higher in magnitude at 1% level of significance. The direct effect of number of branches plant^{-1} and third leaf length against shoot infestation were negative (-0.082 and -0.067 respectively) and lower in magnitude at 5% level of significance. They also reported that that the higher plant height, stem diameter, third leaf width and more number of leaves increased infestation of BSFB. On the other hand, higher number of branches plant^{-1} reduced infestation because it may be reduced stem diameter.

3. MATERIAL AND METHODS

The details of materials used and methods employed for the present investigation entitled, "Physico-chemical mechanisms of resistance to *Leucinodes orbonalis* Guenee in brinjal" are presented hereunder with appropriate headings and sub-headings.

3.1 Field screening of brinjal genotypes against shoot and fruit borer

A statistically designed field experiments with randomized block design, were laid out to study the response of twenty brinjal genotypes obtained from the germplasm collection of the center of All India Co-ordinated Vegetable Improvement Project, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar (Maharashtra). These were selected on the basis of their diverse morphological characters, fruit size and shape, colour of the fruit, yield and consumers' preference. All these genotypes were assigned code numbers. The details of their phenotypic characteristics are presented in Table 1.

3.1.1 Experimental site

Field experiment was conducted on the field of All India Co-ordinate Vegetable Improvement Project, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar (Maharashtra) during *Kharif* 2010 and *Rabi* 2011-12. The site selected was uniform with typical medium black cotton soil.

3.1.2 Details of the field experiment

Both the trials were laid out in a randomized block design with twenty treatments and three replications (Plate 1 and 2). The details of the experiment are as given below;

i)	Design	:	Randomized Block Design
ii)	No. of Treatments	:	Twenty
iii)	No. of Replications	:	Three
iv)	Spacing	:	90 x 60 cm
v)	Plot size	:	3.6 x 3.6 m
vi)	No of plants/plot	:	15
vii)	Type of layout for transplanting	:	Ridges and furrows
viii)	Date of sowing	:	*Kharif* - 26/06/2010 *Rabi* - 13/08/2011
ix)	Date of transplanting	:	*Kharif* - 17/08/2010 *Rabi* - 27/09/2011
x)	Treatment details	:	Following brinjal entries were tested

1.	RHRB-20	11.	RHRB-60
2.	RHRB-7	12.	RHRB-42
3.	RHRB-37	13.	RHRB-73
4.	RHRB-21	14.	RHRB-74
5.	RHRB-35	15.	RHRB-75
6.	RHRB-28	16.	RHRB-79
7.	RHRB-11	17.	RHRB-67
8.	RHRB-34	18.	RHRB-68
9.	RHRB-12	19.	RHRB-69
10.	RHRB-53	20.	RHRB-70

After transplanting in main field, normal recommended agronomical practices were adopted; the intercultural operations as well as fertilizer application were done as per the university recommendations. Protective irrigations were given after cessation of rains. No control measures were adopted against any insect pest in order to screen the genotypes for their resistance and susceptibility against brinjal shoot and fruit borer, *L. orbonalis* under field conditions.

Table 1: Phenotypic characteristics of the brinjal genotypes used for study

Sr. No.	Name of the genotype	Growth habit	Stem colour	Leaf Colour	Fruiting habit	Flower colour	Fruit		
							Colour	Shape	Spinyness
1.	RHRB-20	Semi spreading	Purplish-green Non-spiny	Green	Solitary	Purple corolla with green calyx	Light green	Round	Non-spiny
2.	RHRB-7	Erect	Greenish Non-spiny	Green	Solitary	Purplish white with green calyx	Light green with white stripes	Long	Spiny
3.	RHRB-37	Spreading	Purplish green Non-spiny	Green with purple veins	Clustering	Purple corolla with green calyx	Purple	Oval	Non-spiny
4.	RHRB-21	Semi spreading	Green Non-spiny	Green	Solitary	Light purple with green calyx	Light green	Round	Non-spiny
5.	RHRB-35	Erect	Green with spines	Green with spines	Clustering	Light purple corolla with green and spiny calyx	Green with white stripes at tip end	Oval	Spiny

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Table 1 (contd…)

Sr. No.	**Name of the genotype**	**Growth habit**	**Stem colour**	**Leaf colour**	**Fruiting habit**	**Flower colour**	**Fruit**		
							Colour	**Shape**	**Spinyness**
6.	RHRB-28	Semi spreading	Green Non-spiny	Green	Solitary	White corolla with green calyx	White	Round with 4-5 ridges	Non-spiny
7.	RHRB-11	Erect	Green with spines	Green with spines	Solitary	Purple corolla with green and spiny calyx	Dark purple with white stripes	Round	Spiny
8.	RHRB-34	Spreading	Green Non-spiny	Green	Clustering	Light purple corolla with green and calyx	Light green with milky white stripes at end	Oval	Non-spiny
9.	RHRB-12	Spreading	Greenish with spines and hairs	Dark green with whitish green veins and spines	Solitary	Pinkish white corolla with green and spiny calyx	Greenish purple with white and green stripes	Small Round	Spiny
10.	RHRB-53	Spreading	Green with spines	Green with spines	Solitary	Purple corolla with green and calyx	Purple with white stripes	Oval	Spiny

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Table 1 (contd…)

Sr. No.	Name of the genotype	Growth habit	Stem colour	Leaf colour	Fruiting habit	Flower colour	Fruit		
							Colour	Shape	Spinyness
11.	RHRB-60	Erect	Green Non-spiny	Green Non-spiny	Solitary	Pinkish corolla with green and calyx	Light green	Long	Non-spiny
12.	RHRB-42	Semi spreading	Greenish with spines and hairs	Green with spines	Solitary	Pinkish white corolla with green and spiny calyx	Purple with white stripes	Round	spiny
13.	RHRB-73	Spreading	Purple Non-spiny	Purplish green Non-spiny	Solitary	Purple corolla and purple calyx	Purple	Oval	Non-spiny
14.	RHRB-74	Erect	Greenish-purple Non-spiny	Green with purple veins Non-spiny	Clustering	Purple corolla and purplish green calyx	Purple	Round	Non-spiny
15.	RHRB-75	Spreading	Green Non-spiny	Green Non-spiny	Solitary	Pinkish corolla with green calyx	Green	Round	Non-spiny

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Table 1 (contd…)

Sr. No.	**Name of the genotype**	**Growth habit**	**Stem colour**	**Leaf colour**	**Fruiting habit**	**Flower colour**	**Fruit**		
							Colour	**Shape**	**Spinyness**
16.	RHRB-79	Semi erect	purple Non-spiny	Green with purple veins	Solitary	Purple corolla and purplish green calyx	Green	Round	Non-spiny
17.	RHRB-67	Erect	Green Non-spiny	Green	Solitary	Purple corolla with green calyx	Light purple	Round	Non-spiny
18.	RHRB-68	Spreading	purple Non-spiny	Greenish purple	Solitary	Purple corolla and purple calyx	Dark purple	Round	Non-spiny
19.	RHRB-69	Semi erect	purple Non-spiny	Greenish purple	Clustering	Purple corolla and purple calyx	Dark purple	Oval	Non-spiny
20	RHRB-70	Spreading	Green Non-spiny	Green	Clustering	Pinkish white corolla with green calyx	Light purple	Oval	Non-spiny

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3.1.3 Method of recording observations

For the field screening of different brinjal genotypes under natural conditions, the infestation of *L. orbonalis* at vegetative growth phase and fruit bearing phase was recorded.

3.1.3a Vegetative growth phase

After transplanting at vegetative growth phase number of infested shoots from five randomly selected and tagged plants from a plot were counted as against total number of shoots per plant and per cent shoot infestation was worked out. The observations on shoot infestation were taken at 15 days interval up to the fruiting stage and mean per cent shoot infestation was calculated. After fruiting, shoot infestation was not observed and all the attack was found shifted over the fruits. Mean per cent shoot infestation of each genotype were calculated and categorized by using grades adopted by Subbaratnam and Butani (1981).

Grade	Category	Level of shoot infestation (%)
R	Total resistance	0
T	Tolerant	below 2
M	Moderately tolerant	2.1-3.0
S	Susceptible	3.1-5.0
HS	Highly susceptible	Above 5.0

3.1.3b Fruit bearing stage

At the time of harvesting, the fruits of each plot were harvested separately and numbers of healthy and infested fruits per plot were counted. At the same time weight of healthy and infested fruits were taken to work out per cent infestation on weight basis. The observations were taken at each picking of 10 days interval till 13th picking. The per cent fruit infestation was worked out on the basis of number and weight of healthy and damaged fruits collected at each picking. It was then averaged for the season. The genotypes were later graded into six categories considering per cent fruit infestation as per criterion given by Lal *et al.* (1976).

Grade	Category	Level of fruit infestation (%)
1	Immune	0
2	Highly resistant	1-10
3	Fairly resistant	11-20
4	Tolerant	21-30
5	Susceptible	31-40
6	Highly susceptible	Above 41

3.1.3c Yield of marketable fruits

Yield was recorded on weight basis from a plot of each genotype and finally average marketable fruit yield per plant was worked out.

3.2 Larval and post-larval development of *L. orbonalis* on selected brinjal entries

In order to understand the suitability of the host plant to the pest and to know whether any antibiosis is involved, it is necessary to rear the pest and study it's larval and post-larval development. For that purpose the larval and post-larval development of *L. orbonalis* was studied on artificial diet fortified with brinjal shoot and fruit powder from selected entries in order to locate the possible antibiotic principle possibly responsible for resistance.

3.2.1 Mass rearing of *L. orbonalis*

A mass culture of *L. orbonalis* was maintained in the laboratory on brinjal slices. The technique of rearing and handling of larvae and adults of the pest was done as per the method given by Taley *et al.* (1984) and Patil (1990). Rearing of larvae was done at ambient temperature (25-27^{0}C) with 70 to 85 per cent relative humidity in the rearing room of Department of Entomology, MPKV, Rahuri.

The damaged fruits of brinjal collected from the university farm and cultivators field were cut open to obtain the caterpillars. The individual larvae were reared in specimen tubes of 4 x 5 cm size (Plate 3). Proper sanitary conditions were maintained to avoid contamination of fungi and other pathogen by daily cleaning and repeated sterilization of glass wares and plastic wares with 0.1 % sodium hypochlorite in the laboratory. The grooved folded papers were kept for pupation. The pupae were also obtained by placing the infested fruits on sand inside the rearing cage (Plate 4); the larvae inside the fruits after completion of growth came out and pupate in the sand below the fruits. Two days after pupation the pupae become hard and tanned. These pupae were collected and transferred to oviposition chamber (Plate 5). The newly emerged adult moths in cages were fed with honey solution (5%). For this purpose a cotton swab was soaked in honey solution (5%) containing 0.01 g sorbic acid and 0.02 g Methyl *p*-hydroxyl benzoate per 100 ml to control mould growth on swab. The swab with honey based adult diet was suspended inside the cage with the help of thread. A twig of brinjal plant was kept in each cage for oviposition every day (Plate 5). Eggs were kept in the plastic jar for incubation covering with muslin cloth and fixed with rubber band.

3.2.2 Development of semi-synthetic diet for rearing *L. orbonalis* larvae

Initially, the semi-synthetic diet developed for *L. orbonalis* by Patil (1990) was used as a basal diet for the rearing of larvae. The diet was modified by adding 10 per cent brinjal fruit powder as per method suggested by Talekar *et al.* (1999). Finally, a semi-synthetic diet comprising the following ingredients was found most suitable for growth and development of *L. orbonalis* larvae.

The composition of diet used for the present investigation is given in table 2.

Table 2. Composition of diet used for rearing *L. orbonalis*

Sr. No.	Ingredients	Quantity (g/1000ml)
1.	Brinjal powder	100
2.	Black gram flour	40
3.	Yeast	13
4.	Ascorbic acid	4.3
5.	Sorbic acid	1.2
6.	Methyl *p* hydroxyl benzoate	2.6
7.	Wesson's salt mixture	5.0
8.	Agar	17
9.	Formaldehyde solution 10 % (ml)	2.6
10.	Vitamin Solution (ml)	10
11.	Distilled Water (ml)	1000

3.2.2a Method of diet preparation

All the ingredients except vitamin solution, formaldehyde and agar were blended in 600 ml of distilled water for a minute. Agar was dissolved in 400 ml of boiling water and this solution was mixed in with the other ingredients in the blender. The mixture was again blended for one minute for proper mixing of ingredients in the agar solution. Finally, vitamin solution and formaldehyde were added and the mixture was again blended for one minute. Diet prepared in this way was kept for conditioning in an incubator at ambient temperature for 48 hr. and then preserved in freezer. It was later used when required (Plate 6).

3.2.3 Study of larval and post-larval development of *L. orbonalis* on diet fortified with fruit powder of selected brinjal entries

For this experiment the pest was reared at room temperature in the laboratory on semi-synthetic diet fortified with 10 per cent brinjal fruit powder of corresponding brinjal entries as described earlier.

Following genotypes were selected for studies on growth and development of the pest on diet fortified with fruit powder of corresponding genotypes in laboratory.

Sr. No.	Genotype	Infestation (%)	Category
T_1	RHRB-20	8.94	Highly resistant
T_2	RHRB-28	9.54	Highly resistant
T_3	RHRB-37	15.81	Fairly resistant
T_4	RHRB-12	19.95	Fairly resistant
T_5	RHRB-11	30.29	Susceptible
T_6	RHRB-42	34.03	Susceptible
T_7	RHRB-53	42.50	Highly susceptible
T_8	RHRB-7	44.67	Highly susceptible

Twenty 1st instar larvae, constituting a replication were released on such diets and their growth and development, including mortality was monitored daily until the larvae have pupated and adults emerged (Srinivasan *et al.*, 2005). There were three replications. The rectangular slices of diet were cut out and used for rearing (Plate 6 and 7). These slices were kept on blotting paper in the plastic vials. The slices were changed from time to time till pupation. The newly emerged adults from the rearing of different entries were released into the glass jar with their tops (open end) covered with muslin cloth. The swab with honey based adult diet was suspended inside the cage with the help of thread and a twings of brinjal plant was kept in each jar for oviposition.

Three such sets for each entry were arranged for this study. The individual female moths obtained from rearing of different entries were allowed to mate with their respective male partner in the jar. In each set one male and two females were released. From the second night of emergence until the fourth night, the female moths were allowed to lay eggs on twigs. The total number of eggs laid during the three consecutive nights was recorded.

Following observations were taken in order to study the effect of various genotypes on the larval and post-larval development of brinjal shoot and fruit borer, *L. orbonalis*.

3.2.3a Larval period

It is the average period in days from hatching to pupation of a larva. It was calculated by adding the time taken by each larva to pupate and dividing the same by the total number of larvae.

3.2.3b Per cent pupation

It was calculated by multiplying the number of larvae pupated by hundred and dividing the same by total number of newly hatched larvae released at the time of setting the experiment.

3.2.3c Pupal period

It is the average time taken from pupation to emergence of adults. It was calculated by adding the number of days taken by each pupa to become an adult and dividing the same by total number of pupae.

3.2.3d Pupal weight

Newly formed pupa was light brown in colour and covered with light brown cocoon. The fifth and sixth segment of pupa was marked dorsally with two pairs of blood red coloured dots. Later on, pupa turned dark brown. The weight of such dark brown pupae was recorded and averages worked out.

3.2.3e Per cent moth emergence

The total number of adults emerged from the pupae were counted. The per cent emergence was calculated in relation to the number of larvae released at the time of setting experiment.

3.2.3f Growth index

It was calculated by dividing the percentage of adults emerged by the average number of days taken by the larvae to become adult.

3.2.3g Fecundity

It was calculated by counting the total number of eggs laid by all the females and dividing by number of females laying eggs.

3.2.3h Adult longevity

It is the average period in days from emergence to death of an adult moth. It was calculated by adding the time taken by each male or female moth from emergence to death and dividing the same by the total number of males or females.

A) Male:

It measures an average 10.35 mm in length and 19.18 mm in breath across the wings. Antennae are shorter than the female. The abdomen is cylindrical and provided with numerous brown and white hairs at the last two segments.

B) Female:

The female is bigger in size than the male. It measures on an average 15.42 mm in breath across the wings. The antennae are long and situated at the apex of the head. Eyes are dark and prominent. Forewings are white and marked with brown red and black markings. Hind wings are white and marked with black brown and black specks at the upper angle of the cell. Abdomen is white grey, swollen in the middle and marked with tuft of white dark brown hairs at the intersegmental portion. Legs are pale grey.

3.3 Biophysical attributes of brinjal entries associated with resistance to shoot and fruit borer

3.3.1 Characters influencing shoot infestation

3.3.1a Trichome density

The trichomes were counted from the lower side of brinjal leaves when the plants were attracted to ovipositing female moths during shoot infestation stage of the plants. Leaf samples of these brinjal plants were taken from the apical region of the plant. Trichome density was worked out as per the method suggested by Naqvi *et al.* (2008).

A) Sample preparation for microscopic observations of trichomes

Leaf segments of about 1 cm^2 were heated in 20 ml water in small glass vials (7.5 cm x 2 cm) for 15 minutes in an oven at 85^0C. The water was drained out and 20 ml of 95 per cent ethyl alcohol was added and heated for 15 minutes. The process was repeated till the chlorophyll was completely removed from the leaves and the trichomes present on the leaves on leaf lamina and veins were made clearly visible. Such leaf pieces were mounted on a glass slide and covered with a cover slip after adding a drop of lactic acid on it and observed under binocular microscope. Counts of trichomes were taken on randomly selected microscopic field of 1mm x 5 mm size and trichome density per cm^2 was worked out.

3.3.1b Shoot thickness

Five randomly selected shoots per plant were taken for measuring their girth at 2.5 cm below the tip and averages were calculated. A vernier caliper was used for this purpose.

3.3.2 Pedicel and calyx characters associated with fruit infestation

3.3.2a Length of pedicel

Pedicel lengths of five randomly selected fruits per plant per genotype were measured with the help scale from point of attachment to the base of calyx.

3.3.2b Length of calyx

The same fruit taken for measuring the length of pedicel were used to measure length of calyx. The length of calyx was measured in centimeters with the help of scale from the base of calyx up to the tip.

3.3.3 Fruit characters associated with fruit infestation

3.3.3a Length of fruit

At the time of harvesting, five mature fruits of average size from each genotype were selected in three replications and Lengths of fruits were measured in cm with the help of standard scale and average per replication was worked out (Naqvi *et al.*, 2009).

3.3.3b Diameter of fruit

Diameter of above mentioned fruit was measured in centimeters at the centre with the help of vernier caliper and average was worked out for each genotype.

3.3.3c Thickness of pericarp

At the time of harvesting, five mature fruits of average size from each genotype were cut horizontally and the pericarp thickness was measured with the help of scale.

3.3.3d Colour of the fruit

The colour of fruits was observed visually and cultivars were grouped into green, light green, purple, light purple, dark purple, purple fruits with white stripes, greenish fruits with white strips and white in different cultivars. The colour of the fruit from each of brinjal cultivar was then related with degree of fruit borer infestation.

3.3.3e Shape of the fruit

The shape of fruits was observed visually and varieties were grouped into small sized round, round, oval and long slender categories. The shape of the fruit was then related with degree of borer infestation.

3.4 Biochemical attributes of brinjal entries associated with resistance to shoot and fruit borer

Biochemical constituents in twenty different entries studies in order to know if there was any significant differences in chemical composition.

3.4.1 Chemicals

Most of the chemicals used in this investigation were analytical grade. They were obtained from M/S Glaxo Laboratories, Mumbai and M/S Merck (India), Mumbai.

3.4.2 Methods

3.4.2a Growing of the plants and collection of sample

The samples were collected from earlier described field experiment wherein all the twenty entries were raised in the field under uniform conditions in three replications. The uninfested healthy plants were used. The analysis of shoots and fruits was carried out at Department of Biochemistry, Mahatma Phule Krishi Vidhyapeeth, Rahuri. Green samples of healthy apical shoots were collected between 9 and 11 a.m. on clear sunlight morning. The leaves were clipped off and remaining shoots portion was taken. Similarly samples of edible size healthy brinjal fruits of the same physiological age were picked when the plants were four months old. All the samples were collected at the same time. The portions of shoot and fruit samples were completely dried at 60^0C and stored at 4^0C until used for analysis. Each sample was analyzed in triplicate for total sugars, crude proteins, crude fat polyphenols, ash and crude fibres and mean values were worked out.

3.4.2b Preparation of samples for analysis

The dried shoots and fruits were powdered separately in Multiplex grinding mill so as to pass through 60 mesh sieve. The powdered material was used for different estimations. A portion of the powdered material was defatted using carbon tetrachloride. The analysis of both shoots and fruits was undertaken separately.

3.4.3 Chemical composition

The biochemical contents were estimated on per cent basis according to the standard A.O.A.C. (1975) procedures, with some modifications. The biochemical attributes *viz.* moisture content, total sugar, crude protein, crude fat, polyphenols, ash, crude fibre and activities of polyphenol oxidase and peroxidase enzymes from different brinjal entries were studied.

3.4.3a Moisture

Ten grams of green samples each of healthy shoots and fruits were accurately weighed and dried in oven at 100^0 C for 24 hours. After cooling in desiccator they were weighed. Drying was continued for one more hour and samples were weighed again. The drying and weighing were repeated until constant weight was obtained. The loss in weight was recorded as moisture content.

3.4.3b Ash

Well mixed samples weighing 5 g each were taken into pre-weighed silica crucibles. The latter were ignited in muffle furnace at 550^{0}C (dull red) until light gray ash resulted. After cooling in desiccators to room temperature, crucibles were weighed. The loss in weight was recorded and ash content was calculated.

3.4.3c Crude Proteins

The work was carried out at Department of Agricultural Chemistry and Soil Science, MPKV, Rahuri. Total proteins were estimated by the Micro-kjeldhal method.

I. Reagents

a) NaOH 40 per cent: NaOH 400 g was dissolved in one litre of distilled water.

b) NaOH 0.02 N: NaOH pellets 800 mg were dissolved in distilled water and final volume was made to one litre.

c) H_2SO_4 0.02 N: Concentrated sulphuric acid 0.56 ml specific gravity 1.84 was slowly added to 500 ml of distilled water and final volume was made one liter.

d) Methyl red indicator: one gram of methyl red was dissolved in 100 ml of 95 per cent ethyl alcohol.

e) Hydrogen peroxide

II. Procedure

a) Digestion

Oven dried brinjal sample of 0.2 g was digested by 5 ml of H_2SO_4 solution. Then the final volume was made to 100 ml.

b) Distillation and titration

Ten ml of the above solution was transferred to distillation flask and 10 ml of 40 per cent NaOH solution was added. Ammonia evolved was collected in 10 ml of 0.02 N H_2SO_4 solution to which two to three drops of methyl red indicator were added. It was then titrated with 0.02 N NaOH solution and the percentage of nitrogen was calculated (Ranganna, 1977). Protein content was calculated by multiplying N percentage by a factor of 6.25.

3.4.3d Crude fat

The crude fat content was determined by ether extraction using Soxhlet Appararus (A.O.A.C., 1975).

I. Reagent

Petroleum ether having boiling point 40-60 ^{0}C.

II. Procedure

Five grams of powdered sample was accurately weighed. The sample was transferred to thimble. The thimble was plugged with cotton and placed in extraction flask of the Soxhlet apparatus. Sufficient quantity of petroleum ether was taken in preweighted dry collection flask and assembly was connected to tap water. The flask was heated and the temperature was regulated at 60 ^{0}C. The extraction was continued till 5 to 6 siphonings. It was ensured that very little quantity of ether was present in the contents of the flask. The flask was then disconnected and the flask was dried in oven. The difference in initial and final weight of the flask was used to calculate the crude fat content of the sample.

III. Calculation

$$\%\ \text{crude fat} = \frac{\text{Weight of Soxhlet flask with oil} - \text{Weight of empty Soxhlet flask}}{\text{Weight of the sample}} \times 100$$

3.4.3e Crude fibre

I. Principle

During acid and subsequent alkali treatment, oxidative hydrolytic degradation of the native cellulose and considerable degradation of lignin occur. The residue obtained after final filtration is weighed, incinerated, cooled and weighed again. The loss in weight gives the crude fiber content.

II. Material

a) A Sulphuric acid solution (0.255 ±0.005N): 1.25g concentrated sulphuric acid diluted to 100 ml (concentration must be checked by titration)

b) A Sodium hydroxide solution (0.313 ±0.005N): 1.25g sodium hydroxide in 100 ml distilled water (concentration must be checked by titration with standard acid)

III. Procedure

Residue left in the filter paper after the ether extract was used for determination of crude fibre (Motiramani and Wankhede, 1971).

Two grams of ether extracted sample of each genotype was transferred to 400 ml beaker. Then it was boiled with 200 ml of sulphuric acid for 30 min with bumping chips. After 30 minutes, boiling was stopped and all the contents were filtered through muslin and washed with boiling water until washing are no longer acidic. Again transferred back the entire residue from the cloth to original beaker and again boiled with 200 ml of sodium hydroxide solution for 30min. Again filtered through muslin cloth again and wash with 25 ml of boiling 1.25% H_2SO_4, three 50 ml portions of water and 25 ml alcohol to remove the residue.

Finally, residues were washed once with 95 % alcohol and once with ether. Then, whole of the residues were transferred to a clean dry crucibles which was previously weighted (W_1). Residues were dried in the oven at 100^{0}C to constant weight. Cooling was done in desiccator and weighted (W_2). Then residues were completely till white or grayish white ash obtained and weighted (W_3). The difference in the two weights represented the weight of crude fibre.

IV. Calculation

$$\% \text{ crude fibre} = \frac{\text{Loss in weight on ignition } (W_2 - W_1) - (W_3 - W_1)}{\text{Weight of the sample}} \times 100$$

3.4.3f Total soluble sugar

Total soluble sugar was determined as per method given by Dubois *et al.* (1956).

I. Reagent

a) 80% ethyl alcohol (ethanol): 800 ml of ethanol was mixed in water to mix up to 1 lit solution.

b) 5 % phenol: 5 g of phenol dissolved in water to make up 100 ml solution.

c) 96 % sulphuric acid (v/v)

d) Glucose (w/v) standard (stock = 1000 mg/1000 ml)

II. Procedure

Defatted dried fruit sample of 500 mg was weighed and 25 to 30 ml of hot 80 % ethanol was added in the boiling tube and shaking was given on a vertex mixture. Material was allowed to settle for 20 to 30 min. all the material was then filtered into a beaker through a Whatman No. 41 filter paper. Extract was kept in a hot water bath until the ethanol evaporated, then about 10 ml water was added and dissolved contents were transferred into a 100 ml volumetric flask. The contents were washed 2 to 3 times and then added to volumetric flask by making it up to 100 ml with water.

One ml aliquat from above contents and 1 ml water as blank was taken in a test tube and 1 ml of 5 % phenol was assed and shaking was given vigorously on a vertex mixture and allowed to cool in water. Absorbance of golden yellow colour was measured at 490 nm against the blank. Standard was then run with different concentrations (i.e. 10, 20, 30, 40 and 50 mg of glucose standard). Per cent total soluble sugar was calculated with the help of standard graph.

3.4.3g Total phenols

Total phenols from brinjal shoots and fruits were determined by method given by Bray and Thorpe (1954).

I. Materials

Alcohol extracted brinjal samples, pipettes, test tubes, water bath, and spectrophotometer

II. Reagents

1. Folin-ciocalteu reagent ‘ready to use’ reagent (2.0 normal)
2. 20 % Sodium carbonate
3. Tannic acid solution

III. Method

One ml of plant extract (alcohol evaporated after extraction with 80 % alcohol) was pipetted out into a test tube, 1 ml of folin ciocalteu reagent followed by 2 ml of Na_2CO_3 solution was added. Shakings were given to the tubes with automatic shaker and heated in a boiling water bath for exactly 1 min. after boiling, solutions were allowed to cool and diluted the blue solution to 100 ml with distilled water and absorbance was measured at 650 nm in a spectrophotometer. A blank containing all the reagents (without plant extract) was used to adjust the absorbance to Zero. A standard graph was prepared by plotting absorbance v/s tannic acid concentration (0.2, 0.3, 0.4 and 0.5) with the help of a standard graph; per cent total phenols were calculated.

3.4.3h Enzyme activities

The peroxidase and polyphenoloxidase activities from the shoot and fruits of different brinjal genotypes under study were accessed by the method described by Kumar and Khan (1982).

A) Peroxidase activity

I. Reagents

a) 0.1 M Phosphate buffer (pH 7.0): It was prepared by mixing 47.8 ml of 0.2 M NaH_2PO_4. $2H_2O$ solution and 76.3 ml 0.2 M Na_2HPO_4. $2H_2O$ the pH was adjusted to 7.0 and final volume was made to 250 ml.

b) Pyrogallol reagent (0.01M): It was prepared fresh by dissolving o.126 g of pyrogallol in 100 ml of distilled water.

c) Hydrogen Peroxide solution (0.005 M): 103 µl of 30 % (v/v) hydrogen peroxide was pipette in a 100 ml volumetric flask and the volume was made with distilled water. From this stock solution (1 M), 0.5 ml was pipette in 100 ml volumetric flask and the volume was made with distilled water. This solution had the concentration of 0.005 M. the solution was prepared freshly at the time of experiment.

II. Procedure

A known quantity (0.5 g) of sample was macerated separately with 6 ml of 0.1 M phosphate buffer in prechilled mortar and pistle. The homogenate was centrifuged at 15,000 x g at 4 ^{0}C for 30 min. One ml supernatant was diluted to 10 ml with distilled water and was used as the enzyme source. The assay mixture of peroxidase contained 3.6 ml of 0.1 M phosphate buffer (pH 7.0), 1 ml of 0.005 M hydrogen peroxide, 1 ml of 0.01 M pyrogallol and 1 ml of well diluted enzyme extract. The absorbance was read at 420 nm on a Spectronic- 20 spectrophotometer for every 30 sec. upto 3 min. and reaction was stopped by adding 2.5 N H_2SO_4 exactly after 3 min.

One unit of peroxidase activity was expressed as change in O.D. by 0.1/min/g fresh weight of tissue.

B) Polyphenoloxidase activity

I. Reagents

a) 0.1 M phosphate buffer (pH 7.0): It was prepared by mixing 47.8 ml of 0.2 M NaH_2PO_4. $2H_2O$ solution and 76.3 ml 0.2 M Na_2HPO_4. $2H_2O$ the pH was adjusted to 7.0 and final volume was made to 250 ml.

b) Pyrogallol reagent (0.01M): It was prepared fresh by dissolving o.126 g of pyrogallol in 100 ml of distilled water.

II. Procedure

The enzyme extract was prepared as described under the assay of peroxidase and was used as the enzyme source. The assay mixture of polyphenoloxidase contained 2 ml of 0.1 M phosphate buffer (pH 7.0), 1 ml of 0.01 M pyrogallol and 1 ml of well diluted enzyme extract. The absorbance was read at 420 nm on a Spectronic- 20 spectrophotometer for every 30 sec. and reaction was stopped exactly after 3 min.

One unit of enzyme activity was calculated as change in O.D. by 0.1/min/g fresh weight of sample.

3.5 Statistical analysis

Statistical analysis after appropriate transformation of data was undertaken as per Gomez and Gomez (1976). Data from field experiments were analyzed by Randomized Block Design (RBD), while the data from laboratory studies were analyzed by Completely Randomized Design (CRD).

3.6 Correlation studies

The correlation studies were undertaken to find out the correlation of the morphological as well as biochemical attributes with shoot and fruit infestation. The coefficient of correlation was worked out by equation;

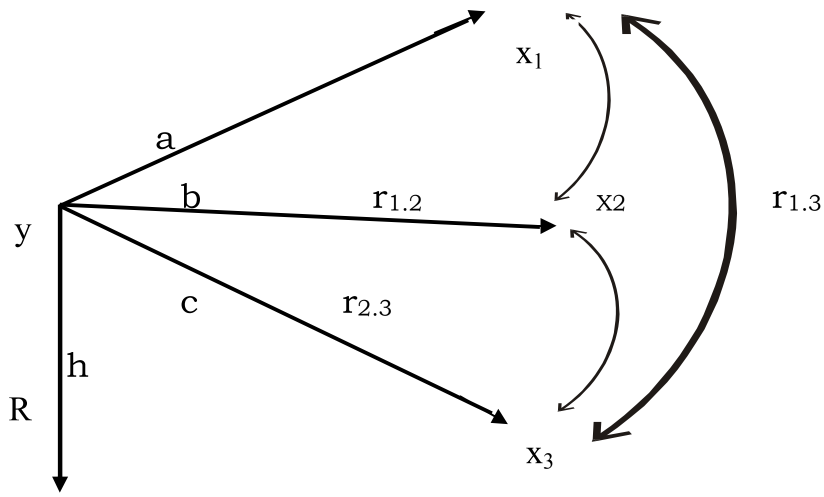
$$R = \frac{\sum xy}{\sqrt{\sum x^2 \times \sum y^2}}$$

The per cent infestation was taken as dependent factor (x) and the morphological and biochemical attributes were taken as independent factor (y). To work out correlation co-efficient morphological factors of vegetative phase were taken as 'y' and shoot infestation as 'x' and morphological factors at bearing stage were taken as 'y' and fruit infestation taken as 'x'. In biochemical factors, the different ingredients from the chemical composition of shoot was taken as 'y' and per cent infestation of shoot was taken an 'x', and the ingredients of chemical composition of fruit were taken as 'y' and per cent infested fruit was taken as 'x'.

3.7 Path coefficient analysis

To establish a cause and effect relationship, the correlation coefficients were partitioned in direct and indirect effect by path analysis.

The concept behind this is that various morphological and biochemical characters like x_1, x_2, x_3 associated with degree of pest infestation then these characters show following type of association with one another.



From this figure, it is obvious that pest infestation is the result of x_1, x_2 and x_3 and some other undefined factors designated by 'R'. The double arrowed lines indicate mutual association as measured by correlation coefficients and the single arrowed line represented direct influence as measured by path coefficients Pij.

Path coefficients were obtained by solving a set of simultaneous equation of the form,

$r_{ny} = P_{ny} + r_{n2} + 4n_2P_y + 4n_3 + \ldots\ldots$

Where,

r_{ny} = Represented correlation between one component and pest infestation

P_{ny} = Represented path coefficient between one component and pest infestation

r_{n2} = Represented correlation between that character and each of the other characters in turn

Matrix A

$$\begin{bmatrix} r_{1y} \\ r_{2y} \\ r_{ny} \end{bmatrix}$$

Matrix B

$$\begin{bmatrix} 1 & r_{1.2} & r_{1.3} \ldots\ldots\ldots\ldots\ldots\ r_{1n} \\ r_{2.1} & 1 & r_{2.3} \ldots\ldots\ldots\ldots\ r_{2n} \\ r_{n1} & r_{n2} & r_{n3} \ldots\ldots\ldots\ldots\ldots 1 \end{bmatrix}$$

Where,

$r_{1.2}$ = $r_{1.2}$ and so on

r_{1y} = Correlation between one component character and pest infestation

The 'B' matrix (P_{ij}) were obtained as

$(P_{ij}) = A \times (B^{-1})$

The indirect effect of a particular character through other characters was obtained by multiplication of direct path and particular correlation coefficients between these characters separately.

Indirect effect = $r_{ij} \times P_{ij}$

Where,

i = 1 to 6

j = 1 to 6

P_{ij} = P_1Y_1, P_2Y_2, ----P_nY_n

Path coefficient (P_{ij}), correlation coefficient (r_{ij}) and residual factor (s) were diagrammatically presented.

The residual factors i.e. variation in pest infestation unaccounted for by these association was calculated from the following formula,

Residual factor (x) = $1 - R^2$

Where,

$R^2 = P_{1y}r_{1y} + P_{2y}r_{2y} + P_{3y}r_{3y}\ldots\ldots + P_{ny}r_{ny}$

Where,

$P_{1y}, P_{2y}\ldots\ldots P_{ny}$ = Path values

$r_{1y}, r_{2y}\ldots\ldots r_{ny}$ = Correlation coefficients

4. EXPERIMENTAL FINDINGS

Brinjal, (*Solanum melongena* Linnaeus) is an important solanaceous vegetable crop cultivated worldwide. The shoot and fruit borer, *Leucinodes orbonalis* Guenee is a ubiquitous pest of the crop causing heavy losses. Farmers use large quantities of chemical insecticides singly or in combination to get blemish free fruits, this practice of indiscriminate use of pesticides pose several problems. The best alternative to manage this pest is the use of resistant varieties which can provide in-built mechanism of protection against the pest. The present investigation was carried out to screen different brinjal genotypes to locate the source of resistance; to study larval development on different genotypes and to study biophysical and biochemical attributes of different genotypes in relation to resistance and susceptibility.

The numerical data, so obtained through observations on various aspects, were subjected to statistical analysis wherever necessary and the compiled mean data are tabulated in the following pages. Findings, so obtained, are presented aspect wise hereunder.

4.1 Field screening of brinjal genotypes for their reaction to brinjal shoot and fruit borer, *Leucinodes orbonalis* Guen. in *Kharif* and *Rabi* season

Twenty brinjal genotypes were screened in the field under natural conditions during *Kharif* and *Rabi* seasons. The infestation of *L. orbonalis* at vegetative growth and bearing phase was recorded. The data obtained during the findings are described here under.

4.1.1 Per cent shoot infestation of *L. orbonalis*

The data regarding per cent shoot infestation during *Kharif* and *Rabi* season (Table 3 and Fig. 2) revealed that the per cent shoot infestation in *Kharif* season was more than *Rabi* season in all the genotypes except V_6 (RHRB-28). The per cent shoot infestation ranged from 1.60 to 11.49 per cent in *Kharif* and 0.91 to 8.77 per cent in *Rabi* season. The pooled mean of shoot infestation of both the trials ranged from 1.38 to 9.96 per cent. Significantly, minimum per cent shoot infestation (1.38 %) was registered in genotype RHRB-60. It was at par with that recorded in genotypes RHRB-20 (1.78 %), RHRB-12 (1.99 %) and RHRB-79 (2.00%). Brinjal genotype RHRB-73 recorded maximum (9.96%) per cent shoot infestation which was statistically similar with RHRB-7 (9.94%), RHRB-35 (9.48%), RHRB-42 (9.38%), RHRB 53 (8.57%) and RHRB-69 (8.52%).

To determine the relative susceptibility or tolerance against shoot infestation of brinjal shoot and fruit borer, the genotypes were categorized (Table 4 and Fig. 3) as per the scales given by Subbaratnam and Butani (1981). According to that none of the genotypes had complete resistance to shoot and fruit borer however, the genotypes RHRB-60 (1.38 %), RHRB-20 (1.78 %), RHRB-12 (1.99 %) and RHRB-79 (2.00 %) were categorized as tolerant to shoot and fruit borer as having less than 2 % infested shoots. The next promising group including moderately tolerant genotypes having shoot infestation in the range of 2.1 to 3.0 per cent included RHRB-70 (2.38 %), RHRB-28 (2.42 %), RHRB-37 (2.44 %) and RHRB-74 (2.96 %). The genotypes RHRB-21 (3.27%), RHRB-11 (3.74 %), RHRB-34 (4.07 %) and RHRB-67 (4.94 %) were found susceptible to the attack of *L. orbonalis.* However, most of the genotypes *viz.* RHRB-75, RHRB-68, RHRB-69, RHRB-53, RHRB-42, RHRB-35, RHRB-7 and RHRB-73 recording shoot infestation of 5.02, 7.05, 8.52, 8.57, 9.38, 9.48, 9.94 and 9.96 per cent, respectively found highly susceptible to the attack of *L. orbonalis.*

Table 3: Per cent shoot infestation in different genotypes of brinjal in *Kharif* and *Rabi* season

Tr. No.	Genotype	Per cent infestation		Pooled mean (%)	Grades
		Kharif	***Rabi***		
V_1	RHRB-20	2.22 (8.57)*	1.33 (6.63)	1.78 (7.66)	T
V_2	RHRB-7	11.10 (19.46)	8.77 (17.23)	9.94 (18.37)	HS
V_3	RHRB-37	2.57 (9.22)	2.32 (8.76)	2.44 (8.99)	M
V_4	RHRB-21	3.33 (10.51)	3.21 (10.32)	3.27 (10.42)	S
V_5	RHRB-35	10.57 (18.97)	8.39 (16.84)	9.48 (17.93)	HS
V_6	RHRB-28	2.39 (8.90)	2.44 (8.99)	2.42 (8.94)	M
V_7	RHRB-11	3.77 (11.20)	3.72 (11.12)	3.74 (11.16)	S
V_8	RHRB-34	4.24 (11.88)	3.90 (11.39)	4.07 (11.64)	S
V_9	RHRB-12	3.08 (10.10)	0.91 (5.47)	1.99 (8.11)	T
V_{10}	RHRB-53	9.15 (17.61)	8.00 (16.43)	8.57 (17.03)	HS
V_{11}	RHRB-60	1.60 (7.26)	1.16 (6.19)	1.38 (6.75)	T
V_{12}	RHRB-42	11.08 (19.44)	7.69 (16.10)	9.38 (17.84)	HS
V_{13}	RHRB-73	11.49 (19.82)	8.43 (16.88)	9.96 (18.40)	HS
V_{14}	RHRB-74	3.45 (10.71)	2.47 (9.05)	2.96 (9.91)	M
V_{15}	RHRB-75	5.57 (13.65)	4.47 (12.20)	5.02 (12.94)	HS
V_{16}	RHRB-79	2.55 (9.18)	1.46 (6.93)	2.00 (8.13)	T
V_{17}	RHRB-67	5.12 (13.08)	4.76 (12.60)	4.94 (12.84)	S
V_{18}	RHRB-68	8.23 (16.68)	5.87 (14.02)	7.05 (15.40)	HS
V_{19}	RHRB-69	9.42 (17.87)	7.63 (16.03)	8.52 (16.97)	HS
V_{20}	RHRB-70	2.94 (9.88)	1.82 (7.76)	2.38 (8.88)	M
	SE ±	0.83	0.75	0.50	
	CD at 5 %	2.40	2.17	1.44	
	CV %	10.88	11.23	6.94	

* Figures in the parentheses are arc sine transformed values.

Table 4: Categorization of brinjal based on level of shoot infestation

Grade	Category	Per cent infestation	Genotypes
R	Total resistance	0	--
T	Tolerant	Below 2	RHRB-60 (1.38 %) RHRB-20 (1.78 %) RHRB-12 (1.99 %) RHRB-79 (2.00 %)
M	Moderately tolerant	2.1-3.0	RHRB-70 (2.38 %) RHRB-28 (2.42 %) RHRB-37 (2.44 %) RHRB-74 (2.96 %)
S	Susceptible	3.1-5.0	RHRB-21 (3.27 %) RHRB-11 (3.74 %) RHRB-34 (4.07 %) RHRB-67 (4.94 %)
HS	Highly susceptible	Above 5.0	RHRB-75 (5.02 %) RHRB-68 (7.05 %) RHRB-69 (8.52 %) RHRB-53 (8.57 %) RHRB-42 (9.38 %) RHRB-35 (9.48 %) RHRB-7 (9.94 %) RHRB-73 (9.96 %)

4.1.2 Per cent fruit infestation of *L. orbonalis*

The fruit infestation by *L. orbonalis* was recorded at each picking on number as well as weight basis.

4.1.2.1 Number basis

The differences in per cent fruit infestation on number basis in twenty genotypes in both the seasons were statistically significant (Table 5 and Fig. 4). Mean infestation levels in *Kharif* and *Rabi* seasons expressed that all the genotypes tested had almost similar reaction during both the seasons. However, in *Kharif* screening the infestation was high, (10.61 to 46.88 %) as compared to R*abi* season (7.04 to 42.47 %).

Results of pooled analysis of both the seasons revealed that the fruit infestation ranged from 8.94 to 44.67 per cent. Genotype RHRB-20 emerged as the most promising against shoot and fruit borer which recorded lowest of 8.94 per cent fruit infestation on number basis. It was at par with genotypes RHRB-28 (9.54%), RHRB-60 (10.39%) and RHRB-79 (11.14%). Genotype RHRB-7 with 44.67 per cent fruit infestation was the most susceptible to the pest however; it was statistically similar with genotypes RHRB-53 (42.50%) and RHRB-69 (40.17%).

4.1.2.2 Weight basis

Data pertaining to per cent fruit infestation due to *L. orbonalis* on weight basis are presented in Table 6 and Fig 5. The data on *Kharif* and *Rabi* screening of genotypes expressed similar reaction although the level of fruit infestation in R*abi* was low (7.64 to 41.82 %) as compared to *Kharif* season (10.39 to 47.22 %) except RHRB-60 and RHRB-73 in which infestation was higher in *Rabi* season.

Table 5: Per cent fruit infestation (number basis) in different genotypes of brinjal in *Kharif* and *Rabi* season

Tr. No.	Genotype	Per cent infestation		Pooled mean (%)	Grades
		Kharif	***Rabi***		
V_1	RHRB-20	10.85 (19.23)*	7.04 (15.38)	8.94 (17.40)	2
V_2	RHRB-7	46.88 (43.21)	42.47 (40.67)	44.67 (41.94)	6
V_3	RHRB-37	16.18 (23.72)	15.45 (23.14)	15.81 (23.43)	3
V_4	RHRB-21	15.11 (22.88)	12.85 (21.00)	13.98 (21.96)	3
V_5	RHRB-35	33.18 (35.17)	30.24 (33.36)	31.71 (34.27)	5
V_6	RHRB-28	11.52 (19.84)	7.57 (15.97)	9.54 (17.99)	2
V_7	RHRB-11	31.56 (34.18)	29.02 (32.60)	30.29 (33.39)	5
V_8	RHRB-34	22.13 (28.06)	20.98 (27.26)	21.55 (27.66)	4
V_9	RHRB-12	21.19 (27.41)	18.72 (25.64)	19.95 (26.53)	3
V_{10}	RHRB-53	42.98 (40.96)	42.03 (40.42)	42.50 (40.69)	6
V_{11}	RHRB-60	10.61 (19.01)	10.16 (18.59)	10.39 (18.80)	3
V_{12}	RHRB-42	34.78 (36.14)	33.28 (35.23)	34.03 (35.69)	5
V_{13}	RHRB-73	34.79 (36.14)	37.26 (37.62)	36.02 (36.88)	5
V_{14}	RHRB-74	23.82 (29.21)	21.58 (27.68)	22.70 (28.45)	4
V_{15}	RHRB-75	25.24 (30.16)	21.63 (27.71)	23.44 (28.95)	4
V_{16}	RHRB-79	12.05 (20.31)	10.23 (18.65)	11.14 (19.49)	3
V_{17}	RHRB-67	30.00 (33.21)	28.22 (32.09)	29.11 (32.65)	4
V_{18}	RHRB-68	38.11 (38.12)	35.44 (36.53)	36.78 (37.33)	5
V_{19}	RHRB-69	41.25 (39.96)	39.09 (38.70)	40.17 (39.33)	6
V_{20}	RHRB-70	19.08 (25.90)	17.40 (24.66)	18.24 (25.28)	3
	SE ±	1.66	1.58	0.97	
	CD at 5 %	4.83	4.60	2.83	
	CV %	9.59	9.59	5.75	

* Figures in the parentheses are arc sine transformed values.

Table 6: Per cent fruit infestation (weight basis) in different genotypes of brinjal in *Kharif* and *Rabi* season

Tr. No.	Genotype	Per cent infestation		Pooled mean (%)	Grades
		Kharif	***Rabi***		
V_1	RHRB-20	10.39 (18.80)*	7.64 (16.04)	9.01 (17.47)	2
V_2	RHRB-7	47.22 (43.40)	41.82 (40.29)	44.52 (41.85)	6
V_3	RHRB-37	16.88 (24.26)	15.75 (23.39)	16.32 (23.83)	3
V_4	RHRB-21	15.84 (23.46)	13.75 (21.77)	14.80 (22.62)	3
V_5	RHRB-35	32.49 (34.75)	30.58 (33.57)	31.54 (34.16)	5
V_6	RHRB-28	11.08 (19.45)	8.78 (17.24)	9.93 (18.37)	2
V_7	RHRB-11	32.94 (35.02)	28.12 (32.03)	30.53 (33.54)	5
V_8	RHRB-34	21.59 (27.69)	21.24 (27.44)	21.41 (27.56)	4
V_9	RHRB-12	21.69 (27.76)	19.14 (25.94)	20.42 (26.86)	3
V_{10}	RHRB-53	43.66 (41.36)	41.23 (39.95)	42.44 (40.65)	6
V_{11}	RHRB-60	10.56 (18.96)	11.23 (19.58)	10.89 (19.27)	3
V_{12}	RHRB-42	34.76 (36.13)	32.66 (34.85)	33.71 (35.49)	5
V_{13}	RHRB-73	35.30 (36.45)	37.97 (38.04)	36.63 (37.25)	5
V_{14}	RHRB-74	24.03 (29.35)	21.31 (27.49)	22.67 (28.43)	4
V_{15}	RHRB-75	23.70 (29.13)	21.40 (27.55)	22.55 (28.35)	4
V_{16}	RHRB-79	13.12 (21.23)	10.39 (18.80)	11.75 (20.05)	3
V_{17}	RHRB-67	29.35 (32.80)	27.64 (31.72)	28.50 (32.26)	4
V_{18}	RHRB-68	38.31 (38.24)	35.53 (36.59)	36.92 (37.42)	5
V_{19}	RHRB-69	44.17 (41.65)	39.70 (39.06)	41.94 (40.36)	6
V_{20}	RHRB-70	18.20 (25.25)	16.21 (23.74)	17.20 (24.51)	3
	SE ±	1.50	1.55	0.90	
	CD at 5 %	4.37	4.50	2.63	
	CV %	8.61	9.35	5.31	

* Figures in the parentheses are arc sine transformed values.

Results of pooled analysis indicated the fruit infestation ranged from 9.01 to 44.52 per cent on weight basis. Genotype RHRB-20 was the most promising with 9.01 per cent fruit infestation on weight basis. It was at par with RHRB-28 and RHRB-60 recording 9.93 and 10.89 per cent infested fruits, respectively. Genotype RHRB-7 with 44.52 per cent fruit infestation was the most susceptible to the pest however; it was statistically at par with genotypes RHRB-53 (42.44%) and RHRB-69 (41.94%).

The various genotypes tested during the investigation were categorized according to grades given by Lal *et al.,* (1976) as presented in Table 7 and Fig 4 and 5. According to that none of the genotypes was found immune to shoot and fruit borer infestation however, the genotypes RHRB-20 and RHRB-28 were observed to be highly resistant to the attack of *L. orbonalis* recording less than 10 % fruit infestation. The next promising group of genotypes found fairly resistant (10-20 % fruit infestation) to *L. orbonalis* comprised RHRB-60, RHRB-79, RHRB-21, RHRB-37, RHRB-70 and RHRB-12. Genotypes showing fruit infestation in the range of 21 to 30 per cent were categorized in tolerant group which include RHRB-34, RHRB-74, RHRB-75 and RHRB-67. The genotypes RHRB-11, RHRB-35, RHRB-42, RHRB-73 and RHRB-68 were categorized as susceptible. The genotypes RHRB-69, RHRB-53 and RHRB-7 were observed highly susceptible to the attack of *L. orbonalis* recording more than 40 per cent fruit infestation.

4.1.3 Yield of marketable fruits per plant

The data on yield of marketable fruits per plant obtained from 13 pickings are presented in Table 8 and Fig 6. The data revealed that there were significant differences in yield of marketable fruits per plant among different genotypes in both the seasons. However, yield level in *Rabi* season was high (0.528 to

Table 7: Categorization of brinjal genotypes based on level of fruit infestation

Grade	Category/ Designation	Per cent infestation	Genotypes	
			Number basis	Weight basis
1	Immune (I)	0	--	--
2	Highly resistant (HR)	1-10	RHRB-20 (8.94 %) RHRB-28 (9.54 %)	RHRB-20 (9.01 %) RHRB-28 (9.93 %)
3	Fairly resistant (FR)	11-20	RHRB-60 (10.39 %) RHRB-79 (11.14 %) RHRB-21 (13.98 %) RHRB-37 (15.81 %) RHRB-70 (18.40 %) RHRB-12 (19.95 %)	RHRB-60 (10.89 %) RHRB-79 (11.75 %) RHRB-21 (14.80 %) RHRB-37 (16.32 %) RHRB-70 (17.20 %) RHRB-12 (20.42 %)
4	Tolerant (T)	21-30	RHRB-34 (21.55 %) RHRB-74 (22.70 %) RHRB-75 (23.44 %) RHRB-67 (29.11 %)	RHRB-34 (21.41 %) RHRB-75 (22.55 %) RHRB-74 (22.67 %) RHRB-67 (28.50 %)
5	Susceptible (S)	31-40	RHRB-11 (30.29 %) RHRB-35 (31.71 %) RHRB-42 (34.03 %) RHRB-73 (36.02 %) RHRB-68 (36.78 %)	RHRB-11 (30.53 %) RHRB-35 (31.54 %) RHRB-42 (33.71 %) RHRB-73 (36.63 %) RHRB-68 (36.92 %)
6	Highly susceptible (HS)	Above 40	RHRB-69 (40.17 %) RHRB-53 (42.50 %) RHRB-7 (44.67 %)	RHRB-69 (41.94 %) RHRB-53 (42.44 %) RHRB-7 (44.52 %)

Table 8: Yield of marketable fruits per plant obtained from different genotypes of brinjal in *Kharif* and *Rabi* season

Tr. No.	Genotype	Yield per plant (kg)		Pooled mean (kg)
		Kharif	***Rabi***	
V_1	RHRB-20	1.669	1.930	1.799
V_2	RHRB-7	0.799	1.067	0.933
V_3	RHRB-37	1.234	1.330	1.282
V_4	RHRB-21	1.966	2.163	2.064
V_5	RHRB-35	0.926	0.860	0.893
V_6	RHRB-28	1.847	1.881	1.864
V_7	RHRB-11	0.823	0.886	0.854
V_8	RHRB-34	1.318	1.253	1.285
V_9	RHRB-12	0.486	0.528	0.520
V_{10}	RHRB-53	0.656	0.682	0.669
V_{11}	RHRB-60	2.166	2.194	2.180
V_{12}	RHRB-42	0.852	0.854	0.853
V_{13}	RHRB-73	1.470	1.653	1.561
V_{14}	RHRB-74	1.720	1.664	1.692
V_{15}	RHRB-75	1.330	1.335	1.332
V_{16}	RHRB-79	1.712	1.758	1.735
V_{17}	RHRB-67	1.054	1.046	1.050
V_{18}	RHRB-68	0.988	0.959	0.974
V_{19}	RHRB-69	0.899	0.931	0.915
V_{20}	RHRB-70	1.415	1.508	1.461
	SE ±	0.05	0.07	0.05
	CD at 5 %	0.15	0.21	0.15
	CV %	6.82	9.39	6.28

2.194 kg/plant) as compared to *Kharif* (0.486 to 2.166 kg/plant) in most of the genotypes except RHRB-35, RHRB-34, and RHRB-74.

From pooled mean it was revealed that genotype RHRB-60 recorded significantly highest 2.18 kg marketable fruits per plant which was at par with that recorded in RHRB-21 (2.064 kg/plant). The lowest 0.520 kg yield per plant was registered in RHRB-12, which was statistically similar to that of recorded in RHRB-53 (0.669 kg/plant).

In general, resistant genotypes such as RHRB-20 (1.799 kg/plant), RHRB-28 (1.864 kg/plant), RHRB-60 (2.180 kg/plant) and RHRB-79 (1.735 kg/plant) recorded highest yield per plant and susceptible genotypes such as RHRB-53 (0.669 kg/plant), RHRB-35 (0.893 kg/plant), RHRB-11 (0.854 kg/plant) and RHRB-42 (0.853 kg/plant) recorded lower yield of marketable fruits per plant. However, RHRB-12 (0.520 kg/plant) showed poor performance with respect to yield though it was found fairly resistant to *L. orbonalis*. It may be due to the small size and low weight of fruits. Also RHRB-73 showed higher yield 1.561 kg/plant though it was found susceptible to *L. orbonalis*.

It is observed that most of the genotypes which recorded higher yield of marketable fruits per plant were found to be resistant or tolerant to the infestation of *L. orbonalis* whereas, low yielding genotypes were almost susceptible with some exceptions.

4.2 Larval and post-larval development of *L. orbonalis* on diet prepared from selected brinjal genotypes

In order to locate the possible antibiosis principles in brinjal fruits, an artificial diet (Patil, 1990) was fortified individually with brinjal fruit powder (Talekar *et al.,* 1999). Twenty 1st instar larvae, constituting a replication were released on such diets and their growth and development, including mortality was monitored daily until the larvae have pupated and adults emerged (Srinivasan *et al.*, 2005).

The data pertaining to larval and post-larval development on artificial diet fortified with fruit powder of selected brinjal genotypes are presented in Table 9.

4.2.1 Larval period

The data (Table 9 and Fig. 7) revealed that, the differences in larval periods recorded on different diets were statistically significant. *L. orbonalis* reared on diet fortified with fruit powder of resistant genotype RHRB-28 showed maximum larval period of 17.11 days which was at par with that observed on diets fortified with highly resistant genotype RHRB-20 (16.36 days) and fairly resistant genotype RHRB-37 (16.23 days). It was followed by diet fortified with fruit powder of genotypes RHRB- 12 (FR), RHRB- 11 (S), RHRB-7 (HS) and RHRB-53 (HS) recording larval period of 15.62, 15.30, 14.33 and 14.26, respectively in descending order. Significantly minimum period (14.12 days) was required for larval development in case of diets fortified with susceptible genotype RHRB-42. In general, descending trend of larval period was observed from resistant to susceptible genotypes.

4.2.2 Per cent pupation

The pupation on diet prepared from different genotype ranged from 51.67 to 66.67 per cent (Table 9 and Fig. 8). Higher pupation of 66.67, 65.00, 63.33 and 60.00 per cent was observed in diets made from susceptible and highly susceptible genotypes, RHRB-42, RHRB-53, RHRB-7 and RHRB-11, respectively. The diet fortified with fruit powder of genotypes RHRB-12 (FR), RHRB-37 (FR) and RHRB-20 (HR) recorded 58.33, 53.33 and 53.33 per cent pupation, respectively in descending order of their sequence.

Significantly minimum (51.67 %) pupation was observed in highly resistant genotype RHRB-28.

4.2.3 Pupal period

Pupal period was an average extended significantly in the larvae reared on diets made from highly resistant genotype RHRB-28 (10.12 days) and RHRB-20 (9.82 days). Larvae reared on diets fortified with fairly resistant genotypes also recorded higher pupal period 9.71 days (RHRB-37) and 9.39 days (RHRB-12) and comparable with that observed in diets fortified with highly resistant genotypes. However, shorter pupal periods of 8.37, 8.44 and 8.94 days were noticed in the larvae reared on the diets fortified with fruit powder of susceptible and highly susceptible genotypes RHRB-42, RHRB-53 and RHRB-7. Here, the descending trend of pupal period was observed on diet made from resistant to susceptible genotype.

4.2.4 Pupal weight

Larvae reared on diets made from highly resistant genotypes RHRB-28 and RHRB-20 recorded lowest weight of pupa 14.68 mg and 15.31 mg, respectively (Table 9 and Fig. 7). Larvae reared on diets fortified with fairly resistant genotypes also recorded lower pupal weight 16.11 mg (RHRB-37) and 16.50 mg (RHRB- 12) and comparable with that recorded on diets fortified with fruit powder of highly resistant genotypes. Highest weight gained in pupal stage was observed in larvae reared on susceptible and highly susceptible genotype RHRB-42 (20.13 mg), RHRB-53 (19.40 mg), RHRB-7 (18.80 mg) and RHRB-11 (17.23 mg). Pupal weight increased significantly from the larvae reared on diets fortified with resistant genotypes to susceptible genotypes.

Table 9: Larval and post larval development of *L. orbonalis* on diet prepared from selected brinjal entries

Tr. No.	Genotypes used in diet	Average Larval period (Days)	Per cent pupation	Average Pupal period (Days)	Average weight of pupa (mg)	Per cent moth emergence	Average fecundity/ female	Growth index	Adult longevity (Days)	
									Male	Female
T_1	RHRB-20	16.36	53.33 (46.91)	9.82	15.31	43.33 (41.17)	84.00	1.66	4.50	5.20
T_2	RHRB-28	17.11	51.67 (45.96)	10.12	14.68	41.67 (40.20)	76.89	1.53	4.22	5.13
T_3	RHRB-37	16.23	53.33 (46.91)	9.71	16.11	46.67 (43.09)	86.00	1.81	4.55	5.37
T_4	RHRB-12	15.62	58.33 (49.80)	9.39	16.50	48.33 (44.04)	91.44	1.93	4.94	5.43
T_5	RHRB-11	15.30	60.00 (50.77)	9.23	17.23	50.00 (45.00)	94.66	2.04	5.11	5.63
T_6	RHRB-42	14.12	66.67 (54.74)	8.37	20.13	58.33 (49.80)	123.33	2.59	5.56	6.33
T_7	RHRB-53	14.26	65.00 (53.73)	8.44	19.40	56.67 (48.83)	115.00	2.50	5.50	6.33
T_8	RHRB-7	14.33	63.33 (52.73)	8.94	18.80	56.67 (48.83)	112.44	2.44	5.33	5.87
	SE ± m	0.30	1.45	0.19	0.51	1.07	4.14	0.09	0.18	0.10
	CD at 1 %	1.23	6.00	0.80	2.11	4.44	17.10	0.38	0.73	0.43
	CV %	3.33	5.01	3.63	5.13	4.13	7.32	7.66	6.14	3.20

* Figures in the parentheses are arc sine transformed values.

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4.2.5 Per cent moth emergence

The data (Table 9 and Fig. 8) on average moth emergence differed significantly ranging from 41.67 to 58.33 per cent. The larvae reared on diet fortified with fruit powder of highly resistant genotype RHRB-28 recorded minimum (41.67 %) moth emergence followed by the diet containing RHRB-20 (43.33%) being at par with each other. The larvae reared on diet fortified with fairly resistant genotypes RHRB-37 and RHRB-12 recorded 46.67 and 48.33 per cent moth emergence, respectively and comparable to that recorded in highly resistant genotypes. Maximum moth emergence (58.33 %) was recorded in diet fortified with susceptible genotype RHRB-42 which was comparable with that observed in highly susceptible genotypes RHRB-53 and RHRB-7 recording 56.67 per cent moth emergence each. However, susceptible genotype RHRB-11 occupied intermediate position recording (50.00 %) moth emergence.

4.2.6 Fecundity

The data on average fecundity per female (Table 9 and Fig. 8) revealed that the pest reared on diet fortified with highly resistant genotype RHRB-28 laid less number of eggs (76.89) per female followed by diet containing highly resistant genotype RHRB-20 (84.00) and fairly resistant genotypes RHRB-37 (86.00) and RHRB-12 (91.44) which observed statistically similar. The diet fortified with fruit powder of all resistant genotypes recorded significantly lowest fecundity per female over susceptible genotypes RHRB-42 (123.33 eggs/female), RHRB-53 (115.00 eggs/female) and RHRB-7 (112.44 eggs/female).

4.2.7 Growth Index

The data (Table 9 and Fig. 9) indicated that, the pest reared on the diet fortified with fruit powder of susceptible genotype RHRB-42 recorded a maximum growth index (2.59). It was at par with that recorded in diet fortified with fruit powder of highly susceptible genotypes RHRB-53 (2.50) and RHRB-7 (2.44). Significantly lower growth indices 1.53, 1.66, 1.81 and 1.93 were observed in diets fortified with fruit powder of resistant and fairly resistant genotypes RHRB-28, RHRB-20, RHRB-37 and RHRB-12, respectively.

4.2.8 Adult longevity

Data on average longevity of male and female (Table 9 and Fig. 9) revealed that the average longevity of male ranged from 4.22 to 5.56 days while that of female 5.13 to 6.33 days which indicated females have higher longevity than males. Also pest reared on diet fortified with resistant genotypes has recorded significantly lower longevity of male and female than that reared on diet containing susceptible genotypes. Diet containing highly resistant genotype RHRB-28 recorded significantly lowest longevity of male (4.22 days) and female (5.13 days). It was followed by diet containing fruits of genotype RHRB-20 (HR) (male 4.50 days and female 5.20 days), RHRB-37 (FR) (male 4.55 days and female 5.37 days) and RHRB-12 (FR) (male 4.94 days and female 5.43 days) all being statistically at par with each other. The susceptible genotype RHRB-42 recorded maximum longevity of 5.56 days (male) and 6.33 days (female) and comparable with that recorded in highly susceptible genotypes RHRB-53 (male 5.50 days and female 6.33 days) and RHRB-7 (male 5.33 days and female 5.87 days).

In general, it was observed that, diet fortified with fruit powder of highly resistant and fairly resistant genotypes influenced adversely the growth and development of *L. orbonalis* However, enhanced development and reproduction of brinjal shoot and fruit borer was noticed when the larvae was reared on diet fortified with fruit powder of the susceptible and highly susceptible genotypes.

4.3 Biophysical attributes of brinjal genotypes associated with resistance to *L. orbonalis*

4.3.1 Studies on characters influencing shoot infestation

4.3.1a Trichome density

The data on trichome density per cm^2 of leaf surface are presented in Table 10. The trichome density at lower side of leaf surface ranged from 458.67 to 1192.67 per cm^2. The genotype RHRB-28 (MT) recorded maximum trichome density (1192.67 per cm^2). It was at par with RHRB-20 (T) (1147.33 per cm^2). The next successive genotypes in descending order recording trichome density were RHRB-60 (T), RHRB-74 (MT) and RHRB-70 (MT) with trichome density 1118.67, 1097.33 and 1066.00 per cm^2, respectively and were at par with each other. The least trichome density (458.67 per cm^2) was recorded in RHRB-73 (HS) which was statistically similar with the trichome density recorded in RHRB-53 (HS) (478.00 per cm^2). In general, descending trend of trichome density from tolerant to susceptible genotypes was observed with some exceptions.

4.3.1b Shoot thickness

The data pertaining to shoot thickness of different brinjal genotypes are presented in Table 10. Perusal of mean shoot thickness of *Kharif* and *Rabi* season revealed that, the shoot thickness of different brinjal genotypes were statistically significant in both the seasons. However, the shoot thickness observed in most of the genotypes was more in *Kharif* than that recorded in *Rabi* season.

In *Kharif*, the shoot thickness of different brinjal genotypes was 0.28 to 0.62 cm. The genotype RHRB-12 recorded a minimum

Table 10: Trichome density and shoot thickness in different genotypes of brinjal in *Kharif* and *Rabi* season

Tr. No.	Genotype	Trichome density /cm²	Shoot thickness (cm)		
			Kharif	***Rabi***	**Mean**
V_1	RHRB-20	1147.33* (33.89)***	0.33	0.33	0.33
V_2	RHRB-7	540.00 (23.25)	0.62	0.61	0.62
V_3	RHRB-37	732.67 (27.08)	0.44	0.43	0.44
V_4	RHRB-21	747.33 (27.35)	0.51	0.51	0.51
V_5	RHRB-35	657.33 (25.66)	0.60	0.60	0.60
V_6	RHRB-28	1192.67 (34.55)	0.56	0.55	0.55
V_7	RHRB-11	555.33 (23.59)	0.40	0.40	0.40
V_8	RHRB-34	614.67 (24.81)	0.42	0.42	0.42
V_9	RHRB-12	714.67 (26.75)	0.28	0.27	0.27
V_{10}	RHRB-53	478.00 (21.87)	0.42	0.41	0.42
V_{11}	RHRB-60	1118.67 (33.46)	0.32	0.31	0.32
V_{12}	RHRB-42	734.67 (27.11)	0.53	0.52	0.52
V_{13}	RHRB-73	458.67 (21.43)	0.62	0.64	0.63
V_{14}	RHRB-74	1097.33 (33.14)	0.40	0.39	0.40
V_{15}	RHRB-75	883.33 (29.74)	0.61	0.60	0.60
V_{16}	RHRB-79	600.00 (24.51)	0.32	0.32	0.32
V_{17}	RHRB-67	958.00 (30.97)	0.48	0.46	0.47
V_{18}	RHRB-68	611.33 (24.74)	0.42	0.41	0.42
V_{19}	RHRB-69	648.67 (25.49)	0.38	0.38	0.38
V_{20}	RHRB-70	1066.00 (32.66)	0.30	0.29	0.30
SE ±		14.32	0.01	0.01	0.01
CD at 5 %		54.78	0.03	0.03	0.03
CV %		3.19	3.47	3.24	2.80
Correlation coefficient (r)		(-) 0.621 **	-	-	0.632 **

* Mean of three observations

** Indicate significant correlation at 1 %

*** Figures in the parentheses are $\sqrt{n+1}$ transformed values shoot thickness of 0.28 cm. It was at par with that recorded in RHRB-70 (0.30 cm). The maximum shoot thickness (0.62 cm) was observed in RHRB-7 and RHRB-73 followed by RHRB-75 (0.61 cm), RHRB-35 (0.60 cm).

More or less similar trend was found in *Rabi* season here also, RHRB-12 recorded minimum shoot thickness of 0.27 cm followed by RHRB-70 (0.29 cm) being statistically similar to it. Maximum shoot thickness (0.64 cm) was observed in RHRB-73. It was followed by RHRB-7 (0.61 cm), RHRB-35 (0.60 cm) and RHRB-75 (0.60 cm) all being statistically at par with each other.

Results of pooled analysis indicated the shoot thickness in the range of 0.27 to 0.63 cm. Genotype RHRB-12 (T) recorded minimum (0.27 cm) shoot thickness and it was statistically similar with the shoot thickness (0.30 cm) recorded in the genotype RHRB-70 (MT). The next successive genotypes in ascending order of shoot thickness were RHRB-79 (T), RHRB-60 (T), RHRB-20 (T), RHRB-69 (HS), RHRB-11 (S), RHRB-74 (MT), RHRB-34 (S), RHRB-53 (HS), RHRB-68 (HS), RHRB-37 (MT), RHRB-67 (S), RHRB-21 (S), RHRB-42 (HS), RHRB-28 (MT), RHRB-35 (HS), RHRB-75 (HS) and RHRB-7 (HS) recording shoot thickness of 0.32, 0.32, 0.33, 0.38, 0.40, 0.40, 0.42, 0.42, 0.42, 0.44, 0.47, 0.51, 0.52, 0.55, 0.60, 0.60 and, 0.62 cm respectively. Genotype RHRB-73 (HS) recorded maximum shoot thickness of 0.63 cm. In general, tolerant genotypes recorded minimum shoot thickness as compared to susceptible genotypes with some exceptions.

The values of correlation coefficient (r) for trichome density and shoot thickness in relation to shoot infestation of brinjal shoot and fruit borer are presented in Table 10. It could be seen from the table that there was significant negative correlation between trichome densities per cm^2 and incidence of shoot borer, the 'r' value being (-) 0.621. Although shoot thickness exhibited significant positive correlation (r = 0.632) in relation to incidence of shoot borer.

4.3.2 Studies on pedicel and calyx characters of brinjal genotypes associated with infestation of *L. orbonalis*

4.3.2a Length of pedicel

The differences in pedicel length of genotypes were statistically significant in both the seasons. Most of the genotypes recorded more pedicel length in *Kharif* than *Rabi* season except RHRB-7, RHRB-12 and RHRB-73 (Table 11).

In *Kharif*, the pedicel length ranged from 3.42 to 11.91 cm. Genotype RHRB-12 recorded a minimum pedicel length of 3.42 cm. It was statistically similar with that recorded in genotype RHRB-28 (3.63 cm), RHRB-37 (3.67 cm) and RHRB-70 (3.71 cm). The genotype RHRB-7 recorded maximum (11.91 cm) pedicel length which was significantly more than that recorded in rest of the entries. It was followed by RHRB-60 (6.85 cm), RHRB-11 (6.64 cm) and RHRB-73 (6.61 cm) which were statistically at par with each other.

Pedicel length in different genotypes ranged from 3.47 to 12.11 cm in *Rabi* season. Here also the more or less similar trend was found. The genotype RHRB-12 recorded significantly minimum pedicel length of 3.47 cm followed by RHRB-28, RHRB-37 and RHRB-70 recording pedicel length of 3.56, 3.63 and 3.71cm, respectively. Significantly maximum 12.11 cm pedicel length was observed in genotype RHRB-7.

Results of pooled analysis indicated the pedicel length in different genotypes ranged from 3.44 to 12.01 cm. Genotype RHRB-12 (FR) recorded a minimum (3.44 cm) pedicel length followed by RHRB-28 (HR), RHRB-37 (FR) and RHRB-70 (FR) recording 3.59, 3.65 and 3.71 cm length of pedicel and being statistically at par with it. Genotype RHRB-7 (S) recorded maximum (12.01 cm) length of pedicel which was significantly

Table 11: Length of pedicel in different genotypes of brinjal in *Kharif* and *Rabi* season

Tr. No.	Genotype	Length of pedicel (cm)		
		Kharif	***Rabi***	**Pooled mean**
V_1	RHRB-20	4.36	4.31	4.34
V_2	RHRB-7	11.91	12.11	12.01
V_3	RHRB-37	3.67	3.63	3.65
V_4	RHRB-21	6.21	6.20	6.20
V_5	RHRB-35	7.41	7.44	7.42
V_6	RHRB-28	3.63	3.56	3.59
V_7	RHRB-11	6.64	6.63	6.64
V_8	RHRB-34	4.95	4.92	4.94
V_9	RHRB-12	3.42	3.47	3.44
V_{10}	RHRB-53	5.43	5.35	5.39
V_{11}	RHRB-60	6.85	6.80	6.83
V_{12}	RHRB-42	5.43	5.42	5.43
V_{13}	RHRB-73	6.61	6.65	6.63
V_{14}	RHRB-74	4.34	4.31	4.33
V_{15}	RHRB-75	4.85	4.82	4.83
V_{16}	RHRB-79	5.93	5.89	5.91
V_{17}	RHRB-67	5.77	5.73	5.75
V_{18}	RHRB-68	3.98	3.93	3.95
V_{19}	RHRB-69	5.83	5.78	5.81
V_{20}	RHRB-70	3.71	3.71	3.71
	SE ±	0.14	0.14	0.13
	CD at 5 %	0.39	0.40	0.38
	CV %	4.27	4.42	4.04
	Correlation coefficient (r)			0.473628 *

* Indicate significant correlation at 5 %

more than that recorded in rest of the genotypes. Remaining genotypes occupied intermediate position recorded a pedicel length from 3.95 to 7.42 cm.

In case of pedicel length ascending trend was observed from resistant to susceptible genotypes. The value of correlation coefficient (r) for pedicel length of different genotypes in relation to fruit infestation of *L. orbonalis* revealed that there was good and positive correlation (r = 0.473628) between length of pedicel (cm) and per cent fruit infestation by *L. orbonalis.*

4.3.2b Length of calyx

Data on calyx length of different genotypes recorded in both the seasons are presented in Table 12. All the genotypes except RHRB-7, RHRB-53 and RHRB-79 recorded more calyx length in *Kharif* than in *Rabi* season.

In *Kharif*, the calyx length ranged from 1.88 to 4.06 cm. Genotype RHRB-37 recorded a minimum calyx length of 1.88 cm. It was statistically similar with that observed in RHRB-70 recording 1.97 cm length. Maximum (4.06 cm) length of calyx was observed in RHRB-7 followed by RHRB-73 (3.87 cm) being at par with each other. The similar trend of calyx length was observed in *Rabi* season; here it ranged from 1.83 to 4.09 cm.

Results of the pooled analysis of both the seasons indicated that the differences in mean calyx length were statistically significant. The calyx length in different genotypes ranged from 1.83 to 4.07 cm. Genotype RHRB-37 (FR) recorded a minimum (1.83 cm) calyx length which was significantly lower than that recorded in rest of the genotypes except RHRB-70 (FR) recording calyx length of 1.96 cm. It was followed by RHRB-60 (FR) (2.26 cm), RHRB-12 (FR) (2.28 cm), RHRB-21(FR) (2.39 cm) and RHRB-28 (R) (2.45 cm) which were at pat with each other. Genotype RHRB-7 (HS) recorded maximum (4.07 cm) length of calyx which

Table 12: Calyx length in different genotypes of brinjal in *Kharif* and *Rabi* season

Tr. No.	Genotype	Calyx length (cm)		
		Kharif	***Rabi***	**Pooled mean**
V_1	RHRB-20	2.89	2.88	2.89
V_2	RHRB-7	4.06	4.09	4.07
V_3	RHRB-37	1.88	1.83	1.85
V_4	RHRB-21	2.39	2.39	2.39
V_5	RHRB-35	3.28	3.28	3.28
V_6	RHRB-28	2.45	2.44	2.45
V_7	RHRB-11	3.07	3.03	3.05
V_8	RHRB-34	2.89	2.81	2.85
V_9	RHRB-12	2.28	2.27	2.28
V_{10}	RHRB-53	2.71	2.74	2.72
V_{11}	RHRB-60	2.30	2.22	2.26
V_{12}	RHRB-42	3.21	3.10	3.16
V_{13}	RHRB-73	3.87	3.79	3.83
V_{14}	RHRB-74	2.31	2.28	2.30
V_{15}	RHRB-75	3.00	2.96	2.98
V_{16}	RHRB-79	2.68	2.69	2.69
V_{17}	RHRB-67	3.16	3.12	3.14
V_{18}	RHRB-68	3.12	3.10	3.11
V_{19}	RHRB-69	2.65	2.60	2.63
V_{20}	RHRB-70	1.97	1.95	1.96
	SE ±	0.09	0.06	0.07
	CD at 5 %	0.27	0.17	0.21
	CV %	5.82	3.81	4.54
	Correlation coefficient (r)			0.615638 **

** Indicate significant correlation at 1 %

was significantly more than that recorded in rest of the genotypes. It was followed by RHRB-73 (S) recording 3.83 cm length of calyx.

In general, ascending trend of calyx length from resistant to susceptible genotypes was observed. The value of correlation coefficient (r) for calyx length of different genotypes in relation to fruit infestation of *L. orbonalis* revealed that the length of calyx exhibited strong positive correlation (r = 0.615638) in relation to per cent infestation by *L. orbonalis*.

4.3.3 Studies on fruit characters of brinjal genotypes associated with infestation of *L. orbonalis*

4.3.3a Length of fruit

The differences in length of fruit were statistically significant in both the seasons (Table 13). Most of the genotypes recorded more fruit length in *Kharif* season except RHRB-35 and RHRB-12. In *Kharif*, the fruit length ranged from 3.79 to13.39 cm and in *Rabi* it was 3.80 to 13.03 cm.

Pooled analysis of fruit length of both seasons indicated that the differences in fruit length were statistically significant. The mean fruit length ranged from 3.80 to 13.21 cm. The genotype RHRB-60 (FR) recorded maximum (13.21 cm) length of fruit which was significantly more than that recorded in the rest of the genotypes. It was followed by RHRB-7 (HS) (9.17 cm) which in turn recorded significantly more fruit length than that observed in rest of the genotypes. The next successive genotypes were RHRB-20 (HR) and RHRB-73 (S) which recorded fruit length of 8.24 and 8.05 cm, respectively and were at par with each other. Genotype RHRB-12 (FR) recorded significantly minimum (3.80 cm) length of fruit. Remaining genotypes occupied intermediate position recording fruit length from 4.64 to 6.80 cm.

Table 13:Length of fruit in different genotypes of brinjal in *Kharif* and *Rabi* season

Tr. No.	Genotype	Length of fruit (cm)		
		Kharif	***Rabi***	**Pooled mean**
V_1	RHRB-20	8.41	8.07	8.24
V_2	RHRB-7	9.24	9.10	9.17
V_3	RHRB-37	6.07	6.01	6.04
V_4	RHRB-21	6.60	6.51	6.56
V_5	RHRB-35	6.45	6.48	6.47
V_6	RHRB-28	6.89	6.71	6.80
V_7	RHRB-11	6.04	5.81	5.93
V_8	RHRB-34	5.77	5.67	5.72
V_9	RHRB-12	3.79	3.80	3.80
V_{10}	RHRB-53	6.43	6.27	6.35
V_{11}	RHRB-60	13.39	13.03	13.21
V_{12}	RHRB-42	6.04	5.97	6.01
V_{13}	RHRB-73	8.12	7.97	8.05
V_{14}	RHRB-74	6.77	6.59	6.68
V_{15}	RHRB-75	7.04	6.94	6.99
V_{16}	RHRB-79	7.06	6.83	6.95
V_{17}	RHRB-67	4.69	4.59	4.64
V_{18}	RHRB-68	4.97	4.86	4.92
V_{19}	RHRB-69	6.11	6.07	6.09
V_{20}	RHRB-70	4.79	4.68	4.74
	SE ±	0.27	0.17	0.19
	CD at 5 %	0.77	0.47	0.55
	CV %	6.95	4.36	5.01
	Correlation coefficient (r)			(-) 0.17223

From the value of correlation coefficient (r) it was observed that there was no significant correlation between fruit infestation and length of fruit the ‘r’ value being (-) 0.17223.

4.3.3b Diameter of fruit

Data pertaining to fruit diameter of different brinjal genotypes (Table 14) revealed that the differences in fruit diameter were statistically significant in both the seasons. Most of the genotypes recorded more fruit diameter in *Kharif* season except RHRB-35, RHRB-28, RHRB-42 and RHRB-79. In *Kharif* season the diameter of fruit ranged from 3.35 to 5.99 cm and in *Rabi* it was 3.33 to 5.92cm.

The results of pooled analysis of both the seasons indicated that the mean fruit diameter ranged from 3.34 to 5.96 cm. The genotype RHRB-60 (FR) recorded minimum (3.34 cm) diameter of fruit which was at par with that observed in the genotypes RHRB-12 (FR) and RHRB-70 (FR) recording 3.58 and 3.64 cm diameter of fruit. The next successive genotypes in ascending order were RHRB-7 (HS), RHRB-67 (T), RHRB-74 (T), RHRB-34 (T), RHRB-28 (HR), RHRB-35 (S), RHRB-79 (FR), RHRB-37 (FR), RHRB-42 (S), RHRB-69 (HS), RHRB-21 (FR), RHRB-11 (S), RHRB-68 (S) and RHRB-75 (T) recording fruit diameter 3.97, 4.27, 4.48, 4.59, 4.61, 4.64, 4.65, 4.67, 4.69, 4.88, 5.12, 5.33, 5.33 and 5.46, respectively. The genotype RHRB-53 (HS) recorded significantly maximum fruit diameter of 5.96 cm followed by RHRB-20 (HR) (5.68 cm) and RHRB-73 (S) (5.52 cm).

From Table 14 it is also indicated that diameter of fruit exhibited non-significant correlation (r = 0.249097) in relation to fruit infestation by *L. orbonalis*.

Table 14: Diameter of fruit in different genotypes of brinjal in *Kharif* and *Rabi* season

Tr. No.	Genotype	Diameter of fruit (cm)		
		Kharif	***Rabi***	**Pooled mean**
V_1	RHRB-20	5.74	5.62	5.68
V_2	RHRB-7	3.99	3.95	3.97
V_3	RHRB-37	4.69	4.65	4.67
V_4	RHRB-21	5.14	5.10	5.12
V_5	RHRB-35	4.63	4.65	4.64
V_6	RHRB-28	4.60	4.62	4.61
V_7	RHRB-11	5.34	5.31	5.33
V_8	RHRB-34	4.63	4.55	4.59
V_9	RHRB-12	3.61	3.56	3.58
V_{10}	RHRB-53	5.99	5.92	5.96
V_{11}	RHRB-60	3.35	3.33	3.34
V_{12}	RHRB-42	4.67	4.70	4.69
V_{13}	RHRB-73	5.55	5.49	5.52
V_{14}	RHRB-74	4.58	4.37	4.48
V_{15}	RHRB-75	5.49	5.43	5.46
V_{16}	RHRB-79	4.63	4.67	4.65
V_{17}	RHRB-67	4.28	4.25	4.27
V_{18}	RHRB-68	5.35	5.31	5.33
V_{19}	RHRB-69	4.90	4.86	4.88
V_{20}	RHRB-70	3.66	3.63	3.64
	SE ±	0.15	0.11	0.13
	CD at 5 %	0.43	0.33	0.37
	CV %	5.53	4.23	4.70
	Correlation coefficient (r)			0.249097

4.3.3c Thickness of pericarp

Data on thickness of pericarp (Table 15) revealed that the differences in thickness of pericarp were statistically significant in both the seasons. Most of the genotypes except RHRB-7, RHRB-35, RHRB-12 and RHRB-68 recorded more thickness of pericarp in *Kharif* season. In *Kharif* the pericarp thickness ranged from 0.25 to 0.99 cm and in *Rabi* it was 0.27 to 0.97 cm.

Considering the pooled mean of both the season it was observed that the mean thickness of pericarp ranged from 0.26 to 0.98 cm. The genotype RHRB-42 (S) recorded maximum (0.98 cm) thickness of pericarp which was significantly more than that recorded in rest of the genotypes. It was followed by RHRB-20 (HR) which in turn recorded significantly more (0.91 cm) pericarp thickness than rest of the genotypes. The next successive genotypes were RHRB-79 (FR), RHRB-69 (HS), RHRB-75 (T), RHRB-37 (FR), RHRB-35 (S), RHRB-53 (HS), RHRB-68 (S), RHRB-7 (HS), RHRB-74 (T), RHRB-21 (FR), RHRB-34 (T), RHRB-67 (T), RHRB-28 (HR) and RHRB-73 (S) regarding 0.78, 0.72, 0.67, 0.65, 0.64, 0.64, 0.63, 0.60, 0.60, 0.56, 0.52, 0.44, 0.40 and 0.33 cm thickness of pericarp, respectively in descending order. Significantly minimum (0.26 cm) thickness of pericarp was observed in genotype RHRB-12 (FR) followed by RHRB-60 (FR) (0.28 cm), RHRB-70 (FR) (0.29 cm) and RHRB-11 (S) (0.32 cm).

In case of pericarp thickness the similar trend was observed as no significant correlation was found between fruit infestation and thickness of pericarp having 'r' value 0.126222. The results indicate the lack of correlation between different fruit characters and infestation by *L. orbonalis*.

Table 15: Thickness of pericarp in different genotypes of brinjal in *Kharif* and *Rabi* season

Tr. No.	Genotype	Thickness of pericarp (cm)		
		Kharif	***Rabi***	**Pooled mean**
V_1	RHRB-20	0.91	0.91	0.91
V_2	RHRB-7	0.59	0.61	0.60
V_3	RHRB-37	0.66	0.65	0.65
V_4	RHRB-21	0.57	0.56	0.56
V_5	RHRB-35	0.64	0.65	0.64
V_6	RHRB-28	0.41	0.40	0.40
V_7	RHRB-11	0.32	0.32	0.32
V_8	RHRB-34	0.52	0.51	0.52
V_9	RHRB-12	0.25	0.27	0.26
V_{10}	RHRB-53	0.64	0.64	0.64
V_{11}	RHRB-60	0.28	0.27	0.28
V_{12}	RHRB-42	0.99	0.97	0.98
V_{13}	RHRB-73	0.34	0.33	0.33
V_{14}	RHRB-74	0.60	0.60	0.60
V_{15}	RHRB-75	0.68	0.67	0.67
V_{16}	RHRB-79	0.79	0.77	0.78
V_{17}	RHRB-67	0.44	0.43	0.44
V_{18}	RHRB-68	0.62	0.63	0.63
V_{19}	RHRB-69	0.73	0.71	0.72
V_{20}	RHRB-70	0.29	0.29	0.29
	SE ±	0.02	0.02	0.02
	CD at 5 %	0.06	0.06	0.06
	CV %	5.88	5.82	5.43
	Correlation coefficient (r)			0.126222

4.3.3d Colour of the fruit

During the present investigations, different colour patterns of fruits were observed in different brinjal genotypes. The fruits were white, green, light green, light green with white stripes, purple, light purple, dark purple, purple with white stripes in different genotypes.

Table 16: Colour of fruit in relation to infestation of brinjal shoot and fruit borer

Sr. No.	Genotypes	Colour of fruit	Range of infestation (%)
1.	RHRB-75, RHRB-79	Green	11.14 - 23.44
2.	RHRB-20, RHRB-21, RHRB-60	Light green	8.94 - 13.98
3.	RHRB-37, RHRB-73, RHRB-74	Purple	15.81 - 36.02
4.	RHRB-67, RHRB-70	Light purple	18.24 - 29.11
5.	RHRB-68, RHRB-69	Dark purple	36.78 - 40.17
6.	RHRB-11, RHRB-53, RHRB-42	Purple fruits with white stripes	30.29 - 42.50
7.	RHRB-7, RHRB-35, RHRB-34	Greenish fruits with white strips	21.55 - 44.67
8.	RHRB-28	White	9.54

The per cent fruit infestation in green and light green genotypes was in the range of 11.14 to 23.44 and 8.94 to 13.98 per cent, respectively (Table 16). The per cent fruit infestation in purple, light purple and dark purple genotypes was in the range of 15.81 to 36.02, 18.24 to 29.11 and 36.78 to 40.17 per cent, respectively. The fruit infestation varied from 30.29 to 42.50 per cent in genotypes having purple fruits with white stripes. The genotypes having greenish fruits with white strips recorded fruit infestation in the range of 21.55 to 44.67 per cent, whereas in genotype having white fruits, the per cent fruit infestation was 9.54 per cent.

Data of the present investigation revealed that the colour of the fruit did not have any direct relation with per cent fruit infestation. However, lower level of fruit infestation was found in cultivars having white to light green colour.

4.3.3e Shape of the fruit

The shape of the fruits from different brinjal genotypes (Table 17) ranged from small sized round to long slender. The average per cent fruit infestation ranged from 8.94 to 44.67. The brinjal genotype with small sized round fruits recorded 19.95 per cent fruit infestation. In cultivars having round and oval fruits, the fruit infestation was in the range of 8.94 to 36.78 and 15.81to 42.50 per cent, respectively. The long fruited genotypes recorded 10.39 to 44.67 per cent fruit infestation by brinjal shoot and fruit borer.

Table 17: Shape of fruit in relation to infestation of brinjal shoot and fruit borer

Sr. No.	Genotypes	Shape of fruit	Range of infestation (%)
1.	RHRB-20, RHRB-21, RHRB-11, RHRB-42, RHRB-74, RHRB-75, RHRB-79, RHRB-67, RHRB-68	Round	8.94 - 36.78
2.	RHRB-12	Small sized round fruits	19.95
3.	RHRB-28	Round with ridges	9.54
4.	RHRB-37, RHRB-35, RHRB-34, RHRB-53, RHRB-73, RHRB-69, RHRB-70	Oval	15.81- 42.50
5.	RHRB-7, RHRB-60	Long	10.39 - 44.67

It was evident from the present studies that the fruit shape had no role in imparting resistance against brinjal shoot and fruit borer.

4.4 Studies on biochemical attributes of brinjal genotypes associated with resistance to *L. orbonalis*

4.4.1 Biochemical constituents in shoots of different brinjal genotypes

The various biochemicals in shoot imparting resistance against shoot and fruit borer were estimated from apical portion of shoots and presented in Table 18.

4.4.1.1 Moisture content

The moisture content ranged from 74.10 to 86.90 per cent (Table 18) in shoots of different genotypes. Significantly Minimum (74.10 %) moisture content was observed in genotype RHRB-12 (T) which was at par with that observed in genotypes RHRB-20 (T), RHRB-79 (T) and RHRB-74 (MT) recording 74.95, 76.33 and 76.41 per cent moisture, respectively. The genotype RHRB-73 (HS) recorded a maximum (86.90 %) moisture which was statistically similar to that of observed in genotypes RHRB-7 (HS) (86.35%), RHRB-42 (HS) (86.78%), RHRB-11 (S) (86.35%) and RHRB-21 (S) (85.06 %). rest of the genotypes occupied intermediate position between 76.91 to 83.82 per cent.

The value of correlation coefficient (r) for moisture content in brinjal shoots in relation to shoot infestation was 0.526 which indicated the good positive correlation between moisture content and shoot infestation.

4.4.1.2 Total sugar

In shoots, the total sugar content ranged from 5.17 to 10.58 per cent. The genotype RHRB-21 (S) recorded significantly lowest (5.17 %) total sugar however, it was at par with that observed in RHRB-28 (MT) (5.68%). The next successive genotypes in ascending order were RHRB-20 (T), RHRB-70 (MT), RHRB-37 (MT), RHRB-60 (T), RHRB-79 (T), RHRB-12 (T), RHRB-75 (HS), RHRB-69 (HS), RHRB-53 (HS), RHRB-74 (MT), RHRB-35 (HS), RHRB-34 (S) and RHRB-73 (HS) recording 7.17, 7.17, 7.33, 7.33, 7.50, 7.67, 8.58, 8.58, 8.92, 9.08, 9.33, 9.42 and 9.42 per cent total sugar, respectively. Highest (10.58 %) total sugar in shoot was recorded in genotype RHRB-42 (HS) followed by RHRB-7 (HS) (10.42%), RHRB-11 (S) (9.92%), RHRB-67 (S) (9.83 %) and RHRB-68 (HS) (9.83%) all being statistically at par with each other.

In general, shoots of tolerant and moderately tolerant genotypes recorded minimum sugar content as compared to susceptible genotypes with some exceptions. The value of correlation coefficient with shoot infestation (r = 0.651) also indicated that there was strong and positive correlation between shoot infestation and total sugar content.

4.4.1.3 Crude protein

Shoots of different brinjal genotypes recorded protein content in the range of 2.33 to 9.92 per cent (Table 18). The genotype RHRB-79 (T) recorded a minimum (2.33%) crude protein which was significantly lower than that observed in rest of the genotypes. It was followed by genotypes RHRB-28 (MT) and RHRB-20 (T) recording 2.92 and 3.21 per cent crude proteins, respectively and statistically similar to it. Maximum per cent crude protein (9.92%) in shoots was observed in genotype RHRB-42 (HS) followed by RHRB-73 (HS) and RHRB-68 (HS) recording 9.63 per cent crude protein each and statistically at par with it. The remaining genotypes occupied intermediate positions recording crude protein content of 3.79 to 9.04 per cent.

Here also the ascending trend of crude protein content was found from resistant to susceptible genotypes. The correlation coefficient (r = 0.842) also indicated that there was strong and positive correlation between shoot infestation and crude protein content.

4.4.1.4 Crude fat

In shoots, the crude fat content ranged from 1.33 to 2.93 per cent. Significantly low (1.33%) crude fat was recorded by the genotype RHRB-12 (T). It was followed by the genotypes RHRB-11 (S) and RHRB-70 (MT) both having 1.53 per cent crude fat content and statistically at par with it. The genotype RHRB-68 (HS) recorded a maximum (2.93 %) crude fat which was significantly more than that recorded in the rest of the genotypes except RHRB-35 (HS) recording 2.80 per cent of crude fat and thus being statistically at par with it. The remaining genotypes occupied intermediate positions recording 1.80 to 2.53 per cent crude fat in shoots.

A positive correlation was noticed between crude fat and shoot infestation (r = 0.476).

4.4.1.5 Ash

Shoots of different brinjal genotypes recorded ash content in the range of 8.27 to 13.87 per cent. The genotype RHRB-12 (T) recorded significantly highest (13.87 %) ash. It was statistically similar with that recorded in RHRB-79 (T) (13.27%) and RHRB-28 (MT) (13.13%). Significantly minimum (8.27 %) ash was observed in RHRB-42 (HS) followed by RHRB-69 (HS) (8.67 %), RHRB-67 (S) (8.80 %), RHRB-53 (HS) (9.00 %) and RHRB-7 (9.20 %) all being statistically at par with each other. The remaining genotypes occupied intermediate position recording ash contents from 9.60 to 12.47 per cent.

Significantly strong negative correlation (r = - 0.754) was noticed between ash content and per cent infestation in shoots.

Table 18: Biochemical constituents in shoots of different brinjal genotypes

Category	Genotype	Moisture (%)	Total Sugar (%)	Crude protein (%)	Crude Fat (%)	Ash (%)	Crude fibre (%)	Polyphenols (%)	Enzyme activity (units/min/g)	
									PPO	PO
Tolerant (< 2%)	RHRB-60	79.44	7.33	4.08	2.40	12.33	7.47	1.93	3.21	9.20
	RHRB-20	74.95	7.17	3.21	1.87	12.33	8.73	2.60	3.63	9.71
	RHRB-12	74.10	7.67	3.79	1.33	13.87	7.33	2.90	4.65	10.81
	RHRB-79	76.33	7.50	2.33	1.93	13.27	9.73	2.67	3.77	10.55
Moderately tolerant (2.1-3.0%)	RHRB-70	78.17	7.17	4.67	1.53	11.60	8.67	1.63	3.24	4.55
	RHRB-28	78.49	5.68	2.92	2.00	13.13	9.80	2.75	4.83	9.93
	RHRB-37	77.36	7.33	3.79	2.13	12.47	7.33	1.45	3.48	4.95
	RHRB-74	76.41	9.08	5.83	1.80	11.20	6.93	2.28	2.65	5.91
Susceptible (3.1-5.0%)	RHRB-21	85.06	5.17	4.67	2.33	11.93	8.13	2.55	3.75	9.95
	RHRB-11	86.35	9.92	6.13	1.53	9.60	6.80	1.62	3.00	6.56
	RHRB-34	81.09	9.42	5.83	2.13	10.20	6.73	1.57	2.72	6.75
	RHRB-67	82.23	9.83	7.00	2.53	8.80	6.67	1.43	1.81	4.45
Highly susceptible (>5.0%)	RHRB-75	81.75	8.58	4.96	2.13	9.87	7.60	1.95	3.43	7.20
	RHRB-68	83.82	9.83	9.63	2.93	9.73	5.87	1.43	2.31	8.40
	RHRB-69	79.36	8.58	7.88	2.40	8.67	5.40	1.47	1.71	4.39
	RHRB-53	76.91	8.92	7.00	2.07	9.00	5.53	2.15	1.31	7.00
	RHRB-42	86.78	10.58	9.92	2.13	8.27	7.60	1.37	2.81	8.27
	RHRB-35	78.83	9.33	6.13	2.80	10.47	7.67	1.95	1.45	6.88
	RHRB-7	86.35	10.42	9.04	2.07	9.20	6.27	1.48	1.44	5.81
	RHRB-73	86.90	9.42	9.63	2.40	10.27	5.40	1.47	1.33	4.23
SE ± m		0.73	0.23	0.24	0.08	0.25	0.16	0.04	0.08	0.14
CD at 1 %		2.80	0.88	0.93	0.29	0.96	0.61	0.16	0.29	0.55
Correlation coefficient (r)		0.526*	0.651**	0.842**	0.476*	-0.754**	-0.623**	-0.538*	-0.801**	-0.431

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

4.4.1.6 Crude fibre

The per cent crude fibre content in shoots of different brinjal genotypes ranged from 5.40 to 9.80 per cent. Significantly maximum (9.80%) crude fibre in shoots was observed in genotype RHRB-28 (MT). It was statistically at par with that observed in RHRB-79 (T) recording 9.73 per cent of crude fibre. The genotype RHRB-73 (HS) and RHRB-69 (HS) recorded minimum (5.40 %) crude fibre which was significantly lower than that recorded in rest of the genotypes except RHRB-53 (HS) (5.53%) and RHRB-68 (HS) (5.87%) and thus being statistically at par with each other. The remaining genotypes occupied intermediate positions recording 6.27 to 8.73 per cent.

It was observed that the tolerant genotypes recorded maximum amount of crude fibre than that observed in susceptible genotypes. The value of correlation coefficient (r) also indicated the strong and negative correlation (r = - 623) between crude fibre content and shoot infestation.

4.4.1.7 Polyphenols

In shoots of different brinjal genotypes the polyphenols content ranged from 1.37 to 2.90 per cent. The genotype RHRB-12 (T) recorded maximum (2.90 %) Polyphenols which was significantly more than that observed in rest of the genotypes except RHRB-28 (MT) (2.75%) and thus being statistically at par with it. The next successive genotypes in descending order of polyphenols were RHRB-79 (T), RHRB-20 (T), RHRB-21 (S), RHRB-74 (MT), RHRB-53 (HS), RHRB-35 (HS), RHRB-75 (HS), RHRB-60 (T), RHRB-70 (MT), RHRB-11 (S), RHRB-34 (S), RHRB-7 (HS), RHRB-73 (HS), RHRB-69 (HS), RHRB-37 (MT), RHRB-67 (S) and RHRB-68 (HS) recording 2.67, 2.60, 2.55, 2.28, 2.15, 1.95, 1.95, 1.93, 1.63, 1.62, 1.57, 1.48, 1.47, 1.47, 1.45, 1.43 and 1.43 per cent polyphenol content respectively. Significantly minimum 1.37 per cent polyphenols were observed in RHRB-42 (HS).

It is indicated that the tolerant and moderately tolerant genotypes recorded higher levels of polyphenols as compared to susceptible genotypes. The value of correlation coefficient for polyphenol content was (-) 538, which also indicated the strong and negative correlation between polyphennol content per cent shoot infestation.

4.4.1.8 Polyphenol oxidase activity

The genotypes showed significant variation of 1.31 to 4.83 units/min/g fresh weight for the polyphenol oxidase activity in shoots (Table 18). The genotype RHRB-28 (MT) recorded maximum polyphenol oxidase activity of 4.83 units /min/g fresh weight in shoots; however it was statistically at par with the polyphenol oxidase activity observed in shoots of RHRB-12 (T) (4.65 units/min/g). Significantly minimum polyphenol oxidase activity (1.31 units/min/g) in the shoots was observed in RHRB-53 (HS). It was followed by polyphenol oxidase activity recorded in genotypes RHRB-73 (HS) (1.33 units /min/g), RHRB-7 (HS) (1.44 units/min/g), and RHRB-35 (HS) (1.45 units/min/g).

The descending trend of polyphenol oxidase activity from tolerant to susceptible genotypes was observed. From Table 18 it was also observed that the polyphenol activity had strong and negative correlation with per cent shoot infestation, the ‘r’ value being (-) 801.

4.4.1.9 Peroxidase activity

In shoots of different brinjal genotypes significant variation was observed regarding peroxidase activity from 4.23 to 10.81 units /min/g fresh weights (Table 18). The genotype RHRB-12 (T) showed maximum peroxidase activity (10.81 units /min/g fresh weight) which was significantly higher than that observed in rest of the genotypes except RHRB-79 (T) (10.55 units /min/g fresh weight) thus being statistically at par with it. Significantly minimum peroxidase activity (4.23 units /min/g fresh weight) in shoots was observed in RHRB-73 (HS). It was followed by RHRB-69 (HS) (4.39 units /min/g), RHRB-67 (S) (4.45 units /min/g), being statistically at par with each other.

From Table 18 it is indicated that peroxidase activity does not have any significant correlation with shoot infestation as the value of ‘r’ being (-) 431.

4.4.2 Biochemical constituents in fruits of different brinjal genotypes

The important biochemical attributes related to infestation of shoot and fruit borer are presented in Table 19.

4.4.2.1 Moisture content

The moisture content in the fruits of tested genotypes (Table 19) ranged from 74.16 to 87.95 per cent. Genotype RHRB-12 (FR) recorded significantly minimum (74.16 %) moisture content. It was statistically similar with that observed in RHRB-28 (HR), RHRB-20 (HR) and RHRB-60 (FR) recording 74.94, 75.46 and 76.29 per cent moisture content. The maximum 87.95 per cent of moisture content was determined in genotype RHRB-7 (HS) followed by RHRB-73 (S) (86.83%), RHRB-75 (T) (86.80%), RHRB-42 (S) (86.26%), and RHRB-11 (S) (85.77%) all being statistically at par with each other.

Lower levels of moisture were observed in case of resistant genotypes than that recorded in susceptible genotypes. Also a strong positive correlation of moisture content (%) in relation to fruit infestation was observed, the ‘r’ value being 0.717.

4.4.2.2 Total sugar

The per cent total sugar content in fruits of different genotypes ranged from 15.25 to 31.33 per cent. The genotype RHRB-21 (FR) recorded significantly lowest (15.25%) total sugar. It was statistically at par with RHRB-20 (HR) recording 15.83 per cent total sugar. The next genotypes recording the total sugar were RHRB-28 (HR), RHRB-74 (T), RHRB-37 (FR), RHRB-69 (HS), RHRB-75 (T), RHRB-12 (FR), RHRB-79 (FR), RHRB-34 (T), RHRB-68 (S), RHRB-11 (S), RHRB-70 (FR) and RHRB-60 (FR) which recorded 17.83, 18.83, 19.58, 20.08, 20.25, 21.67, 22.50, 23.67, 26.75, 27.08, 27.17 and 27.83 per cent total sugar, respectively in ascending order of their sequence. Maximum total sugar content (31.33%) was recorded in genotype RHRB-73 (S) followed by RHRB-42 (S) (31.00%), RHRB-53 (HS) (29.83%), RHRB-35 (S) (29.67%), RHRB-67 (T) (29.58%) and RHRB-7 (HS) (29.17%).

In general, it was observed that susceptible genotypes recorded higher percentage of total sugar as compared to resistant genotypes. The value of correlation coefficient (r = 0.604) also indicated highly significant correlation of total sugar content with per cent fruit infestation.

4.4.2.3 Crude protein

Per cent crude protein content in fruits ranged from 8.17 to 21.00 per cent. The genotype RHRB-28 (HR) recorded a minimum (8.17 %) crude protein which was significantly lower than that recorded in rest of the genotypes except RHRB-37 (FR) recording 9.33 per cent of crude protein and thus at statistically at par with it. The next successive genotypes recording crude protein content in ascending order were RHRB-20 (HR), RHRB-79 (FR), RHRB-60 (FR), RHRB-12 (FR), RHRB-21 (FR), RHRB-53 (HS), RHRB-67 (T), RHRB-70 (FR), RHRB-34 (T), RHRB-74 (T), RHRB-69 (HS), RHRB-11 (S), RHRB-35 (S) and RHRB-7 (HS) recording 10.79, 11.38, 11.96, 12.25, 13.42, 13.71, 16.04,16.33, 17.50, 17.79, 17.79, 18.08, 19.25 and 19.54 per cent crude protein, respectively. Significantly maximum (21.00 %) crude protein was recorded in RHRB-68 (S) followed by RHRB-73 (S) (20.42%) and RHRB-42 (S) (19.83%) being at par with each other.

Here also, the susceptible genotypes recorded higher percentage of crude protein as compared to resistant genotypes. Crude protein content showed significantly positive correlation with per cent fruit infestation of the pest (r = 0.750).

4.4.2.4 Crude fat

In fruits, the content of crude fat ranged from 1.47 to 4.07 per cent. Lowest (1.47 %) crude fat was recorded in genotype RHRB-12 (FR) which was followed by RHRB-11 (S) (1.80%) and both of these are at par with each other. The next genotypes for regarding the crude fat content were RHRB-20 (HR), RHRB-70 (FR), RHRB-28 (HR), RHRB-42 (S), RHRB-37 (FR), RHRB-53 (HS), RHRB-74 (T), RHRB-75 (T), RHRB-79 (FR), RHRB-60 (FR), RHRB-67 (T) RHRB-34 (T), RHRB-68 (S), RHRB-69 (HS) and RHRB-7 (HS) which recorded 1.93, 2.07 and 2.13, 2.20, 2.27, 2.27, 2.27, 2.40, 2.40, 2.80, 2.87, 3.07, 3.13, 3.27 and 3.53 per cent crude fat, respectively in ascending order of their sequence. The genotype RHRB-35 (S) recorded a maximum (4.07 %) crude fat followed by RHRB-21 (FR) and RHRB-73 (S) recording 3.73 and 3.67 per cent crude fat, respectively and statistically at par with it.

A weak positive correlation was noticed (r = 0.366) between fruit infestation and crude fat content in the fruits of brinjal.

4.4.2.5 Ash

In fruits, the per cent ash content ranged from 5.67 to 8.67 per cent. The genotype RHRB-21 (T) recorded maximum (8.67 %) ash. It was statistically at par with that observed in RHRB-79 (FR) and RHRB-28 (HR) recording 8.27 and 8.20 per cent ash. The genotype RHRB-68 (S) recorded significantly minimum (5.67 %) ash followed by RHRB-53 (HS) (5.80%) and RHRB-7 (HS) (6.13%) which were statistically at par with each other. Remaining genotypes occupied intermediate position recording ash content from 6.27 to 8.13 per cent.

In general, it was observed that the resistant genotypes contain higher levels of ash as compared to susceptible genotypes. Significantly highly significant negative correlation was observed (r = - 0.816) between fruit infestation and ash content in the fruits.

4.4.2.6 Crude fibre

In fruits, the per cent crude fibre content ranged from 7.93 to 16.53 per cent. The genotype RHRB-28 (HR) recorded a maximum (16.53 %) crude fibre which was significantly more than that observed in the rest of the genotypes. This was followed by genotype RHRB-79 (FR) recording 16.47 per cent of crude fibre content, being statistically at par with it. The next successive genotypes were RHRB-20 (HR), RHRB-70 (FR), RHRB-37 (FR), RHRB-74 (T), RHRB-35 (S), RHRB-75 (T), RHRB-34 (T), RHRB-12 (FR), RHRB-60 (FR), RHRB-21 (FR), RHRB-11 (S), RHRB-68 (S), RHRB-69 (HS), RHRB-7 (HS) and RHRB-73 (S) recording crude fibre content of 15.20, 15.13, 14.60, 14.40, 13.20, 12.40, 12.27, 11.67, 11.60, 11.33, 11.27, 10.07, 9.80, 9.33 and 9.07 per cent, respectively in descending order of their sequence. Minimum crude fibre was observed in genotype RHRB-42 (S) (7.93 %) which was significantly lower than that recorded in rest of the genotypes. It was followed by RHRB-67 (S) and RHRB-53 (HS) recording 8.33 and 8.47 per cent of crude fibre content and statistically similar to each other.

The descending trend of crude fibre content was observed from resistant to susceptible genotypes. Similarly, the value of correlation coefficient (r = (-) 0.759) indicated strong and negative correlation between fruit infestation and crude fibre content in fruits.

Table 19: Biochemical constituents recorded in fruits of different brinjal genotypes

Category	Genotype	Moisture (%)	Total Sugar (%)	Crude Protein (%)	Crude Fat (%)	Ash (%)	Crude Fibre (%)	Polyphenols (%)	Enzyme activity (units/min/g)	
									PPO	PO
Highly resistant (1-10%)	RHRB-20	75.46	15.83	10.79	1.93	7.80	15.20	1.87	4.65	11.77
	RHRB-28	74.94	17.83	8.17	2.13	8.20	16.53	1.97	5.68	12.16
Fairly resistant (11-20%)	RHRB-60	76.29	27.83	11.96	2.80	7.93	11.60	1.77	4.00	10.76
	RHRB-79	78.45	22.50	11.38	2.40	8.27	16.47	1.65	4.48	13.23
	RHRB-21	80.31	15.25	13.42	3.73	8.67	11.33	1.97	4.83	12.92
	RHRB-37	82.20	19.58	9.33	2.27	7.73	14.60	0.83	4.29	6.41
	RHRB-70	78.56	27.17	16.33	2.07	7.40	15.13	1.08	4.17	4.97
	RHRB-12	74.16	21.67	12.25	1.47	8.13	11.67	2.10	5.35	13.65
Tolerant (21-30%)	RHRB-34	84.19	23.67	17.50	3.07	6.93	12.27	0.97	3.52	8.65
	RHRB-74	80.11	18.83	17.79	2.27	7.40	14.40	1.42	3.15	8.97
	RHRB-75	86.80	20.25	14.58	2.40	7.07	14.40	1.43	4.37	9.69
	RHRB-67	84.99	29.58	16.04	2.87	6.87	8.33	0.75	3.01	4.99
Susceptible (31-40%)	RHRB-11	85.77	27.08	18.08	1.80	6.87	11.27	1.05	3.76	7.25
	RHRB-35	83.27	29.67	19.25	4.07	7.13	13.20	1.33	2.69	8.51
	RHRB-42	86.26	31.00	19.83	2.20	6.93	7.93	0.65	3.76	10.32
	RHRB-73	86.83	31.33	20.42	3.67	7.67	9.07	0.90	2.29	4.45
	RHRB-68	82.64	26.75	21.00	3.13	5.67	10.07	0.68	3.21	9.73
Highly susceptible (>40%)	RHRB-69	81.73	20.08	17.79	3.27	6.27	9.80	0.87	2.93	5.83
	RHRB-53	84.06	29.83	13.71	2.27	5.80	8.47	1.17	2.25	8.81
	RHRB-7	87.95	29.17	19.54	3.53	6.13	9.33	0.82	2.72	6.97
SE ± m		0.77	0.58	0.37	0.11	0.12	0.23	0.03	0.09	0.14
CD at 1 %		2.93	2.23	1.43	0.41	0.47	0.87	0.13	0.35	0.55
Correlation coefficient (r)		0.717**	0.604**	0.750**	0.366	-0.816**	-0.759**	-0.700**	-0.798**	-0.536*

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

4.4.2.7 Polyphenols

In fruits, content of polyphenols ranged from 0.65 to 2.10 per cent. The genotype RHRB-12 (FR) recorded significantly maximum (2.10 %) polyphenols. It was at par with that observed in RHRB-21 (FR) and RHRB-28 (HR) recording 1.97 per cent of polyphenols each. The next successive genotypes recording polyphenol content in descending order were RHRB-20 (HR), RHRB-60 (FR), RHRB-79 (FR), RHRB-75 (T), RHRB-74 (T), RHRB-35 (S), RHRB-53 (HS), RHRB-70 (FR), RHRB-11 (S), RHRB-34 (T), RHRB-73 (S), RHRB-69 (HS), RHRB-37 (FR) and RHRB-7 (HS) recording 1.87, 1.77, 1.65, 1.43, 1.42, 1.33, 1.17, 1.08, 1.05, 0.97, 0.90, 0.87, 0.83 and 0.82 per cent polyphenols, respectively. The genotype RHRB-42 (S) recorded significantly minimum (0.65 %) Polyphenols followed by RHRB-68 (0.68%) and RHRB-67 (0.75%) being statistically similar to it.

Here also, the descending trend was observed from resistance to susceptible genotypes. Also highly significant and negative correlation (r = - 0.700) was observed between fruit infestation and polyphenol content in the fruits.

4.4.2.8 Polyphenol oxidase activity

Polyphenol oxidase activity observed in fruits of different brinjal genotypes ranged from 2.25 to 5.68 units/min/g fresh weight. The genotype RHRB-28 (HR) showed significantly maximum polyphenol oxidase activity (5.68 units/min/g fresh weight). It was followed by polyphenol oxidase activity observed in fruits of RHRB-12 (FR) (5.35 units /min/g fresh weight) and is statistically at par with it. The next successive genotypes showing polyphenol oxidase activity in descending order were RHRB-21 (FR), RHRB-20 (HR), RHRB-79 (FR), RHRB-75 (T), RHRB-37 (FR), RHRB-70 (FR), RHRB-60 (FR), RHRB-42 (S), RHRB-11 (S), RHRB-

34 (T), RHRB-68 (S), RHRB-74 (T), RHRB-67 (T), RHRB-69 (HS), RHRB-7 (HS) and RHRB-35 (S) recording 4.83, 4.65, 4.48, 4.37, 4.29, 4.17, 4.00, 3.76, 3.76, 3.52, 3.21, 3.15, 3.01, 2.93, 2.72 and 2.69 units/min/g fresh weight polyphenol oxidase activity, respectively. Minimum polyphenol oxidase activity (2.25 units/min/g) was observed in fruits of genotype RHRB-53 (HS). Followed by polyphenol oxidase activity observed in RHRB- 73 (S) (2.29 units /min/g fresh weight) being statistically similar to it.

Higher polyphenol oxidase activity was observed in fruits of resistant genotypes as compared to that of susceptible genotypes with some exceptions. A significantly highly significant and negative correlation (r= -798) was observed between fruit infestation and polyphenol oxidase activity observed in fruits.

4.4.2.9 Peroxidase activity

The genotypes showed significant variation of 4.45 to 13.65 units /min/g fresh weight for the peroxidase activity in fruits (Table 19). Significantly maximum peroxidase activity (13.65 units /min/g fresh weight) was observed in genotype RHRB-12 (FR). It was statistically similar to that of observed in RHRB-79 (FR) (13.23 units/min/g fresh weight). The next genotypes recording the peroxidase activity were, RHRB-21 (FR), RHRB-28 (HR), RHRB-20 (HR), RHRB-60 (FR), RHRB-42 (S), RHRB-68 (S), RHRB-75 (T), RHRB-74 (T), RHRB-53 (HS), RHRB-34 (T), RHRB-35 (S), RHRB-11 (S) RHRB-7 (HS), RHRB-37 (FR) and RHRB-69 (HS) recording 12.92, 12.16, 11.77, 10.76, 10.32, 9.73, 9.69, 8.97, 8.81, 8.65, 8.51, 7.25, 6.97, 6.41 and 5.83 units/min/g fresh weight, respectively in descending order of their sequence. The genotype RHRB-73 (S) recorded minimum peroxidase activity (4.45 units/min/g fresh weight) followed by RHRB-70 (FR) and RHRB-67 (T) recording 4.97 and 4.99 units/min/g fresh weight peroxidase activities, respectively.

In general, fruits of resistant brinjal genotypes showed maximum peroxidase activity as compared to susceptible genotypes with some exceptions. Similarly, the significant negative correlation (r = - 536) was found between per cent fruit infestation and peroxidase activity observed in fruits of different brinjal genotypes.

4.5 Quantitative relationships

Infestation by the pest also depends upon various independent characters therefore, it is essential to know the relationship between the characters. Correlation analysis is greatly used to find out the mutual association between level of infestation and the related characters. The estimate of correlation provides an effective way for isolation of individual genotypes with desirable characters for resistance. To study the association of characters the correlation coefficient were computed in all possible combinations among the characters responsible for shoot and fruit borer infestation and presented in Table 20 and 21, respectively.

4.5.1 Correlation between shoot characters and per cent shoot infestation caused by *L. orbonalis*

The correlation coefficient were computed in all among the characters responsible for shoot infestation and presented in Table 20.

The per cent shoot infestation showed positive and highly significant correlation with shoot thickness (r= 0.632), total sugar (r= 0.651), crude protein (r= 0.842), while positive and significant correlation with moisture content (r= 0.526) and crude fat (r= 0.476). The characters trichome density (r= -0.621), ash content (r= -0.754), crude fibre (r= -0.623) and polyphenol oxidase activity

Table 20: Correlation matrix between shoot characters and per cent shoot infestation caused by *L. orbonalis*

Characters	Trichome density	Shoot thickness	Moisture	Total sugar	Crude protein	Crude fat	Ash	Crude fibre	Poly-phenols	PPO	PO
Trichome density	1.000										
Shoot thickness	-0.259	1.000									
Moisture	-0.405	0.595**	1.000								
Total sugar	-0.484*	0.282	0.451*	1.000							
Crude protein	-0.517*	0.455*	0.680**	0.766**	1.000						
Crude fat	-0.184	0.448*	0.299	0.215	0.433	1.000					
Ash	0.411	-0.421	-0.580**	-0.748**	-0.810**	-0.394	1.000				
Crude fibre	0.563**	-0.184	-0.364	-0.619**	-0.742**	-0.323	0.658**	1.000			
Polyphenols	0.343	-0.294	-0.589**	-0.661**	-0.714**	-0.395	0.721**	0.601**	1.000		
Polyphenol oxidase (PPO)	0.511*	-0.385	-0.386	-0.693**	-0.759**	-0.513*	0.761**	0.747**	0.650**	1.000	
Peroxidase (PO)	0.193	-0.270	-0.268	-0.467*	-0.488*	-0.160	0.570**	0.575**	0.760**	0.667**	1.000
Infestation (%)	-0.621**	0.632**	0.526*	0.651**	0.842**	0.476*	-0.754**	-0.623**	-0.538*	-0.801**	-0.431

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

(r= -0.801) exhibited negative and highly significant correlation with shoot infestation, while negative and non-significant correlation was found between peroxidase activity and shoot infestation (r= -0.431).

The trichome density had positive and highly significant correlation with crude fibre (r= 0.563) and positive and significant correlation with polyphenol oxidase activity (r= 0.511). Negative and significant correlation was observed between trichome density and total sugar (r= -0.484), crude protein (r= -0.517), while shoot thickness, moisture content and crude fat showed negative and non significant correlation with trichome density.

Shoot thickness had positive and highly significant correlation with moisture content (r= 0.595) while positive and significant correlation with crude protein (r= 0.445) and crude fat content (r= 0.448). The characters ash, crude fibre, polyphenols, polyphenol oxidase activity and peroxidase activity showed negative and non significant correlation with shoot thickness.

Moisture content showed positive and highly significant correlation with total sugar. However, negative and highly significant correlation was found with ash (r= -0.580) and polyphenol content (r= -0.589).

Total sugar content showed positive and highly significant correlation with crude protein (r= 0.766). However, negative and highly significant correlation was found with ash (r= -0.748), crude fibre (r= -0.619), polyphenol (r= -0.661), polyphenol oxidase activity (r= -0.693).

Crude protein content exhibited positive and non significant correlation (r= 0.430) with crude fat content. The charcters ash (r= -0.810), crude fibre (r= -0.742), polyphenol (r= -0.714) and polyphenol oxidase activity (r= -0.759) showed negative and highly significant correlanton with crude protein, while peroxidase activity had negative and significant correlation with crude protein content (r= -0.488).

Crude fat had negative and significant correlation with polyphenol oxidase activity (r= -0.513), while negative and non significant correlation was found with ash (r= -0.394), crude fibre (r= -0.658), polyphenols (r= -0.395) and peroxidase activity (r= -0.160).

Ash content exhibited positive and highly significant correlation crude fibre (r= 0.658), polyphenols (r= 0.721), polyphenol oxidase activity (r= 0.761) and peroxidase activity (r= 0.570).

Crude fibre content showed positive and highly significant correlation with polyphenol (r= 0.601) and polyphenol oxidase (r= 0.747) and peroxidase activity (r= 0.575).

Phenol content had positive and highly significant correlation with polyphenol oxidase (r= 0.650) and peroxidase activity (r= 0.760).

Polyphenol oxidase exhibited positive and highly significant correlation with peroxidase activity (r= 0.667).

4.5.2 Correlation between fruit characters and per cent fruit infestation caused by *L. orbonalis*

The correlation coefficient among the different fruit characters were computed in all combinations and presented in Table 21.

The per cent fruit infestation showed positive and highly significant correlation with length of calyx (r= 0.616), moisture content (r= 0.717), total sugar (r= 0.604), crude protein (r= 0.750), while positive and significant correlation with length of pedicel (r= 0.474). The characters diameter of fruit (r= 0.249), thickness of pericarp (r= 0.126) and crude fat (r= 0.366) showed positive but non significant correlation with per cent fruit infestation. Negative and highly significant correlation of per cent fruit infestation observed with ash (r= -0.816), crude fibre (r= -0.759), polyphenols (r= -0.700) and polyphenol oxidase activity (r= -0.798). The peroxidase activity had negative and significant correlation (r= -0.536) with per cent fruit infestation, while negative and non significant correlation (r= -0.172) was found between length of fruit and per cent fruit infestation.

Length of fruit had positive and significant correlation with length of pedicel (r= 0.485) while positive and non-significant correlation was found with length of calyx, total sugar, crude fat, ash, crude fibre, polyphenol and peroxidase activity. The characters diameter of fruit, thickness of pericarp, moisture content, crude protein and polyphenol oxidase activity showed negative and non significant correlation with fruit length.

Diameter of fruit showed positive and non significant correlation with length of pedicel, length of calyx, moisture content, crude protein and crude fat while negative and non significant correlation was found between diameter of fruit and length of pedicel, total sugar, ash, crude fibre, polyphenol, polyphenol oxidase and peroxidase activities.

Thickness of pericarp exhibited positive and non significant correlation with length of pedicel, length of calyx, moisture content, crude fibre and peroxidase activity. However, negative and non significant correlation observed with total sugar, ash, crude fibre, polyphenol and polyphenol oxidase activity.

Length of pedicel exhibited positive and highly significant correlation with length of calyx (r= 0.674) and crude fat (r= 0.570) while positive and significant correlation with moisture content (r= 0.499). The characters total sugar and crude protein showed positive and non-significant correlation with length of pedicel. Negative and significant correlation (r= -0.487) was found between

Table 21: Correlation matrix between fruit characters and per cent fruit infestation caused by *L. orbonalis*

Characters	Fruit length	Fruit diameter	Pericarp thickness	Pedicel length	Calyx length	Moisture	Total sugar	Crude protein	Crude fat	Ash	Crude fibre	Poly-phenols	PPO	PO
Fruit length	1.000													
Fruit diameter	-0.132	1.000												
Pericarp thickness	-0.019	0.424	1.000											
Pedicel length	0.485*	-0.111	0.030	1.000										
Calyx length	0.144	0.296	0.175	0.674**	1.000									
Moisture	-0.071	0.346	0.191	0.499*	0.633**	1.000								
Total sugar	0.065	-0.115	-0.194	0.433	0.538*	0.522*	1.000							
Crude protein	-0.156	0.095	0.049	0.408	0.624**	0.660**	0.596**	1.000						
Crude fat	0.230	0.079	0.059	0.570**	0.476*	0.414	0.232	0.471*	1.000					
Ash	0.176	-0.253	-0.213	-0.260	-0.442	-0.576**	-0.497*	-0.602**	-0.179	1.000				
Crude fibre	0.028	-0.160	-0.006	-0.406	-0.532*	-0.608**	-0.603**	-0.594**	-0.327	0.573**	1.000			
Phenols	0.227	-0.134	-0.184	-0.234	-0.422	-0.740**	-0.597**	-0.677**	-0.266	0.716**	0.547*	1.000		
Polyphenol oxidase (PPO)	-0.079	-0.230	-0.098	-0.487*	-0.564*	-0.658**	-0.656**	-0.713**	-0.525*	0.691**	0.614**	0.690**	1.000	
Peroxidase (PO)	0.105	-0.016	0.204	-0.233	-0.266	-0.575**	-0.485*	-0.506*	-0.279	0.479*	0.352	0.766**	0.666**	1.000
Infestation (%)	-0.172	0.249	0.126	0.474*	0.616**	0.717**	0.604**	0.750**	0.366	-0.816**	-0.759**	-0.700**	-0.798**	-0.536*

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

length of pedicel and polyphenol oxidase activity, while ash, crude fibre, polyphenols and peroxidase activity showed negative and non-significant correlation.

Length of calyx had positive and highly significant correlation with moisture (r= 0.633) and crude protein (r= 0.624), while positive and significant correlation observed with total sugar (r= 0.538), crude fat (r= 0.476). Negative and significant correlation was found between length of calyx and crude fibre (r= -0.532) and polyphenol oxidase activity (r= -0.564), while negative and non significant correlation observed with ash, polyphenol and peroxidase activity.

Moisture content had positive and highly significant correlation with crude protein (r= 0.660), positive and significant correlation with total sugar (r= 0.522), while positive and non significant correlation with crude fat (r= 0.414). Negative and highly significant correlation was found between moisture content and ash (r= -0.576), crude fibre (r= -0.608), polyphenols (r= -0.740), polyphenol oxidase (r= -0.658) and peroxidase (r= -0.575) activities.

Total sugar had significant and positive correlation with crude protein (r= 0.596) and non significant positive correlation with crude fat (r= 0.232). Negative and highly significant correlation was found between total sugar and crude fibre (r= -0.603), polyphenols (r= -0.656), while negative and significant correlation with ash (r= -0.497) and peroxidase (r= -0.485).

Crude protein exhibited positive and significant correlation with crude fat (r= 0.471). It showed negative and highly significant correlation with ash (r= -0.602), crude fibre (r= -0.594), polyphenols (r= -0.677) and polyphenol oxidase activity (r= -0.713), while negative and significant correlation with peroxidase activity (r= -0.506).

Crude fat had negative and significant correlation with polyphenol oxidase activity (r= -0.525), while negative and non significant correlation was observed with ash, crude fibre, polyphenols, and peroxidase activity.

Ash content exhibited positive and highly significant correlation with crude fibre (r= 0.573), polyphenols (r= 0.716) and polyphenol oxidase activity (r= 0.691) and positive and significant correlation with peroxidase activity (r= 0.479).

Crude fibre had positive and highly significant correlation with polyphenol oxidase activity (r= 0.614), positive and significant correlation with polyphenols (r= 0.547) and positive and non significant correlation with peroxidase activity (r= 0.352).

Polyphenols exhibited positive and highly significant correlation with polyphenol oxidase peroxidase activities (r= 0.690 and 0.766, respectively).

Polyphenol oxidase activity showed positive and highly significant correlation with peroxidase activity (r= 0.666).

4.6 Path coefficient analysis

The estimated correlation coefficients among shoot and fruit infestation caused by *L. orbonalis* and tested shoot and fruit characters were partitioned into direct and indirect effects and have been presented by path coefficient analysis in Table 22 and 23.

4.6.1 Path coefficient analysis of shoot characters influencing shoot infestation caused by *L. orbonalis*

The correlation coefficients between different shoot characters were further partitioned into direct and indirect effects and are presented in Table 22 and Fig. 10.

The results indicated that, the character trichome density had negative direct effect (-0.2464) on per cent shoot infestation. Its indirect effects *via* moisture content, total sugar, crude fat, crude fibre and peroxidase activity were positive, while its indirect effects *via* shoot thickness, crude protein, ash, polyphenols and polyphenol oxidase activity were negative.

The shoot thickness had positive direct effect (0.4149) on per cent shoot infestation. Its indirect effects *via* trichome density,

Table 22: Path coefficient analysis of shoot characters influencing shoot infestation caused by *L. orbonalis*

Characters	Trichome density	Shoot thickness	Moisture	Total sugar	Crude protein	Crude fat	Ash	Crude fibre	Poly-phenols	PPO	PO
Trichome density	**-0.2464**	0.0638	0.0998	0.1192	0.1275	0.0453	-0.1013	-0.1387	-0.0845	-0.126	-0.0476
Shoot thickness	-0.1074	**0.4149**	0.2469	0.1171	0.1886	0.1859	-0.1748	-0.0764	-0.1219	-0.1598	-0.112
Moisture	0.1446	-0.2125	**-0.3571**	-0.161	-0.2429	-0.1068	0.2069	0.1299	0.2103	0.1379	0.0957
Total sugar	0.0937	-0.0547	-0.0874	**-0.1937**	-0.1483	-0.0416	0.145	0.1199	0.1281	0.1343	0.0905
Crude protein	-0.3418	0.3004	0.4495	0.5059	**0.6608**	0.2864	-0.5355	-0.4904	-0.4718	-0.5018	-0.3221
Crude fat	0.0232	-0.0566	-0.0378	-0.0271	-0.0547	**-0.1262**	0.0497	0.0408	0.0498	0.0647	0.0202
Ash	-0.0779	0.0799	0.1099	0.1418	0.1536	0.0747	**-0.1896**	-0.1247	-0.1366	-0.1443	-0.108
Crude fibre	0.0861	-0.0282	-0.0556	-0.0947	-0.1135	-0.0494	0.1006	**0.1529**	0.0919	0.1142	0.088
Polyphenols	-0.0364	0.0312	0.0624	0.0701	0.0757	0.0418	-0.0764	-0.0637	**-0.106**	-0.0689	-0.0806
Polyphenol oxidase (PPO)	-0.1979	0.1491	0.1494	0.2683	0.2938	0.1983	-0.2947	-0.289	-0.2517	**-0.387**	-0.2581
Peroxidase (PO)	0.0392	-0.0549	-0.0545	-0.0948	-0.099	-0.0325	0.1157	0.1169	0.1544	0.1355	**0.2031**
Total correlation with % shoot infestation	-0.621**	0.632**	0.526*	0.651**	0.842**	0.476*	-0.754**	-0.623**	-0.538*	-0.801**	-0.431

Note: Underlined Figures show direct effects

Residual effect: 0.09516

** Significant at 1 % level

* Significant at 5 % level

crude protein, ash, polyphenol and polyphenol oxidase activity were positive while its indirect effects *via* moisture content, total sugar, crude fat, crude fibre and peroxidase activity were negative.

Moisture content had negative direct effect (-0.3571) on per cent shoot infestation. Its indirect effects *via* trichome density, shoot thickness, crude protein, ash, polyphenol and polyphenol oxidase activity were positive while its indirect effects *via* total sugar, crude fat, crude fibre and peroxidase activity were negative.

Total sugar had negative direct effect (-0.1937) on per cent shoot infestation. Its indirect effects *via* trichome density, shoot thickness, crude protein, ash, polyphenol and polyphenol oxidase activity were positive while its indirect effects *via* crude moisture, crude fat, crude fibre and peroxidase activity were negative.

Crude protein had positive direct effect (0.6608) on per cent shoot infestation. Its indirect effects *via* trichome density, shoot thickness, ash, polyphenols and polyphenol oxidase activity were positive while its indirect effects *via* moisture, total sugar, crude fat, crude fibre and peroxidase activity activity were negative.

Crude fat had negative direct effect (-0.1262) on per cent shoot infestation. Its indirect effects *via* trichome density, shoot thickness, crude protein, ash, polyphenol and polyphenol oxidase activity were positive while its indirect effects *via* moisture, total sugar, crude fibre and peroxidase activity activity were negative.

Ash content had negative direct effect (-0.1896) on per cent shoot infestation. Its indirect effects *via* moisture, total sugar, crude fat, crude fibre and peroxidase activity were positive while its indirect effects *via* trichome density, shoot thickness, crude protein, polyphenol and polyphenol oxidase activity were negative.

Crude fibre had positive direct effect (0.1529) on per cent shoot infestation. Its indirect effects *via* moisture, total sugar, crude fat and peroxidase activity were positive while its indirect effects *via* trichome density, shoot thickness, crude protein, ash, polyphenol and polyphenol oxidase activity activity were negative.

Polyphenol had negative direct effect (-0.106) on per cent shoot infestation. Its indirect effects *via* moisture, total sugar, crude fat, crude fibre and peroxidase activity were positive while its indirect effects *via* trichome density, shoot thickness, crude protein, ash, polyphenols and polyphenol oxidase activity activity were negative.

Polyphenol oxidase activity had negative direct effect (-0.387) on per cent shoot infestation. Its indirect effects *via* moisture, total sugar, crude fat, crude fibre and peroxidase activity were positive while its indirect effects *via* trichome density, shoot thickness, crude protein, ash and polyphenol activity were negative.

Peroxidase activity had positive direct effect (0.2031) on per cent shoot infestation. Its indirect effects *via* moisture, total sugar, crude fat and crude fibre were positive while its indirect effects *via* trichome density, shoot thickness, crude protein, ash, polyphenol and polyphenol oxidase activity were negative.

4.6.2 Path coefficient analysis of fruit characters influencing fruit infestation caused by *L. orbonalis*

The correlation coefficients between different fruit characters were further partitioned into direct and indirect effects and are presented in Table 23 and Fig. 11.

The results indicated that, the character length of fruit had negative direct effect (-0.222) on per cent fruit infestation. Its indirect effects *via* length of pedicel, polyphenol and polyphenol oxidase activity were positive, while its indirect effects *via* diameter of fruit, length of calyx, moisture, total sugar, crude protein, crude fat, ash, crude fibre and peroxidase activity were negative.

Diameter of fruit had positive direct effect (0.059) on per cent fruit infestation. Its indirect effects *via* length of fruit, thickness of

Table 23: Path coefficient analysis of fruit characters influencing fruit infestation caused by *L. orbonalis*

Characters	Fruit length	Fruit diameter	Pericarp thickness	Pedicel length	Calyx length	Moisture	Total sugar	Crude protein	Crude fat	Ash	Crude fibre	Poly-phenols	PPO	PO
Fruit length	**-0.222**	0.029	0.004	-0.108	-0.032	0.016	-0.014	0.035	-0.051	-0.039	-0.006	-0.05	0.018	-0.023
Fruit diameter	-0.008	**0.059**	0.025	-0.007	0.017	0.020	-0.007	0.006	0.005	-0.015	-0.009	-0.008	-0.014	-0.001
Pericarp thickness	0.000	0.008	**0.018**	0.001	0.003	0.003	-0.004	0.001	0.001	-0.004	0.000	-0.003	-0.002	0.004
Pedicel length	0.132	-0.030	0.008	**0.273**	0.184	0.136	0.118	0.111	0.156	-0.071	-0.111	-0.064	-0.133	-0.064
Calyx length	-0.003	-0.005	-0.003	-0.012	**-0.018**	-0.011	-0.010	-0.011	-0.009	0.008	0.01	0.008	0.01	0.005
Moisture	-0.002	0.007	0.004	0.011	0.013	**0.021**	0.011	0.014	0.009	-0.012	-0.013	-0.016	-0.014	-0.012
Total sugar	-0.001	0.002	0.003	-0.007	-0.008	-0.008	**-0.015**	-0.009	-0.004	0.008	0.009	0.009	0.01	0.008
Crude protein	-0.022	0.013	0.007	0.057	0.087	0.092	0.083	**0.139**	0.065	-0.084	-0.083	-0.094	-0.099	-0.070
Crude fat	-0.016	-0.005	-0.004	-0.04	-0.033	-0.029	-0.016	-0.033	**-0.070**	0.012	0.023	0.019	0.037	0.019
Ash	-0.062	0.089	0.075	0.091	0.155	0.202	0.174	0.211	0.063	**-0.351**	-0.201	-0.251	-0.242	-0.168
Crude fibre	-0.008	0.044	0.002	0.111	0.145	0.166	0.165	0.162	0.089	-0.156	**-0.273**	-0.149	-0.168	-0.096
Polyphenols	0.026	-0.015	-0.021	-0.027	-0.048	-0.085	-0.069	-0.078	-0.031	0.082	0.063	**0.115**	0.079	0.088
Polyphenol oxidase (PPO)	0.019	0.054	0.023	0.114	0.132	0.154	0.154	0.167	0.123	-0.162	-0.144	-0.162	**-0.235**	-0.156
Peroxidase (PO)	-0.007	0.001	-0.014	0.016	0.018	0.039	0.033	0.035	0.019	-0.033	-0.024	-0.053	-0.046	**-0.069**
correlation with % fruit infestation	-0.172	0.249	0.126	0.474*	0.616**	0.717**	0.604**	0.750**	0.366	-0.816**	-0.759**	-0.700**	-0.798**	-0.536*

Note: Underlined Figures show direct effects
Residual effect: 0.105087

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

pericarp, moisture, total sugar, crude protein, ash, crude fibre, polyphenol oxidase activity and peroxidase activity were positive, while its indirect effects *via* length of pedicel, length of calyx, crude fat and polyphenols were negative.

Thickness of pericarp had positive direct effect (0.018) on per cent fruit infestation. Its indirect effects *via* length of fruit, diameter of fruit, length of pedicel, moisture, total sugar, crude protein, ash, crude fibre and polyphenol oxidase activity were positive, while its indirect effects *via* length of calyx, crude fat, polyphenol and peroxidase activity were negative.

Length of pedicel had positive direct effect (0.273) on per cent fruit infestation. Its indirect effects *via* thickness of pericarp, moisture, crude protein, ash, crude fibre, polyphenol oxidase and peroxidase activity were positive, while its indirect effects *via* length of fruit, diameter of fruit, length of calyx, total sugar, crude fat and polyphenols were negative.

Length of calyx had negative direct effect (-0.018) on per cent fruit infestation. Its indirect effects *via* diameter of fruit, thickness of pericarp, length of pedicel, moisture, crude protein, ash, crude fibre, polyphenol oxidase and peroxidase activity were positive, while its indirect effects *via* length of fruit, total sugar, crude fat and polyphenols were negative.

Moisture content had positive direct effect (0.021) on per cent fruit infestation. Its indirect effects *via* length of fruit, diameter of fruit, thickness of pericarp, length of pedicel, crude protein, ash, crude fibre, polyphenol oxidase and peroxidase activity were positive, while its indirect effects *via* length of calyx, total sugar, crude fat and polyphenols were negative.

Total sugar had negative direct effect (-0.015) on per cent fruit infestation. Its indirect effects *via* length of pedicel, moisture, crude protein, ash, crude fibre, polyphenol oxidase and peroxidase activity were positive, while its indirect effects *via* length of fruit, diameter of fruit, thickness of pericarp, length of calyx, crude fat and polyphenols were negative.

Crude protein had positive direct effect (0.139) on per cent fruit infestation. Its indirect effects *via* length of fruit, diameter of fruit, thickness of pericarp, length of pedicel, moisture, ash, crude fibre, polyphenol oxidase and peroxidase activity were positive, while its indirect effects *via* length of calyx, total sugar, crude fat and polyphenols were negative.

Crude fat had negative direct effect (-0.070) on per cent fruit infestation. Its indirect effects *via* diameter of fruit, thickness of pericarp, length of pedicel, moisture, crude protein, ash, crude fibre, polyphenol oxidase and peroxidase activity were positive, while its indirect effects *via* length of fruit, length of calyx, total sugar and polyphenols were negative.

Ash had negative direct effect (-0.351) on per cent fruit infestation. Its indirect effects *via* length of calyx, total sugar, crude fat and polyphenols were positive, while its indirect effects *via* length of fruit, diameter of fruit, thickness of pericarp, length of pedicel, moisture, crude protein, crude fibre, polyphenol oxidase and peroxidase activity were negative.

Crude fibre had negative direct effect (-0.273) on per cent fruit infestation. Its indirect effects *via* length of calyx, total sugar, crude fat and polyphenols were positive, while its indirect effects *via* length of fruit, diameter of fruit, length of pedicel, moisture, crude protein, ash, polyphenol oxidase and peroxidase activity were negative.

Polyphenol content had positive direct effect (0.115) on per cent fruit infestation. Its indirect effects *via* length of calyx, total sugar and crude fat were positive, while its indirect effects *via* length of fruit, diameter of fruit, thickness of pericarp, length of pedicel, moisture, crude protein, ash, crude fibre, polyphenol oxidase and peroxidase activity were negative.

Polyphenol oxidase activity had negative direct effect (-0.235) on per cent fruit infestation. Its indirect effects *via* length of fruit, length of calyx, total sugar, crude fat and polyphenols were positive, while its indirect effects *via* diameter of fruit, thickness of pericarp, length of pedicel, moisture, crude protein, ash, crude fibre and peroxidase activity were negative.

Peroxidase activity had negative direct effect (-0.069) on per cent fruit infestation. Its indirect effects *via* thickness of pericarp, length of calyx, total sugar, crude fat and polyphenols were positive, while its indirect effects *via* length of fruit, diameter of fruit, length of pedicel, moisture, crude protein, ash, crude fibre and polyphenol oxidase activity were negative.

5. DISCUSSION

In the present investigation, twenty brinjal genotypes with diverse morphological characters were used. The different brinjal genotypes were evaluated for their reaction to brinjal shoot and fruit borer on the basis of per cent infested shoots and fruits. The results obtained in these aspects are discussed below.

5.1 Field screening of brinjal genotypes

5.1.1 Per cent shoot infestation

The data on pooled mean (Table 3 and fig. 2 and 3) indicated that the shoot infestation ranged from 1.38 to 9.96 per cent. Shoots of all brinjal genotypes screened were prone to the attack by *L. orbonalis*. Among 20 genotypes, none was found complete resistant to shoot borer. Immunity to *L. orbonalis* was reported only either in wild species of brinjal like *Solanum khasianum* (Lal *et al.,* 1976) and *S. anomalum* and *S. incanum* (Behera *et al*., 1999) or in the derivatives of wild species like Arka Mahima and Arka Sanjivans (Kale et *al*., 1986a). But in the present study, none was immune to *L. orbonalis* as only cultivated genotypes of brinjal were screened.

Tolerant reaction was exhibited by the genotypes (RHRB-60, RHRB-20, RHRB-12 and RHRB-79) at the vegetative stage and the infestation ranged from 1.38 to 2.00 per cent. However, the results could not be compared for want of relevant literature on specific genotypes.

Comparatively susceptible reaction was noticed in genotypes RHRB-21, RHRB-11, RHRB-34 and RHRB-67. The infestation in these varieties ranged from 3.27 to 4.94 per cent. The genotypes RHRB-75, RHRB-68, RHRB-69, RHRB-53, RHRB-42, RHRB-35, RHRB-7 and RHRB-73 proved highly susceptible recording 5.02 to

9.96 per cent damaged shoots. During the present investigation the shoot infestation was found in the range of 1.38 to 9.96 per cent. Raut and Sonone (1980) also recorded fruit infestation in the range of 1.12 to 9.84 per cent under Rahuri conditions. The similar results were obtained by Behera *et al.* (1999) who observed shoot infestation in the range of 2.92 to 13.67 per cent.

5.1.2 Per cent fruit infestation

It was clear from Table 5 and 6 that the trend in varietal susceptibility was quite similar in both *Kharif* and *Rabi* season though the higher infestation was observed in *Kharif* season. In *Kharif* screening trial the infestation was high, (10.61 to 46.88 %) as compared to R*abi* season (7.04 to 42.47 %) on number basis; on weight basis it was 10.39 to 47.22 % and 7.64 to 41.82 % in *Kharif* and *Rabi* season, respectively. Pooled analysis of both the seasons indicated that infestation was in the range of 8.94 to 44.67 % and 9.01 to 44.52 % on number and weight basis, respectively. Similar differences in susceptibility were reported in eggplant varieties by Panda *et al.* (1971), Butani *et al.* (1977) and Gill and Chadha (1979). Srinivas and Peter (1995) also recorded the infestation of fruit borer in the range of 4.78 to 42.58 per cent on weight basis. Under Rahuri conditions Darekar *et al.* (1991) also recorded fruit infestation in the range of 7.93 to 33.00 per cent.

The increase in infestation of *L. orbonalis* during the fruit bearing stage was observed in the present investigation. The succulent, fleshy, soft and nutritious fruits were attacked more than the shoots and pest population progressively increased during the fruiting stage. Similar views were proposed by Isahaque and Choudhary (1984a). Singh and Pandita (2009) also observed lower infestation on shoots (1.5 %) and higher infestation on fruits (60%) in Karnal, Haryana and Gill and Chadha (1979) in Ludhiana, Punjab.

According to categorization of brinjal genotypes in different grades (Table 7) it was indicated that none of the genotypes showed immune reaction against shoot and fruit borer. All the genotypes tested in present investigation were prone to the attack of the pest. The results confirmed the findings of earlier workers such as Elanchezhyan *et al.* (2008), who reported the lack of immunity in cultivated germplasm of brinjal against shoot and fruit borer. Immunity to *L. orbonalis* was reported only in wild species of brinjal like *Solanum khasianum* (Lal *et al.*, 1976) and *S. anomalum* and *S. incanum* (Behera *et al.*, 1999). As only cultivated genotypes of brinjal were used in present study none of them had shown immune reaction to shoot and fruit borer.

Highly resistant reaction was exhibited by genotypes RHRB-20 and RHRB-28 recording 8.94 and 9.54 per cent infested fruits on number basis and 9.01 and 9.93 per cent fruit infestation on weight basis, respectively. However, the results obtained during the present investigation could not be compared due to want of literature regarding specific genotypes. The genotypes RHRB-69, RHRB-53 and RHRB-7 were observed highly susceptible to the attack of *L. orbonalis* recording more than 40.00 per cent infested fruits on number as well as well as weight basis. However, the susceptibility of these genotypes could not be compared due to paucity of literature.

5.1.3 Yield of marketable fruits

It is evident from the data (Table 8 and Fig. 6) that the genotype RHRB-60 recorded significantly highest 2.18 kg marketable fruits per plant. It was followed by RHRB-21, RHRB-28, RHRB-20, RHRB-79, RHRB-74, RHRB-73, RHRB-70, RHRB-75, RHRB-34, RHRB-37, RHRB-67, RHRB-68, RHRB-7, RHRB-69, RHRB-35, RHRB-11, RHRB-42, RHRB-53 and RHRB-12 in descending order.

The data indicated that the genotypes which registered higher trends of yield were highly tolerant to the damage of pest except RHRB-12 (0.520 kg/plant) which showed poor performance with respect to yield though it was found fairly resistant to *L. orbonalis*. It may be due to the small size and low weight of fruits. However, rest of the low yielding genotypes exhibited susceptibility to the pest. The genotype RHRB-73 showed higher yield 1.561 kg/plant though it was found susceptible to *L. orbonalis*, it may be due to the genetic characters of high yield potential or suitable climatic or environmental conditions of the region. More or less similar findings have been reported by Panda *et al.* (1971), Raut and Sonone (9180), Patil and Ajri (1993) and Dadmal (2003) regarding yield of different varieties from resistant to susceptible categories.

RHRB-21 and RHRB-60 had slightly more fruit infestation as compared to RHRB-20. However, the former genotypes yielded more than the later. This may perhaps be due to yield potentiality of an individual variety and tolerance to the damage caused by the pest. Lowest yield was recorded in RHRB-42 and RHRB-53 due to heavy damage by the pest.

The overall results indicated that, RHRB-20, RHRB-28, RHRB-60, RHRB-79, RHRB-21, RHRB-37 and RHRB-70 have emerged as the most promising genotypes having lower infestation and higher yield potential.

5.2 Larval and post-larval development of *L. orbonalis* on diet prepared from selected brinjal genotypes

For successful rearing of any insect outside its host plant, it is necessary to provide an ideal diet on which the insect can develop normally. Earlier different methods were used to rear the larvae of brinjal shoot and fruit borer for biological studies. The brinjal fruits were offered in different ways by using fresh fruits of different shapes, sizes and maturity; different surface sterilants to prevent fungal growth; sand layer at bottom of glass jar and brinjal fruit slices, did not serve the purpose of rearing the larvae. Also, as there was problem of rotting of fruits, repeated changing of brinjal slices was required which disturbed the larvae. Hence, to feed the *L. orbonalis*, we started with the semi-synthetic diet developed for *L. orbonalis* by Patil (1990). In the same diet we added a fine powder of dried egg plant fruits as per the method suggested by Talekar *et al.* (1999) to study antibiosis. Srinivasan *et al.* (2005) also used the artificial diet fortified with brinjal fruit or shoot powder in order to locate the antibiotic principle in egg plant shoot and fruits.

The data (Table 9 and Fig. 7, 8 and 9) indicated that there were several differences in behavior of different life stages of brinjal shoot and fruit borer when reared on diet fortified with fruit powder of genotypes having different grades of resistance.

Comparatively less per cent pupation (51.67 %) and less weight of pupa (14.68 mg) with prolonged larval and pupal period (17.11 and 10.12 days, respectively) were noticed when larvae reared on artificial diet fortified with fruit powder of resistant genotype RHRB-28. Similarly, less moth emergence (41.67 %), lower fecundity (76.89 eggs/female), poor growth index (1.53) and less adult longevity (4.22 and 5.13 in male and female, respectively) were noticed.

The diet fortified with fruit powder of susceptible genotype RHRB-42 favoured the development of larvae resulting into highest per cent pupation (66.67 %) and highest weight gain in pupal stage (20.13 mg) within a short larval and pupal period (14.12 and 8.37, respectively) due to poor antibiosis characters.

Similar views were expressed by Panda and Das (1975) who observed the antibiosis effect in resistant varieties. They found that the per cent survival of larvae, weight gain by the larvae and pupae, growth index and average fecundity were significantly less in case of pest reared on resistant cultivars.

Fast growth and development with reduced larval and pupal period was observed by Isahaque and Choudhari (1984b) in case of *L. orbonalis* reared on susceptible cultivars namely, Bhola Bengana, Bobengana, Powal and the slowest growth was observed on resistant cultivars Kuchia and Pusa Purple Cluster.

Raju *et al.* (1987) also noticed antibiosis effect in resistant brinjal entry SM-204, they reported that larvae feeding on resistant variety (SM-204) showed decreased larval and pupal period as compaired to susceptible varieties (Panjab Chamkila, SM-95, SM-82, SM-66, SM-192 and Long violet Dutch). Decreased survival percentage of larvae, pupal weight, growth index and fecundity with prolonged larval and pupal period was also reported by Dadmal (2003) when the larvae were fed with highly resistance cultivar pusa purple cluster, while increased larval and pupal weight with lower larval and pupal period was noticed in susceptible variety Puneri Kateri.

Perusal of literature revealed that there is lack of literature regarding larval development on diet fortified with brinjal fruit powder. Related to this aspect Srinivasan *et al.* (2005) did not find significant differences when the larvae were reared on artificial diet fortified with brinjal fruit powder. However, the diet fortified with shoot powder of different brinjal genotypes showed poor growth and development of *L. orbonalis*.

The overall results indicated that the larval growth, per cent pupation and emergence of moths from the pupae obtained from diet fortified with fruit powder of susceptible genotypes were higher than those on resistant genotypes. Subsequently, female moths obtained from the diet with susceptible brinjal fruits laid higher number of eggs than the resistant ones. Fast development and higher fecundity in case of susceptible brinjal varieties are some of the important factors for speedy multiplication of borer population in brinjal growing areas. However, the survival, development as well as the reproductive behavior of the borer pest was adversely affected in case of resistant genotypes which clearly indicated the presence of antibiotic principle which may be responsible for resistance in case of the genotypes RHRB-28, RHRB-20 and RHRB-37.

5.3 Association of biophysical attributes with resistance to shoot and fruit borer

The results obtained from the study of important biophysical attributes in relation to shoot and fruit infestation are discussed under this heading.

5.3.1 Characters influencing shoot infestation

5.3.1a Trichome density

The mean trichome density at lower side of leaf surface recorded in different brinjal genotypes ranged from 458.67 to 1192.67 per cm^2 (Table 10). Also there was strong negative correlation between trichome densities per cm^2 and incidence of shoot borer, the 'r' value being (-) 0.621. This indicated that maximum trichome density was found in tolerant cultivars as compared to susceptible cultivars. The earlier results reported by Naqvi *et al.* (2009) specify the trichome density in the range of 550.5 to 1068.5 per cm^2. Dense trichomes in immune and wild cultivars were reported by Kale *et al.* (1986a). Javed *et al.* (2011) also reported strong and negative correlation between trichome density and infestation of *L. orbonalis.*

Trichomes play vital role in imparting resistance in plants to the pest, as long and dense trichome do not favour the female moth for oviposition and then to the neonate larvae to reach towards normal boring site. Similar findings were reported by Panda and Das (1974) who observed that the trichome acted as barrier for newly hatched larvae to reach the boring site. Mote (1981), Ishaque and Choudhari (1984a), Duffey (1986) and Kale *et al.* (1986a) reported that resistant varieties had large number of hairs on lower surface of leaf. Lit *et al.* (2000) also found that trichome characters can serve as resistance factors in some egg plant varieties and probably a combination of trichomes and chemical factors on the surface of the leaves in other egg plants. However, the present findings do not conform the results of Srinavasan *et al.* (2005) who found the higher trichome density on susceptible cultivar EG075 and less on resistant cultivar EG058 and reported that role of trichome in imparting resistance to BSFB is negligible or nil.

5.3.1b Shoot thickness

Maximum thickness of shoot (0.63 cm) was recorded in the highly susceptible genotype RHRB-73, while the minimum shoot thickness (0.27 cm) was found in tolerant cultivar RHRB-12. In the present findings shoot thickness showed strong and positive correlation (r = 0.632) in relation to incidence of shoot borer. This indicated the higher shoot thickness in susceptible genotypes as compared to tolerant. Genotypes having thick shoots provide more space for movement of larvae and the larvae show enhanced growth and development therefore, the thick shoots are vulnerable to the arrack of shoot borer.

A positive relationship between the thickness of shoot and the pest infestation has already been reported by earlier workers. Panda *et al.* (1971) reported that the sclerenchymatous hypodermis in the least susceptible entry was heavily lignified and the vascular bundles are closely packed and arranged like a ring, which acted as barrier to borer entry. The shoots of most susceptible entry unlike those of least susceptible one had neither the lignified sclerenchymatous layer nor the closely packed vascular bundle and the pith area was large, having bigger cells. Isahaque and Chaudhuri (1984a) also found that resistant brinjal variety Kuchia had more lignified and compact shoots with fewer diameters as compared to susceptible variety Bhola bengena which had less lignified, less compact shoots with more diameter. Malik *et al.* (1986) reported that thin shoots of brinjal found tolerant to *L. orbonalis*. The earlier workers Patil and Ajri (1993), Jat and Pareek (2003), Hazra *et al.* (2004) and Naqvi *et al.* (2009) also reported the strong and positive correlation between shoot thickness and shoot infestation by *L. orbonalis.*

5.3.2 Pedicel and calyx characters

5.3.2a Length of pedicel

The pedicel length have found to have a good and positive correlation (r = 0.473628) with infestation of fruit borer (Table 11). Thus the genotypes with fruits having long pedicel were more susceptible than those with short pedicel. The present findings are in agreement with Patil and Ajri (1993), who also observed that the pedicel length had a strong and positive correlation with the susceptibility to fruit borer. Positive correlation of length of pedicel and fruit infestation was also reported by Naik (2010).

5.3.2b Length of calyx

Calyx is the most important morphological component which has strong association with pest infestation. From the pooled mean (Table 12) it could be seen that the highly susceptible genotype RHRB-7 recorded maximum (4.07 cm) length of calyx however, short calyx length was observed in resistant genotypes as the length of calyx exhibited strong positive correlation (r = 0.615638) in relation to per cent infestation by *L. orbonalis*. The present results are in conformity with those of Patil and Ajri (1993) and Naik (2010) reported a strong and positive correlation between calyx length and fruit infestation by brinjal fruit borer.

The long and big or loose calyx in the highly susceptible genotypes might help the young borer to hide and get easily into the fruit through the soft tissue below the calyx. On the other hand as reported by Panda *et al.* (1971) fruits with tight and semi tight calyx hinder the initial borer penetration into the fruit. Kale *et al.* (1986a) also reported the compact and tight calyx in case of genotypes which found resistant to fruit borer.

5.3.3 Fruit characters

5.3.3a Length of fruit

A weak negative correlation was noticed between length of fruits and damage by the pest (r = (-) 0.17223) which showed practically no effect of the length of fruit on susceptibility to fruit borer. A weak and negative correlation between length of fruit and infestation of pest has also been reported by Patil and Ajri (1993). According to Grewal and Singh (1995) and Gupta and Kauntey (2008) there was no linear correlation observed between length of fruit and degree of infestation, while Shukla *et al.* (2001) revealed that the fruit length was insignificant to establish any relationship with fruit damage by the borer. However, resistance in long fruited genotypes was reported by Dhooria and Chadha (1981), Ishaque and Choudhari (1984a), Malik *et al.* (1986), Shelke (1989) and Grewal *et al.* (1995). Naqvi *et al.* (2009) also observed significant negative correlation between fruit length and infestation by fruit borer.

The overall results have indicated that there was a very weak but negative correlation which did not show much influence on host plant resistance in different genotypes.

5.3.3b Diameter of fruit

The results of pooled analysis of both the seasons indicated that the mean fruit diameter ranged from 3.34 to 5.96cm and it was observed that diameter of fruit exhibited weak and positive correlation (r = 0.249097) in relation to fruit infestation by *L. orbonalis* (Table 14). Positive correlation between fruit diameter and degree of infestation was also reported by Sharma *et al.* (1985), Patil and Ajri (1993). According to Shelke (1989) the susceptible varieties (Manjri Gota, ABV-4) had higher fruit diameter than the resistant cultivars (Aruna and Vaishali). Highly significant and positive correlation between fruit diameter and degree of fruit infestation was reported by Subbaratnam (1982) and Naqvi *et al* (2009). However, Grewal and Singh (1995) and Gupta and Kauntey (2008) did not find any linear correlation between diameter of fruits and degree of fruit infestation recording very weak and negative correlation between fruit diameter and infestation by fruit borer.

5.3.3c Thickness of pericarp

The results indicated that, mean thickness of pericarp ranged from 0.26 to 0.98 cm (Table 15). The susceptible genotype RHRB-42 recorded maximum (0.98 cm) thickness of pericarp, while fairly resistant genotype RHRB-12 recorded minimum (0.26 cm) thickness of pericarp. A very weak and positive correlation (r = 0.126222) with degree of fruit infestation indicated practically no effect of pericarp thickness on susceptibility to fruit borer. According to Grewal and Singh (1995) and Gupta and Kauntey (2008) the varieties with narrow pericarp were less susceptible. Chandrashekhar *et al.* (2009) also reported highly significant and positive correlation between pericarp thickness and fruit infestation.

5.3.3d Colour of the fruit

Data of the present investigation revealed that the colour of the fruit did not have any direct relation with per cent fruit infestation. However lower level of fruit infestation was found in cultivars having white to light green colour. Gupta and Kauntey (2008) observed that dark coloured fruits were most susceptible as compared to green fruited varieties. Susceptibility of dark purple fruits was also reported by Grewal and Singh (1995). The results are in conformity with the results of Lal *et al.* (1976) and Naqvi *et al.* (2009). They reported that the fruit colour had no impact on the degree of fruit infestation.

5.3.3e Shape of the fruit

It was evident from the present studies that the fruit shape had no role in imparting resistance against brinjal shoot and fruit borer. The present findings are in conformity with Naqvi *et al* (2009) who also noticed that shape of fruit had no impact on the preference of fruit borer. Similarly, Gangopadhyay *et al.* (1996) also revealed that the resistance is not confirmed by any single physical character of germplasm like spinyness, shape and size of the fruits. However, Dhooria and Chadha (1981) found that, the brinjal varieties bearing long fruits were less attacked by the fruit borer than the varieties with round fruits. In the same way, Ishaque and Choudhari (1984a) reported that round, oblong and oval fruits were more attacked than the slender fruits.

5.4 Association of biochemical attributes with resistance to shoot and fruit borer

Many biochemical factors are known to be associated with insect resistance in crop plants. It is obvious in many cases that the biochemical factors are more important than morphological and physiological factors in conferring non-preference and antibiosis. The ability of plant to withstand attack of insect is due to certain biochemical characteristics which exert unfavorable effects on the insects. Some biochemical constituents may act as feeding stimuli for insects. Occurrence at lower concentration or total absence of such biochemicals leads to insect resistance (Singh,1983). The biochemical constituents like glycoalkaloid (solasodine), phenols, phenolic oxidase enzymes namely polyphenol oxidase and peroxidase are synthesized in brinjal and these biochemical constituents possess insect resistant properties (Kalloo, 1988).

Chemical analysis of all the twenty genotypes of brinjal was undertaken with a view to find out as to whether the differences in resistance or susceptibility of brinjal genotypes were due to differences in the various chemical constituents of shoots and fruits. It was found that the biochemical constituents in shoots and fruits varied significantly in different grades of cultivars from resistant to susceptible (Table 18 and 19).

5.4.1 Moisture

From Table 19, it could be seen that in the highly resistant genotypes RHRB-28 and RHRB-20, the moisture content in fruits was relatively less (74.94 and 75.46%, respectively) whereas in highly susceptible genotypes RHRB-53 and RHRB-7 it was 84.06 and 87.95 per cent, respectively. Fairly resistant and tolerant genotypes contained moisture in the range of 74.16 to 82.20% and 80.11 to 85.77%, respectively, while susceptible genotypes contained moisture from 81.73 to 86.83 per cent. There was a strong and positive correlation (r = 0.717) between moisture content of fruits and resistance to fruit borer. Almost similar trend was noticed with respect to moisture content in shoots and there was a good positive correlation (r = 0.526) with shoot borer attack.

Similar correlation was reported by the earlier workers (Kale *et al.*, 1986b; Patil *et al.*, 1994; Jat and Pareek, 2003; Dadmal *et al.,* 2004; Elanchezhyan *et al.,* 2008; Chandrashekhar *et al.*, 2009) who reported increased palatability of the food material with more moisture content in case of susceptible varieties. Phytophagous insects normally feed on diets with high water content, as water serves to prevent dehydration in the body of insects and for adequate osmotic balance of the body cells and tissues as well as organs.

5.4.2 Total sugar

The lowest total sugar (15.25%) was found in the fruits of resistant genotype, RHRB-21 as compared to highest quantity in the fruits of susceptible genotype, RHRB-73 (31.33%). A strong positive correlation between total sugars and the infestation of fruit borer was noticed (r = 0.604) (Table 19). In case of shoots, more or less similar trend was noticed with 'r' value 0.651.

The present findings are in accordance with Panda and Das (1975); Darekar *et al.* (1991); Patil *et al.* (1994); Hazra *et al.* (2004) who observed highly significant positive correlation between total sugars and per cent fruit infestation of the borer. Elanchezhyan *et al.* (2008) reported that insect susceptible plant parts had higher concentration of sugars and also stated that the total soluble sugars acted as feeding stimulant in the susceptible varieties. Similarly, Hanife (2006) also stated that sugars are powerful feeding stimulants and act as most common source of energy utilized by insects.

5.4.3 Crude protein

Relatively higher percentage of crude protein was noticed in fruits and shoots of susceptible genotypes as compared to resistant genotypes. More crude protein in the susceptible genotypes indicated significantly positive correlation between shoot and fruit infestation and crude protein (r= 0.842 and 0.750, respectively).

Ishaque and Choudhari (1984a), Patil *et al.* (1994), Girish *et al.* (2001), Jat and Pareek (2003), Hazra *et al.* (2004) and Chandrashekhar *et al.* (2009) reported significant and positive correlation between protein content and incidence of shoot and fruit borer. Plant proteins are the dominant source of amino acids and insect digest proteins in their food in order to get amino acids. Also the protein foods are necessary for egg production and adequate adult longevity (Behmer, 2006)

5.4.4 Crude fat

Relatively high crude fat content was noticed in shoots of susceptible genotypes while shoots of resistant genotypes recorded low crude fat content. A positive correlation was noticed between crude fat and shoot infestation (r = 0.476). No such correlation however could be found in case of crude fat content in fruits with infestation of fruit borer.

Similar trend has already been reported by the earlier workers (Panda and Das, 1975 and Kale *et al.,* 1986b). Behmer, 2006 also stated that plant feeding insects have high dietary requirement of polyunsaturated fatty acids and the fatty acids also seems to play role in reproduction.

5.4.5 Ash

Content of total minerals as evidenced by ash varied from 11.20 to 13.87 per cent in the shoots of tolerant and moderately tolerant genotypes while in susceptible and highly susceptible genotypes it ranged from 8.27 to 11.93 per cent. Highly significant and negative correlation (r = (-) 0.754) was noticed between ash content and per cent infestation in shoots. Almost similar trend was noticed in case of ash content in fruits of different genotypes having strong positive correlation (r = 0.816) with per cent fruit infestation.

This result is in conformity with the findings of Panda and Das (1975), Patil *et al.* (1994), Dadmal *et al.,* (2004) and Elanchezhyan *et al.,* (2008) who reported significantly negative correlation between the ash content and infestation by the pest in brinjal. Ash consists of total mineral matter along with silica which is completely indigestible material and having adverse effects on insect metabolism.

High ash content in shoots than fruits noticed in present findings also confirmed the results obtained by Patil *et al.* (1994) and Dadmal *et al.,* (2004).

5.4.6 Crude fibre

Relatively high crude fibre content was noticed in resistant genotypes as compared to susceptible genotypes. In present study higher amount of crude fibre content was recorded in fruits than that in shoots of different brinjal genotypes which is in conformity with that reported by Patil *et al.* (1994), Dighe *et al.* (1997) and Dadmal *et al.* (2004).

The value of correlation coefficient (r) indicated the strong and negative correlation between crude fibre content and infestation (r = (-) 0.623 and (-) 0.759 for shoots and fruits, respectively). The present findings are in accordance with report of

Panda and Das (1975), Kale *et al.* (1986b) and Chandrashekhar *et al.* (2009) who have observed the significant negative correlation between crude fibre content and per cent infestation of the borer.

5.4.7 Polyphenols

Phenols are the extremely abundant plant allelochemicals, often associated with feeding deterrence or growth inhibition of herbivores. Phenolics in a fairly large concentration could ward off insect pests because of direct toxicity (Mohan *et al.*, 1987). In the present studies, maximum contents of total phenols were recorded in resistant genotypes and minimum in susceptible genotypes. Also there is strong and negative correlation of polyphenol content in fruits and fruit infestation (r = (-) 0.700) and good and negative correlation with polyphenol content in shoots and shoot infestation (r = (-) 0.538) indicating that it plays an important role in imparting resistance against the pest. Raju *et al.* (1987); Darekear *et al.* (1991); Muthukumar (2002); Jat and Pareek (2003); Dadmal *et al.* (2004); Asati *et al.* (2004) and Hazra *et al.* (2004) reported similar type of correlation.

Bajaj *et al.* (1989) reported that higher phenolic compounds with glycoalkaloids were associated with resistance in plants towards the pest. Thakre and Khode (1992) reported 3% solasodine in wild brinjal. It means wild genotypes had higher phenolic contents with glycoalkaloids and hence it is one of the factors due to which the wild genotypes show immune reaction against the pest. Ranjal and Chakravarti (2002) found high level of phenolic content in the resistant cultivar PPC as compared to rest of the tested cultivars.

5.4.8 Enzyme activities

Insect resistance properties of some oxidative enzymes like polyphenol oxidase and peroxidase were reported by Kalloo (1988). During the present investigation polyphenol oxidase and peroxidase were activities studied. Significant variation was observed regarding enzyme activities in different brinjal genotypes belonging to various categories from resistant to susceptible. The results obtained are discussed here.

5.4.8.a Polyphenol oxidase activity

During the present investigation fruits of the different brinjal genotypes recorded highest polyphenol oxidase activity than that recorded in shoots. Higher polyphenol oxidase activity in fruits than shoots was also reported by Khorsheduzzaman *et al.* (2010). The highest polyphenol oxidase activity in the fruits was recorded in the resistant genotypes ranging from 4.00 to 5.68 units/min/g fresh weight, while fruits of susceptible genotypes showed lower activity from 3.76 to 2.25 units/min/g fresh weight (Table 19). Also, the genotypes showed significant variation of 1.31 to 4.83 units/min/g fresh weight for the polyphenol oxidase activity in shoots (Table 18). A highly significant and negative correlation was observed between polyphenol oxidase activity and pest infestation. The results are in conformity with those of Bhattacharya *et al.* (2009) who observed the PPO activity in the range of 2.40 to 4.60 units/min/g fresh weight and also recorded highest PPO activity in the fruits of cultivars having less infestation. Similarly higher PPO activity in resistant cultivar BL009 (6.17 and 6.32 units/min/g in fruits and shoots, respectively) was observed as compared to susceptible cultivar EG 075 (2.85 and 3.04 units/min/g in fruits and shoots, respectively) by Khorsheduzzaman *et al.* (2010).

5.4.8.b Peroxidase activity

Relatively higher peroxidase activity was observed in fruits of highly resistant genotypes RHRB-28 and RHRB-20 (12.16 and 11.77 units/min/g fresh weight, respectively) however, lower activity was observed in highly susceptible genotypes RHRB-69, RHRB-53 and RHRB-7 (5.83, 6.97 and 8.81 units/min/g fresh weight, respectively). Significant negative correlation was found in peroxidase activity and fruit infestation (r = -0.536). No such correlation however could be found in case of peroxidase activity in shoots and shoot borer attack. Dighe *et al.* (1997) found peroxidase activity in the range of 8.0 to 23.5 units/min/g fresh weights in the fruits of different brinjal genotypes. Higher peroxidase activity in fruits of less susceptible cultivars was reported by Bhattacharya *et al.* (2009).

5.5 Path coefficient analysis

Resistance is a complex phenomenon, According to Hazra *et al.* (2004) all the three mechanisms of resistance *viz.* antibiosis, antixenosis and recovery resistance operated in the plant for resistance to most of the insect pests. Grewal and Singh (1995) also observed that the resistance was not governed by any single character and the resistance in brinjal to the fruit borer was found to be collectively contributed by number of fruit characters. Therefore, the knowledge of magnitude and type of association between degree of infestation and characters associated with it is very necessary. Correlation does not provide exact picture of the direct and indirect causes of such association which can be understood through path analysis. Direct selection of any character is useful when its direct effect is more or less of the same magnitude as that of total effect and indirect selection is practiced when its indirect effect is responsible for its total effect. Thus path coefficient analysis is very useful to point out the important components of resistance which can be utilized for recommending selection indices.

The path coefficient analysis permits the separation of direct effect from indirect effects through other related traits by partitioning the correlation coefficients. In the present study, the residual effect was low (0.09516 and 0.105087 for shoot and fruit infestation, respectively) indicating the adequacy of the characters chosen for the study.

The path coefficient analysis of shoot characters (Table 22) revealed that the characters like shoot thickness, crude protein, crude fibre and peroxidase activity exerted positive direct effect on per cent shoot infestation. The characters like trichome density, moisture, total sugar, crude fat, ash, polyphenols and polyphenol oxidase activity exerted negative direct effect.

The direct effect caused by shoot thickenss (0.4149) and crude protein (0.6608) were positive and higher in magnitude indicating that higher shoot thickness and crude protein increase the infestation caused by brinjal shoot and fruit borer. Susceptibility of genotypes having thick shoots was reported by earlier workers Patil and Ajri (1993), Jat and Pareek (2003), Hazra *et al.* (2004), Naqvi *et al.* (2009), while Malik *et al.* (1986) reported that thin shoots of brinjal found tolerant to *Leucinodes orbonalis*. Jat and Pareek (2003), Hazra *et al.* (2004) and Chandrashekhar *et al.* (2009) reported the strong association of crude protein with susceptibility to shoot and fruit borer.

On the other hand trichome density (-0.2464) and polyphenol oxidase activity (-0.387) showed higher negative direct effect and their total correlation with shoot infestation was also highly negative indicating that higher trichome density and polyphenol oxidase activity are directly responsible for providing resistance against brinjal shoot and fruit borer. Mote (1981), Ishaque and

Choudhari (1984a), Duffey (1986) and Kale *et al* (1986a) also reported that resistant varieties had large number of hairs on lower surface of leaf. The present finding also conform the results of Doshi *et al.* (1999) who reported the higher direct effect (-0.2442) of polyphenol oxidase activity on shoot and fruit borer infestation.

The path coefficient analysis of fruit characters (Table 23) revealed that the characters like diameter of fruit, thickness of pericarp, length of pedicel, moisture, crude protein and polyphenols exerted positive direct effect on per cent fruit infestation. The characters like length of fruit, length of calyx, total sugar, crude fat, ash, crude fibre, polyphenol oxidase activity and peroxidase activity exerted negative direct effect.

The direct effect caused by pedicel length (0.273) and crude protein (0.139) were positive and higher in magnitude indicating that higher length of pedicel and crude protein content increased infestation caused by brinjal shoot and fruit borer. Susceptibility of genotypes having higher length of pedicel was reported by earlier workers Patil and Ajri (1993) and Naik (2010).

On the contrary, length of fruit (-0.222), ash (-0.351), crude fibre (-0.273) and polyphenol oxidase activity (-0.235) showed higher negative direct effect indicating that higher length of fruit, ash content, crude fibre and increased polyphenol oxidase activity may provide resistance against the infestation caused by fruit borer. Resistance in long fruited genotypes was reported by Ishaque and Choudhari (1984), Malik *et al.* (1986), Grewal *et al.* (1995) and Naqvi *et al.* (2009). Role of ash and crude fibre in providing resistance against the pest was observed by Patil *et al.* (1994), Dadmal *et al.,* (2004), Elanchezhyan *et al.,* (2008) and Chandrashekhar *et al.* (2009).

It was observed that, the characters trichome density, shoot thickness, protein content and polyphenol oxidase activity in case of shoot and length of pedicel, length of fruit, ash, crude fibre and polyphenol oxidase activity in case of fruits are directly associated with resistance indicating these characters have direct relation with shoot and fruit infestation. So, while seeking improvement regarding host plant resistance these characters should get priority. The genotypes with high trichome density, fruit length, ash, crude fibre, polyphenols and polyphenol oxidase activity and lower in shoot thickness, pedicel length and crude protein content could be utilized in the breeding programme for the development of shoot and fruit borer resistant varieties in brinjal crop. Genotypes with diverse combination of these characters can be used in breeding programmes to broaden the genetic base and increase the level of resistance against pest.

6. SUMMERY AND CONCLUSIONS

Brinjal, *Solanum melongena* Linneaus, is an important and popular vegetable cultivated in India. It is grown throughout the country except high altitude region round the year. Among the constraints in achieving higher yield, damage by the insect pest is most important one. Among those, shoot and fruit borer, *Leucinodes orbonalis* Guenee is the major threat to brinjal cultivation. The pest is responsible for considerable loss in crop yield and for deterioration of fruit quality, which ultimately affects the market value of the fruits. In Maharashtra, 48 per cent losses have been reported by Mote (1981). The larva is the actual damaging stage of the pest and being an internal feeder is difficult to control even by the synthetic chemicals. Also the ill effects of chemical insecticides are well known. In such situation, there is need to find out alternate safe management practices against the pest. Use of resistant varieties may become alternative method which can provide in built control against the pest and can be used to minimize the pest population as a major tool of IPM.

Resistant or tolerant varieties form the basic component of Integrated Pest Management over which other components are to be built up. It contributes helpfully in IPM by reducing the use of insecticides and improving the performance of natural enemies of pest. The most important advantage of the use of resistant varieties in IPM are specificity, cumulative effect, persistence, harmony with the environment, ease of adoption and compatibility with other tactics of pest management (Dhaliwal and Arora, 1996).

In the present investigation an attempt was made to study the reaction of different brinjal genotypes to locate the source of resistance; to study larval development on different genotypes and to study biophysical and biochemical attributes of different genotypes in relation to resistance and susceptibility. The studies were undertaken in the field condition at All India Co-ordinated Vegetable Improvement Project, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar (Maharashtra) and laboratory experiments were laid out at Department of Agricultural Entomology and Department of Biochemistry, Mahatma Phule Krishi Vidyapeeth, Rahuri during the year 2010 to 2012. The results obtained from various studies are summarized in this chapter.

6.1 Field screening of brinjal genotypes against *L. orbonalis*

6.1.1 Per cent shoot infestation

The per cent shoot infestation ranged from 1.60 to 11.49 per cent in *Kharif* and 0.91 to 8.77 per cent in *Rabi* season. The pooled mean of shoot infestation of both the trials ranged from 1.38 to 9.96 per cent. Significantly, minimum per cent shoot infestation (1.38 %) was registered with the genotype RHRB-60 while brinjal genotype RHRB-73 recorded maximum (9.96%) per cent shoot infestation.

The scale obtained by Subbaratnam and Butani (1981) has been preferred to determine the relative resistance of the genotypes against brinjal shoot and fruit borer. According to that none of the genotype had complete resistance to shoot and fruit borer however, the genotypes *viz.,* RHRB-60 (1.38 %), RHRB-20 (1.78 %), RHRB-12 (1.99 %) and RHRB-79 (2.00 %) were categorized as tolerant to shoot and fruit borer as having less than 2 per cent infested shoots. The next promising group including moderately tolerant genotypes having shoot infestation in the range of 2.1 to 3.0 per cent included RHRB-70 (2.38 %), RHRB-28 (2.42 %), RHRB-37 (2.44 %) and RHRB-74 (2.96 %). The genotypes RHRB-21 (3.27%), RHRB-11 (3.74 %), RHRB-34 (4.07 %) and RHRB-67 (4.94 %) were found susceptible to the attack of *L. orbonalis.* However, most of the genotypes *viz.* RHRB-75, RHRB-68, RHRB-69, RHRB-53, RHRB-42, RHRB-35, RHRB-7 and RHRB-73 recording shoot infestation of 5.02, 7.05, 8.52, 8.57, 9.38, 9.48, 9.94 and 9.96 per cent, respectively and found highly susceptible to the attack of *L. orbonalis*.

6.1.2 Per cent fruit infestation

The fruit infestation by *L. orbonalis* was recorded at each picking on number as well as weight basis. The pooled results of the data of two seasons, both on number and weight basis of fruit infestation revealed that, genotype RHRB-20 emerged as the most promising against shoot and fruit borer which recorded lowest of 8.94 and 9.01 per cent fruit infestation on number and weight basis, respectively. It was at par with genotypes RHRB-28, RHRB-60 and RHRB-79. Genotype RHRB-7 with 44.67 and 44.52 per cent fruit infestation on number and weight basis, respectively was the most susceptible to the pest however; it was statistically similar with genotypes RHRB-53 and RHRB-69.

In general, almost all genotypes exhibited similar reaction in both number and weight basis of fruit infestation. The rating index adopted by Lal *et al.* (1976) was preferred to determine the relative resistance of the different genotypes against brinjal shoot and fruit borer. According to that none of the genotypes was found immune to shoot and fruit borer infestation however, the genotypes RHRB-20 and RHRB-28 were observed to be highly resistant to the attack of *L. orbonalis* recording less than 10 % fruit infestation. The next promising group of genotypes found fairly resistant (10-20 % fruit infestation) to *L. orbonalis* comprised RHRB-60, RHRB-79, RHRB-21, RHRB-37, RHRB-70 and RHRB-12. Genotypes showing fruit infestation in the range of 21 to 30 per cent were categorized in tolerant group which include RHRB-34, RHRB-74, RHRB-75 and RHRB-67. The genotypes RHRB-11, RHRB-35, RHRB-42, RHRB-

73, RHRB-68 and RHRB-69 having 31 to 40 per cent fruit infestation were categorized as susceptible. The genotypes RHRB-69, RHRB-53 and RHRB-7 were observed highly susceptible to the attack of *L. orbonalis* recording more than 40 per cent fruit infestation.

6.1.3 Yield of marketable fruits per plant

Yield of marketable fruits was found to be highest in RHRB-60 (2.18 kg/plant) and the lowest yield (0.520 kg/plant) was recorded in genotype RHRB-12.

In general, resistant genotypes such as RHRB-20 (1.799 kg/plant), RHRB-28 (1.864 kg/plant), RHRB-60 (2.180 kg/plant) and RHRB-79 (1.735 kg/plant) recorded highest yield and susceptible genotypes such as RHRB-53 (0.669 kg/plant), RHRB-35 (0.893 kg/plant), RHRB-11 (0.854 kg/plant) and RHRB-42 (0.853 kg/plant) recorded lower yield of marketable fruits per plant.

6.2 Larval and post larval development of *L. orbonalis*

Larvae of *L. orbonalis* Guen. when reared on artificial diet fortified with fruit powder of genotypes from five different categories showed distinct values. The larval and post larval development on diet fortified with resistant entries was delayed as evidences by longer larval period (15.62 to 17.11 days), lower percentage of pupation (51.67 to 58.33%), longer pupal period (9.39 to 10.12 days), lower pupal weight (14.68 to 16.50 mg), lower percentage of moth emergence (41.67 to 48.33%), lower fecundity (76.89 to 91.44) and growth index (1.53 to 1.93) as compared to diet fortified with fruit powder of susceptible genotypes which recorded shorter larval period (14.12 to 15.30 days), higher percentage of pupation (60.00 to 66.67%), shorter pupal period (8.37 to 9.23 days), higher pupal weight (17.23 to 20.13 mg), higher percentage of moth emergence (50.00 to 58.33%), fecundity (94.66 to 123.33) and growth index (2.04 to 2.59). Adult longevity was also found more in case of susceptible genotypes as compared to resistant genotypes.

6.3 Association of biophysical attributes of brinjal genotypes with resistance to *L. orbonalis*

Among the characters influencing shoot infestation the trichome density at lower side of leaf surface ranged from 458.67 to 1192.67 per cm^2. The moderately tolerant genotype RHRB-28 recorded maximum trichome density (1192.67 per cm^2), while lowest (458.67 per cm^2) was recorded in highly susceptible genotype RHRB-73. In case of shoot thickness RHRB-12 (T) recorded minimum (0.27 cm) shoot thickness however, highly susceptible genotype RHRB-73 recorded maximum shoot thickness of 0.63 cm. Trichome density exhibited strong and negative correlation (r = - 0.621) with respect to shoot infestation however, strong and positive correlation (r = 0.632) was found between shoot thickness and per cent shoot infestation.

Among the pedicel and calyx characters, length of pedicel in different genotypes ranged from 3.44 (RHRB-12) to 12.01 cm (RHRB-7). Significantly positive correlation (r = 0.473628) between length of pedicel (cm) and per cent fruit infestation by *L. orbonalis.* The calyx length in different genotypes ranged from 1.85 to 4.07cm. Fairly resistant genotype RHRB-37 recorded a minimum (1.85 cm) length of calyx, while maximum (4.07 cm) length was found in RHRB-7. Length of calyx exhibited strong positive correlation (r = 0.615638) in relation to per cent infestation by *L. orbonalis.*

The fruit characters, length of fruit, diameter of fruit, thickness of pericarp recorded in different genotypes were statistically significant. However, there was no significant correlation observed between fruit infestation and different fruit characters. Similarly, it was observed the colour and shape of fruit did not have any direct relation with per cent fruit infestation.

6.4 Association of biochemical attributes of brinjal genotypes with resistance to *L. orbonalis*

Biochemical constituents were studied to know their association with resistance to shoot and fruit borer. Among the different biochemical constituents studied from shoots of different genotypes the moisture, total sugar, crude protein and crude fat were observed higher level in susceptible genotypes as compared to resistant genotypes having positive correlation with shoot infestation. However, the negative correlation with shoot infestation was found in case of ash, crude fibre and polyphenol content. Higher activities of oxidative enzymes polyphenol oxidase and peroxidase were found in shoots of resistant genotypes as compared to susceptible genotypes. Highly significant negative correlation was found between polyphenol oxidase activity and degree of shoot infestation.

With regard to association of biochemical constituents in fruits with fruit borer incidence it was observed that moisture, total sugar and crude protein content have highly significant correlation with degree of fruit infestation, however crude fat content does not have significant correlation with fruit infestation. Higher levels of ash, crude fibre and polyphenols were found in resistant cultivars as compared to susceptible cultivars having strong and negative correlation with per cent fruit infestation. Similarly, high polyphenol oxidase activity was observed in resistant genotypes as compared to susceptible genotypes. Highly significant and negative correlation was found between polyphenol oxidase activity and fruit infestation, while peroxidase activity showed significant and negative correlation with per cent fruit infestation.

6.5 Path coefficient analysis

The estimated correlation coefficients among shoot and fruit infestation caused by *L. orbonalis* and tested shoot and fruit characters were partitioned into direct and indirect effects and have been presented by path coefficient analysis. In the present study, the residual effect was low (0.09516 and 0.105087 for shoot and fruit infestation, respectively) indicating the adequacy of the characters chosen for the study.

The direct effect of shoot thickness, crude protein, crude fibre and peroxidase activity against shoot infestation caused by BSFB were positive, while the direct effect of trichome density, moisture content, total sugar, crude fat, ash, polyphenols and polyphenoloxidase activity against shoot infestation were negative.

The path coefficient analysis in case of charcters influencing fruit infestation revealed that the characters like diameter of fruit, thickness of pericarp, length of pedicel, moisture content, crude protein and polyphenols exerted positive direct effect on per cent fruit infestation. The characters like length of fruit, calyx length, total sugar, crude fat, ash, crude fibre, polypenoloxidase and peroxidase activity exerted negative direct effect.

It was observed that, the direct effect caused by shoot thickness (0.4149) and crude protein (0.6608) on shoot infestation and pedicel length (0.273) and crude protein (0.139) on fruit infestation were positive and higher in magnitude. It indicated that higher shoot thickness, pedicel length and crude protein content increased the infestation. On the other hand trichome density (-0.2464) and polyphenol oxidase activity (-0.387) with shoot infestation and length of fruit (-0.222), ash (-0.351), crude fibre (-0.273) and polyphenol oxidase activity (-0.235) with fruit infestation showed higher negative direct effect indicating that higher trichome density, fruit length, ash, crude fibre and polyphenol oxides activity were directly responsible for providing resistance against brinjal shoot and fruit borer.

6.6 Conclusions

a) On the basis of categorization of brinjal genotypes based on level of fruit infestation, the brinjal genotypes *viz.* RHRB-20, RHRB-28, RHRB-60, RHRB-79, RHRB-21, RHRB-37 and RHRB-70 emerged as resistant to brinjal shoot and fruit borer. These genotypes were therefore, indentified as a source of resistance, which could be used in breeding programme and development of IPM strategies.

b) Some resistant genotypes RHRB-60, RHRB-21, RHRB-28, and RHRB-79 also exhibited a high yield potential, they need to be harnessed by the breeders for developing varieties resistant to shoot and fruit borer with desirable qualities.

c) Larval and post-larval development of fruit borer was delayed on artificial diet fortified with fruit powder of resistant genotypes. Similarly per cent pupation, per cent moth emergence and fecundity were less in these genotypes which indicated the presence of antibiotic or nutrient deficient factor, which suppressed the development of pest whereas; diet fortified with susceptible genotypes favoured the fast development of pest.

d) The biophysical characters *viz.* trichome density /cm^2, shoot thickness (cm), calyx length (cm) and length of pedicel (cm) were found to be strongly associated with resistance to shoot and fruit borer and were accessed as important characters imparting resistance and susceptibility in brinjal to *L. orbonalis*.

e) The biochemical factors also found to be strongly associated with the pest infestation in different genotypes. Significantly negative correlations were found between polyphenols content, ash content, crude fibre content and pest infestation however, presence of high sugars, proteins and fats favored infestation of pest.

f) Path coefficient analysis studies indicated that the genotypes with high trichome density, fruit length, ash, crude fibre, polyphenols and polyphenol oxidase activity and lower in shoot thickness, pedicel length and crude protein content could be utilized in the breeding programme for the development of shoot and fruit borer resistant varieties in brinjal crop.

The results obtained in the present investigation are based on two seasons and one location data. Therefore in order to arrive at definite conclusion, it is necessary to continue the studies with long duration and multi-location trials to find out source of resistance and appropriate mechanism responsible for resistance which will provide in-built resistance against the pest to keep the pest infestation at low level and to get higher returns from brinjal.

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* Original not seen

8. APPENDIX

Meteorological observations during the period of experiment at Central Campus MPKV, Rahuri

Month	MW	Temperature(⁰C)		Humidity(%)		Wind Velo(km/h)	Rain Fall(mm)	Sunshine hrs.
		Max.	Min.	Morn	Even			
Jan.10	1	28.0	11.7	90	46	2.7	0.0	8.6
	2	28.6	11.9	91	39	2.9	0.0	7.7
	3	28.1	9.8	91	38	2.2	0.0	8.9
	4	28.1	8.1	90	34	2.1	0.0	9.6
	5	29.7	11.9	89	37	2.3	0.0	8.4
Feb.10	6	29.9	14.3	89	44	2.6	0.0	7.1
	7	31.2	13.9	91	41	2.9	0.0	8.6
	8	32.8	13.6	89	33	3.6	0.0	9.9
	9	33.6	13.9	88	31	2.6	0.0	10.0
March 10	10	34.3	14.5	88	32	3.5	0.0	9.4
	11	35.4	16.2	89	29	3.6	20.2	9.0
	12	37.8	17.2	88	23	3.5	0.0	9.7
	13	37.7	17.3	87	22	4.6	0.0	9.3
April 10	14	38.1	18.2	86	21	4.9	0.0	9.8
	15	39.5	21.0	90	19	4.8	0.0	7.7
	16	40.5	22.3	87	17	7.6	0.0	10.3
	17	40.3	21.2	86	16	6.5	0.0	10.6
	18	37.2	21.2	87	27	6.4	6.4	7.4
May 10	19	40.6	20.3	87	22	7.1	0.0	10.3
	20	41.2	22.1	88	23	7.7	0.0	10.3
	21	41.2	24.6	89	26	13.8	0.0	9.7
	22	37.5	23.8	91	36	10.4	3.8	10.1
June 10	23	36.1	23.0	93	38	10.8	25.2	9.7
	24	32.4	22.7	93	60	8.5	75.9	2.7
	25	33.4	22.9	93	54	7.9	15.2	4.6
	26	33.3	23.0	94	57	6.6	132.8	6.5
July 10	27	30.5	22.1	93	67	10.7	35.4	3.2
	28	31.6	22.4	93	68	7.9	84.9	5.2
	29	30.9	22.3	93	64	12.4	18.7	4.5
	30	29.5	22.3	94	65	12.6	11.4	1.7
	31	30.0	21.3	93	66	12.8	18.2	1.9
Aug. 10	32	29.8	21.1	93	63	9.0	26.6	5.4
	33	30.1	21.9	93	67	4.6	20.2	4.5
	34	29.1	21.1	92	70	3.0	11.9	2.1
	35	28.7	21.6	94	75	7.0	138.3	2.2
Sept.10	36	29.0	21.5	92	68	8.1	46.3	2.8
	37	31.0	20.6	91	53	5.8	0.0	7.8
	38	30.8	21.6	94	62	4.0	105.8	6.4
	39	30.8	21.5	94	64	3.0	103.4	7.4
Oct.10	40	30.6	20.8	92	56	2.1	1.5	8.1
	41	32.0	19.1	94	42	2.8	1.0	7.4
	42	31.2	21.7	92	56	4.2	8.6	5.1
	43	30.7	19.8	92	47	2.8	3.2	6.6
	44	29.9	17.7	91	44	4.0	0.0	8.2
Nov.10	45	29.1	19.5	92	44	4.6	3.8	4.3
	46	30.5	19.9	92	66	2.7	58.5	5.9
	47	29.8	20.1	91	59	5.0	1.0	6.4
	48	30.3	16.2	90	51	2.9	0.0	7.7
Dec.10	49	28.4	13.8	90	44	3.5	0.0	7.8
	50	28.0	9.7	91	38	3.0	0.0	5.0
	51	27.5	5.3	88	30	2.7	0.0	4.5
	52	28.9	10.0	91	34	3.3	0.0	7.5

APPENDIX (contd...)

Month	MW	Temperature(°C)		Humidity(%)		Wind Velo(km/h)	Rain Fall(mm)	Sunshine hrs.
		Max.	Min.	Morn	Even			
Jan.11	1	25.1	9.2	92.0	50.0	2.9	0.0	5.1
	2	28.4	5.1	90.0	30.0	2.3	0.0	10.0
	3	29.8	8.1	89.0	30.0	2.4	0.0	10.0
	4	30.5	9.6	88.0	29.0	2.7	0.0	10.0
	5	31.2	10.1	90.0	31.0	3.3	0.0	10.0
Feb.11	6	31.8	10.0	91.0	28.0	2.6	0.0	10.1
	7	30.9	11.5	90.0	29.0	3.8	0.0	9.8
	8	30.2	11.6	91.0	32.0	4.1	0.0	9.6
	9	32.4	14.2	91.0	32.0	3.8	0.0	8.7
Mar. 11	10	34.7	14.2	91.0	27.0	3.2	0.0	9.8
	11	34.2	11.9	89.0	26.0	3.7	0.0	10.6
	12	36.4	14.7	90.0	26.0	4.3	0.0	10.0
	13	36.4	15.2	88.0	22.0	4.9	0.0	10.3
Apr.11	14	35.6	15.4	89.0	23.0	4.6	0.0	10.0
	15	36.8	20.5	93.0	25.0	4.4	8.5	9.1
	16	37.7	21.5	92.0	27.0	5.3	0.0	10.2
	17	38.2	21.5	91.0	28.0	5.0	0.0	10.2
	18	38.8	22.0	90.0	28.0	7.8	0.0	10.7
May 11	19	38.0	21.3	91.0	28.0	7.7	0.0	10.7
	20	39.1	22.7	91.0	29.0	7.9	0.0	8.5
	21	37.1	23.1	90.0	32.0	10.4	0.0	9.1
	22	37.7	23.8	91.0	35.0	10.7	9.0	9.7
June 11	23	34.2	22.7	93.0	55.0	8.8	14.1	6.9
	24	32.1	22.2	93.0	55.0	14.7	16.1	5.4
	25	33.3	23.5	93.0	53.0	18.2	1.1	5.4
	26	31.2	22.6	94.0	59.0	15.8	3.0	2.4
July 11	27	32.1	21.7	95.0	61.0	9.0	94.9	4.8
	28	29.2	21.8	92.0	65.0	12.1	13.5	3.5
	29	30.4	22.7	92.0	63.0	13.5	2.4	1.9
	30	30.4	22.1	94.0	61.0	8.4	44.2	2.2
	31	30.3	22.0	93.0	63.0	10.8	4.0	3.0
Aug.11	32	30.7	22.3	93.0	57.0	16.5	1.3	3.6
	33	30.9	21.8	91.0	58.0	12.3	6.3	4.8
	34	30.0	21.7	94.0	69.0	4.1	54.0	3.8
	35	28.7	24.4	94.0	74.0	6.9	50.3	2.2
Sept.11	36	29.3	21.7	93.0	70.0	12.5	27.2	5.3
	37	31.1	20.8	91.0	57.0	6.7	15.6	5.4
	38	30.4	19.6	92.0	54.0	5.4	5.2	7.8
	39	30.9	20.2	91.0	53.0	2.8	29.1	6.8
Oct. 11	40	30.0	20.3	91.0	57.0	1.8	1.0	5.7
	41	32.6	20.1	90.0	44.0	3.5	3.5	7.4
	42	32.6	20.7	93.0	44.0	2.4	17.2	6.3
	43	32.1	15.8	90.0	33.0	3.6	0.0	10.0
	44	31.9	14.3	91.0	39.0	3.1	0.0	9.8
Nov. 11	45	31.8	13.2	90.0	33.0	2.6	0.0	10.0
	46	31.6	12.3	90.0	31.0	3.3	0.0	9.7
	47	30.4	8.9	90.0	30.0	3.2	0.0	9.2
	48	30.8	14.4	90.0	38.0	3.4	0.0	8.0
Dec. 11	49	31.7	10.6	91.0	31.0	2.4	0.0	9.6
	50	29.9	8.7	87.0	35.0	1.8	0.0	8.8
	51	29.4	8.3	86.0	32.0	2.0	0.0	8.3
	52	29.5	7.0	87.0	25.0	1.7	0.0	9.6

APPENDIX (contd...)

Month	MW	Temperature(^{o}C)		Humidity(%)		Wind Velo(km/h)	Rain Fall(mm)	Sunshine hrs.
		Max.	Min.	Morn	Even			
Jan.12	1	31.5	12.0	90.0	28.0	2.9	0.0	8.9
	2	26.5	6.3	90.0	29.0	1.7	0.0	8.8
	3	28.6	5.8	89.0	27.0	2.6	0.0	9.2
	4	28.9	10.9	86.0	31.0	1.4	0.0	9.5
	5	29.3	9.9	88.0	32.0	1.2	0.0	9.3
Feb.12	6	29.7	8.6	89.0	26.0	2.0	0.0	9.0
	7	31.7	10.7	89.0	27.0	1.6	0.0	8.9
	8	34.1	12.4	88.0	22.0	1.0	0.0	8.7
	9	34.0	10.0	88.0	21.0	2.3	0.0	9.0
March 12	10	32.7	9.2	88.0	22.0	2.8	0.0	9.9
	11	35.0	12.4	87.0	19.0	1.8	0.0	10.0
	12	37.4	13.6	87.0	18.0	2.0	0.0	10.2
	13	37.6	16.4	89.0	16.0	2.5	0.0	10.1
April 12	14	38.8	20.1	88.0	17.0	3.3	0.0	10.5
	15	38.6	20.0	91.0	21.0	2.8	0.0	10.3
	16	37.4	21.6	91.0	28.0	2.1	4.2	9.3
	17	37.3	14.1	88.0	29.0	1.9	0.0	10.0
	18	39.2	20.9	89.0	21.0	6.0	0.0	10.3

9. VITA

SHRIRANG SHARAD WAGH

A candidate for the degree
of

DOCTOR OF PHILOSOPHY (AGRICULTURE)
in

AGRICULTURAL ENTOMOLOGY

2012

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