Achieving Multiple Pest Tolerance Through Manipulation of Morphological Features in Cotton

B.M. Khadi, V.N. Kulkarni and S.S. Narajji
Agricultural Research Station, Dharwad Farm - 580 007 Karnataka , India.

ABSTRACT

Breeding for tolerance to sucking pests and bollworm in cotton is treated as mutually exclusive events. Selection for resistance to sucking pests with more hairy leaves brought increased susceptibility to bollworms. An effort was made to select genotypes with high density hair on the lower leaf surface and low density hair on the upper surface. The number of hairs on both the upper and lower surfaces of the leaf blade and midribs and glands on the calyx were recorded. The yield was also assessed. The material used represented collections from India, the USA, China and the Central Asian Republics. Generally lower numbers of hairs on the midribs and leaf blade with more glands on the calyx and less bracteole teeth were recorded on bollworm tolerant genotypes. The bollworm tolerant lines exhibited higher yields than susceptible lines under unprotected conditions. Few of these lines showed differences in hair density on the upper and lower leaf surfaces. When the lower leaf surface had 70% more hair than the upper surface, the line had a jassid grade II. Only indigenous lines exhibited bollworm tolerance. Use of multiple tolerant genotypes in transgenic cotton studies opens new dimensions in pest tolerance breeding in cotton.

Introduction

Cotton plants are a preferred host for many insect pests. The majority of production costs especially in tetraploid American cottons, are concerned with plant protection. *Helicoverpa armigera* is a common pest of cotton irrespective of agro climatic zones in Asia. Bollworm affects the product itself while sucking pests affect plant morphology. Jassid (*Amrasca biguttula biguttula*) is the major pests in irrigated tracts of Karnataka, India. For the control of insect pests, farmers are already spending more on insecticides and creating environmental problems. Hence breeding for pest tolerance is one of the hopes for the future.

An example of breeding for tolerance to jassids and bollworms is difficult. The contrasting feature of such programmes is hairyness on the leaf surface or stem tips (Khadi,1996). Increasing the density of trichomes, will increase the tolerance to jassids (Tidke and Sane, 1962; Yadav *et al.*,1967) but make the plants more susceptible to bollworms as it attracts female moths for egg laying (Kadapa *et al.*, 1983 and 1987). One option for a breeder is to have a plant type having leaves with highly pubescent lower surface and glabrous upper surface that will take care of both the insects to some extent. Hence an experiment was under taken to study the morphological characters leaf hair, gossypol glands and bracteole teeth in indigenous and exotic genotypes.

Material and Methods

Sixteen *G.hirsutum* genotypes representing four cotton growing countries viz., USSR (2), India (7), China (3) and USA (4) were planted at Agricultural Research Station, Dharwad under rainfed conditions. The Indian genotypes possessed tolerance to bollworm. These genotypes were raised in a single row of 5.4 metres with spacing of 90 x 20 cm under unprotected conditions. Observations on morphological characters were recorded on 5 randomly selected plants. Number of hairs in 2.5 mm.sq.area was recorded using a 10X hand lens on the leaf midrib. The top most leaf of the plant was selected for this purpose. Glands on the calyx were also recorded by using 10X hand lens. Bracteole teeth were counted. Jassid grade was recorded ranging from I to IV where I/II were considered to be resistant/tolerant types and III/IV susceptible. Yield parameters number of bolls per plant, boll weight and seed cotton yield per plant were recorded.

The data was subjected for analysis of variance. The genotypic (GCV) and phenotypic (PCV) coefficients of variation were estimated according to Burton and Devane (1953). Heritability (Hanson etal., 1956) and genetic advance (Allard, 1960) were also calculated.

Results and Discussion

Analysis of variance indicated significant genotypic difference for all the characters.

Leaf hair. The data on leaf hairs indicated more trichomes on both upper surface of leaf lamina and midrib than the lower surface in almost all the genotypes (Table 1). Similarly hairs on leaf lamina were less than on midrib in most of the genotypes. The density of trichomes both on leaf lamina and midrib were significantly less on CPD 418, CPD 432, DS 5, 2-193-1-3, Sahana and SIMA than on Russian, Coker and Chinese lines. Sahana and 2-193-1-3 had more hairs on the lower surface of leaf lamina and midrib than other Indian cultures. Other lines CPD 418, CPD

432, DS-5, and SIMA had fewer hairs on both lower and upper surfaces.

Jassid grade. The representative germplasm other than Indian in the experiment recorded either I or II grade indicating tolerance to jassids. The reason for this was the high trichome number on leaf surface which acts as physical barrier to jassids (Khadi, 1996). Conversely, all the Indian genotype except 2-193-1-3 and Sahana exhibited a score of III or IV i.e., towards susceptible and it was obvious that they had less pubescence. The genotypes Sahana and 2-193-1-3 scored a jassid grade of II i.e., towards tolerance. The reason for this was the presence of more trichomes on the lower surface of the leaf.

Glands on calyx. Significantly more glands on calyx were observed in all Indian genotypes except SIMA compared to other genotypes.

Bracteole teeth. No trend in number of bracteole teeth was observed. However, Sahana (6.1) and 2-193-1-3 (5.8) exhibited numerically less bracteole teeth.

Yield components: Significantly more bolls per plant were observed in all native genotypes as compared with genotypes from other countries. Similar observations were also made with yield per plant. Sahana recorded the highest seed cotton yield (345 g) followed by CPD 432 (247 g), DS 5 (241 g) and Zero monopodia (238.5g). Other entries did not exceed 50 g. except Russian culture-1 (55.0 g).

A strong association was found between glabrous nature of the leaf and yield produced by the plant under unprotected conditions. A similar relationship was evident for glands on calyx and boll number. It was apparent that a high number of glands on calyx and glabrous leaf contributed to bollworm tolerance. This was also observed by Kadapa *et al.*, (1987) and Khadi (1996). Pubescence is the preferred leaf surface for oviposition by bollworms. Once eggs are laid there is increased risk of damage compared to glabous types as migration of larva is restricted. More gossypol glands on the calyx is a non-preferred type and bollworms do not like to feed on genotypes having high gossypol content.

There was an opposite trend for jassid infestation as they prefer glabrous types for feeding. But the genotypes that scored II grade for jassids and had similar bollworm tolerance were Sahana and 2-193-1-3. The specialities of these genotypes were, a) they possessed trichomes on the lower surface of leaf conferring tolerance to jassids, b) upper surface of the leaf consisted of very low number of hairs, discouraging bollworm oviposition and thus escaping primary infestation, c) more gossypol glands on calyx hindered bollworm feeding habit conferring tolerance to bollworms. Less bractiole teeth affected physical movement of the larvae and oviposition. The ultimate result was higher yields per plant resulting from higher boll retention.

Variability studies

All the traits related to bollworm or jassid tolerance exhibited wide variability (Table 2). The estimate of phenotypic coefficient of variation (PCV) was more than genotypic coefficient of variation (GCV). The GCV was near to PCV for most of the traits except bracteole teeth, boll weight and seed cotton yield per plant. The closeness of GCV and PCV indicates a predominant role of genotypic variation and less environment effect. The selection in such traits is predicted to be effective.

Heritability estimates were high for hairs on leaf, glands on calyx, yield and boll number/plant under unprotected conditions. These characters possessed high heritability as well as genetic advance providing ample scope for effective selection as additive gene action was expected.

The data indicated the possibility of selecting for upper and lower leaf surface hairs independently. Thus selection for less upper surface trichomes and more lower surface trichomes could give bollworm tolerance combined with jassid tolerance. The selections Sahana and 2-193-1-3 were of these types and possessed tolerance to both. These observations need to be supported by further studies on insect eggs per plant, damage to fruiting bodies and jassid number per plant.

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Table 1. Performance of different genotypes for morphological as well as yield related characters.

Genotypes	Jassid grade	Boll/ plant	Hairs per 25mm square on Leaf U	Leaf L	Midrib U	Midrib L	Glands on Calyx	Bract-eole teeth	Boll Wt. (g)	Yield/ plant (g)
Russian Culture-6	II	2.0	94.0	134.7	79.4	136.7	55.5	8.0	4.0	38.0
Russian Culture-1	II	5.5	23.4	50.3	47.7	75.1	46.5	6.2	4.6	55.0
CPD-418	III	5.5	9.6	43.4	22.1	46.3	90.7	6.8	4.9	197.5
CPD-432	IV	6.6	5.8	23.2	20.1	46.2	87.1	6.9	4.3	247.5
DS-5	III	6.1	13.4	31.8	23.2	55.1	102.5	6.0	3.1	241.0
2-193-1-3	II	10.8	21.7	61.4	34.6	68.9	66.9	5.8	3.5	160.0
Sahana	II	6.1	15.7	60.9	35.4	92.2	108.8	6.1	3.8	345.0
SIMA	III	1.7	15.0	58.9	26.6	56.2	62.6	6.4	3.3	189.0
Chang Yang	II	2.3	91.3	145.4	201.4	359.2	46.0	8.6	4.1	27.5
Chang Yang -2	II	3.1	42.8	131.0	54.6	91.5	49.4	8.3	3.5	49.5
Chinese King	I	1.9	80.3	105.8	159.5	222.2	51.3	10.2	4.9	80.5
Coker 100	II	0.8	42.0	60.9	45.3	80.2	56.8	9.6	3.1	31.0
Coker 213	II	0.7	56.7	106.3	70.8	107.4	42.9	10.1	4.4	31.5
Coker UL DIS	II	3.1	23.7	70.9	66.2	69.8	54.4	9.7	3.9	19.5
Colombia 4	I	1.1	31.9	101.2	48.7	81.9	34.7	9.2	3.7	45.0
Zero monopodia	III	7.9	42.6	147.8	61.9	99.9	60.3	9.2	3.8	238.5
C.D		1.1	8.4	13.5	9.8	15.8	10.2	2.7	1.0	15.8
C.V (%)		12.8	7.9	6.1	9.1	8.7	7.6	15.8	11.7	5.9

U = Upper and L = Lower

Table 2. Variability parameters of different morphological and yield related characters.

Character		Mean	Range	VG	VP	GCV	PCV	h2	GA
Hairs on	Upper	49.9	5.8- 91.3	2080.0	2095.0	91.3	91.7	99.2	93.3
leaf	Lower	104.3	23.2-145.3	7298.0	7338.0	81.9	82.1	99.4	174.7
Hairs on	Upper	50.5	20.1-201.4	506.6	526.6	44.5	45.2	96.0	45.4
Midrib	Lower	84.9	46.2-359.2	833.2	888.4	34.0	35.0	93.8	57.1
Glands on calyx		63.5	34.7-108.8	478.4.	501.5	34.4	35.2	95.4	44.0
Bracteole teeths		7.9	5.8-10.2	1.8	3.4	17.0	23.2	53.0	2.01
Boll weight (g)		3.9	3.1- 4.9	0.2	0.4	12.0	16.8	51.2	0.69
Yield/ plant		124.8	19.5-345.0	9978.0	12032	80.0	88.2	82.9	185.3
Bolls/plant		4.1	0.7-10.8	8.3	8.9	70.0	0.72	94.3	5.78