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Biochemical basis of resistance in brinjal to *Leucinodes orbonalis* Guenee and their correlation with shoot and fruit damage

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Abstract
The field experiment was conducted with twenty brinjal genotypes to identify biochemical characteristics of brinjal plants for their resistance against shoot and fruit borer damage at Mahatma Phule Krishi Vidyapeeth, Rahuri (MS). Various biochemical parameters like moisture, ash, crude protein, crude fat, total sugar, polyphenols, peroxidase activity and polyphenol oxidase activity were recorded from shoots and fruits of twenty different brinjal genotypes. Among the genotypes moisture, total sugar, crude protein and crude fat were positively correlated with shoot and fruit damage. While ash content, polyphenols, peroxidase activity and polyphenol oxidase activity were negatively correlated with shoot and fruit damage. The present investigation provides precise information for the selection of important biochemical characters which may contribute more towards resistance to shoot and fruit borer.

Keywords: Biochemical analysis, shoot and fruit borer, genotypes, resistance, biochemical parameters

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, expect high altitudes (Choudhary, 1970) [8]. 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 is being grown extensively in India, Bangladesh, Pakistan, China, Japan, Philippines, France, Italy and USA. Brinjal has been cultivated in India for the last 4,000 years, as its centre of origin is Indo-Burma region (Vavilov, 1928) [27]. In production and productivity of brinjal, India is the second in the world after China. In India, brinjal occupies 8.0 per cent of total vegetable area with 8.1 per cent share in production. Being a major vegetable crop in India, brinjal is cultivated in about 7.27 lakh hectares with an annual production of 123.23 lakh tonnes during 2017-18 (Anonymous, 2019) [1, 2].

The major brinjal growing states in India are Andhra Pradesh, Karnataka, West Bengal, Tamil Nadu, Maharashtra, Orrisa, Uttar Pradesh, Bihar and Rajasthan. Maharashtra accounts thirty five thousand hectares area and produces about four hundred ninety thousand tonnes of fruits annually with productivity of 14.00 tonnes per hectare. (Anonymous, 2019) [1, 2]. Brinjal (*Solanum melogena* L.) belongs to the *Solanaceae* family and referred by various names *viz.*, *egg-plant, aubergine, garden egg, baingan, badanekai, vangi etc*. The name brinjal is popular in Indian subcontinents and is derived from Arabic and Sanskrit. Whereas, the name egg-plant has been derived from the shape of the fruit of some varieties, which are white and resemble in shape to chicken eggs. It is one of the major and principle vegetable crop widely grown in both temperate and tropical regions of the globe mainly for its immature fruits as vegetables (Rai, *et al.*, 1995) [25].

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 management. Among the major constraints 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) [12]. 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) [15]. Of these, shoot and fruit borer, *L. orbonalis* is the most destructive pest of brinjal. It is widely distributed in the Indian sub-continent and has been categorized as the most destructive and serious pest causing huge losses in brinjal (Patil, 1990). It also damages potato and other solanaceous crops. This pest is active throughout the year at places having moderate climate but it is adversely affected by severe cold. It is known to damage the shoot and fruit of brinjal in all stages of its growth. The yield loss due to the pest is to the extent of 70-92 per cent, (Chakraborti and Sarkar, 2011) [6]. The damage by this insect starts soon after transplanting of the seedlings and continues till harvest of fruits. Eggs are laid singly on ventral surface of leaves, shoots, and flower-buds and occasionally on fruits. In young plants, appearance of wilted drooping shoots is the typical symptom of damage by this pest; these affected shoots ultimately wither and die away. At later stage, the larvae bore into flower buds and fruits, entering from the base of calyx, they have no visible sign of infestation, but the larvae fed inside. The damaged flower buds shed without blossoming. Whereas, the fruits exhibit circular exit holes, such fruits, being partially unfit for human consumption, reduce their market value considerably. It is also reported that there was reduction in vitamin C content to an extent of 68 per cent in the infested fruits (Hami, 1955) [13].

Some varieties of brinjal exhibit marked biochemical characteristics which enhance durable resistance against *L. orbonalis*. Malik *et al*. (1986) [20] suggested that chemical composition 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) [17]. 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 biochemical attributes of different brinjal cultivars in relation to varying degree of infestation by the shoot and fruit borer.

2. Materials and Methods

2.1 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. The analysis of both shoots and fruits was undertaken separately. The work was carried out at Department of Agricultural Chemistry and Soil Science, MPKV, Rahuri.

2.2 Chemical composition

The biochemical contents were estimated on per cent basis according to the standard A.O.A.C. (1975) [3] procedures, with some modifications. The biochemical attributes *viz.,* moisture content, total sugar, crude protein, crude fat, polyphenols, ash and activities of polyphenol oxidase and peroxidase enzymes from different brinjal entries were studied.

2.2.1 Moisture

Ten grams of green samples each of healthy shoots and fruits were accurately and dried in oven at 100°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.

2.2.2 Ash

Well mixed samples weighing 5 g each were taken into pre-weighed silica crucibles. The latter were ignited in muffle furnace at 550°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.

2.2.3 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.

2.2.4 Crude fat

The crude fat content was determined by ether extraction using Soxhlet Apparatus (A.O.A.C., 1975) [3].

I Reagent

Petroleum ether having boiling point 40°-60°C.

II Procedure

Five grams of powdered sample was accurately weighed. The sample was transferred to thimble was plugged with cotton and placed in extraction flask of the Soxhlet apparatus. Sufficient quantity of petroleum ether was taken in pre-weighted 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

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

2.2.5 Total soluble sugar

Total soluble sugar was determined as per method given by Dubois *et al*. (1956) [10].

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 = 1000mg/1000ml)

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 mixed 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.

2.2.6 Total phenols

Total phenols from brinjal shoots and fruits were determined by method given by Bray and Thorpe (1954) [5].

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_2 CO_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.

2.2.7 Enzyme activities

The peroxidase and polyphenol oxidase activities from the shoot and fruits of different brinjal genotypes under study were accessed by the method described by Kumar and Khan (1982) [19].

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 (0.01 M): It was prepared fresh by dissolving 0.126 g of pyrogallol in 100 ml of distilled water.
c. Hydrogen Peroxide solution (0.005 M): 100 µ 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 (1M), 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 (0.5g) 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 4^0C for 30 min. One ml supernatant was diluted to 10 ml with distilled water and was used as the enzyme sourc. 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) Polyphenol oxidase 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 (0.01 M): It was prepared fresh by dissolving 0.126 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 polyphenol oxidase 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 by 0.1/min/g fresh weight of sample.

3. Results

3.1 Biochemical constituents in shoots of different brinjal genotypes

The various bio chemicals in shoot imparting resistance against shoot and fruit borer were estimated from apical portion of shoots and presented in Table 1.

3.1.1 Moisture content

The moisture content ranged from 74.63 to 85.91 per cent (Table 1) in shoots of different genotypes. Significantly minimum (74.63%) moisture content was observed in

genotype Krishna kathi-1 which was at par with that observed in genotypes Green oval, KS-224, Kudachi, O1 green and Ajay-2 recording 74.97, 76.26, 76.38, 76.64 and 77.46 per cent moisture, respectively. The genotype DBSR-95 recorded a maximum (85.91%) moisture which was statistically similar to that of observed in genotypes Dorli (85.83%), PBSR-52(84.79%) and 12/SPT-4(83.21%). Rest of the genotypes occupied intermediate position between 79. 41 to 82.68 per cent. The value of correlation coefficient (r) for moisture content in brinjal shoots in relation to shoot damage was (r= 0.730) which indicated the good positive correlation between moisture content and per cent shoot damage. Similar correlation was reported by earlier workers (Elanchezhyan *et al*., 2008; Chandrashekhar *et al*., 2009; Prasad *et al*.., 2014) [7, 24] who reported increased palatibility of the food material with more moisture content in case of susceptible varieties.

3.1.2 Total sugar

In shoots, the total sugar content ranged from 5.79 to 10.68 per cent. The genotype Green oval recorded significantly lowest (5.79%) total sugar however, it was at par with that observed in O1 green (5.82%) and Krishna kathi-1 (5.88%). The next successive genotypes in ascending order were IAB-83, Kudachi, CPB Jalgaon, Ajay-2, Pragati, Dorli, IBR-2, Arka keshav, KS-224, Puna selection, HBR-023, 12/SPT-4, Kashitara and IAB-10-1 recording 7.04, 7.14, 7.26, 7.89, 8.32, 8.41, 8.43, 8.64, 8.94, 9.08, 9,16, 9.35, 9.36 and 9.63 per cent total sugar respectively. Highest (10.68%) total sugar in shoot was recorded in genotype DBSR-95 which was at par with genotype PBSR-52 (10.22%). 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 damage(r = 0.712) also indicated that there was strong and positive correlation between per cent shoot damage and total sugar content. The present findings are in accordance with Hazra *et al*. (2004) [14]; Shinde (2006) [26]; Prasad *et al*. (2014) [24]; Nirmala *et al*. (2017) [21] who observed highly significant correlation between total sugars and per cent fruit infestation of the borer.

3.1.3 Crude protein

Shoots of different brinjal genotypes recorded protein content in the range of 2.40 to 9.82 per cent (Table 1). The genotype Krishna kathi-1 recorded a minimum (2.40%) crude protein. It was at par with genotype Arka keshav (2.65%). Maximum per cent crude protein (9.82%) in shoots was observed in genotype DBSR-95 followed by PBSR-52 recording 9.16 per cent crude protein. The remaining occupied intermediate positions recording crude protein content of 2.83 to 6.51 per cent. Here also the ascending trend of crude protein content was found from resistant to susceptible genotypes. The correlation coefficient (r = 0.801) also indicated that there was strong and positive correlation between per cent shoot damage and crude protein content. Hazra *et al*. (2004) [14], Chandrashekhar *et al*. (2009) [7], and Prasad *et al*. (2014) [24] reported significant and positive correlation between protein content and incidence of shoot and fruit borer.

Table 1: Biochemical constituents in shoots of different brinjal genotypes

Tr No.	Genotypes	Shoot damage (%)	Moisture (%)	Total Sugar (%)	Crude Protein (%)	Crude fat (%)	Ash (%)	Polyphenols (%)	Enzyme activity (units/min/g)	
									PO	PPO
T_1	Arka keshav	3.42 (10.66)*	79.35	8.64	2.65	1.95	12.44	2.18	3.22	9.19
T_2	Dorli	7.54 (15.94)	85.83	8.41	5.87	2.09	9.56	1.67	2.18	5.83
T_3	Ajay-2	1.94 (8.01)	77.46	7.89	6.51	2.69	12.4	1.34	2.43	6.73
T_4	Kudachi	1.76 (7.62)	76.38	7.14	3.17	1.44	12.65	1.45	3.28	9.47
T_5	Puna Selection	3.98 (11.51)	79.18	9.08	4.76	2.32	9.71	1.63	3.5	6.35
T_6	Krishna kathi-1	2.88 (9.77)	74.63	5.88	2.4	2.16	10.35	2.4	4.17	9.89
T_7	IBR-2	7.61 (16.01)	82.41	8.43	5.78	1.96	10.53	1.75	4.56	8.26
T_8	CPB Jalgaon	2.99 (9.68)	79.72	7.26	3.95	2.18	12.79	1.58	3.74	6.28
T_9	IAB-83	1.59 (7.24)	75.08	7.04	3.23	1.15	12.63	2.67	3.55	10.77
T_{10}	Kashitara	3.52 (10.81)	81.29	9.36	4.63	1.8	12.89	2.09	3.67	8.41
T_{11}	Green oval	1.84 (7.80)	74.97	5.79	3.5	1.53	13.19	2.47	3.48	10.45
T_{12}	DBSR 95	10.07 (18.50)	85.91	10.68	9.82	2.81	8.39	1.27	1.79	6.23
T_{13}	O1 green	2.75 (9.55)	76.64	5.82	2.83	1.41	12.05	2.42	4.63	9.56
T_{14}	Pragati	4.46 (12.19)	82.17	8.32	6.44	2.45	10.73	1.79	2.94	6.34
T_{15}	MHB 39	8.14 (16.58)	81.4	9.28	6.34	2.58	9.34	1.83	1.71	7.25
T_{16}	HBR-023	8.64 (17.09)	80.53	9.16	7.31	2.62	8.94	2.06	1.58	4.92
T_{17}	KS-224	6.87 (15.20)	76.26	8.94	5.19	2.48	10.15	1.58	2.83	8.59
T_{18}	PBSR 52	8.72 (17.18)	84.79	10.22	9.16	2.87	8.32	1.16	2.34	6.19
T_{19}	12/SPT-4	7.51 (15.91)	83.21	9.35	5.96	2.34	9.14	1.33	1.84	5.84
T_{20}	IAB-10-1	2.96 (10.04)	82.68	9.63	4.93	2.28	10.49	2.11	2.46	7.31
SE ±			1.05	0.20	0.12	0.04	0.16	0.04	0.08	0.12
CD at 5%			2.99	0.58	0.35	0.11	0.47	0.12	0.26	0.34
CV%			2.26	4.26	4.08	3.31	2.63	4.08	4.65	2.66
Correlation coefficient (r)			0.730	0.712	0.801	0.661	-0.868	-0.520	-0.598	-0.632

* Figures in the parentheses are arc sine transformed values
Significant at 1% level = 0.561 Significant at 5% level = 0.444

3.1.4 Crude fat

In shoots, the crude fat content ranged from 1.15 to 2.87 per cent. Significantly low (1.15%) crude fat was recorded by the genotype IAB-83. It was followed by the genotypes O1 green and Kudachi both having 1.41 and 1.44 per cent crude fat content. The genotype PBSR-52 recorded a maximum (2.87%) crude fat which was significantly more than that recorded in the rest of the genotypes except DBSR-95 and Ajay-2 recording 2.81 and 2.69 per cent crude fat and statistically at par with it. The remaining genotypes occupied

intermediate positions recording 1.53 to 2.58 per cent crude fat in shoots. A positive correlation was noticed between crude fat and per cent shoot damage(r = 0.661). Similar trend has already been reported by the earlier workers (Panda and Das, 1975 and Kale *et al*., 1986) [22, 16].

3.1.5 Ash

Shoots of different brinjal genotypes recorded ash content in the range of 8.32 to 13.19 per cent. The genotype Green oval recorded significantly highest (13.19%) ash. It was statistically similar with that recorded in Kashitara (12.89%) and CPB Jalgaon (12.79%). Significantly minimum (8.32%) ash was observed in PBSR-52 and it was followed by genotype HBR-023(8.94%). The remaining genotypes occupied intermediate positions recording 12.65 to 9.14 per cent ash content in shoots. Significantly strong negative correlation (r = -0.868) was noticed between ash content and per cent shoot damage. This result is in conformity with the findings of Patil *et al*. (1994) [23], Dadmal *et al*. (2003) [9], Elanchezhyan *et al*. (2009) [11] and Prasad *et al*. (2014) who reported significantly negative correlation between the ash content and infestation by the pest in brinjal.

3.1.6 Polyphenols

In shoot of different brinjal genotypes the polyphenols content ranged from 1.16 to 2.67 per cent. The genotype IAB-83 recorded maximum (2.67%) polyphenols which was significantly more than that observed in rest of the genotypes and which was followed by genotype Green oval (2.47%). The next successive genotypes in descending order of polyphenols were O1 green, Krishna kathi-1, Arka keshav, IAB-10-1, Kashitara, HBR-023, MHB-39, Pragati, IBR-2, Dorli, Puna selection, CPB Jalgaon, KS-224, Kudachi, Ajay-2 and 12/SPT-4 recording 2.42, 2.40, 2.18, 2.11, 2.09, 2.06, 1.83, 1.79, 1.75, 1.67, 1.63, 1.58, 1.58, 1.45, 1.34 and 1.33 per cent polyphenol content respectively. Significantly minimum (1.16%) polyphenol was observed in genotype PBSR-52 and it was at par with genotype DBSR-95 (1.27%). It is indicated that the tolerant and moderately tolerant genotypes recorded higher level of polyphenols as compared to susceptible genotypes. The value of correlation coefficient for polyphenol content was (-0.520), which also indicated the strong and negative correlation between polyphenol content per cent shoot damage. Elanchezhyan *et al*. (2009) [11]; Prasad *et al*. (2014) and Nirmala *et al*. (2017) [21] reported similar type of correlation.

3.1.7 Peroxidase activity

In shoots of different brinjal genotypes significant variation was observed regarding peroxidase activity from 1.58 to 4.63 units/min/g fresh weights (Table 1). The genotype O1 green recorded maximum peroxidase activity of 4.63 units/min/g fresh weight in shoots; however it was statistically at par with the peroxidase activity observed in shoots of IBR-2 (4.56 units/min/g). Significantly minimum peroxidase activity observed in genotype HBR-023 (1.58 units/min/g) and it was at par with genotype MHB-39(1.71 units/min/g). The remaining genotypes occupied intermediate positions recording 4.17 to 1.84 units/min/g fresh weights peroxidase in shoots.The descending trend of peroxidase activity from tolerant to susceptible genotypes was observed. From table 15 it was also observed that the peroxidase activity had negative correlation with per cent shoot damage, the 'r' value being -0.598. Higher peroxidase activity in fruits of less susceptible cultivars was reported by Bhattacharya *et al*. (2009) [4].

3.1.8 Polyphenol oxidase activity

In shoots of different brinjal genotypes significant variation was observed regarding polyphenol oxidase activity from 4.92 to 10.77 units/min/g fresh weights (Table 1). The genotype IAB-83 recorded maximum peroxidase activity of 10.77 units/min/g fresh weight in shoots; however it was statistically at par with the peroxidase activity observed in shoots of Green oval (10.45 units/min/g). Significantly minimum polyphenol oxidase activity observed in genotype HBR-023 (4.92 units/min/g) and it was followed by genotype 12/SPT-4 (5.84 units/min/g). The remaining genotypes occupied intermediate positions recording 9.89 to 5.83 units/min/g fresh weights polyphenol oxidase in shoots. The descending trend of polyphenol peroxidase activity from tolerant to susceptible genotypes was observed. From table 15 it was also observed that the polyphenol peroxidase activity had negative correlation with per cent shoot damage, the 'r' value being -0.632. The results are in conformity with those of Bhattacharya *et al*. (2009) [4], Khorsheduzzaman *et al.* (2010) [18] and Nirmala *et al*. (2017) [21].

3.2 Biochemical constituents in fruits of different brinjal genotypes

The various biochemicals in fruit imparting resistance against shoot and fruit borer were estimated and presented in Table 2.

3.2.1 Moisture content

The moisture content ranged from 74.25 to 87.62 per cent (Table 2) in fruits. Genotype O1 green recorded significantly minimum (74.25%) moisture content. It was statistically similar with that observed in IAB-83 and Green oval Kudachi recording 74.39 and 76.29 per cent moisture content. The maximum 87.62 per cent of moisture content was determined in genotype PBSR-52 followed by DBSR-95 (86.75%), 12/SPT-4 (86.12%) and Puna selection (85.12%) all being statistically at par with each other.Lower level 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 per cent fruit damage was observed, the 'r' value being 0.831. Similar correlation was reported by earlier workers (Elanchezhyan *et al*., 2008 [11]; Chandrashekhar *et al*., 2009; Prasad *et al*.., 2014) [7, 24] who reported increased palatibility of the food material with more moisture content in case of susceptibile varieties.

3.2.2 Total sugar

The per cent total sugar content in fruits of different genotypes ranged from 15.60 to 31.26 per cent (Table 2). The genotype IAB-10-1 recorded significantly lowest (15.60%) total sugar. It was statistically at par with genotype IAB-83 recording 16.20 per cent. The next genotypes recording the total sugar were Ajay-2, O1 green, CPB Jalgaon, Krishna kathi-1, Kudachi, Arka keshav, Pragati, Green oval, MHB-39, Puna selection, Kashitara, PBSR-52, HBR-023 and KS-224 which recorded 18.26, 18.55, 18.82, 19.58, 19.61, 20.21, 20.75, 21.09, 22.93, 23.12, 23.28, 26.18, 2825 and 29.33 and per cent total sugar, respectively in ascending order of their sequence. Maximum total sugar content (31.26%) was recorded in genotype Dorli and was statistically at par with genotypes 12/SPT-4 (31.20%), IBR-2 (30.68%) and DBSR-95 (29.86%).

Table 2: Biochemical constituents in fruits of different brinjal genotypes

Tr No.	Genotypes	Fruit damage (%)	Moisture (%)	Total Sugar (%)	Crude Protein (%)	Crude fat (%)	Ash (%)	Polyphenols (%)	Enzyme activity (units/min/g)	
									PO	PPO
T_1	Arka keshav	21.83 (27.85)*	80. 47	20.21	17.33	2.14	6.43	0.96	5.25	6.71
T_2	Dorli	34.45 (35.94)	81.73	31.26	14.21	3.81	5.40	0.74	3.11	8.23
T_3	Ajay-2	9.69 (18.14)	79.50	18.26	9.83	1.57	7.81	1.56	4.74	11.92
T_4	Kudachi	10.78 (19.17)	77.84	19.61	13.50	3.19	8.22	1.60	4.57	13.33
T_5	Puna Selection	30.73 (33.67)	85.12	23.12	14.79	2.24	6.89	1.57	3.78	6.70
T_6	Krishna kathi-1	13.94 (21.92)	77.58	19.58	13.32	3.28	8.20	1.73	3.10	12.35
T_7	IBR-2	35.20 (36.39)	83.19	30.68	19.41	1.49	7.50	1.23	2.08	10.13
T_8	CPB Jalgaon	23.11 (28.73)	79.88	18.82	16.23	3.09	7.25	1.55	4.26	10.47
T_9	IAB-83	8.70 (17.15)	74.39	16.20	10.06	1.76	7.28	1.42	5.23	12.16
T_{10}	Kashitara	24.05 (29.37)	81.34	23.28	14.70	2.00	7.18	2.29	5.14	8.40
T_{11}	Green oval	13.73 (21.75)	76.29	21.09	9.32	2.13	8.31	1.66	4.52	10.94
T_{12}	DBSR 95	44.97 (42.11)	86.75	29.86	19.28	2.73	5.28	0.78	2.18	7.34
T_{13}	O1 green	15.54 (23.22)	74.25	18.55	11.26	2.34	7.46	1.70	4.37	11.89
T_{14}	Pragati	33.45 (35.45)	82.98	20.75	16.06	3.19	7.24	0.69	2.86	6.64
T_{15}	MHB 39	40.47 (39.51)	84.96	22.93	13.21	3.18	6.49	0.77	2.58	8.19
T_{16}	HBR-023	38.06 (38.09)	80.96	28.25	20.63	2.35	6.14	0.84	3.10	9.64
T_{17}	KS-224	36.64 (37.25)	83.22	29.33	18.54	3.05	7.34	1.17	2.19	10.24
T_{18}	PBSR 52	42.69 (40.80)	87.62	26.18	18.70	3.19	6.58	0.82	2.14	8.33
T_{19}	12/SPT-4	33.28 (35.23)	86.12	31.20	15.41	2.16	6.55	1.77	3.18	7.31
T_{20}	IAB-10-1	17.74 (24.91)	83.56	15.60	12.09	1.78	7.49	1.40	4.34	6.93
SE ±			0.88	0.51	0.34	0.06	0.09	0.03	0.04	0.13
CD at 5%			2.50	1.46	0.96	0.17	0.28	0.08	0.17	0.38
CV%			1.86	3.78	3.91	4.09	2.37	3.59	2.76	2.40
Correlation coefficient (r)			0.831	0.793	0.783	0.353	-0.733	-0.638	-0.822	-0.633

* Figures in the parentheses are arc sine transformed values
Significant at 1% level = 0.561 Significant at 5% level = 0.444

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 = 0.793) also indicated highly significant correlation of total sugar content with per cent fruit damage. The present findings are in accordance with Hazra *et al*. (2004) [14]; Shinde (2006) [26]; Prasad *et al*. (2014) [24]; Nirmala *et al*. (2017) [21] who observed highly significant correlation between total sugars and per cent fruit infestation of the borer.

3.2.3 Crude protein

Per cent protein content in fruits ranged from 9.32 to 20.63 per cent (Table 2). The genotype Green oval recorded a minimum (9.32%) crude protein which was significantly lower than rest of the genotypes and was at par with genotypes Ajay-2 and IAB-83 recording 9.83 and 10.06 per cent crude content in ascending order were O1 green, IAB-10-1, MHB-39, Krishna kathi-1, Kudachi, Dorli, Kashitara, Puna selection, 12/SPT-4, Pragati, CPB Jalgaon, Arka keshav and KS-224 recording, 11.26, 12.09, 13.21, 13.32, 13.50, 14.21, 14.70, 14.79, 15.41, 16.06, 16.23, 17.33 and 18.54 per cent crude protein respectively. Significantly maximum (20.63%) crude protein was recorded in HBR-023 followed by IBR-2 (19.41%), DBSR-95 (19.28%) and PBSR-52 (18.70%).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 fruit damage of the pest (r = 0.783). Hazra *et al*. (2004) [14], Chandrashekhar *et al*. (2009) [7], and Prasad *et al*. (2014) [24] reported significant and positive correlation between protein content and incidence of shoot and fruit borer.

3.2.4 Crude fat

In fruits, the content of crude fat ranged from 1.49 to 3.81 per cent (Table 2). Lowest (1.49%) crude fat was recorded in genotype IBR-2 which was followed by Ajay-2 (1.57%) and both of these are at par with each other. The next genotypes for regarding crude fat content were IAB-83, IAB 10-1, Kashitara, Green oval, Arka keshav, 12/SPT-4, Puna selection, O1 green, HBR-023, DBSR-95, KS-224, CPB Jalgaon and MHB-39 which recorded 1.76, 1.78, 2.00, 2.13, 2.14, 2.16, 2.24, 2.34, 2.35, 2.73, 3.05, 3.09 and 3.18 per cent crude fat, respectively in ascending order of their sequence. The genotype Dorli recorded a maximum (3.81%) crude fat followed by Krishna kathi-1, PBSR-52, Pragati and Kudachi recording 3.28, 3.19, 3.19 and 3.19 per cent crude fat respectively. A weak positive correlation was noticed (r = 0.353) between per cent fruit damage and crude fat content in the fruits of brinjal. Similar trend has already been reported by the earlier workers (Panda and Das, 1975 and Kale *et al*., 1986) [22, 16].

3.2.5 Ash

In fruits, the per cent ash content ranged from 5.28 to 8.31 per cent (Table 2). The genotype Green oval recorded maximum (8.31%) ash. It was statistically at par with that observed in Kudachi and Krishna kathi-1 recording 8.22 and 8.20 per cent ash respectively. The genotype DBSR-95 recorded significantly minimum (5.28%) ash and was at par with genotype Dorli (5.40%). Other remaining genotypes occupied intermediate position recording ash content from 6.14 to 7.81 per cent. In general, it was observed that the resistant genotypes contain higher level of ash as compared to susceptible genotypes. Significantly highly significant negative correlation was observed (r = -0.733) between per cent fruit damage and ash content in the fruits. This result is in conformity with the findings of Patil *et al*. (1994) [23], Dadmal *et al*. (2004) [9], Elanchezhyan *et al*. (2009) [11] and Prasad *et al*. (2014) [24] who reported significantly negative correlation between the ash content and infestation by the pest in brinjal.

3.2.6 Polyphenols
In fruits, content of polyphenols ranged from 0.69 to 2.29 per cent (Table 2). The genotype Kashitara recorded significantly maximum (2.29%) polyphenols. It was followed by genotype 12/SPT-4 (1.77%). The next successive genotypes recording polyphenol content in descending order were Krishna kathi-1, O1 green, Green oval, Kudachi, Puna selection, Ajay-2, CPB Jalgaon, IAB-83, IAB-10-1, IBR-2, KS-224, Arka keshav, HBR-023, PBSR-52 and DBSR-95 recording 1.73, 1.70, 1.66, 1.60, 1.57, 1.56, 1.55, 1.42, 1.23, 1.17, 0.96, 0.84, 0.82 and 0.78 per cent, polyphenols, respectively. The genotype Pragati recorded significantly minimum (0.69%) and it was at par with genotype Dorli recording 0.74 per cent polyphenols. Here also, the descending trend was observed from resistance to susceptible genotypes. Also highly significant and negative correlation (r = -0.638) was observed between per cent fruit damage and polyphenol content in the fruits. Elanchezhyan *et al*. (2009) [11]; Prasad *et al*. (2014) [24] and Nirmala *et al*. (2017) [21] reported similar type of correlation.

3.2.7 Peroxidase activity
Peroxidase activity observed in fruits of different brinjal genotypes ranged from 2.08 to 5.25 units/min/g fresh weight (Table 2). The genotype Arka keshav showed significantly maximum peroxidase activity (5.25 units/min/g fresh weight). It was followed by peroxidase activity observed in fruits of IAB-83 (5.23 units/min/g fresh weight) and Kashitara (5.14 units/min/g fresh weight) and was at par with each other. The next successive genotypes showing peroxidase activity in descending order were Ajay-2, Kudachi, Green oval, O1 green, IAB-10-1, CPB Jalgaon, Puna selection, 12/SPT-4, Dorli, Krishna kathi-1, HBR-023, Pragati and MHB-39 recording 4.74, 4.57, 4.52, 4.37, 4.34, 4.26, 3.78, 3.18, 3.11, 3.10, 3.10, 2.86 and 2.58 units/min/g fresh weight peroxidase activity, respectively. Minimum peroxidase activity (2.08 units/min/g) was observed in fruits of genotype IBR-2 and it was at par with genotypes DBSR-95 (2.18 units/min/g) and KS-224 (2.14 units/min/g).Higher peroxidase 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 = -0.822) observed between per cent fruit damage and peroxidase activity. Higher peroxidase activity in fruits of less susceptible cultivars was reported by Bhattacharya *et al*. (2009) [4].

3.2.8 Polyphenol oxidase activity
The genotypes showed significant variation of 6.64 to 13.33 units/min/g fresh weight for the polyphenol oxidase activity in fruits (Table 2). Significantly maximum polyphenol oxidase activity (13.33 units/min/g fresh weight) was observed in genotype Kudachi and followed by genotypes Krishna kathi-1 (12.35 units/min/g fresh weight) and IAB-83 (12.16 units/min/g fresh weight). The next successive genotypes showing polyphenol oxidase activity in descending order were Ajay-2, O1 green, Green oval, CPB Jalgaon, KS-224, IBR-2, HBR-023, Kashitara, PBSR-52, Dorli, MHB-39, DBSR-95 and 12/SPT-4 recording 11.92, 11.89, 10.94, 10.47, 10.24, 10.13, 9.64, 8.40, 8.33, 8.23, 8.19, 7.34 and 7.31 units/min/g fresh weight polyphenol oxidase activity, respectively. Significantly minimum (6.64 units/min/g fresh weight) polyphenol oxidase activity was recorded in Pragati followed by Puna selection (6.70 units/min/g), Arka keshav (6.71 units/min/g) and IAB-10-1 (6.93 units/min/g) being at par with each other. In general, fruits of resistant brinjal genotypes showed maximum polyphenol oxidase activity as compared to susceptible genotypes with some exceptions. Similarly, the significant negative correlation (r = -0.633) was found between per cent fruit damage and peroxidase activity observed in fruits of different brinjal genotypes. The results are in conformity with those of Bhattacharya *et al*. (2009) [4], Khorsheduzzaman *et al.* (2010) [18] and Nirmala *et al*. (2017) [21].

4. Conclusion
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 and pest infestation. However, presence of high sugars, proteins and fats favoured infestation of pest.

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