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Studies on Shoot and Fruit Characters of Brinjal Plants and their Quantitative Relationships with Brinjal Shoot and Fruit Borer

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A B S T R A C T

The field experiment was conducted with thirty four brinjal cultivars during September 2013 to December 2013 to identify shoot and fruit characteristics of brinjal plants for their susceptibility/resistance against brinjal shoot and fruit borer infestation. Borer infestation was influenced by different characters of plant shoot and fruit. Various parameters like plant height stem diameter, number of branches and leaves per plant, third leaf length, phenol content in shoot and fruit length, fruit weight, mesocarp thickness, number of seeds, phenol content and tannin content in fruit were recorded from different cultivars used. The shoot infestation highly significant and gave a very strong significant negative correlation between shoot infestation with leaf trichomes (-0.391*) and biochemical factors like phenol content (-0.710**).Fruit infestation had negative significant correlation with fruit weight (-0.455**), mesocarp thickness (-0.389*), number of seeds (-0.740**), phenol content (-0.357*) and yield (-0.825**). The trichomes and hairs on different parts of the plant seem to have a significant role towards non preference for fruit infestation and Phenol content had a high negative direct effect on shoot and fruit borer infestation.

Introduction

Brinjal, *Solanum melongena* Linnaeus is highly cosmopolitan and popular vegetable grown as poor man's crop in India. It is the most-consumed and most-sprayed vegetable in India, where it is grown on more than 5, 00,000 hectares, making it one of the main sources of cash for many farmers (Daniel Miller, 2007). The average yields of brinjal in India are reported to be 17.35 tonnes per hectare (Anon, 2011). Various insects cause enormous losses to this vegetable throughout the season in Bangladesh as well as in Indian sub- continent (Alam, 1969 and Dhankar, 1988), among them brinjal shoot and fruit borer (BSFB), *Leucinodes orbonalis* Guenee, is the most serious and destructive one. Due to the attack of this pest considerable damage is occurred each year affecting the quality and yield of the crop. Only the larvae of this pest cause 12-16 % damage to shoots and 20-60% to fruits (Alam, 1970; Maureal *et al*., 1982). The pest is very active during the rainy and summer season and often causes more than 90% damage (Ali *et al*., 1980; Kalloo, 1988).

The yield loss has been estimated up to 86% (Ali *et al*., 1980) in Bangladesh and up to 95% (Naresh *et al*., 1986) in India. Indiscriminate use of synthetic chemicals for the controlling insect pest resulted hazardous effects causing serious problems including pest resistance, secondary pest outbreak, pest resurgence and environmental pollution. Considering the above fact, the present study was undertaken to find out whether the shoot and fruit characters influencing the infestation rate of BSFB and also their quantitative relationships with infestation which will help to develop resistant/tolerant varieties against this pest.

Materials and Methods

For the experiment thirty four brinjal cultivars were used. The experiment was laid out in a Randomized Complete Block Design (RCBD) with two replications. Uniform and healthy seedlings of 45 days old were taken separately from the seedbed, transplanted in the experimental plots maintaining a spacing of 75cm x 60cm between the row to row and plant to plant. Different intercultural operations (weeding, gap filling and irrigation) were accomplished for better growth and development but no insecticide was used. The data on plant height (cm), stem diameter (cm), number of branches and leaves per plant, third leaf length (cm), phenol content in shoot, fruit length (cm), fruit weight (g), mesocarp thickness (cm), number of seeds, phenol content (mg/g), tannin content (mg/g)in fruit and infestation were recorded at 90 and 120 days after transplantation in shoot and fruit, respectively. Total phenols and tannin content from brinjal shoots and fruits were determined by method given by Bray and Thorpe (1954) and Sadashivam and Manickam (1996) and experiment was carried out in Microbiology Department, UAHS, and the College of Agricultural and Horticultural Sciences, Navile, Shimoga. 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_2C0_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/Stannic acid concentration (0.2, 0.4, 0.6, 0.8 and 1.0). With the help of a standard graph, per cent total phenols were calculated and tannin content estimated by pipetted out Tannic acid working standard solutions (0.05 mg/ml) from 0.2-1 ml to 5 individual test tubes, make up the volume to 1 ml with distilled water. To each tube add 5 ml of Folin-denis reagent was added followed by 10 ml of 35 % Na_2co_3 solution mix the contents well and leave for incubation at room temperature for 30 min. After the incubation read the absorbance at 700 nm against the reagent blank along with test samples. The experimental data recorded on various parameters during the investigation were analyzed statistically by adopting Fischer's method of analysis of variance as outlined by Gomez and Gomez (1976) and mean difference were adjusted with DMRT (Duncan, 1955).

Results and Discussion

Evaluation of traditional brinjal cultivars for shoot and fruit characters of brinjal in relation to shoot and fruit borer infestation (Table 1-4). The stem girth of various traditional brinjal cultivars ranged from 2 cm to 4 cm being maximum in mulla badane (4 cm), minimum in hosajavari badane (2 cm) and

stem girth(-0.016) was non significant negative correlation with shoot and fruit borer infestation. But Hossain *et al*. (2002) reported that the stem diameter positively correlated (0.5472) with BSFB infestation. The genotype Apple badane (55.4cm) showed maximum plant height whereas, minimum plant height showed Thailand badane (24.2cm) and plant height (-0.130) was non significant negative correlation with shoot and fruit borer infestation. But Hossain *et al*. (2002) reported that the plant height positively correlated (0.5310) with BSFB, *L. orbonalis* infestation. The average maximum third leaf length was recorded in the cultivar Sakleshpura badane (9.15 cm), minimum in doddamullina badane (3.9) and third leaf length (-0.290) was non significant negative correlation with shoot and fruit borer infestation. But Hossain *et al*. (2002) reported that third leaf length (cm) of selected brinjal genotypes was positively correlated (0.3158) with BSFB infestation.

Number of shoots ranged from 2.1 to 7 being maximum in Ramadurga badane (7), minimum in biliudda badane (2.1) and number of shoots (0.014) was positive non significant correlation with shoot and fruit borer infestation. The present findings are in line with Hossain *et al*. (2002) number of branches per plant was positively correlated (0.4180) with BSFB infestation.

The average maximum numbers of leaves were recorded in the cultivar dorelo badane (72) and in the cultivar biliudda badane (12.1) and number of leaves (0.064) was non significant positive correlation with shoot and fruit borer infestation. But Hossain *et al.* (2002) observed that the number of leaf per plant were positively correlated (0.3968) with BSFB infestation. Cultivars had the maximum number of trichomes on the leaf surface of Sakleshpura badane (17.55), minimum in bilichendu badane (9.7) and leaf trichomes (-0.391*) was negatively significantly correlated with shoot and fruit borer infestation due to more number of trichomes reduces shoot and fruit borer infestation.

The present findings were in line with Javed *et al*., 2011, who reported that the trichomes and hairs on different parts of the plant seem to have a significant role towards non preference for fruit infestation which is in conformity with the findings of Hossain *et al*., (2004).

According to them, less number of trichomes may be responsible for the susceptibility of brinjal plant to shoot and fruit borer. The traditional cultivars was found to have varying levels of Phenol content in shoot, ranging from 162.5 mg/100gm to 784 mg/100gm being maximum in Heddaragulla badane (761 mg/100gm), minimum in annageri badane (162.5 mg/100gm) and phenol content (-0.710**) was significantly negatively correlated with shoot and fruit borer infestation due to cultivars with maximum amount of Phenol content received the minimum infestation in both shoot and fruit due to phenol content impart resistance against brinjal shoot and fruit borer.

Findings of the present study are supported by several earlier investigators Martin (2004) and Doshi (2004) also reported that PPO activity had a high negative direct effect on shoot and fruit borer infestation. The maximum fruit length 6.95 cm was recorded in Apple badane and minimum fruit length reported in kothithale badane (2.4cm) and fruit length (-0.301) was non significant negative correlation with shoot and fruit borer infestation. Similar findings were reported by Grewal and Singh (1995) and Gupta and Kauntey (2008) who did not find any linear correlation between length and diameter of fruits and degree of fruit infestation (Fig. 1 and 2).

Table.1 Morphological and biochemical characters of brinjal plant in relation to shoot infestation

Cultivar	Mean Shoot infestation	Shoot characters						
		plant height (cm)	Stem girth (cm)	Third leaf length (cm)	No. of leaves / plant	No. of shoots / plant	No. of Trichomes/ leaf	Phenol content mg/100g
Sthaliya badane	28.02	29.65^{j-m}	2.80^{ghi}	6.55^{f-k}	29.00^{g-m}	4.40^{c-j}	11.15^{g-j}	680.50^{a}
Holesalu badane	27.52	31.40^{h-m}	3.25^{def}	7.40^{c-g}	34.30^{f-l}	5.90^{a-d}	10.20^{jk}	721.00^{a}
Heddaragulla badane	29.77	34.00^{f-m}	3.25^{def}	8.15^{abc}	18.40^{mn}	2.80^{ijk}	10.90^{hij}	784.00^{a}
Andhra sahare	30.31	51.64^{abc}	3.19^{ef}	6.75^{d-j}	36.00^{f-k}	5.40^{a-g}	12.39^{fgh}	640.50^{a}
Apple badane	34.97	55.40^{a}	3.76^{ab}	7.92^{a-e}	49.00^{b-f}	5.90^{a-d}	16.52^{ab}	761.00^{a}
Kanakapura badane	35.28	44.00^{c-f}	3.75^{abc}	8.00^{abcd}	43.10^{c-g}	5.90^{a-d}	16.92^{a}	283.00^{bcde}
Biligundu badane	36.35	49.80^{a-d}	3.00^{fgh}	7.42^{c-g}	53.00^{b-e}	5.90^{a-d}	16.52^{ab}	288.5^{bcde}
Annageri badane	38.74	45.75^{a-e}	3.08^{fg}	5.10^{lmno}	49.00^{b-f}	5.50^{a-f}	10.50^{jk}	162.50^{e}
40-A badane	35.69	44.05^{c-f}	3.10^{fg}	7.44^{c-g}	37.50^{e-j}	4.10^{d-k}	15.32^{bc}	171.00^{e}
Biligundi badane	36.34	40.30^{d-j}	2.70^{hi}	5.60^{jklm}	34.60^{h-l}	6.00^{a-d}	10.95^{hi}	304.50^{bcde}
Kalkare badane	39.14	42.20^{c-g}	3.45^{cde}	6.17^{h-l}	56.70^{bc}	6.60^{ab}	14.75^{cd}	348.50^{bcde}
Kothithale badane	36.45	44.30^{b-f}	3.00^{fgh}	6.65^{efg}	19.30^{lmn}	2.50^{k}	11.12^{g-j}	290.50^{bcde}
Sakleshpura badane	40.74	55.05^{ab}	3.00^{fgh}	9.15^{a}	23.00^{i-n}	4.40^{c-j}	17.55^{a}	324.50^{bcde}
Ramadurga badane	42.08	39.95^{d-j}	3.00^{fgh}	7.60^{b-f}	33.60^{f-m}	7.00^{a}	14.35^{cd}	258.50^{bcde}
Keredoddi kollegai badane	40.93	35.65^{e-l}	3.00^{fgh}	5.77^{i-m}	37.80^{e-j}	5.90^{a-d}	10.92^{hij}	295.50^{bcde}

Hosajavari badane	41.45	41.70^{c-h}	2.00^{j}	6.65^{e-k}	19.30^{lmn}	2.50^{jk}	12.62^{fg}	324.50^{bcde}
Bilichandubadane	40.15	39.80^{d-k}	3.50^{bcd}	5.60^{jklm}	40.30^{g-h}	5.5^{a-f}	9.7^{jk}	195.50^{de}
Biliudda badane	39.83	40.60^{d-i}	4.00^{a}	8.05^{abcd}	12.10^{n}	2.1^{k}	13.1^{ef}	177.50^{e}
Naabe badane	41.26	35.80^{e-l}	3.50^{bcd}	5.64^{jklm}	26.40^{h-n}	4.8^{b-j}	9.84^{jk}	166.00^{e}
Ullala badane	41.63	33.70^{f-m}	3.00^{fgh}	5.40^{k-h}	29.10^{g-m}	4.5^{c-j}	10.85^{hij}	250.50^{bcde}
Rosilla badane	41.81	29.50^{klm}	3.50^{bcd}	6.20^{h-l}	29.30^{g-m}	4.5^{c-}	10.1^{jk}	384.00^{bcd}
Mullugai badane	38.84	25.65^{lm}	2.50^{i}	5.52^{j-m}	22.40^{j-n}	3.2^{h-k}	9.67^{jk}	290.50^{bcde}
Hebberalu badane	42.37	40.50^{d-i}	3.50^{bcd}	4.69^{mno}	38.20^{e-i}	6.4^{abc}	8.95^{k}	324.50^{bcde}
Doddamullina	38.86	37.70^{e-k}	3.00^{fgh}	3.90^{o}	21.80^{k-n}	5.1^{a-h}	7.3^{l}	258.50^{bcde}
Javari badane	40.30	36.40^{e-l}	2.00^{j}	5.35 $^{k-n}$	22.30^{j-n}	3.8^{e-k}	9.7^{jk}	395.00^{bc}
Dodda badane	42.63	26.80^{lm}	3.00^{fgh}	5.60^{j-m}	30.40^{g-m}	3.4^{g-k}	10.67^{ij}	425.50^{b}
Harirukempu	36.56	36.40^{e-l}	2.55^{i}	5.85^{i-m}	21.80^{k-n}	3.8^{e-k}	12.12^{f-i}	230.50^{bcde}
Anaamadeya badane	37.55	29.90^{i-m}	2.50^{i}	6.13^{g-l}	28.30^{g-m}	4.1^{d-k}	10.5^{jk}	210.00^{cde}
Hasiruudda badane	41.14	30.00^{i-m}	2.50^{i}	6.00^{h-m}	61.00^{b}	6.7^{ab}	10.9^{hij}	304.50^{bcde}
Mobbugulla badane	38.57	34.20^{f-m}	4.00^{a}	8.90^{ab}	25.40^{h-n}	4.5^{c-j}	16.92^{a}	316.00^{bcde}
Thiland badane	38.51	24.20^{m}	2.50^{i}	4.20^{no}	55.50^{bcd}	3.5^{f-k}	5.98^{l}	290.50^{bcde}
Dorolo badane	40.96	32.80^{g-m}	3.00^{bcd}	7.20^{c-h}	72.50^{a}	4.9^{b-h}	14.6^{cde}	209.50^{cde}
Anemadeha-1	40.31	30.80^{i-m}	3.500^{bcd}	7.00^{c-i}	27.80^{g-m}	3.2^{h-i}	13.6^{def}	213.00^{cde}
Mulla badane	40.16	32.20^{h-m}	4.00^{a}	6.80^{d-j}	35.40^{f-k}	5.8^{a-e}	13.3^{def}	191.50^{cde}
S.Em.±	1.09	0.22	0.01	0.06	0.32	0.10	0.05	48.79
CD	4.44	0.89	0.07	0.25	1.33	0.44	0.23	198.54

Values in each column superscripted by same letter do not differ significantly

Table.2 Correlation between shoot infestation and plant characters

Characters	Plant height (cm)	Stem girth (cm)	Third leaf length (cm)	No. of leaves/plant	No. of shoot/plant	No. of Trichomes/ leaf	Phenols (mg/100g)
Shoot infestation	-0.130	-0.016	-0.290	0.064	0.014	-0.391*	-0.710*

* Correlation is significant at the 0.05 level (2-tailed)
N=34
r=0.389

Table.3 Morphological and biochemical characters of brinjal fruit in relation to fruit infestation

Cultivar	Mean Fruit infestation	Fruit characters						Yield t/ha
		Fruit weight (gm)	Mesocarp thickness (cm)	No. of seeds/fruits	Fruit length (cm)	Phenol Content mg/100g	Tannin Content mg/100g	
Sthaliya badane	29.93	37.09^{h-n}	0.45^{hi}	831.5^{de}	5.40^{bf}	201^{ab}	116.7^{a-h}	9.28^{ab}
Holesalu badane	31.36	53.16^{f-g}	0.82^{e}	1170^{c}	5.40^{c-h}	212.5^{a}	119.1^{a-g}	9.50^{ab}
Heddaragulla badane	31.83	302.39^{a}	1.55^{a}	2160^{a}	5.40^{a-d}	190.5^{a-e}	125^{a-e}	9.64^{a}
Andhra sahare	31.18	81.84^{cde}	0.87^{d}	1480^{b}	5.40^{b-f}	207.5^{ab}	121^{a-f}	9.98^{a}
Apple badane	30.16	70.76^{c-g}	1.10^{c}	660^{ef}	6.95^{a}	192.5^{a-e}	128^{ab}	10.68^{a}
Kanakapurabadane	32.28	123.43^{b}	1.16^{bc}	675^{ef}	3.75^{h-l}	195.5^{a-d}	114.5^{a-h}	6.15^{cd}
Biligundu badane	38.73	137.62^{b}	0.55^{fgh}	649.4^{f}	3.45^{j-l}	151^{gh}	123^{a-f}	5.84^{e-h}
Annageri badane	41.42	18.42^{mn}	0.50^{ghi}	704.6^{ef}	3.40^{g-l}	178.5^{b-g}	129^{ab}	5.14^{fgh}
40-A badane	43.39	81.98^{cd}	0.40^{i}	350.8^{gh}	3.50^{jkl}	193.5^{a-c}	131.1^{a}	5.53^{efgh}
Biligundi badane	38.59	19.95^{lmn}	0.45^{hi}	558.8^{f}	4.00^{e-j}	162^{e-h}	106.7^{c-f}	4.79^{i}
Kalkare badane	38.14	76.67^{c-f}	0.65^{f}	838.0^{de}	3.75^{i-l}	164.5^{c-h}	105^{e-h}	3.94^{i}
Kothithale badane	37.29	117.01^{b}	0.65^{f}	970.0^{d}	2.40^{kl}	185^{a-f}	98.5^{gh}	4.08^{i}

Sakleshpura badane	40.20	81.96^{cd}	0.65^{f}	340^{ghi}	4.65^{c-j}	194.5^{-e}	97^{h}	5.02^{fgh}
Ramadurga badane	38.66	63.19^{c-h}	0.60^{fg}	283^{ghi}	5.15^{b-f}	163.5^{d-h}	115^{a-h}	4.52^{i}
Keredoddi kollegai	40.79	19.93^{lmn}	0.50^{ghi}	198.8^{ghi}	5.95^{a-d}	133.5^{h}	123^{a-f}	4.73^{i}
Hosajavari badane	42.005	39.45^{h-n}	0.50^{ghi}	297.3^{ghi}	2.40^{kl}	178.5^{b-e}	110^{b-h}	4.73^{i}
Bilichandu badane	42.74	22.93^{k-n}	0.50^{ghi}	371^{g}	4.80^{b-e}	198^{ab}	126.1^{a-d}	4.59^{i}
Biliudda badane	42.64	28.92^{j-n}	0.45^{hi}	182.8^{hi}	6.00^{ab}	195.5^{a-d}	121.7^{a-f}	5.45^{efgh}
Naabe badane	40.37	33.11^{i-n}	0.62^{f}	184^{hi}	4.60^{f-k}	151^{gh}	128^{ab}	5.87^{efgh}
Ullala badane	39.43	38.02^{h-n}	0.61^{fg}	200^{ghi}	2.20^{l}	178.5^{b-g}	124^{a-f}	6.29^{cd}
Rosilla badane	39.90	22.43^{k-n}	0.45^{hi}	193^{ghi}	5.60^{c-f}	193.5^{a-e}	124.7^{a-e}	5.35^{efgh}
Mullugai badane	40.50	58.38^{d-i}	0.80^{e}	171.5^{hi}	5.00^{b-f}	165^{c-f}	131.1^{a}	5.13^{fgh}
Hebberalu badane	41.22	37.69^{h-n}	0.80^{e}	187.9^{hi}	4.74^{f-g}	193.5^{a-e}	130^{ab}	4.92^{i}
Doddamullina badane	42.85	11.75^{n}	0.55^{fgh}	178.4^{hi}	5.60^{abc}	195^{a-d}	106^{def}	4.88^{i}
Javari badane	39.89	11.70^{n}	0.45^{hi}	206^{ghi}	4.80^{d-l}	200^{ab}	113^{a-h}	4.45^{i}
Dodda badane	39.47	33.24^{i-n}	1.25^{b}	205^{ghi}	3.00^{kl}	197^{abc}	97^{h}	4.99^{i}
Hariru kempu badane	41.51	46.57^{g-m}	0.45^{hi}	215^{ghi}	3.00^{jkl}	157^{fgh}	103.5^{fgh}	4.39^{i}
Anaamadeya badane	39.43	71.79^{c-g}	0.55^{fgh}	215^{ghi}	4.00^{f-k}	177^{b-g}	117^{a-h}	4.09^{i}
Hasiru udda badane	39.65	49.77^{f-k}	0.80^{e}	168.8^{i}	6.20^{a-d}	191^{a-e}	127.1^{abc}	4.02^{i}
Mobbugulla badane	39.07	30.08^{i-n}	0.40^{i}	164^{i}	4.00^{b-f}	195^{a-d}	111.7^{a-h}	3.69^{i}
Thailand badane	41.98	48.12^{g-l}	1.25^{b}	183^{hi}	3.00^{abc}	185^{a-f}	119.1^{a-g}	3.26^{i}
Dorelo badane	41.82	87.54^{c}	0.95^{d}	172.8^{hi}	5.80^{c-g}	74.52^{b-g}	106.7^{c-h}	3.92^{i}
Anemadeh-1badane	40.96	53.38^{e-j}	1.20^{bc}	172^{hi}	3.00^{jkl}	93.50^{a-e}	111.5^{a-h}	5.36^{efgh}
Mulla badane	41.88	16.83^{n}	0.65^{f}	183^{hi}	4.00^{f-j}	100.98^{ab}	118^{a-g}	5.02^{fgh}
S.Em.±	1.11	7.01	0.02	44.56	0.30	8.00	5.12	0.36
CD at 5%	4.55	28.53	0.11	181.31	1.24	32.57	20.83	1.48

Table.4 Correlation between fruit infestation and fruit characters

Characters	Fruit Weight (g)	Mesocarp Thickness (cm)	No. of seeds	Fruit Length (cm)	Phenol content (mg/g)	Tannin content (mg/g)	Yield
Fruit infestation	-0.455**	-0.389*	-0.740**	-0.301	-0.357*	-0.052	-0.825**

**. Correlation is significant at 0.01 level (2-tailed).
*. Correlation is significant at 0.05 level (2-tailed)
N=34
r=0.389

Fig.1 Correlation between physico-morphic and biochemical characters of shoots of traditional brinjal cultivars against shoot and fruit borer

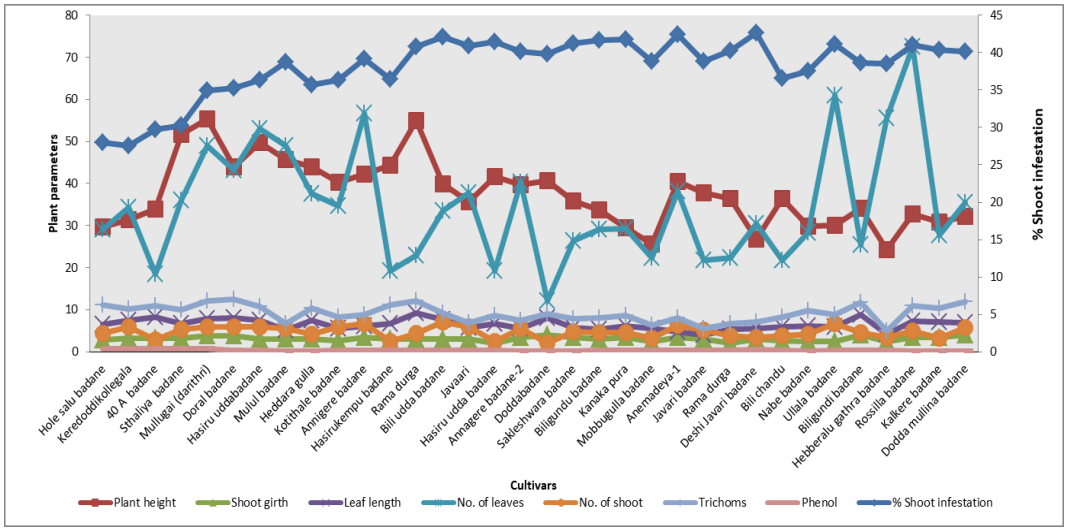
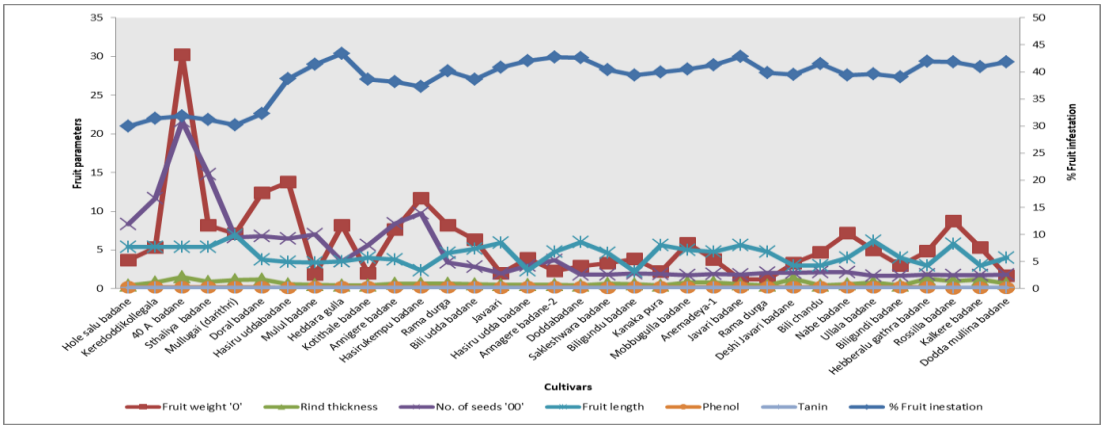


Fig.2 Correlation between physico-morphic and biochemical characters of fruits of traditional brinjal cultivars against shoot and fruit borer



The maximum fruit weight 302.39 gm was recorded in heddaragulla badane (302.39 gm) whereas, minimum fruit weight reported in Javari badane (11.70 gm) and fruit weight (-0.455**) was significant negative correlation with shoot and fruit borer infestation. Similar findings were reported by Hazra *et al.,* 2004, there was a positive and significant effect of fruit weight (0.45) on the susceptibility to fruit infestation of the pest. The maximum mesocarp thickness reported in the cultivar heddaragulla badane (1.55 cm) whereas, minimum in 40-A badane (0.4 cm) and mesocarp thickness (-0.389*) was significant negative correlation with shoot and fruit borer infestation. These findings are in line with Krishnaiah and Vijay (1975). According to them susceptibility might be due to the spherical and oblong fruit with soft mesocarp and loosely arranged seeds. The maximum number of seeds2160 was recorded in heddaragulla badane, the minimum number of seeds was noticed in mobbugulla badane (164) and number of seeds (-0.740**) was non significant negative correlation with shoot and fruit borer infestation. The literature on this aspect of study is lacking in case of brinjal to compare and discusses the present results and therefore this study forms first of its kind. The maximum tannin content 131.1mg/100gm was recorded in 40-A badane and mullugai badane, minimum in kothithale badane (97 mg/100gm) and tannin content (-0.052) was non significant negative correlation with shoot and fruit borer infestation. The maximum phenol content reported in holesalu badane (212.5 mg/100gm), minimumin dorelo badane (74.5 mg/100gm) and phenol content (-0.357*) was significant negative correlation with shoot and fruit borer infestation and findings of the present study are supported by Doshi (2004) also reported that PPO activity had a high negative direct effect on shoot and fruit borer infestation. Maximum yield was recorded in Apple badane (10.68 t ha^{-1}) and the minimum yield was recorded in Thailand badane (3.26 t ha^{-1}). However, the yield was significant negative correlation with incidence of shoot borer (-0.825**).

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