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Physico-morphological and biochemical studies related to sucking pests in upland cotton (*Gossypium hirsutum* L.)

H. B. Kumbhalkar, V. L. Gawande, Vinita Gotmare, V. N. Waghmare

Abstract

The field experiment comprising of 52 *Gossypium hirsutum* genotypes was conducted at Cotton Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during *kharif*, 2017-18.Based on sucking pest infestation, physico-morphological and biochemical traits of cotton, AKH 11-7 was identified as a source of resistance against sucking pests which possessed the highest mean performance for trichome density along with desirable mean performance for total phenol content. Other parental lines *viz*., AKH 9916 and AKH 2012-9 exhibited higher mean performance for trichome density with one or more traits. A cross combination AKH 8828 x DHY 286 recorded maximum trichome density with minimum number of jassids/3 leaves and also exhibited higher total phenol and tannin content over the check. Other hybrids, AKH 8828 x AKH 9916, AKH 081 x AKH 2006-2 and AKH 081 x AKH 10-10 recorded higher trichome density and also showed desirable performance for one or more trait(s) *viz*., total phenol, tannin content and number of gossypol glands/mm2. The correlation between trichome density and number of jassids/3 leaves was negative and highly significant, whereas correlation between trichome density and number of whiteflies/3 leaves was found positive and highly significantfor parental lines and crosses. Positive and highly significant correlation was recorded between total phenol and tannin content with number of whiteflies/3 leaves in parental lines and crosses. Results revealed negative and highly significant correlation between number of whiteflies/3 leaves and number of jassids/3 leaves. Thus, these parent and hybrids may contribute to produce promising sucking pest tolerant variety/hybrids.

Keywords biochemical parameters, cotton, gossypol glands, sucking pests, trichomes

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Introduction

One of the best gifts that nature has given to mankind is cotton (*Gossypium* spp.), commonly known as the "King of Fibers" and the world's most common natural textile fiber. In India, 162 insect pests damage cotton [1-2], and only a few of them are major production challenges that lead to 30-80% economic losses [3]. In recent years, cotton production is stagnant in many countries due to several biotic constraints particularly due to sucking insect pests that seriously harm the crop, drastically reducing production and fiber quality. These sucking pests viz., Whitefly, *Bemisia tabaci* (Gennadius); Thrips, Thrips tabaci [4].

(Lindman); Green leafhopper, Amrasca biguttula biguttula (Ishida); Aphids, Aphis gossypii (Glover); which impose the crop at seedling and cause phenomenal harms. The cotton production is affected approximately 22.85% as a result of these sucking insects. [5]. Loss in lint and seed cotton yield has been estimated as 20–35 per cent by sucking pests alone [6]. Cotton plants have a variety of vital defenses against phytophagous pests [7]. Trichomes and gossypol glands are two protective morphological aspects. Trichomes are epidermal growths from shoots, leaves, and roots that can be unicellular or multicellular. Trichomes could be glandular or hair-like. Smaller insects are kept far away from the surface of leaves by trichomes and leaf hairs that serve as barriers. Hair length, mid-vein density, and trichome density on the ventral surface of the leaves are three significant and readily observable morphological features that may lessen leafhopper oviposition and the resulting damage [8]. Gossypol glands are yellow pigmented polyphenolic compounds distributed on all parts of cotton plant. Certain cotton insect pests are deterred by gossypol glands in the cotton plant's leaves. Plants produce a wide range of biochemical compounds that are allied to insect resistance. These include glycosides, tannin content, phenolic chemicals, and silica concentrations. These are the polyphenolic compounds which are proven as antioxidants and possess a chemo-protective potential. The role of phenol and tannin as the feeding stimulant in insects was reported [9]. It is believed that phenols and polyphenols (tannins) are crucial to the defensive mechanisms of plants. In the present situation, it is impossible to raise a good crop without pest control in cotton and for which a major quantum of insecticides are used. Lepidopterous pest occurrence has significantly decreased as a result of the introduction of transgenic types of many crops; however, cotton sucking insect pest attacks is now a threat. [10]. Jassid nymphs and adults both cause harm by sucking plant sap, which causes phytotoxic symptoms known as "Hopper burn.". The leaves eventually shed prematurely as a result of the yellowing, browning, bronzing, cupping, withering, and necrosis that results [11]. Consequently, a resistant cultivar is a reliable, cost-effective, and alternative pest control strategy. Development of sucking pest-resistant cultivars of cotton is urgently needed considering the current circumstances of outbreaks of piercing-sucking bug outbreaks on cotton or hybrids by utilising sucking pest resistant or tolerant genotypes based on pest population and morphological/ biochemical observations.

The goal of the current study was to better understand the physico-morphological and biochemical factors that affect upland cotton's tolerance to and resistance to sucking pests.

Methodology

The field experiment was conducted during *kharif* season 2017-18 at Cotton Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola. The 15 parents and the 36 hybrids along with 1 check (PKV Hy 2) were calculated in a randomized block design through two replicates to study the physico-morphological and biochemical parameters related to sucking pest tolerance/resistance in upland cotton. For hybrids and parents, a distance of 60 × 60 cm was employed. A set of experiment was sown in the field under natural (uncontrolled) condition. The observations related to sucking pests count (number of jassids/3 leaves/plant and number of whiteflies/3 leaves/plant), physico-morphological parameters (trichome i.e. leaf hair density/mm^2, number of gossypol glands/mm^2 on leaf surface) and biochemical parameters (total phenol content and tannin content in mg/g) associated with sucking pests were recorded. The observation on sucking pest count, i.e. jassids population was recorded by counting the nymph and adults on 3 leaves viz., top, middle and bottom leaf/plant of each genotype in each replication. Density of jassids nymphs and adults were recorded by visually inspecting the leaves' abaxial surface. Similarly, whiteflies population was recorded by counting the whiteflies on 3 leaves viz., bottom middle and top leaf per plant of every genotype in every replicates. The observations on jassids and whiteflies infestation were recorded at 30, 60 and 90 DAS, respectively. Densities of whiteflies were recorded by visually inspecting the leaves' abaxial surface. 3 leaves per plant on average and average jassids and whiteflies count of 30, 60 and 90 DAS

was taken for the analysis. The data regarding physico-morphological parameters viz; trichome (leaf hair) density/mm^2 and number of gossypol glands/mm^2 on leaf surface were estimated by collecting the nascent leaves (leaves of third node from top) at peak flowering stage from 60 days after sowing. The biochemical parameters viz., total phenol and tannin content were calculated from the leaf samples that were taken at 60 days following seedling from each genotype and replication. Folin-Ciocalteau reagent (FCR) method was used to estimate the total phenols contained in plant samples [12]. Similar to that, the Folin-Denis reagent (FDR) method was used to estimate the amount of tannin found in plant samples [13]. INDOSTAT 8.1 software has been used to conduct the statistical analysis and the association of physico-morphological and biochemical parameters in relation to sucking pests were studied by analysing the correlation coefficients.

Results and Discussion

The findings shown that the mean sum of square due to genotypes and parents (Table 1) revealed differences that were significant for all six features associated with sucking pests, showing that all the traits under research were highly genetically variable. Additionally, the genotypic variation was divided into the components of parents, crosses (hybrids), and parents versus crosses, and it was discovered that for each of the six traits, the parents and crosses (hybrids) varied significantly from one another. The parent vs. crosses (hybrids) showed significant differences for number of gossypol glands/mm^2, total phenol and tannin content and non-significant differences for number of jassids/3 leaves, number of whiteflies/3 leaves and trichome density/mm^2. Similar findings were also reported by Ali and Aheer [14], which showed non-significant differences for leafhopper population and non-significant reaction of Bt-transgenic cotton hybrids to whitefly population [15].

Table 1. Analysis of variance for experimental design for physico-morphological and biochemical traits related to sucking pests at Akola environment

Sources of variation	d.f.	Mean Sum of Squares					
		Number of jassids / 3 leaves	Number of whiteflies/ 3 leaves	Trichome density/mm^2	Gossypol glands/mm^2	Total phenol content	Tannin content
Replications	1	0.15	0.77	1.19	0.48	7.78	0.39
Genotypes	50	6.16**	8.92**	79.84**	3.05**	26589.30**	569.37**
Parents	14	10.48**	9.31**	101.66**	2.56**	31580.94**	707.10**
Parent Vs crosses	1	0.74	0.18	0.48	1.54*	1261.88**	24.84**
Crosses	35	4.58**	9.01**	73.39**	3.29**	25316.29**	529.84**
Error	50	1.51	0.73	1.35	0.32	2.35	0.22

*- Significant at 5 % level of significance
**- Significant at 1 % level of significance

Mean performance of parents and hybrids for physico-morphological and biochemical traits related to sucking pests were studied and presented character wise in Table 2. Results obtained based on means had taken into account for further discussion. Higher values are usually desirable for most of the traits except for average jassids count/3 leaves and average whiteflies count/3 leaves for which lower values are being preferred. The mean range for number of jassids/3 leaves was 2.05 to 8.52 and 1.73 to 7.64 for the parents and the hybrids, respectively. Parent AKH 11-7 (2.05) was found to be the best for minimum number of jassids/3 leaves followed by AKH 2012-9 (2.06), AKH 9916 (2.21), which showed very less infestation of jassids, which is desirable while, AKH 10-2 (8.52) recorded as most susceptible having more number of jassids/3 leaves. Only one hybrid out of 36 had shown clear advantage over the check PKV Hy 2 (1.90). The hybrid AKH 8828 x DHY 286 (1.73) showed minimum infestation of jassids followed by AKH 84635 x AKH 9916 (2.22), AKH 84635 x AKH 2012-9 (2.44), while hybrid AKH 081 x SURAJ (7.64) recorded maximum jassid infestation. The average number of whiteflies/3 leaves amongst the parents and hybrids ranged from 2.50 to 9.69

and 3.13 to 13.97, respectively.AKH 10-2 (2.50) recorded minimum number of whiteflies/3 leaves followed by AKH 081 (2.68), AKH 10-10 (3.39) which showed very less infestation of whiteflies, while parent AKH 9916 (9.59) was found to be most susceptible for whiteflies infestation having more number of whiteflies/3 leaves. A significant improvement over the check [PKV Hy2 (7.34)] was seen in seventeen hybrids. The hybrid AKH 081 x SURAJ (3.13) showed minimum infestation of whiteflies followed by AKH 84635 x AKH 10-5 (3.20), AKH 081 x AKH 11-7 (3.30), while hybrid AKH 8828 x DHY 286 (13.97) recorded maximum whiteflies infestation (Table 2). Parents as well as hybrids showed a very good range for trichome density. The trichome density ranged among the parents from 1.50 to 23.50/mm^2 (Table 2). AKH 11-7 (23.50/mm^2) recorded maximum trichome density among the parents, followed by AKH 9916 (22.50/mm^2), AKH 2012-9 (15.50/mm^2) showing tolerance to the sucking pest i.e. jassids as compared to AKH 10-2 (1.50/mm^2) which showed a very less trichome density on leaf and found susceptible to jassids (Figure 1 and 2). Only 2 hybrids exhibited noteworthy superiority for trichome density over the check PKV Hy 2 (21.50/mm^2). The range among crosses for trichome density varied from 2.50 to 28.50/mm^2. AKH 8828 x DHY 286 recorded highest trichome density (28.50/mm^2) followed by AKH 8828 x AKH 9916 (24.0/mm^2). The hybrid AKH 081 x SURAJ (2.50/mm^2) recorded the lowest trichome density and found susceptible for jassids.

The number of gossypol glands/mm^2 amongst the parents and hybrids under study ranged from 2.50 to 6.50/mm^2 and 1.50 to 7.50/mm^2, respectively. SURAJ (6.50/mm^2) recorded the best parent for maximum number of gossypol glands/mm^2 followed by AKH 11-7 (5.50/mm^2) and DHY 286 (5.00/mm^2), while AKH 9916 and AKH-09-5 (2.50/mm^2) recorded the lowest gossypol glands/mm^2. Among the hybrids, AKH 081 x SURAJ (7.50/mm^2) recorded maximum number of gossypol glands/mm^2 followed by AKH 8828 x AKH 976 (6.50/mm^2), as compared to hybrid AKH 84635 x AKH 09-5 (1.50/mm^2) which recorded minimum number of gossypol glands/mm^2 (Figure 1 and 2).

Table 2. Mean performance of parents and hybrids for physico-morphological and biochemical traits related to sucking pests at Akola environment

S.N.	Genotypes	Number of jassids/3 leaves	Number of whiteflies/3 leaves	Trichome density/mm^2	Number of gossypol glands/mm^2	Total phenol content (mg/g)	Tannin content (mg/g)
	Females						
1	AKH 84635	5.06	5.76	5.50	5.00	403.50	45.52
2	AKH 8828	6.09	4.22**	3.50	3.50	219.79	35.94
3	AKH 081	7.87	2.68**	2.00	4.50	493.82	44.71
	Males						
1	AKH 10-2	8.52	2.50**	1.50	3.50	198.84	33.69
2	AKH 10-5	2.55	8.24	10.50	3.50	455.55	64.41
3	AKH 10-10	8.08	3.39**	2.00	5.00	201.37	40.75
4	AKH 11-7	2.05	8.57	23.50	5.50	589.62**	86.59
5	AKH 2006-2	4.34	6.16	6.00	4.00	291.67	40.26
6	AKH 2012-8	4.94	5.33*	5.00	4.50	395.19	40.63
7	AKH 2012-9	2.06	7.02	15.50	3.00	503.83*	72.00
8	AKH 09-5	3.63	6.48	6.50	2.50	374.72	44.75
9	AKH 976	5.40	3.87**	4.50	4.50	268.92	35.75
10	AKH 9916	2.21	9.69	22.50	2.50	541.08**	87.71**
11	DHY 286	2.50	6.73	13.50	5.00	457.43	72.67
12	SURAJ	2.65	6.56*	11.50	6.50	401.64	64.55
	Mean	**4.53**	**5.81**	**8.90**	**4.20**	**386.46**	**53.99**

Table 2. Cont.

S.N.	Crosses	Number of jassids/ 3 leaves	Number of whiteflies/ 3 leaves	Trichome density/ mm²	Number of gossypol glands/ mm²	Total phenol content (mg/g)	Tannin content (mg/g)
1	AKH 84635 X AKH 10-2	3.85	5.87	6.50	3.00	343.30	50.34
2	AKH 84635 X AKH 10-5	7.77	3.20**	3.00	2.50	403.91	42.79
3	AKH 84635 X AKH 10-10	4.76	4.52**	6.00	2.50	422.62	42.89
4	AKH 84635 X AKH 11-7	4.70	4.21**	5.50	3.50	456.36	38.85
5	AKH 84635 X AKH 2006-2	3.67	5.20*	8.00	4.00	349.73	54.64
6	AKH 84635 X AKH 2012-8	5.38	3.75**	5.00	2.50	224.44	40.80
7	AKH 84635 X AKH 2012-9	2.44	7.89	16.50	4.50	469.85	73.37
8	AKH 84635 X AKH 09-5	6.36	3.72**	4.00	1.50	236.58	38.09
9	AKH 84635 X AKH 976	3.79	6.17	8.50	4.50	358.65	55.63
10	AKH 84635 X AKH 9916	2.22	7.80	18.50	4.50	482.63	78.21
11	AKH 84635 X DHY 286	3.01	8.89	12.50	4.00	500.98	74.49
12	AKH 84635 X SURAJ	4.62	3.72**	5.00	3.50	361.87	45.91
13	AKH 8828 X AKH 10-2	2.93	6.58	14.50	4.00	472.39	70.05
14	AKH 8828 X AKH 10-5	2.51	7.03	15.00	2.00	400.32	65.34
15	AKH 8828 X AKH 10-10	5.11	3.80**	5.00	2.50	241.30	42.91
16	AKH 8828 X AKH 11-7	5.86	4.26**	5.00	3.00	301.62	38.80
17	AKH 8828 X AKH 2006-2	3.16	6.24	9.00	4.00	389.13	59.37
18	AKH 8828 X AKH 2012-8	3.39	5.82	9.50	5.50	426.26	62.80
19	AKH 8828 X AKH 2012-9	3.00	7.60	17.00	3.50	476.00	79.54
20	AKH 8828 X AKH 09-5	5.09	5.94	6.00	4.00	324.47	44.00
21	AKH 8828 X AKH 976	4.40	6.09	6.50	6.50	334.12	48.76
22	AKH 8828 X AKH 9916	2.47	7.94	24.00*	4.00	551.54**	89.02**
23	AKH 8828 X DHY 286	1.73*	13.97	28.50**	3.00	786.81**	92.23**
24	AKH 8828 X SURAJ	5.40	3.71**	4.50	2.50	386.81	37.02
25	AKH 081 X AKH 10-2	5.02	3.80**	4.50	4.00	322.35	35.08
26	AKH 081 X AKH 10-5	4.40	5.50*	5.50	3.50	286.90	42.14
27	AKH 081 X AKH 10-10	3.23	6.67	10.50	4.00	468.49	63.52
28	AKH 081 X AKH 11-7	6.97	3.30**	3.50	5.00	221.91	36.24
29	AKH 081 X AKH 2006-2	2.88	7.58	12.00	3.00	496.73	69.01
30	AKH 081 X AKH 2012-8	3.95	5.90	6.00	5.50	327.87	40.74
31	AKH 081 X AKH 2012-9	4.18	6.24	6.00	4.00	306.77	41.03
32	AKH 081 X AKH 09-5	6.09	4.11**	3.50	4.00	265.58	35.24
33	AKH 081 X AKH 976	4.81	5.59*	5.50	6.00	277.60	43.48
34	AKH 081 X AKH 9916	3.72	6.13	8.00	5.50	354.11	53.00
35	AKH 081 X DHY 286	5.84	3.99**	4.00	4.50	252.00	39.90
36	AKH 081 X SURAJ	7.64	3.13**	2.50	7.50**	352.81	39.63
	Check PKV Hy-2	1.90	7.34	21.50	5.50	500.63	86.08
	Mean	4.27	5.76	9.09	3.97	382.04	53.81
	SE(m)±	0.86	0.61	0.84	0.40	1.09	0.33
	CD (5%)	2.45	1.73	2.39	1.14	3.09	0.95
	CD (1%)	3.26	2.31	3.19	1.52	4.12	1.26

*- Significant at 5 % level of significance
**- Significant at 1 % level of significance

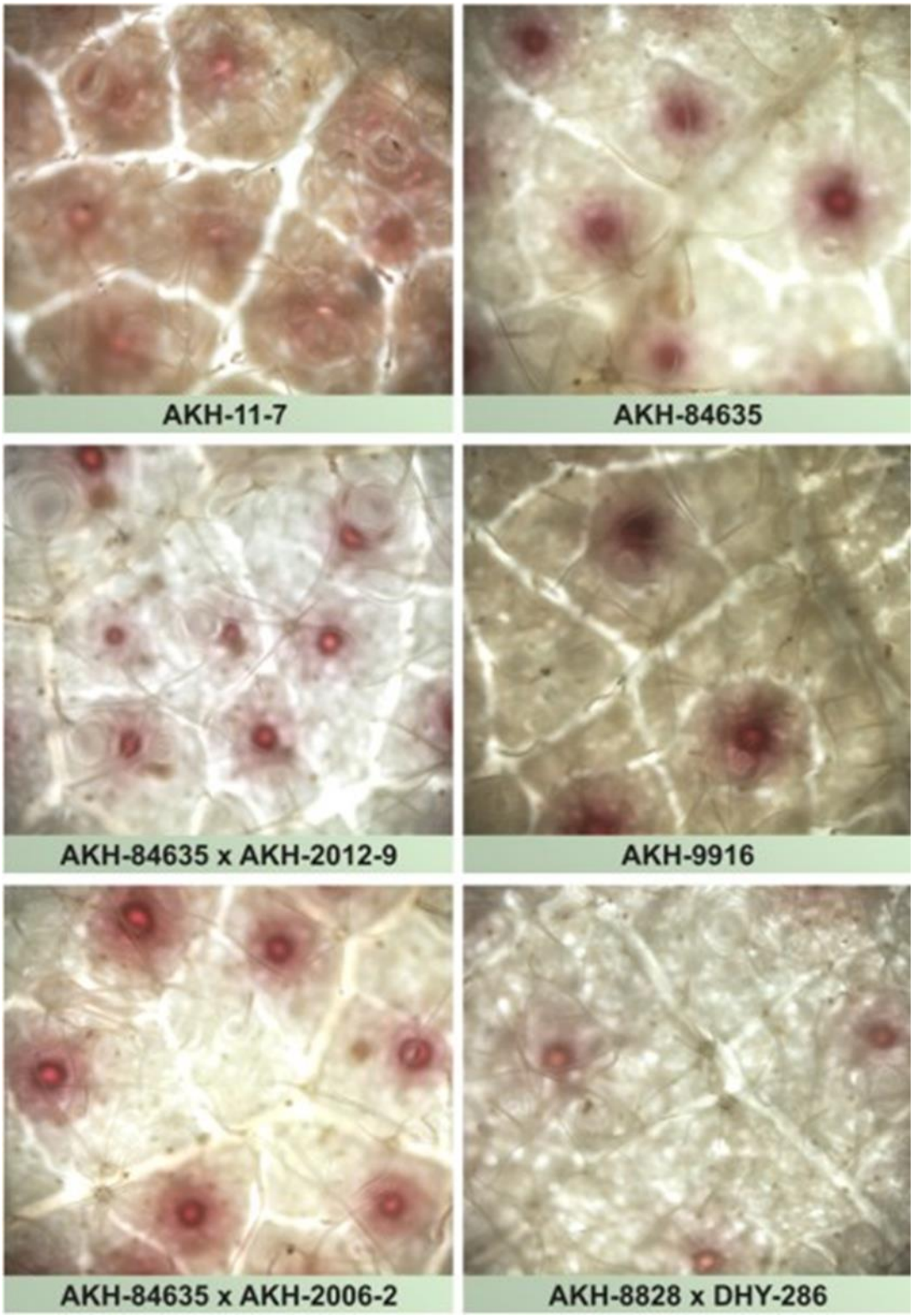

Figure 1. Trichome (leaf hair) density/mm² in different cotton genotypes and hybrids

The total phenol content recorded among the parents range from 198.94 to 589.62 mg/g (Table 2). AKH 11-7 (589.62 mg/g) recorded maximum total phenol content amongst the parents, followed by AKH 9916 (541.08 mg/g), AKH 2012-9 (503.83 mg/g) showing tolerance/resistance to the sucking pest (jassids) as compared to AKH 10-2 (198.84 mg/g), which recorded minimum total phenol content and found susceptible to jassids. A vast range of variability for total phenol content was observed among the hybrids under study.

Two hybrids showed significant superiority for total phenol content over the check PKV Hy2 (500.63 mg/g). The range among crosses for total phenol content varied from 221.91 to 786.81 mg/g. AKH 8828 x DHY 286 recorded maximum total phenol content (786.81 mg/g) followed by AKH 8828 x AKH 9916 (551.54 mg/g), while the hybrid AKH 081 x AKH 11-7 (221.91 mg/g) recorded the minimum total phenol content. Among the parents, tannin content ranged from 33.69 to 87.71 mg/g. Out of 15 parents, AKH 9916 recorded highest tannin content (87.71 mg/g) followed by AKH 11-7 (86.59 mg/g) and DHY 286 (72.67 mg/g), whereas, parent AKH 10-2 recorded lowest tannin content (33.69 mg/g).The mean range for tannin content was 35.08 to 92.23 mg/g for the hybrids. Among the 36 hybrids, only two hybrids had significantly high for tannin content over the check PKV Hy 2 (86.08 mg/g). The hybrid AKH 8828 x DHY 286 (92.23 mg/g) recorded highest tannin content followed by AKH 8828 x AKH 9916 (89.02 mg/g), while the hybrid AKH 081 x AKH 10-2 (35.08 mg/g) recorded lowest tannin content. Among parents, AKH 11-7 possessed the highest mean performance for trichome density (23.50/mm^2) with desirable mean performance for other characters such as total phenol content (589.62).

Table 3. Correlation matrix of the parents and crosses (hybrids) with physico-morphological and biochemical traits in relation to sucking pests

	NJ/3L	NW/3L
Parents		
NJ/3L	1	
NW/3L	-0.9290**	1
TD	-0.8379**	0.8844**
NGG	0.0401	-0.1499
TPC	-0.7026**	0.7185**
TC	-0.8032**	0.8474**
Crosses (Hybrids)		
NJ/3L	1	
NW/3L	-0.8260**	1
TD	-0.8304**	0.8778**
NGG	-0.0144	0.0317
TPC	-0.6894**	0.8183**
TC	-0.8444**	0.8527**

*- Significant at 5 % level of significance

**- Significant at 1 % level of significance

NJ/3L - Number of jassids/3 leaves, NW/3L - Number of whiteflies/3 leaves,

TD-Trichome density/mm^2, NGG - Number of gossypol glands/mm^2, TPC -Total Phenol content (mg/g), TC-Tannin content (mg/g)

Similarly, other parents viz., AKH 9916 (22.50/mm^2) and AKH 2012-9 (15.50/mm^2) exhibited higher mean performance for trichome density with one or more physico-morphological and biochemical traits and some of them may also contributed to produce promising sucking pest tolerant variety/hybrids. Significance of desirable attributes for trichomes and its associated physico-morphological traits related to sucking pests were also reported [16-17]. Among the hybrids, a cross combination AKH 8828 x DHY 286 (28.50/mm^2) recorded maximum trichome density with minimum number of jassids/3 leaves and also exhibited higher total phenol and tannin content over the check PKV Hy2. Similarly, the other hybrids, AKH 8828 x AKH 9916 (24.0/mm^2), AKH 081 x AKH 2006-2 (12.0/mm^2) and AKH 081 x AKH 10-10 (10.50/mm^2) recorded higher trichome density and also

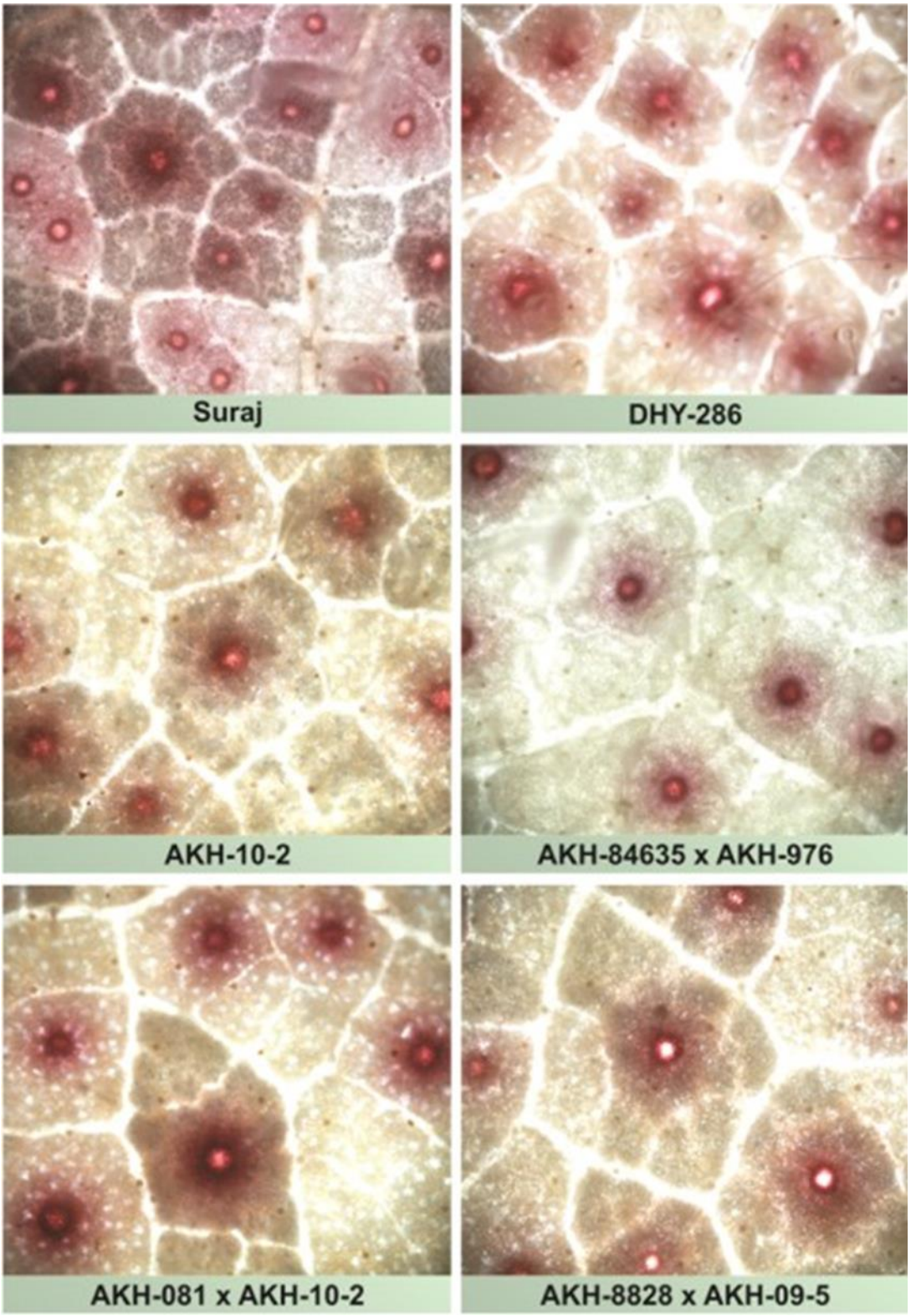

Figure 2. Gossypol glands/mm² in different cotton genotypes and hybrids

showed desirable performance for one or more physico-morphological trait(s) viz., total phenol, tannin content and number of gossypol glands/mm^2. Thus these newly developed hybrids appeared promising for sucking pest tolerance/resistance. Similar results were also found by several workers [18-20] for most of the physico-morphological and biochemical traits among the studied hybrids. Considering the correlation analyses, negative and highly significant correlation was reported between trichome density and number of jassids/3 leaves (-0.8379 and -0.8304), in parental lines and F_1 crosses, respectively (Table 3). Denstiy of trichomes conferring resistance to jassids were also reported [21-24].Positive and highly significant correlation was noticed between trichome density (0.8844 and 0.8778) and number of whiteflies/3 leaves in parental lines and crosses, respectively. Similar findings were also reported by Amin et al., and Khalil et al., [25, 22]. Study also reported the negative and significant correlation of total phenol (-0.7026 and -0.6894) and tannin content (-0.8032 and -0.8444) with number of jassids/3 leaves in parental lines and crosses, respectively, whereas positive and highly significant correlation was recorded between total phenol (0.7185 and 0.8183) and tannin content (0.8474 and 0.8527) with number of whiteflies/3 leaves in parents as well as in crosses, respectively. Other workers [21-23] also reported the similar results. The study revealed negative and highly significant correlation between number of whiteflies/3 leaves and number of jassids/3 leaves (-0.9290 and -0.8260) in parental lines as well in crosses, respectively.

Conclusion

This study revealed that parent AKH 11-7 possessed the highest mean performance for trichome density with desirable mean performance for other characters such as total phenol content. Similarly, other parents viz., AKH 9916 and AKH 2012-9 exhibited higher mean performance for trichome density with one or more physico-morphological and biochemical traits and some of them may also contributed to produce promising sucking pest tolerant variety/hybrids. Among the hybrids, AKH 8828 x AKH 9916, AKH 081 x AKH 2006-2 and AKH 081 x AKH 10-10 recorded higher trichome density and also showed desirable performance for one or more physico-morphological trait(s) viz., total phenol, tannin content and number of gossypol glands/mm2. The study also revealed the negative and highly significant correlation between trichome density and number of jassids/3 leaves in parental lines and F_1 crosses. Thus, utilization of parental genotypes with higher trichome density associated with high phenol and tannin content in breeding programme may aid in developing promising superior lines resistance to jassids as well as these newly developed hybrids appeared promising for sucking pest tolerance/resistance.

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Disclosure statement

No potential conflict of interest was reported by the authors.

References

[1] C. D. Mayee, P. Singh, A. B. Dongre, M. R. K. Rao and Sheo Raj **(2002)**. Transgenic Bt cotton. CICR Technical Bulletin No. 22.

[2] T. M. Manjunath **(2004)**. Bt cotton in India: The technology wins as the controversy wanes. Presented at the 63rd Plenary Meeting of International Cotton Advisory Committee Meeting, Mumbai..

[3] D. K. Makwana, K. A. Chudasama and T. K. Balas **(2018)**. Estimation of yield losses due to major sucking insect pests of Bt cotton. Int. J. Curr. Microbiol. App. Sci, **7:** 956-959.
[4] K. A. Kulkarni, S. B. Patil and S. S. Udikeri **(2003)**. Status of sustainable IPM of cotton pests: A scenario in Karnataka. In: Proceedings of natural symposium on sustainable insect pest management, ERI, Loyola College, Chennai, Feb 6-7, pp42-52.
[5] U. S. Satpute, V. N. Patil, S. R. Katole, V. B. Men, V. R. Bhagwat and A. V. Thakare **(1990)**. Avoidable field losses due to sucking pests and bollworms in cotton. J. Appl. Zool. Res., **1:** 67-72.
[6] F. R. Parnell, H. E. King and D. F. Ruston **(1949)**. Insect resistance and hairiness of the cotton plant. Bull. Entomol. Res., **39:** 539-575.
[7] R. D. Stipanovic **(1983)**. Function and chemistry of plant trichomes and glands in insect resistance. In: Plant Resistance to Insects, Ed. by P. A. Hedin, pp69-100. American Chemical Society, Washington, DC.
[8] N. Murugesan and A. Kavitha **(2010)**. Host plant resistance in cotton accessions to the leafhopper, Amrascadevastans (Distant). J. Biopestic., **3:** 526-533.
[9] P. N. Damodaran, K. Udaiyan and H. J. Jee **(2010)**. Biochemical changes in cotton plants by Arbuscular Mycorrhizal colonization. Res. Biotech., **1:** 6-14.
[10] K. R. Kranthi, C. S. Dhawad, S. Naidu, K. Mate, E. Patil and S. Kranthi **(2005)**. *Bt*- cotton seed as a source of *Bacillus thuringiensis* insecticidal Cry1Ac toxin for bioassays to detect and monitor bollworm resistance to Bt-cotton. Curr. Sci., **88:** 796- 800.
[11] O. S. Bindra and M. S. Mahal **(1981)**. Varietal resistance in egg plant (brinjal) (*Solanum Melongena* L.) to the cotton jassid (*Amrasca biguttula biguttula*). Phytoparasitica, 9: 119-131.
[12] H. G. Bray and W. Y. Thorpe **(1954)**. Analysis of phenolic compounds of interest in metabolism. Methods Biochem. Anal., **1:** 27-52.
[13] B. G. Chan, A. C. Waiss and M. J. Lukefahr **(1978)**. Condensed tannin, an antibiotic chemical from Gossypiumhirsutum, J. Insect. Physiol., **24:** 113-118.
[14] A. Ali and G. M. Aheer **(2007)**. Varietal resistance against sucking pests of cotton under Bahawalpur ecological conditions. J. Agric. Res., **45:** 205-208.
[15] P. R. Zanwar, D. B. Deosarkar, G. A.Yadav andL.T. Shelke **(2010)**. Field performance of Btcotton genotypes against sucking pests. Ann. Pl. Protection. Sci., **18:** 489-556.
[16] A. Rohini, N. V. V. S. D. Prasad, M. S. V. Chalam and K. Veeraiah **(2011)**. Identification of suitable resistant cotton genotypes against sucking pests. J. Ento. Res., **35:** 197-202.
[17] T. C. Divya, I. S. Katageri, M. P. Jadhav, S. Adiger, H. M. Vamadevaiahand and N. S. Olekar **(2017)**. Biochemical constituents imparting resistance to sucking pest aphid in cotton (Gossypiumspp spp.). Int. J. Curr. Microbiol. App. Sci., **6:** 2749-2757.
[18] S. Deb, T. M. Bharpoda and M. D. Suthar **(2015)**. Physico-chemical basis of resistance in cotton with special reference to sucking insect pests. AGRES Int. e-J., **4:** 87-96.
[19] G. Grover, B. Kaur, D. Pathak and V. Kumar **(2016)**. Genetic variation for leaf trichome density and its association with sucking insect-pests incidence in Asiatic cotton. Indian J. Genet., **76:** 365-368.
[20] H. Meghana, S. B. Jagginavar and N. D. Sunitha **(2018)**. Population dynamics of sucking insect pest complex on intra-specific and inter-specific Bt cotton under rainfed situation. J. Entomol. Zool. Stud., **6:** 466-471.
[21] S. Javed, M. Javaid, A. Hassan, M. Awais and S. Gulzar **(2016)**. Genetic diversity and morphological traits association in upland cotton imparting resistance against insect pests. American-Eurasian J. Agric. Environ. Sci., **16:** 924-927.
[22] H. Khalil, A. B. Muhammad Raja, M. Afzal, M. A. Aqueel, S. Khalil and M. M. Mansoor **(2017)**. Effect of plant morphology on the incidence of sucking insect pests complex in few genotypes of cotton. J. Saudi Soc. Agric. Sci., **16:** 344-349.
[23] R. S. Bhoge, U. B. Hole, S. M. Gangurde and R. S. Wagh **(2019)**. Biochemical and morphological factors responsible for jassid resistance in cotton. Int. J. Chem. Stud., **7:** 166-169.

[24] R. Rushpam and R. Ravikesavan **(2019)**. Morphological and biochemical basis of resistance to jassid (*Amrasca devastans*) in cotton *Gossypium hirsutum* L. J. Cotton Res. Dev., **33:** 116-122.
[25] M. R. Amin, R. Afrin, M. Z. Alam, M. M. Hossain and Y. J. Kwon **(2017)**. Effect of leaf trichomes and meterological parameters on population dynamics of aphid and jassid in cotton. Bangladesh J. Agril. Res., **42:** 13-25.