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Inheritance of frego bract, okra leaf type and red colour leaves in cotton (*Gossypium hirsutum* L.)

O. SANGWAN*, S.R. PUNDIR AND SHIWANI MANDHANIA

Department of Genetics and Plant Breeding, CCS Haryana Agricultural University, Hisar-125 004

**Email: osangwan@gmail.com*

ABSTRACT : Inheritance studies of morphological characters in cotton are of considerable interest for genetic improvement. A thorough knowledge of the mode of inheritance of various characters help in solving the various breeding problems and in estimating the relative purity of hybrids and varieties. The present study was conducted in the Research Area Cotton Section, Department of Genetics and Plant Breeding, CCS Haryana Agricultural University, Hisar during 2012-2013 and 2013-2014 to study the inheritance of characters *viz.,* frego bract, okra leaf type and red colour leaves in cotton. In case of frego bract inheritance the genotype GCA 136 having frego bract was crossed with normal bract parent H 1098-i. In F_1 population all the plants were observed with normal bracts and in F_2 population normal bract and frego bract plants were in the ratio of 3:1 showing monogenic inheritance of the trait, frego bract being recessive. The test cross ratio of 1:1 confirmed the monogenic inheritance. For okra leaf type inheritance the genotype GCA 278 with okra leaves was crossed with H 1157 of normal leaves showed sub okra leaves in F_1 population. The segregation of the leaf shape in F_2 generation into three classes *i.e.* 1 normal: 2 sub okra: 1 okra was observed showing the incomplete dominance pattern of inheritance. In case of inheritance of red colour leaves the genotype GCA 289 with red leaves was crossed with green leaves parent H 1098-i. In F_1 population plants with intermediate leaves towards redness were observed and in F_2 population 1green : 2 intermediate red : 1 red leaves plants were observed indicating the incomplete dominance pattern of inheritance.

Key words : Cotton, frego bract, genotypes, *Gossypium*, inheritance, okra leaf type, red leaves

Cotton is a major fibre crop of global importance. It provides employment to millions of people the world over for different activities as research, seed production, marketing, industrial utilization etc. For multiple uses of cotton fibre and other by products, it is referred to as “White Gold”. The most important factor in the process of crop production has always been a good variety in any crop. Continuous improvement in genetic architecture of crop plants for increasing production/unit area is the prime breeding philosophy. To evolve high yielding varieties with acceptable fibre quality, the genetic information about different polygenic traits may assist the breeders in upgrading the genetic make up of the plant in a particular direction.

Nature has provided cotton with certain insect nonpreference traits. Some morphological traits have been identified which confer resistance to insect pests in cotton. Incorporation of such traits in the cotton cultivars has been advocated for stable, economic and environment friendly insect resistance in cotton by many researchers (Rahman *et al.*, 2008). These traits include trichomes, okra leaf, nectariless, gossypol glands, frego bract etc. which make cotton plant unattractive to insects for feeding, oviposition, shelter etc. Okra leaf types were proposed as modified leaf types suppressing whiteflies. In upland cotton, okra and normal leaves are two major types. Okra leaf is a deeply lobed leaf shape which is a monogenic trait governed by incompletely dominant (L0) to normal leaf gene (l0) in the upland cotton.

The hybrid of normal × okra leaves was intermediate leaf shape between the two phenotypic extremes, which indicated the incomplete pattern of inheritance. The leaf of the hybrid of normal × okra was intermediate (Nawab *et* al., 2011). The gene for narrow okra leaf is controlled by L0 (Nawab *et al.*, 2011). Whereas, okra leaf type trait belongs to an allelic series having a minimum of five members: L0 (okra), Ls (super okra), Le (sea island), Lu (sub okra) and l (normal) (Nawab *et al.*, 2011). There are some traits for which the quantitative method of measurement cannot be applied. Instead, this including leaf shape can be measured on phenotypic basis by using the visual rating system.

Frego bract is narrow and twisted compared to normal broad bract. Due to less width and reduced bracteole surface, frego bract doesn't provide shelter to insect's eggs/nymphs. Frego bracts leave the boll exposed so the eggs/nymphs are vulnerable to environmental vagaries, pesticides and predators. Frego bract had a significant positive correlation with fibre strength. Frego bract is a mutant type of floral bract in upland cotton. It is an important insect resistant trait; however, some reports in the literature show that frego bract gene has some negative effects on growth and fibre quality of cotton (Malik *et al.*, 2009). Inheritance studies of morphological characters in cotton are of considerable interest for genetic improvement. A thorough knowledge of the mode of inheritance of various characters help in solving the various breeding problems and in estimating the relative purity of hybrids and varieties.

MATERIALS AND METHODS

The field studies were carried out during *kharif,* 2012-2013 and 2013-2014 to study the inheritance of characters *viz;* frego bract, okra leaf type and red colour leaves in cotton. Five genotypes of cotton *i.e.* GCA 136 with frego bract, H 1098-i of normal bract with green leaves, GCA 278 with okra leaf type, H 1157 with normal leaves and GCA 289 with red leaves were selfed to maintain the purity. The parents were planted in a single row length of 6 meter with 30 cm plant to plant distance during 2011-2012. Crosses were made between parents *i.e.* GCA 136 x H 1098-i, GCA 278 x H 1157 and GCA 289 x H 1098-i during 2012-2013 to obtain fresh seed for planting F_1. The F_1 and their parents were sown during the normal crop season of 2012-2013. The seeds of the F_1, F_2, BC_1 and BC_2 generations were produced for each cross through manual selfing and crossing. The F_1 plants of each cross were divided in three groups for developing BC_1, BC_2 and F_2 for each combination. The experiment in the field was laid out in a randomized complete block design with three replications for each set of the six generations of the three crosses. A single plot (6.0 × 0.67 m) was assigned to each of the parents and their respective F_1 in each replication while, four rows in each replication were assigned to each of the backcrosses and eight rows were assigned to raise the F_2 population of each cross. The seeds of each of the six generations of the three crosses was dibbled, maintaining 15 plants in a row spaced 30 cm within the row and 67.5 cm between the rows during the normal crop season of the year 2013-2014. The research was conducted at the Research Area, Cotton Section, Department of Genetics and Plant Breeding, CCS HAU, Hisar. Ten plants were selected randomly from the parents and their F_1 while, fifty and thirty plants in each replication were selected in F_2 and backcrosses to record the data during 2013-2014. The segregating ratios of plants in F2 and test cross generations for the traits were tested for their fitness to a theoretical ratio through chi square test.

RESULTS AND DISCUSSION

Inheritance studies of frego bract: Data of F_2 and test/backcross populations of the cross (GCA 136 × H 1098-i) Fig. 1 was used to study the genetics of this trait. Chi square test was used to test the difference of expected and observed phenotypic ratios. The results of Chi Square test are given in the Table 1. Normal bract and frego bract plants were in a ratio of 3:1 in the F_2 population (Table 1) showing monogenic inheritance, frego bract being recessive trait. The test cross ratio of 1:1 confirmed the monogenic inheritance. These findings support the results of earlier work on the genetics of frego bract (Malik *et al.,* 2009, Rahman *et al.,* 2008). In the present studies it was observed that in frego bract phenotype there were differences in the size and shape in plants of segregating populations, which suggested that the phenotype might vary in different genetic backgrounds or some modifier genes affect the phenotype. The progenies of single plants selection may be further tested for their genetics. Simple monogeneic inheritance of the traits suggests it may be manipulated easily in a breeding programme. The mutant frego bract trait has very narrow bracts, which are flared away from bud, flower and boll. It does not provide shelter to the eggs/larvae of bollworms and boll weevil (Malik *et al.,* 2009, Rahman *et al.,* 2008) as well as help in escaping boll rot disease.

Inheritance studies for red colour leaf : Non significant chi squared values were observed for the segregating ratios in F_2 and backcross generations of the cross (GCA 289 x H 1098-i) (Fig. 2). Observations of 1 green: 2 intermediate red: 1 red, leaf types were noted in the F_2 populations. In the backcrosses with parent- GCA 289, ratios of 1 red: 1 intermediate red, leaf types were obtained. Similarly, in the backcrosses with parent H 1098-i, ratios of 1 green: 1 intermediate red, leaf types were observed (Table 2). Almost an equal number of plants exhibited red and green leaf types, while a large number of plants exhibited intermediate leaf type (intermediate red) in the F_2 generation (Hosseini, 2014).

Inheritance studies for okra leaf type : Non significant chi-squared values were observed for the segregating ratios in F_2 and backcross generations of the cross (GCA 278 x H 1157) (Fig. 3). Observations of 1 normal: 2 sub okra: 1 okra, leaf types were noted in the F_2

Table 1. Mode of segregation for frego bract in cotton

Parents/crosses	Generation	Observed value		Expected value		Expected ratio	χ^2 Value	P value
		Normal	Frego	Normal	Frego			
GCA 136	P_1	—	20	—	20	—	—	—
H 1098-i	P_2	25	—	25	—	—	—	—
GCA 136 x H 1098-i	F_1	50	—	50	—	—	—	—
GCA 136 x H 1098-i	F_2	80	18	73.5	24.5	3:1	2.30	0.1294
(GCA 136 x H 1098-i) x GCA 136	Test Cross	39	27	34	34	1:1	2.18	0.1398

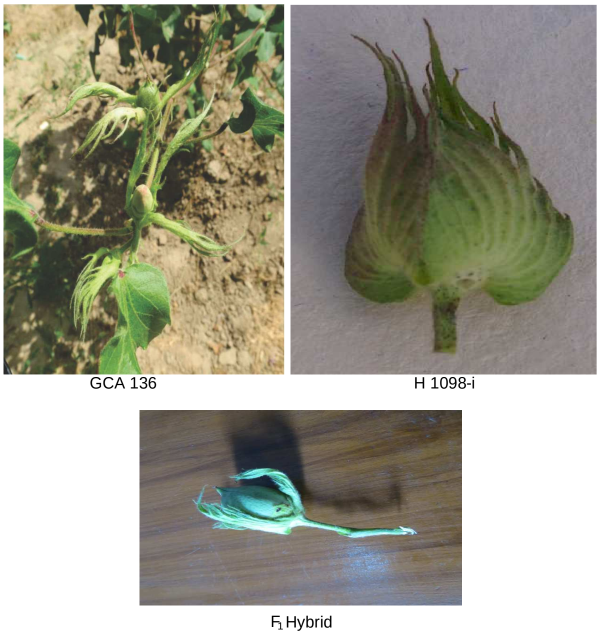


Fig. 1. Cross between GCA126 x H1098-i

populations. In the backcrosses with parent GCA 278, ratios of 1 okra: 1 sub okra, leaf types were obtained. Similarly, in the backcrosses with parent- H 1157, ratios of 1 normal: 1 sub okra, leaf types were observed (Table 3). Almost an equal number of plants exhibited okra and normal leaf types, while a large number of plants exhibited intermediate leaf type (sub okra) in the F_2 generation. The cross involving okra leaf and normal leaf plants were hybridized to obtain sub okra (L0l0) progeny in F_1 showing incomplete dominance (Table 1). The segregation in the backcross with parent I and parent II also confirm to the theoretical ratio of 1:1 further confirmed the incomplete pattern of inheritance. The segregation of the leaf shape in F_2 generation into three classes: okra leaf, normal and the intermediate leaf shape (sub-okra) and fitting into the theoretical 1:2:1 a monohybrid ratio of incomplete dominance in the present study corroborated the findings of Nawab *et al.,* (2014) and Nawab *et al.,* (2011). The non significant chi squre in F_2 for leaf shape in all the crosses fit well against the theoretical ratio. The segregating pattern in F_2 for leaf shape into three different types or shapes suggested incomplete dominance (Nawab *et al.,* 2011).

The results of the present study provided the evidence for incomplete dominance of okra leaf trait and red colour leaves whereas for frego bract monogenic inheritance, frego bract being recessive trait. It is obvious from the present findings that the increase in yield, associated with okra leaf morphology is due to its non-preference for insect pests and reduced leaf area allowing better air flow and maximum sunlight penetration (Nawab *et al.,* 2011). Malik *et al.,* (2009) evaluated the effects of morphological traits on yield and quality and concluded that frego bract traits did not have major negative association and incorporation of the trait in a

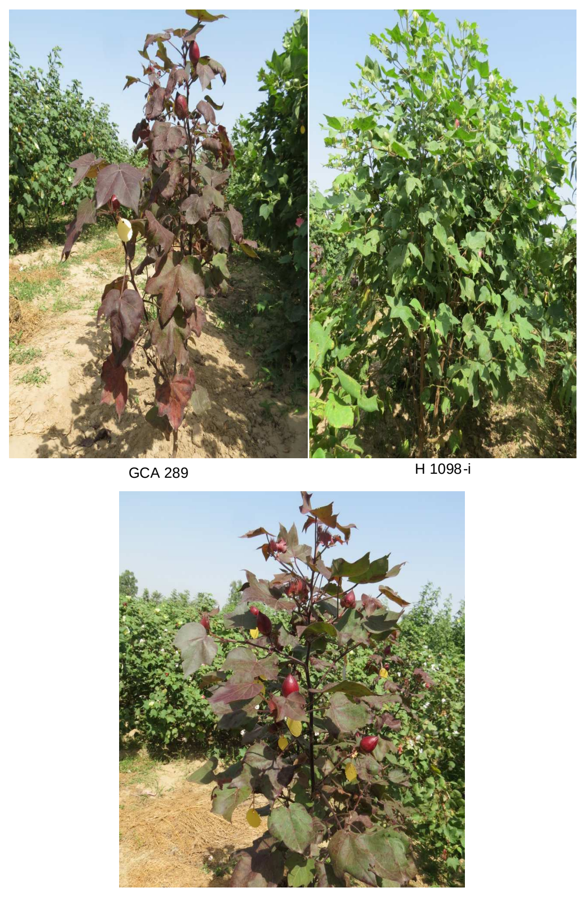
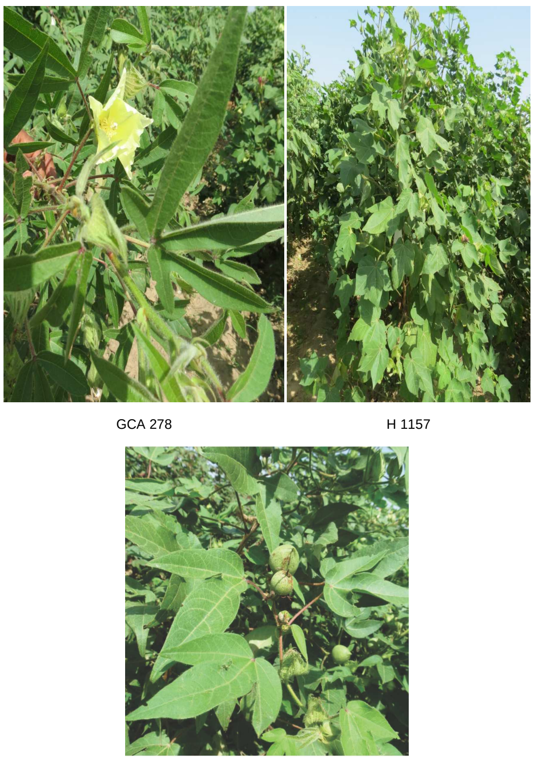


Fig. 2. Cross between GCA 289 x H1098i

Table 2. Mode of segregation for red colour leaf in cotton

Parents/crosses	Generation	Observed value			Expected value			Expected ratio	χ^2 Value	P value
		Green	Inter-mediate	Red	Green	Inter mediate	Red			
GCA 289	P_1	—	—	25	—	—	25	—	—	—
H 1098-i	P_2	35	—	—	35	—	—	—	—	—
GCA 289 x H 1098-i	F_1	—	45	—	—	45	—	—	—	—
GCA 289 x H 1098-i	F_2	23	62	31	27	58	27	1:2:1	1.46	0.4819
(GCA 289 x H 1098-i) x GCA 289	BC_1							1:1	0.82	0.3652
(GCA 289 x H 1098-i) x H 1098-i	BC_2							1:1	0.27	0.6033



GCA 278 H 1157

F_1 Hybrid

Fig. 3. Cross between GCA 278 x H1157

cultivar was practically feasible and beneficial. Similarly Nawab *et al.,* (2014) and Rahman *et al.,* (2008) studied the effect on yield and quality associated with frego bract, okra leaf and red colour leaves genes. Earlier findings corroborate the results of present study, hence it may be suggested that morphological traits like frego bract should be incorporated in the commercial cultivars. The incorporation of morphological characters related to insect resistance would help reduce pesticide load without affecting the desirable genetic combinations. It is obvious from the present findings that the increase in yield, associated with okra leaf morphology is due to its non-preference for insect pests and reduced leaf area allowing better air flow and maximum sunlight penetration (Nawab *et al.*, 2011).

Table 3. Mode of segregation for okra leaf type in cotton

Parents/crosses	Generation	Observed value			Expected value			Expected ratio	χ^2 Value	P value
		Normal leaf	Sub okra	okra	Normal leaf	Sub okra	okra			
GCA 278	P_1	—	—	25	—	—	25	—	—	—
H 1157	P_2	20	—	—	20	—	—	—	—	—
GCA 278x H 1157	F_1	—	55	—	—	55	—	—	—	—
GCA 278x H 1157	F_2	32	56	22	27.5	55	27.5	1:2:1	1.85	0.3965
(GCA 278x H 1157)x GCA278	BC_1	—	43	35	—	39	39	1:1	0.91	0.3401
(GCA 278x H 1157)x H1157	BC_2	26	34	—	30	30	—	1:1	2.34	0.1261

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