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Morphological and Biochemical Bases of Resistance in Groundnut Germplasm Against Leafhopper, *Empoasca kerri* (Pruthi)

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ABSTRACT

Screening of forty germplasm lines for leaf hopper resistance was carried out at College Farm, College of Agriculture, Rajendranagar, PJTSAU, Hyderabad during *rabi*, 2019-2020. The screening experiment was laid in Randomized block design (RBD) with two replications. Five germplasm lines viz., ICGV 15083, 02266, 07222, 16679, 93468 and 86031 was found to be highly resistant to the leaf hoppers, 16 germplasm lines were moderately resistant and 19 germplasm lines were susceptible. Various morphological characters and biochemical characters were recorded and correlated with incidence of leaf hopper to know their role in imparting resistance/ susceptibility to insect pests. The results obtained were subjected to correlation to draw the impact of these parameters on incidence of leaf hopper. Morphological characters like plant height showed positive correlation and no. of branches, main stem thickness and trichomes showed negative correlation with leaf hopper incidence. Biochemical parameters like total sugars, proteins showed positive correlation (r = 0.659 and 0.680) and phenols, tannins showed negative correlation (r = –0.637 and –0.567) with leaf hopper incidence. Resistance to various insect pests in germplasm lines was due to significantly higher trichome density on leaf lamina, higher phenol and tannin content.

Keywords Leaf hopper, Groundnut, Biochemical, Morphological, Correlation

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INTRODUCTION

Groundnut (*Arachis hypogaea* L.) is an important leguminous food crop in India and is known as peanut, earthnut, monkey nut, and goobers (Dwivedi *et al*. 2003). It has originated in South America, where the genus *Arachis* is widely distributed. It is cultivated

mostly in the semi-arid tropical and sub-tropical regions (Sharma *et al.* 2003). Studies revealed that 15-20% of the total oilseed production is lost directly or indirectly by the attack of insect and mite pests every year (Biswas and Das 2011). The avoidable yield loss due to major insect pests of groundnut was recorded to the tune of 48.57% in pod and 42.11% in fodder (Dabhade *et al.* 2012).

A wide range of insecticides have been proved to be effective in reducing the insect pest population. Host plant resistance is an effective biological approach for plant protection (Iqbal *et al*. 2011) and using insect resistant varieties is an important component of integrated pest management (Rama Prasad 1997). The morphological traits can be used as phenotypic markers to identify groundnut germplasm lines with resistance to leaf hopper. The main reasons of variability in the pattern of resistance shown by different genotypes were explained by Painter (1951). He pointed out three mechanisms of resistance, viz., non-preference (antixenosis), antibiosis and tolerance. The morphological features of plants are associated with attraction, feeding and egg laying of insect pests (Bhatti *et al.* 1976). The identification of important morphological and biochemical characteristics of varieties will help to understand the resistance mechanisms of plant against insect pests which in turn can be used in the breeding programs for development of insect resistant varieties.

MATERIALS AND METHODS

The present investigations were conducted at College farm, College of Agriculture, Rajendranagar, Hyderabad (Telangana) under field conditions during *rabi* 2019-20. Geographic location of Hyderabad pertains to 17.3850 ^{o}North latitude, 78.4867 ^{o}East longitude and elevation of 536 metres above mean sea level (MSL).

(a) Experimental layout

The experiment was laid out in a randomized Block Design (RBD) with 40 treatments, each replicated twice. The plot size was 225 m^2. Each treatment was sown in two rows of 3 m each, with row to row distance of 30 cm and plant to plant distance of 10 cm along with susceptible (ICGV 91114) and resistant (ICGV 86031) check. The recommended package of practices was followed to raise the crop except the plant protection measures.

(b) Observations

(i) For varietal resistance/susceptibility to sucking pests like leaf hoppers, population counts were recorded on top three open leaves of ten randomly selected plants. The mean population of leaf hopper on groundnut was categorized on the basis of formula given below (Gocher *et al*. 2020).

$$\bar{X} \pm \sigma$$

Where,
$\bar{X}$= Mean of insect population
σ = Standard deviation of peak insect population

Mean insect population/ three leaves	**Category**
Below $\bar{X} - \sigma$	Highly resistant
$\bar{X} - \sigma$ to $\bar{X} + \sigma$	Moderately resistant
Above $\bar{X} + \sigma$	Least resistant

(ii) The morphological and biochemical parameters were estimated by following standard procedures as prescribed by earlier workers. These parameters were correlated with leaf hopper incidence to study their relationship.

RESULTS AND DISCUSSION

The incidence of leaf hoppers was recorded during vegetative, flowering and post flowering stages of the crop growth during *rabi* 2019-20.

Incidence of leaf hopper

The mean population counts (hopper per three open leaves per plant) ranged from 1.33 to 2.72. The lowest population count was recorded in the germplasm line ICGV 93468 (1.33 hoppers per three open leaves per plant). The resistant check, ICGV 86031 recorded 1.43 hopper per three open leaves per plant. Seven germplasm lines (ICGV 15083, ICGV 16679, ICGV 07222, ICGV 06424, ICGV 93468, ICGV 99195

Table 1. Incidence of leaf hoppers in germplasm lines. RC- Resistant check, SC- Susceptible check. Figures in parentheses indicate square root transformed $\sqrt{(x+0.5)}$ values.

Genotype	No. leaf hoppers / 3 open leaves per plant			
	Vegetative	Flowering	Post-flowering	Mean
ICGV 15083	1.08 (1.25)	2.43 (1.71)	1.05 (1.24)	1.52 (1.42)
ICGV 181052	1.88 (1.54)	3.50 (2.00)	1.13 (1.27)	2.17 (1.63)
ICGV 181011	1.88 (1.54)	3.15 (1.91)	1.13 (1.27)	2.05 (1.60)
ICGV 171015	1.73 (1.49)	3.30 (1.95)	1.03 (1.23)	2.02 (1.59)
ICGV 16679	1.20 (1.30)	2.30 (1.67)	0.70 (1.10)	1.40 (1.38)
ICGV 03043	1.68 (1.47)	3.85 (2.09)	0.95 (1.20)	2.16 (1.63)
ICGV 07222	1.18 (1.29)	2.20 (1.64)	0.98 (1.21)	1.45 (1.40)
ICGV 06424	1.40 (1.38)	3.05 (1.88)	0.70 (1.10)	1.72 (1.49)
ICGV 13189	2.10 (1.61)	4.05 (2.13)	1.45 (1.40)	2.53 (1.74)
ICGV 13200	1.83 (1.52)	3.58 (2.02)	0.75 (1.12)	2.05 (1.60)
ICGV 14421	1.55 (1.43)	3.15 (1.91)	0.93 (1.19)	1.88 (1.54)
ICGV 15423	2.15 (1.63)	3.88 (2.09)	1.40 (1.38)	2.48 (1.72)
ICGV 15426	1.78 (1.51)	3.25 (1.94)	1.10 (1.26)	2.04 (1.59)
ICGV 93468	1.08 (1.25)	2.15 (1.63)	0.75 (1.12)	1.33 (1.35)
ICGV 99195	1.45 (1.40)	2.75 (1.80)	1.00 (1.22)	1.73 (1.49)
ICGV 00298	1.88 (1.54)	3.10 (1.90)	1.40 (1.38)	2.13 (1.62)
ICGV 00350	2.10 (1.61)	3.05 (1.88)	1.15 (1.28)	2.10 (1.61)
ICGV 00351	2.08 (1.60)	3.28 (1.94)	1.48 (1.41)	2.28 (1.67)
ICGV 06040	1.78 (1.51)	3.20 (1.92)	1.55 (1.43)	2.18 (1.64)
ICGV 02266	1.20 (1.30)	2.25 (1.66)	0.83 (1.15)	1.43 (1.39)
ICGV 86015	1.83 (1.52)	3.55 (2.01)	1.33 (1.35)	2.23 (1.65)
ICGV 93437	1.70 (1.48)	3.78 (2.07)	1.38 (1.37)	2.28 (1.67)
ICGV 93382	1.63 (1.46)	3.53 (2.01)	1.28 (1.33)	2.14 (1.63)
ICGV 10001	1.58 (1.44)	3.43 (1.98)	1.70 (1.48)	2.23 (1.65)
ICGV 10021	2.08 (1.60)	3.73 (2.06)	1.48 (1.41)	2.43 (1.71)
ICGV 15264	2.15 (1.63)	3.73 (2.06)	1.58 (1.44)	2.48 (1.73)
ICGV 15307	1.88 (1.54)	3.20 (1.92)	2.15 (1.37)	1.38 (1.63)
ICGV 87141	1.85 (1.53)	3.53 (2.01)	1.45 (1.40)	2.28 (1.67)
ICGV SM 90704	1.70 (1.48)	3.33 (1.96)	1.08 (1.25)	2.03 (1.59)
ICGV 90320	1.83 (1.52)	3.20 (1.92)	1.00 (1.22)	2.01 (1.58)
JCG 4798	2.30 (1.67)	3.68 (2.06)	1.55 (1.43)	2.51 (1.73)
JCG 5834	2.25 (1.66)	3.95 (2.11)	1.95 (1.57)	2.72 (1.79)
JCG 2141	1.80 (1.52)	3.03 (1.88)	0.93 (1.19)	1.92 (1.55)
JCG 3341	2.05 (1.60)	3.50 (2.00)	1.30 (1.34)	2.28 (1.67)
K 6	2.38 (1.70)	3.80 (2.07)	1.75 (1.50)	2.64 (1.77)
K 9	1.88 (1.54)	3.15 (1.91)	0.85 (1.16)	1.96 (1.57)
KDG 128	1.48 (1.41)	3.08 (1.89)	1.00 (1.22)	1.85 (1.53)
Dharani	1.98 (1.57)	3.88 (2.09)	1.68 (1.47)	2.51 (1.73)
ICGV 86031 (RC)	1.13 (1.27)	2.30 (1.67)	0.88 (1.17)	1.43 (1.39)
ICGV 91114 (SC)	2.23 (1.65)	3.70 (2.05)	1.63 (1.46)	2.52 (1.74)
Mean	1.77 (1.50)	3.26 (1.94)	1.22 (1.31)	2.08 (1.61)
SEm±	0.09	0.07	0.06	0.09
CD (p=0.05%)	0.25	0.19	0.16	0.24

and ICGV 02266) were on par with the resistant check and significantly different from the susceptible check. The highest population count was recorded in germplasm line JCG 5834 (2.72 hoppers per three open leaves) (Table 1).

Categorization of germplasm lines into degree of resistance against *E. kerri*

The data presented in Table 2 shows the categorization of varieties based on mean incidence of leafhoppers. The formula ($X + \sigma$) was used for cat-

Table 2. Categorization of germplasm lines into degree of resistant against leaf hopper. HR- Highly Resistant, MR- Moderately Resistant, S- Susceptible.

Sl. No.	Mean hoppers / three open leaves	Germplasm lines	Category
1	Below 1.72	ICGV 15083, 02266, 07222, 16679, 93468 and 86031	HR
2	1.72-2.08	ICGV 181011, 171015, 06424, 14421, 99195, 13200, 15426, 90320, ICGV SM 90704, K 9, JCG 2141 and KDG 128	MR
3	Above 2.08	JCG 4798, 5834, 3341, ICGV 181052, 03043, 13189, 15423, 00298, 00350, 00351, 06040, 86015, 93437, 93382, 87141, 10001, 10021, 15264, 15307, 91114, K 6 and Dharani	S

egorization. The mean (X) for the data was 2.08. As per the mentioned categorization the varieties having leafhoppers below 1.72 per three open leaves were categorized as highly resistant, between 1.72 to 2.08 per three open leaves were categorized as moderately resistant and above 2.08 per three open leaves, were categorized as least resistant.

Morphological parameters of groundnut germplasm lines

Various morphological parameters viz., plant height, growth habit, number of branches per plant, trichomes on leaf lamina, leaf midrib and petiole, main stem thickness, stem pigmentation, leaflet color were recorded to know the morphological basis of resistance in forty germplasm lines of groundnut. Similar nature of work was done by Iqbal *et al.* (2011), Taylo and Bernardo (1995), Naqvi *et al.* (2008), Ullah *et al.* (2012) and Khalil *et al.* (2017). The data of the above characters is presented in Table 3. The morphological characters have been correlated with leafhopper incidence and the data are presented in Table 4.

The plant height, no. of branches and main stem

Table 3. Morphological characters of 40 germplasm lines of groundnut. RC- Resistant check, SC-Susceptible check.

Genotype	Plant height (cm)	No. of branches	Main stem thickness (cm)	Trichome density (No. of trichomes / 0.25 cm^2) Leaf lamina	Midrib	Petiole	Growth habit	Stem pigmentation	Leaflet color
ICGV 15083	12.68	7.50	2.55	34.25	54.15	63.55	Semi erect	Green	Dark green
ICGV 181052	15.83	7.40	2.25	30.96	55.13	65.78	Prostrate	Green	Dark green
ICGV 181011	16.73	5.80	2.43	35.25	66.33	76.00	Erect	Green	Dark green
ICGV 171015	26.60	5.80	2.51	54.56	60.01	59.37	Semi erect	Green	Dark green
ICGV 16679	18.00	5.60	2.88	34.85	68.59	76.60	Erect	Green	Dark green
ICGV 03043	21.70	5.60	2.45	40.85	63.66	78.86	Erect	Green	Dark green
ICGV 07222	16.82	7.80	2.58	44.65	73.22	80.55	Erect	Green	Dark green
ICGV 06424	21.75	8.00	2.54	31.95	38.25	52.10	Semi erect	Green	Dark green
ICGV 13189	24.10	4.80	2.22	30.89	62.55	68.55	Erect	Green	Light green
ICGV 13200	18.30	4.30	2.31	27.12	56.96	62.58	Erect	Green	Green
ICGV 14421	16.31	6.00	2.28	33.88	59.65	73.99	Erect	Green	Light green
ICGV 15423	22.88	5.80	2.19	27.67	48.54	64.20	Erect	Green	Green
ICGV 15426	18.15	4.60	2.42	31.39	48.56	65.23	Erect	Green	Green
ICGV 93468	13.15	4.50	2.94	47.56	68.26	84.75	Erect	Green + Purple	Dark green
ICGV 99195	22.70	5.60	2.54	47.35	66.89	71.64	Erect	Green	Green
ICGV 00298	21.89	4.80	2.43	30.93	61.50	70.25	Erect	Green	Green
ICGV 00350	16.43	5.00	2.38	33.96	60.36	68.95	Erect	Green	Green
ICGV 00351	16.57	5.20	2.31	38.23	44.15	61.96	Erect	Green + Purple	Green

Table 3. Continued.

Genotype	Plant height (cm)	No. of branches	Main stem thickness (cm)	Trichome density (No. of trichomes / 0.25 cm^2) Leaf lamina	Midrib	Petiole	Growth habit	Stem pigmentation	Leaflet color
ICGV 06040	18.71	5.00	2.07	34.37	48.70	62.58	Semi erect	Green	Dark green
ICGV 02266	14.97	5.00	3.12	45.66	78.55	83.55	Erect	Green + Purple	Dark green
ICGV 86015	18.18	4.80	2.45	27.57	62.55	94.84	Erect	Green	Dark green
ICGV 93437	21.25	7.50	2.47	34.25	40.66	57.97	Erect	Green	Light green
ICGV 93382	20.85	7.00	2.55	31.17	66.95	73.84	Erect	Green	Green
ICGV 10001	26.16	5.50	2.36	29.54	53.98	69.31	Erect	Green + Purple	Green
ICGV 10021	22.90	4.20	2.35	31.56	40.56	61.11	Erect	Green	Light green
ICGV 15264	19.65	4.50	2.28	32.25	63.56	77.17	Erect	Green + Purple	Light green
ICGV 15307	18.40	4.40	2.51	29.58	55.89	66.31	Erect	Green + Purple	Dark green
ICGV 87141	21.90	4.60	2.29	41.56	51.65	71.38	Erect	Green	Dark green
ICGV SM 90704	20.00	5.40	2.18	36.25	70.65	86.17	Erect	Green	Dark green
ICGV 90320	21.40	4.50	2.56	38.65	72.68	87.31	Erect	Green	Green
JCG 4798	19.45	4.30	2.34	42.56	53.65	61.91	Erect	Green + Purple	Light green
JCG 5834	25.60	4.30	2.43	36.90	66.95	80.33	Erect	Green	Light green
JCG 2141	20.45	5.20	2.49	43.65	59.69	66.85	Erect	Green	Dark green
JCG 3341	20.65	5.20	2.33	30.65	66.94	87.97	Semi erect	Green	Dark green
K 6	23.65	4.20	2.37	25.68	50.65	56.87	Erect	Green	Light green
K 9	18.10	5.60	2.45	44.25	71.25	81.56	Erect	Green	Dark green
KDG 128	13.37	5.20	2.51	34.68	76.43	87.25	Erect	Green + Purple	Dark green
Dharani	16.35	4.50	2.92	32.56	63.89	73.55	Semi erect	Green + Purple	Green
ICGV 86031 (RC)	22.45	4.60	3.33	48.65	96.01	102.87	Erect	Green + Purple	Dark green
ICGV 91114 (SC)	27.90	4.40	2.88	33.26	57.56	63.37	Erect	Green	Light green
Mean	19.82	5.35	2.49	36.03	60.65	72.47			

thickness ranged between 12.68 cm (ICGV 15083) to 27.90 cm (ICGV 91114), 4.20 (K 6) to 8.00 (ICGV 06424) and 2.07 cm (ICGV 06040) to 3.33 (ICGV 86031), respectively with their mean values being 19.82 cm, 5.35 and 2.49 cm, respectively. The no. of trichome on leaf lamina, midrib and petiole per 0.25 cm^2 ranged between 25.68 (K 6) to 54.56 (ICGV 171015), 38.25 (ICGV 06424) to 96.01 (ICGV 86031) and 52.10 (ICGV 06424) to 102.87 (ICGV 86031), respectively with mean value being 36.03, 60.65 and 72.47, respectively (Table 3). Of the forty germplasm lines, 33 germplasm lines had erect growth habit, 6 germplasm lines (ICGV 171015, ICGV 15083, ICGV 06424, ICGV 06040, JCG 3341 and Dharani) had semi-erect growth habit and one germplasm line (ICGV 181052) had spreading growth habit. Based on stem pigmentation, 30 germplasm lines were found to have green stem pigmentation while remaining 10 germplasm lines had green-purple stem pigmentation. Based on the leaflet color, 19 germplasm lines had dark green leaflet color, 11 germplasm lines had green leaflet color and remaining 10 germplasm lines had light green leaflet color. (Table 3). Most of the resistant and moderately resistant germplasm lines had dark green leaflet color, with increased mainstem thickness and greenish purple stem pigmentation.

Table 4. Relationship between morphological characters of germplasm lines and incidence of leaf hoppers. *Significant at 0.05 level; ** Significant at 0.01 level.

Sl. No.	Parameters	Correlation coefficient	Regression equation
1.	Plant height (X) vs no./plant (Y)	0.5026**	Y = 1.1022 + 0.0494 X
2.	No. of branches (X) vs no./plant (Y)	-0.3676*	Y = 2.7538 - 0.1251 X
3.	Main stem thickness (X) vs no./plant (Y)	-0.5465**	Y = 3.9802 - 0.7638 X
4.	Trichome density on lamina (X) vs no./plant (Y)	-0.5039**	Y = 3.0473 - 0.0268 X
5.	Trichome density on midrib (X) vs no./plant (Y)	-0.4485**	Y = 3.0039 - 0.0147 X
6.	Trichome density on petiole (X) vs no./plant (Y)	-0.3499*	Y = 2.9036 - 0.0114 X

Significant positive correlation was observed between no. of hoppers per plant and plant height whereas significant negative correlation was seen with no. of branches per plant, main stem thickness, trichome density on lamina, trichome density on midrib and trichome density on petiole and no. of hoppers per plant (Table 4). Our results are in conformity with the findings of Iqbal *et al.* (2011) in okra wherein he reported that no. of branches and trichomes on leaf lamina were negatively correlated with leaf hopper incidence. Also, Taylo and Bernardo (1995) found that the number of primary branches did not differ significantly in resistant and susceptible okra varieties.

The results can also be compared with Naqvi *et al.* (2008) who reported that trichome density had negative correlation with leafhopper population on brinjal crop. Ullah *et al.* (2012) also reported that correlation coefficients between population of *A. biguttula biguttula* and physio-morphic characters of okra resulted in highly significant, strong and negative correlation for hair density on lamina, while non-significant, weak and negative correlation for hair density on midrib. Khalil *et al.* (2017) also revealed adult and nymph population of jassid showed negative response with hair density on leaf lamina and midrib in cotton.

Table 5. Biochemical characters of selected germplasm lines.

Sl. No.	Germplasm lines	Total sugars (mg)	Proteins (mg)	Phenols (mg)	Tannins (mg)
1	ICGV 15083	2.67	2.57	0.94	0.0026
2	ICGV 181011	4.90	2.39	0.82	0.0030
3	ICGV 13189	5.91	2.58	0.76	0.0028
4	ICGV 93382	2.50	2.89	0.68	0.0023
5	ICGV 10001	3.54	2.92	0.78	0.0032
6	ICGV 10021	4.81	2.98	0.64	0.0022
7	ICGV 02266	4.10	2.36	0.73	0.0040
8	ICGV 00298	3.15	2.35	0.90	0.0047
9	ICGV 93468	2.24	2.14	0.92	0.0050
10	K 6	3.85	2.52	0.75	0.0032
11	JCG 4798	6.82	2.82	0.81	0.0035
12	ICGV 86031 (R)	2.53	2.23	0.97	0.0045
13	ICGV 91114 (S)	4.86	2.94	0.61	0.0024

Biochemical attributes of resistance/susceptibility in selected groundnut germplasm lines

About 13 germplasm lines were selected under different levels of resistance and their biochemical attributes like total sugars, proteins, phenols and tannins were analyzed and correlated with leafhopper incidence to know their role in imparting resistance/susceptibility to germplasm lines.

The total sugars, proteins, phenols and tannins ranged from 2.24 (ICGV 93468) to 6.82 mg/g (JCG 4798), 2.14 (ICGV 93468) to 2.98 mg/g (ICGV 10021), 0.67 (ICGV 91114) to 0.97 mg/g (ICGV 86031) and 0.0022 (ICGV 10021) to 0.0050 mg/g (ICGV 93468) of leaf sample, respectively in the selected germplasm lines (Table 5).

Table 6. Relationship between biochemical characters of selected germplasm lines and leaf hopper incidence. *Significant at 0.05 level, ** Significant at 0.01 level.

Biochemical characters	Leaf hopper population ('r' value)
Total sugars	0.659**
Proteins	0.680**
Phenols	-0.637*
Tannins	-0.567*

Correlation studies carried out between biochemical characters and incidence of leafhoppers (Table 6). There was significant positive relationship between leaf hopper population and total sugars and proteins while significant negative correlation was seen with phenols and tannins.

In line with our findings, Sandhi *et al.* (2017) also reported that the cotton entries with higher phenols, tannins exhibited resistance against jassids. Similar results were reported in okra by Simmonds, (2003), Hooda *et al.* (1997), Halder *et al.* (2016). Studies conducted by Nanda *et al.* (2000) revealed that low total amino acid and total starch contents were factors potentially affecting varietal resistance to *N. lugens* which is in accordance to our findings.

REFERENCES

Biswas GC, Das GP (2011) Insect and mite pests diversity in the oilseed crops ecosystems in Bangladesh. *Bangladesh J Zoology* 39 (2) : 235—244.

Bhatti MA, Saeed M, Chatta N, Iqbal S (1976) Host plant resistance and importance to insect population suppression in cotton crop. I*n Proc Cott Prod Seminar ESSO Pak Fertilizer Co Ltd* 132—142.

Dabhade PL, Bapodra JG, Jethva DM, Rathod RT, Dabhi MV (2012) Estimation of yield losses due to major insect pests of groundnut in Gujarat. *Leg Res An Int J* 35 (4) : 354—356.

Dwivedi SL, Crouch JH, Nigam SN, Ferguson ME (2003) Molecular breeding of groundnut for enhanced. *Adv Agron* 80 : 153.

Gocher S, Priyanka AL, Ahmad S, Jat BL (2020) Screening of improved cultivars of groundnut (*Arachis hypogaea* L.) for resistance against leafhopper. *Empoasca kerri Pruthi* 8 (3) : 1796—1799.

Halder J, Sanwal SK, Deb D, Rai AB, Singh B (2016) Mechanisms of physical and biochemical basis of resistance against leaf-hopper. (*Amrasca biguttula biguttula*) in different okra (*Abelmoschus esculentus*) genotypes. *Ind J Agric Sci* 86 (4) : 481—484.

Hooda VS, Dhankhar BS, Singh R (1997) Evaluation of okra cultivars for field resistance to the leafhopper *Amrasca biguttula biguttula* (Ishida). *Int J Trop Insect Sci* 17 (3-4) : 323—327.

Iqbal J, ul Hasan M, Ashfaq M, Sahi ST, Ali A (2011) Studies on correlation of *Amrasca biguttula biguttula* (Ishida) Population with Physio-morphic Characters of okra. *Abelmoschus esculentus* (L.) Monech. *Pak J Zool* 43 (1) : In press.

Khalil H, Raza AB, Afzal M, Aqueel MA, Khalil MS, Mansoor MM (2017) Effects of plant morphology on the incidence of sucking insect pests complex in few genotypes of cotton. *J Saudi Soc Agric Sci* 16 (4) : 344—349.

Nanda UK, Dash D, Rath LK (2000) Biochemical basis of resistance in rice to the brown planthopper *Nilaparvata lugens*. *Ind J Entomol* 62 (3): 239—241.

Naqvi AR, Pareek BL, Nanda US, Mitharwal BS (2008) Leaf morphology and biochemical studies on different varieties of brinjal in relation to major sucking insect pests. *Ind J Pl Prot* 36 (2) : 245—248.

Painter RH (1951) Insect resistance in crop plants. The Macmillan Publishers Limited.

Rama Prasad G (1997) Integrated management of *Spodoptera litura* (F.) in India. In Proc. Nation. Scientists Forum *Spodoptera litura*, pp 96—103.

Sandhi RK, Sidhu SK, Sharma A, Chawla N, Pathak M (2017) Morphological and biochemical basis of resistance in okra to cotton jassid, *Amrasca biguttula biguttula* (Ishida). *Phytoparasitica* 45 (3) : 381—394.

Sharma HC, Pampapathy G, Dwivedi SL, Reddy LJ (2003) Mechanisms and diversity of resistance to insect pests in wild relatives of groundnut. *J Econ Entomol* 96 (6) : 1886—1897.

Simmonds MS (2003) Flavonoid–insect interactions : Recent advances in our knowledge. *Phytochem* 64 (1) : 21—30.

Taylo LD, Bernardo EN (1995) Morphological and biochemical bases of resistance of eggplant (*Solanum melongena* Linn.) and okra (*Abelmoschus esculentus* (L.) Moench.) to the cotton leafhopper (*Amrasca biguttula* (Ishida)). In 26 PMCP Anniversary and Annual Scientific Meeting, La Trinidad, Benguet (Philippines).

Ullah S, Javed H, Aziz MA (2012) Role of physico-morphic characters of different okra genotypes in relation to population of jassid, *Amrasca biguttula biguttula* Ishida. *J Agric Res* 50 (2) : 217.