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Appala Raju A
Department of Entomology, Agricultural College, Bapatla, Andhra Pradesh, India

Sesha Mahalakshmi M
Department of Entomology, RARS, Lam, Guntur, Andhra Pradesh, India

Sandhya Rani C
Department of Entomology, Agricultural College, Bapatla, Andhra Pradesh, India

Adinarayana M
Department of Entomology, RARS, Lam, Guntur, Andhra Pradesh, India

Corresponding Author:
Appala Raju A
Department of Entomology, Agricultural College, Bapatla, Andhra Pradesh, India

Morphological and biochemical characters of cotton genotypes against Leafhopper, *Amrasca devastans* Dist. (Cicadellidae: Hemiptera) in Lam, Guntur, Andhra Pradesh

Appala Raju A, Sesha Mahalakshmi M, Sandhya Rani C and Adinarayana M

Abstract
The study was conducted during *kharif*, 2016-17 at Regional Agricultural Research Station (RARS), Lam, Guntur, Andhra Pradesh, with objectives to study of morphological and biochemical factors responsible for insect resistance. The study highlighted that Morphological characters like leaf thickness and leaf hair density of cotton leaf, biochemical components *viz*., phenols and tannins were quantified to find out the characters of cotton plant that are associated with tolerance or resistance to leafhoppers. The results revealed that, variation in leaf thickness was very narrow and found non-significant among all the genotypes both at vegetative stage as well as flowering stage. The genotypes, which recorded significantly higher hair density on leaf lamina and midrib at vegetative and flowering stage harboured lower population of leafhoppers. Thus, the present results revealed that the genotypes with more leaf hair density were found to be resistant against leafhoppers. DCH-32 possessing low hair density recorded significantly higher mean leafhopper incidence (24.0 no. of leafhopper/3 leaves/plant). The genotypes recorded more per cent phenol content and tannin content recorded less number of leafhoppers. Hence it can be concluded that the genotypes possessing more phenols and tannins exhibited resistance or tolerance against leafhoppers. The highest seed cotton yield was recorded in GISV-267 (18.5 q/ha), GJHV-497 (18.4 q/ha) and GSHV-173 (18.1 q/ha) which were found to be leafhopper resistant.

Keywords: Cotton, Leaf hopper, Hair density, Thickness, Tannins, Phenols

1. Introduction
Cotton (*Gossypium hirsutum* L.) is an important cash crop grown commercially under diverse agro-climatic conditions around the world for both domestic consumption and export purpose worldwide and hence, called as "King of fibers" or "White gold". India continues to maintain the largest area under cotton and second largest producer next to China with 35.2 per cent of world area and 24 per cent of world production. Andhra Pradesh is an important cotton growing south Indian state with an area of 25.40 lakh ha and a production of 66.4 lakh bales (*www.indiastat.com 2016-17*) [24]. Though India has the largest acreage under cotton in the world, the productivity is low due to abiotic and biotic stresses. It has been reported that around 162 insect pests are known to attack cotton in India from sowing to harvesting (Lingappa, 2001) [11], but only few of them are key production constraints which causes up to of 30-80 per cent losses in yield (Patil, 1988) [17]. The transgenic cottons exhibited great resistance against bollworms (Kranthi and Kranthi, 2004) [8], but lack of resistance against sucking insect pests (Hofs *et al*., 2004; Sharma and Pampapthy, 2006) [7, 20], poses a major constraint in *Bt* cotton cultivation. In *Bt* cotton era sucking pests have become more serious inviting indiscriminate use of pesticides besides use of improper doses of insecticides leads to control failures of sucking pests. The aggravation of sucking pest menace may be due to climate change; however the insecticide resistance is also quite evident (Kshirsagar *et al*., 2012) [9].

Leafhoppers, *Amrasca devastans*, (Dist.), thrips, *Thrips tabaci.* L, aphids, *Aphis gossypii* (Glover) and whiteflies, *Bemisia tabaci* (Genn.) are the important sucking pests which inflict the crop from seedling stage itself and cause phenomenal losses (Kulkarni *et al*., 2003) [10]. Among the sucking pests of cotton, the leafhopper, *Amrasca devastans* is an alarming pest throughout the season. It has a broad host range including cotton, okra, brinjal and jute.

Both nymph and adult stages cause damage to the plants by sucking the sap from leaves and also transmits different viruses. In spite of repeated use of insecticides, we are witnessing the control failures which might be the signals of insecticide resistance in sucking pests of cotton.

Host plant and insect interaction is a dynamic system and co-evolutionary process, which involves development of the defence mechanisms by the plants and counter adaptations by the insects. Defence mechanisms involve either morphological barriers like trichomes and leaf thickness or phytochemicals like tannins and phenols which act as repellents, phagodeterrents and oviposition deterrents exhibiting resistance to plants.

Hence, we studied the morphological and biochemical characters of cotton genotypes against leafhopper *Amrasca devastans* Dist. (Cicadellidae: Hemiptera) in Lam, Guntur, Andhra Pradesh.

2. Methodology

Morphological characters like leaf thickness and hair density of cotton leaf, biochemical characters *viz.,* phenol and tannin contents were quantified for different genotypes.

Determination of Leaf Thickness

The leaves from cotton plants at 30, 60, 90 and 120 DAS were collected from 14 genotypes. From each treatment three plants were selected at random and from each plant three leaves were selected randomly which were replicated thrice. The thickness of leaf was measured by using micrometer. The range of micrometer used for determination of leaf thickness was 0.01 mm to 10 mm. The leaf was made into small bits with the help of blade and the bits were fed to the micrometer to record the readings.

Determination of Leaf Hair Density

The leaves from cotton plants at 30, 60, 90 and 120 DAS were collected from 14 treatments (14 genotypes with 2 replications). From each treatment three plants were selected at random and from each plant three leaves were selected randomly which were replicated thrice. Circular discs of diameter 0.45 cm were made on the leaf with the help of punching machine, the discs were soaked in saffron dye for 5-10 minutes, later the bits were observed under the stereo zoom microscope to count the number of hairs present on the disc of leaf bit.

Quantification of biochemical constituents

Phenol and tannins were quantified in each genotype as per the standard protocols (Acharya and Singh, 2008) [1].

Preparation of samples

The amount of phenol and tannins both during vegetative and reproductive phase was estimated by collecting 40 leaves from the middle canopy of each genotype. The collected leaves were washed with ordinary water and then with distilled water. Later on, these were placed in an oven for two days at 60^0 C temperature for drying. After drying, leaf samples were ground done with the help of electric grinder and the ground leaf samples were tightly packed in polythene bags to avoid absorption of moisture.

Digestion of sample

Powdered material (0.5 g) of each sample was taken in 100 ml conical flask and 10 ml of reagent solution (Sulphuric acid + Perchloric acid in the ratio of 4:1) was added in each flask. These flasks were covered with watch glass and allowed to stand overnight. After 18 hours, heating was done on hot plate until solid particles disappeared and clear colourless solution was obtained. Solutions were allowed to cool and volume was raised to 50 ml with distilled water.

Estimation of total phenols

One ml of the extract was taken in 25 ml volumetric flask and the neck of flask was washed with distilled water. The contents were mixed well and kept for 3 min. Then 0.5 ml of Folin ciocalteau reagent was added. After 3 min., 2 ml of 20% Na_2CO_3 solution was added. The contents were thoroughly mixed and placed in boiling water for exactly 1 minute. After cooling, the absorbance was measured at 650 nm against reagent blank. Total phenol content was determined from a standard curve prepared with catechol.

Estimation of tannins

One ml of extract was taken in 25 ml volumetric flask and 5 ml of vanillin HCl reagent was added. The reagent was prepared by combining equal volumes of 8 per cent HCl in methanol and 4 per cent vanillin in methanol. The absorbance was measured in a spectrophotometer at 500 nm after 20 min. Blank was prepared with vanillin HCl reagent alone. Tannin content was calculated from a standard curve prepared with catechol.

3. Results and discussion

Morphological characters of different cotton genotypes

Leaf thickness

Leaf thickness of different cotton genotypes were measured both at vegetative stage and flowering stage of the crop with the help of micrometer and the results indicated that variation in leaf thickness was very narrow and found non-significant among the genotypes which ranged from 0.22 to 0.25 mm in vegetative stage and 0.27 to 0.33 mm in flowering stage (Table 1).

Table 1: Leaf thickness among the different cotton genotypes during *kharif* 2016-17 at RARS, Lam, Guntur.

Treatments	Genotype	Leaf thickness (mm)	
		Vegetative stage	Flowering stage
T_1	GSHV-173	0.25	0.27
T_2	RAH-1069	0.24	0.32
T_3	CPD-1501	0.22	0.33
T_4	BGDS-1055	0.22	0.31
T_5	GJHV-517	0.22	0.29
T_6	DSC-1501	0.24	0.29
T_7	LHDP-1	0.23	0.27
T_8	GJHV-497	0.23	0.31
T_9	CNH-25	0.24	0.30
T_{10}	TSH-0533-1	0.22	0.30
T_{11}	GISV-267	0.23	0.30
T_{12}	Bunny-*Bt*	0.24	0.30
T_{13}	Bunny non-*Bt*	0.23	0.30
T_{14}	DCH-32	0.24	0.31
F-test		NS	NS
SEm±		0.05	0.21
CD (P=0.05)		NS	NS
CV (%)		3.62	4.55

NS-Non Significant

Leaf hair density

Hair density on leaf lamina and leaf midrib of different cotton

genotypes both at vegetative stage and flowering stage was measured under stereo zoom microscope on leaf disc diameter of 0.45 cm diameter. The hair density on leaf lamina at vegetative and reproductive stage ranged from 20-52 and 45-87 no /0.45 cm leaf disc diameter, respectively. Whereas, the hair density on midrib at vegetative and reproductive stage ranged from 25-58 and 58-132/0.45cm leaf disc diameter, respectively in different genotypes (Table 2) (Plate 1). The hair density was high at flowering stage when compared to vegetative stage in all the genotypes. Further, the hair density was high on midrib when compared to the leaf lamina irrespective of genotype.

The hair density on leaf lamina at vegetative stage was the highest in GISV-267 (52 no. / 0.45 cm leaf disc) followed by GSHV-173 (50 / 0.45 cm leaf disc), GJHV-517 and GJHV-497 (49 no. / 0.45 cm leaf disc) which were found on par among themselves and statistically superior over the other genotypes. Among the screened genotypes, the hair density was the lowest in DSC-1501 and TSH-0533-1 (30 no. / 0.45 cm leaf disc) besides hybrid check *i.e.* DCH-32 hybrid having the lowest number of trichomes on leaf lamina (20 no. / 0.45 cm leaf disc) (Table. 2)

The hair/trichrome density was higher at flowering stage in all the genotypes including checks. However, the hair density was the highest in GISV-267 (87 / 0.45 cm leaf disc), but it was found statistically at par with GSHV-173 (85 / 0.45 cm leaf disc), GJHV-517 (81 / 0.45 cm leaf disc) and GJHV-497 (78 / 0.45 cm leaf disc). But these genotypes were found significantly superior over the other genotypes with respect to hair density at flowering stage (Table 2).

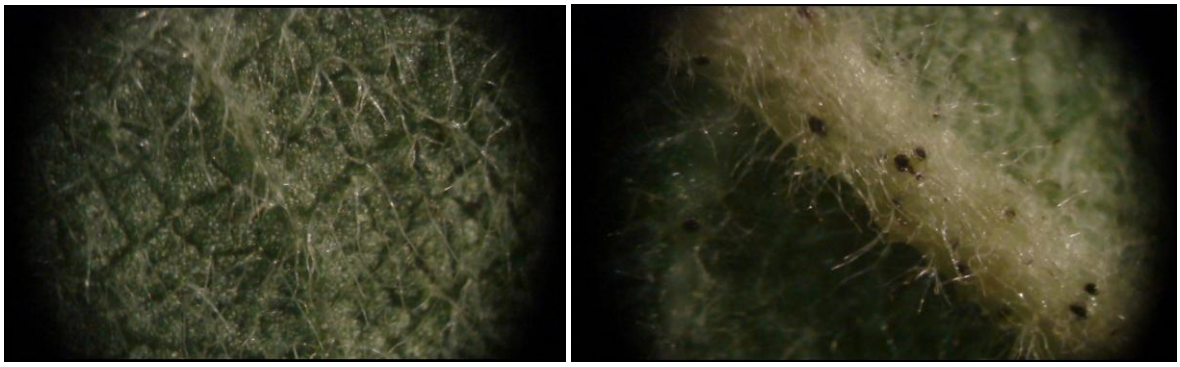
The hair density on midrib was also higher at flowering stage than at vegetative stage in all the genotypes. The hair density on midrib was also found the highest in GISV-267 (58 and 132 no. / 0.45 cm leaf disc) followed by GSHV-173, GJHV-517 and GJHV-497 both at vegetative and flowering stages. These genotypes were found significantly superior over all the other genotypes in having higher trichome density on midrib. In general, the hair density was high on midrib than on leaf lamina irrespective of stage of the crop and genotype. However, the hair density on midrib was lowest in susceptible check, DCH-32 both at vegetative stage as well as flowering stage.

From the present studies, it is clearly evident that the population of leafhoppers decreased as the hair density increased from vegetative and flowering stage. Further, it can be inferred that the genotypes possessing higher hair density on leaf lamina and midrib conferred resistance or tolerance against the leafhoppers. These findings derive support from studies of Deb *et al*. (2015) [6], who stated that plant characters *viz*., hairs or trichomes, thickness, toughness, leaf length/ width, number of leaves/ plant and plant height *etc* are responsible for imparting resistance in cotton crop against sucking insect pests. Similarly, Manendra (2012) [13], reported that the cotton hybrid Ajeet-155 (51 no. /leaf disc of 0.45 cm diameter) recorded highest leaf hair density was found resistant against leafhoppers, whereas the lowest hair density was recorded in Siddu (30 no./ leaf disc of 0.45 cm diameter) and it was susceptible to leafhoppers. The findings of Naveed *et al*. (2011) [15], also revealed that the leafhopper population showed positive correlation with varieties having higher hair density (1011±21.04) with less hair length (644±27.3). Aslam *et al*. (2004) [4], also reported leaf hair length and density were important morphic characters contributing to resistance against leafhoppers infesting cotton. Sajjad *et al*. (2004) [19], the cultivars of CRIS-467 and CRIS-134 were resistant to leafhopper due to greatest hair density. Nizamani *et al*. (2002) [16], and Bashir *et al*. (2001) [5], who have also concluded that the leafhopper population had negative correlation with hair density, leaf thickness, sugars and tannins in the leaf. In contrast Naqvi and his co-workers during (2008) [14], reported that leaf area, leaf thickness and chlorophyll content in cotton genotypes exerted no effect on leafhopper population.

Table 2: Leaf hair density at various stages of different cotton genotypes during *kharif* 2016-17 at RARS, Lam, Guntur.

Treatments	Genotype	Hair density per leaf disc of 0.45 cm diameter					
		Leaf Lamina			Midrib		
		Vegetative stage	Flowering Stage	Mean	Vegetative stage	Flowering Stage	Mean
T_1	GSHV-173	50	85	67.5	57	129	93.0
T_2	RAH-1069	35	67	51.0	40	92	66.0
T_3	CPD-1501	40	73	56.5	45	98	71.5
T_4	BGDS-1055	38	68	53.0	41	98	69.5
T_5	GJHV-517	49	81	65.0	55	128	91.5
T_6	DSC-1501	30	58	44.0	33	80	56.5
T_7	LHDP-1	42	75	58.5	47	107	77.0
T_8	GJHV-497	49	78	63.5	52	122	87.0
T_9	CNH-25	42	75	58.5	47	105	76.0
T_{10}	TSH-0533-1	30	62	46.0	33	77	55.0
T_{11}	GISV-267	52	87	69.5	58	132	95.0
T_{12}	Bunny-*Bt*	31	55	43.0	34	82	58.0
T_{13}	Bunny non-*Bt*	24	49	36.5	29	61	45.0
T_{14}	DCH-32	20	45	32.5	25	58	41.5
F-test		Sig	Sig	Sig	Sig	Sig	Sig
SEm±		1.9	3.0	1.8	2.5	4.4	6.9
CD (P=0.05)		5.5	8.7	5.3	7.5	12.8	20.1
CV (%)		7.0	7.0	4.9	13.8	8.6	13.9

Sig-Significant



Leaf lamina **Leaf midrib**

Plate 1: Trichome density on leaf lamina and leaf midrib of cotton leaf

Biochemical components in different cotton genotypes

The per cent phenol and tannin composition in each genotype were quantified as per the standard protocols (Acharya and Singh, 2008) [1].

Total phenol content

The percent phenol content in the selected genotypes was estimated at different stages of crop growth. The phenol content was low initially at 30 DAS, which increased by 60 DAS and later slightly decreased by 90 DAS and 120 DAS in all the genotypes when compared to all the other stages

At 30 DAS, the per cent phenol content varied from 0.43 to 0.85% in leaves, where as it ranged from 0.68 to 1.39 per cent at 60 DAS. The phenol content was slightly less at 90 DAS. Which varies from 0.54 to 1.06 per cent and it was more than 0.8 per cent in GISV-267 followed by GSHV-173, GJHV-517, and GJHV-497 which were found on par with each other. The genotypes with higher phenol content were LHDP-1 and CNH-25. Among the other genotypes at later stages also the genotypes GISV-267, GSHV-173, GJHV-517 and GJHV-497 recorded high amount of phenols when compared to all the other genotypes (Table 3).

The data on mean per cent phenol content revealed that GISV-267 (0.97%), GSHV-173 (0.96%), GJHV-517(0.93%), GJHV-497(0.91%), LHDP-1(0.90%) and CNH-25 (0.90%) were found to have higher amount of phenols when compared to the other genotypes. The mean phenol content was less in standard checks *i.e.* Bunny *Bt* (0.69%) and its non *Bt* counterpart *i.e.* Bunny non *Bt* (0.60%). However, phenol content was the lowest in susceptible check *i.e* DCH-32 when compared to all the other genotypes at all the stages of crop growth (Table 3).

Table 3: Phenol composition of different cotton genotypes at various stages of crop growth during *kharif* 2016-17 at RARS, Lam, Guntur.

Treatments	Genotype	Per cent Phenol content				
		30 DAS	60 DAS	90 DAS	120 DAS	Mean
T_1	GSHV-173	0.84	1.33	1.05	0.70	0.96
T_2	RAH-1069	0.55	0.87	0.69	0.48	0.64
T_3	CPD-1501	0.64	1.01	0.80	0.56	0.74
T_4	BGDS-1055	0.61	0.97	0.77	0.53	0.71
T_5	GJHV-517	0.82	1.30	1.02	0.57	0.93
T_6	DSC-1501	0.67	0.90	0.84	0.58	0.78
T_7	LHDP-1	0.78	1.24	0.98	0.68	0.90
T_8	GJHV-497	0.79	1.25	0.99	0.69	0.91
T_9	CNH-25	0.78	1.23	0.97	0.67	0.90
T_{10}	TSH-0533-1	0.55	0.93	0.69	0.48	0.64
T_{11}	GISV-267	0.85	1.39	1.06	0.70	0.97
T_{12}	Bunny-*Bt*	0.66	0.84	0.72	0.54	0.69
T_{13}	Non-Bunny-*Bt*	0.54	0.87	0.67	0.46	0.62
T_{14}	DCH-32	0.43	0.68	0.54	0.43	0.52
F-test		sig	sig	sig	sig	Sig
SEm±		0.02	0.03	0.04	0.02	0.03
CD (P=0.05)		0.12	0.20	0.25	0.13	0.19
CV (%)		5.42	6.10	6.67	5.80	6.00

Sig-Significant

Tannins

The per cent tannin content was estimated at different stages of crop growth from all the selected genotypes. The per cent tannin content was high at 60 DAS in all the genotypes when compared to the other stages of crop growth. The per cent tannin content varied from 0.25 to 0.99 at different stages of crop growth among the genotypes (Table 4.).

The per cent tannin content was high in GISV-267, GSHV-173, GJHV-517, GJHV-497, LHDP-1 and CNV-25 and were statistically on par among themselves, the mean per cent tannins content was more than 0.60 per cent in the above genotypes and statistically superior over the other genotypes and checks hybrids. The mean per cent tannin was the lowest in susceptible check, DCH-32 (0.30%) and inferior to all the test genotypes (Table 4).

The biochemical analysis revealed that the genotypes having higher content of phenols and tannins recorded the lower population of leafhoppers and vice-versa. The present findings derive the support from the findings Mandhania *et al.* (2010) [12], who stated that the total phenol, tannin and total

gossypol contents at all growth stages (65, 80 and 95 DAS) showed significant negative relationship with the incidence of leafhoppers in cotton. Deb *et al*. (2015) [6], and also confirmed that the biochemical contents *viz*., phenol, tannin, and gossypol are contributing a major role in conferring the mechanism of resistance to insect pests in cotton. Rohini (2010) [18], also reported that the genotypes which recorded lesser population of sucking pests were having more per cent of phenol, tannin and gossypol than susceptible genotypes. In contrast Vanitha *et al*. (2007) [23], concluded that there was no significant influence of phenols and tannins on incidence of leafhoppers. Syed *et al*. (2003) [21], also reported that the highest leafhopper population of 2.72 insects/plant was observed on Greg-25 V, a gossypol free variety indicating direct positive correlation of phenolic compounds and insect resistance. Nizamani *et al*. (2002) [16], who have studied ten cotton cultivars against their reaction to cotton leafhoppers and reported that leafhopper population had negative correlation with sugars and tannins in the leaf. Aheer *et al*. (1999) [2], who have reported that N-92 showed resistance against leafhopper due to presence of more hair density on midrib and lamina and gossypol glands on midrib which showed significantly negative correlation with leafhopper population.

The present findings also revealed that the biochemical constituents *viz.*, phenols and tannins were more in vegetative stage compared to reproductive stage which is in agreement with Acharya and Singh (2008) [9], who have reported that the total phenols, tannins and gossypol were more in vegetative stage compared to reproductive stage in cotton.

Table 4: Tannin composition of different cotton genotypes at various stages of crop growth during *kharif* 2016-17 at RARS, Lam, Guntur.

Treatments	Genotype	Per cent Tannin content				
		30 DAS	60 DAS	90 DAS	120 DAS	Mean
T_1	GSHV-173	0.61	0.97	0.77	0.53	0.65
T_2	RAH-1069	0.47	0.75	0.59	0.41	0.50
T_3	CPD-1501	0.49	0.78	0.62	0.43	0.52
T_4	BGDS-1055	0.48	0.76	0.60	0.42	0.51
T_5	GJHV-517	0.61	0.92	0.77	0.53	0.63
T_6	DSC-1501	0.37	0.59	0.47	0.32	0.39
T_7	LHDP-1	0.57	0.90	0.71	0.49	0.60
T_8	GJHV-497	0.57	0.91	0.72	0.50	0.61
T_9	CNH-25	0.57	0.90	0.71	0.49	0.60
T_{10}	TSH-0533-1	0.34	0.55	0.43	0.30	0.36
T_{11}	GISV-267	0.63	0.99	0.78	0.54	0.66
T_{12}	Bunny-*Bt*	0.39	0.61	0.48	0.33	0.40
T_{13}	Bunny non-*Bt*	0.35	0.56	0.44	0.30	0.37
T_{14}	DCH-32	0.28	0.45	0.36	0.25	0.30
F-test		Sig	Sig	Sig	Sig	Sig
SEm±		0.01	0.03	0.02	0.01	0.01
CD (P=0.05)		0.08	0.18	0.10	0.07	0.08
CV (%)		4.65	5.90	5.52	4.96	5.25

Sig-Significant

Table 5: Seed Cotton yield in different cotton genotypes

Treatments	Genotypes	Yield (q ha$^{-1)}$
T_1	GSHV-173	18.1
T_2	RAH-1069	16.5
T_3	CPD-1501	17.5
T_4	BGDS-1055	16.2
T_5	GJHV-517	18.0
T_6	DSC-1501	15.9
T_7	LHDP-1	17.8
T_8	GJHV-497	18.4
T_9	CNH-25	17.4
T_{10}	TSH-0533-1	15.8
T_{11}	GISV-267	18.5
T_{12}	Bunny-*Bt*	16.3
T_{13}	Bunny-non *Bt*	15.5
T_{14}	DCH-32	15.10
F-test		Sig
SEm±		0.21
CD (P=0.05)		0.90
CV (%)		10.42

Correlation and Multiple Linear Regression (MLR)

The correlation studies revealed that the hair density on leaf lamina and midrib both at vegetative stage as well as flowering stage was found to have significant negative correlation with leaf hopper incidence among the genotypes. The biochemical compounds *i.e.* phenols and tannins content was also found to be have significant negative correlation with incidence of leaf hoppers in different cotton genotypes (Table 6).

The multiple linear regression analysis revealed that hair density, per cent phenols and per cent tannins were found to exhibit strong and highly significant negative influence on the

incidence of leaf hoppers. Among the different characters studied, leaf thickness was found to have positive correlation but it was non-significant. However, all the morphological and biochemical components together were responsible for 72.7 per cent (R2=0.727) variation in the population of leaf hoppers in different genotypes of cotton (Table 7).

The present findings are in accordance with the negative correlation between hair density, biochemical compounds and leafhopper incidence Nizamani *et al.* (2002) [16], Rohini (2010) [18] and Ullah *et al.* (2012) [22]. In contrast Ashfaq *et al.* (2010) [3] and Naqvi *et al.* [14] (2008), reported no significant correlation between hair density and incidence of leafhoppers.

Table 6: Simple correlation between Incidence of leafhoppers and morphological and biochemical compounds during *kharif* 2016-17 at RARS, Lam, Guntur

Component	Degree of correlation
Leaf thickness at vegetative stage	0.271
Leaf thickness at flowering stage	0.118
Hair density on Leaf lamina at vegetative stage	-0.884*
Hair density on Mid rib at vegetative stage	-0.841*
Hair density on Leaf lamina at flowering stage	-0.889*
Hair density on Mid rib at flowering stage	-0.862*
Per cent Phenols	-0.833*
Per cent Tannins	-0.828*

*Significant at 5 per cent level of significance

Table 7: MLR between incidence of leafhoppers and morphological and biochemical compounds during *kharif* 2016-17 at RARS, Lam, Guntur.

Component	Degree of correlation
Leaf thickness	0.284^{NS}
Hair density on Leaf lamina	-0.835^{**}
Hair density on Mid rib	-0.817^{**}
Per cent Phenols	-0.727^{**}
Per cent Tannins	-0.797^{**}
Constant	32.77
R^2 value	0.727

**Significant at 1 per cent level of significance

Seed Cotton yield in different cotton genotypes

The kapas yield from each plot was recorded separately as Kg/plot from two pickings and converted into q ha^{-1}. The results revealed that GISV-267, GJHV-497, GSHV-173 and GJHV-517 recorded the highest seed cotton yield of more than 18 q ha^{-1}.The genotypes, DCH-32 and Bunny non-*Bt* showed comparatively less yield of 15.10 and 15.50 q ha^{-1} respectively which were categorized as susceptible genotypes based on leafhopper resistant index. The next best genotypes which recorded higher yield were LHDP-1 (17.8), CPD-1501 (17.5) CNH-25(17.4) q ha^{-1}respectively (Table 5).

4. Conclusion

The study depicted that genotypes with high hair density on leaf lamina and midrib recorded less population of leafhoppers but the leaf thickness had no significant impact on the incidence of leaf hoppers in cotton genotypes. The genotypes recorded more per cent phenol content and tannin content were recorded less number of leafhoppers. Hence it can be concluded that the genotypes possessing more phenols and tannins exhibited resistance or tolerance against leafhoppers. The highest seed cotton yield was recorded in GISV-267 (18.5 q/ha), GJHV-497 (18.4 q/ha) and GSHV-173 (18.1 q/ha) which were found to be leafhopper resistant. Hair density and quantity of phenols and tannins of GISV-267, GSHV-173, GJHV-517, GJHV-497, LHDP-1 and CNH-25 genotypes were found resistant against leaf hoppers which can be used for further breeding programme to develop resistant varieties against leafhoppers.

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