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Leaf Modifications to Quantify Yield, Earliness and Fibre Traits in *Gossypium hirsutum* L.

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Ten $BC_4 : F_2$ back-cross derived near-isolines developed from ten different cross combinations, differing in only leaf shape i.e. Normal, Okra, Sub-okra and Super-okra were compared for quantifying their yield, earliness and fibre traits. Sub-okra leaf cotton (L^{u_2}) was observed as an appropriate replacement for the normal leaf to improve the traits. Sub-okra types in all the combinations were superior for most of the traits. On an average over the populations, Sub-okra gave 19.7% higher yield, 1.5% earliness, 4.7% longer fibre and 2.1% more uniform fibre than the normal leaf isolines. Nevertheless, Sub-okra ginned and gave equally better fibre strength with the normal leaf. Yield, earliness, longer and uniform fibre superiority of Sub-okra leaf cotton over the normal leaf coupled with established insect resistance of modified leaves suggested that the potentiality of mutant leaves be exploited in future breeding programmes.

Key words: Leaf modifications, Fibre and earliness characters, *Gossypium hirsutum* L.

Introduction

Very little effort has yet been put to breed cotton for more open canopy types. However, in the recent past, emphasis are being diverted to breed cotton with modified leaf shape BH - 41 is the only Okra leaf type bred and released in Pakistan. Advantages of using open-canopy (Okra, Sub-okra and Super-okra) cotton are numerous as reported by several workers. Jones (1982) summarized their earliness and pest resistance, whereas, Landivar *et al* (1983), using model studies, characterized that under favourable moisture conditions, leaf shapes other than the normal might produce higher yields. Wells *et al* (1986) reported that Sub-okra leaf canopy photosynthesis was 7.0% greater than that of normal leaf near-isolines and is one of the causes for increased yields associated with Sub-okra leaf trait. Meredith (1984), using F_3 bulk hybrid populations of Okra (L^{O_2}), Sub-okra (L^{U_2}), and Super-okra (L^{S_2}) leaves, observed a significant lint yield increase of 4.8% in Sub-okra over normal leaf cotton. It was Burton (1966) who suggested using isolines to compare mutants with the normal leaf. After that suggestion, Meredith (1984) compared the yield of eight BC_4: F_3 Sub-okra leaf (L^{U_2}) lines with the normal leaf (l_2) cotton plants and reported that Sub-okra (L^{U_2}) cotton gave significantly higher yield (3.0%) than normal leaf. From his studies, it was conclude that the use of Sub-okra to replace normal leaf cotton offers a potentiality in yield increase. Recently, comparative studies were conducted by El-Zik and Thaxton (1993) at Texas A&M, USA, who besides yield, compared earliness and fibre traits of Okra cotton with the normal leaf. Comparing with the normal leaf, they reported that Okra leaf produced less or equal lint yield, earlier in maturity, less or equal in lint %, also produced longer, stronger and equally uniform and fine fiber. It appears that there is a room for comparing all the leaf types simultaneously and observe their potentiality over the normal leaf. The present study was carried out to evaluate yield, earliness and fibre differences of genetically similar ($BC_4 : F_2$) isolines of each Okra, Sub-okra, Super-okra and normal leaves produced by the backcross breeding method (Burton 1966).

Materials and Methods

Ten different populations, of which six segregated into Okra, Sub-okra, Super-okra and normal leaves, whereas, four segregated into Okra, Sub-okra and normal but not in Super-okra leaf types. The strains with mutant leaf genes were considered as donor parents of their respective recipient normal leaf types. Four back crosses were made for each of the ten cross combinations. In F_1 and subsequent generations, each leaf type was back crossed with their respective original normal leaf parents. In this way, four back crosses and one self (BC_4: F_2) were made, thus all the leaf types had become near-isolines of their corresponding normal leaf parents except retaining mutant genes in Okra, Sub-okra and Super-okra populations. Since, six crosses segregated into four types (Normal, Okra, Sub-okra and Super-okra) and four segregated into three leaf types (Normal, Okra and Sub-okra), thus in total, 36 $BC_4 : F_2$ populations were produced. All the 36 populations were replicated four times in a split plots with randomized, complete block design arrangement, treating populations as main plots and leaf types as sub-plots. The trial was carriedout at Cotton Research Institute, Sakrand during crop

Table 1

Mean yield, lint % and earliness of various near-isogenic cotton differing in leaf shape

Population	Seed cotton yield (g)					Lint (%)					Earliness (% of bolls picked at 140 DAP)				
	Normal	Okra	Sub okra	Super + okra	Av.	Normal	Okra	Sub okra	Super + okra	Av.	Normal	Okra	Sub okra	Super + okra	Av.
Rode okra x CRIS - 52	72.1	63.1	73.9	41.0	62.5	36.5	35.0	36.0	34.1	35.4	65.5	83.7	75.4	84.3	75.6
Rode okra x 9L - 34 - ICCC	68.3	62.8	75.1	54.2	65.1	35.6	34.0	35.4	33.8	34.7	72.8	91.6	89.8	91.8	86.5
Super okra x CRIS - 9	75.8	71.0	85.0	40.3	68.0	36.7	34.9	36.8	34.0	35.6	80.7	96.5	89.2	92.3	89.7
LA_2 x 9L - 34 -ICCC	47.5	45.3	72.1	-	55.5	34.8	33.1	34.6	-	34.2	71.7	93.6	85.4	-	83.6
BH - 41 x CRIS - 21	77.8	74.8	83.5	-	78.7	37.8	35.2	37.8	-	36.9	61.0	73.0	70.0	-	68.0
BH - 41 x NIAB - 78	93.4	77.3	115.2	-	95.3	34.0	33.2	34.1	-	33.8	67.2	74.3	77.8	-	73.7
BH - 41 x CRIS - 9	94.3	74.9	101.3	-	90.2	35.2	34.1	35.6	-	35.0	63.0	71.2	76.4	-	70.2
Okra, T. Jam x CRIS - 127	91.9	62.4	130.5	45.8	82.6	36.6	34.2	36.4	33.9	35.7	81.1	84.7	85.1	99.4	87.6
Rode okra x CRIS - 129	68.8	44.1	107.2	54.3	69.3	36.8	34.8	36.6	34.0	35.5	65.7	85.8	84.8	90.7	81.7
Super okra x CRIS - 52	49.5	47.3	75.8	34.1	51.7	36.6	34.2	36.1	34.1	35.3	78.9	95.8	94.7	98.7	92.0
Experimental mean	73.9	62.8	92.0	45.0	71.9	36.1	34.3	35.9	34.0	35.2	69.9	85.0	82.9	92.9	80.9

LSD (0.05); For main plots, Seed cotton yield; 17.7, Lint %; 1.6, Earliness; 16.0. LSD (0.05); For sub-plots, Seed cotton yield; 13.2, Lint %; 1.5, Earliness; 12.2. DAP = Days after planting + Some averages excluded Super-okra populations.

Table 2

Mean fibre length, uniformity ratio and fibre strength of various near isogenic cotton differing in leaf shape

Population	Fibre length (mm)					Uniformity ratio					Fibre strength lbs/sq inch				
	Normal	Okra	Sub okra	Super + okra	Av.	Normal	Okra	Sub okra	Super + okra	Av.	Normal	Okra	Sub okra	Super + okra	Av.
Rode okra x CRIS - 52	26.6	26.8	27.0	26.0	26.6	44.7	44.8	46.3	44.9	45.2	97.5	98.5	98.1	98.2	98.1
Rode okra x 9L - 34 - ICCC	27.0	27.9	28.7	26.1	27.4	45.2	45.7	46.0	43.1	45.0	95.1	96.3	95.8	96.5	95.9
Super okra x CRIS - 9	25.1	24.9	26.7	24.8	25.4	45.8	44.9	46.4	44.8	45.5	97.8	98.1	98.0	98.6	98.1
LA_2 x 9L - 34 -ICCC	25.9	26.9	27.8	-	26.9	45.8	41.8	47.0	-	44.9	95.7	96.8	95.9	-	96.1
BH - 41 x CRIS - 21	27.2	27.2	27.8	-	27.4	46.5	45.7	47.9	-	46.7	98.1	99.8	98.3	-	98.7
BH - 41 x NIAB - 78	26.5	27.3	28.6	-	27.5	45.7	45.6	49.3	-	46.9	98.0	98.4	98.2	-	98.2
BH - 41 x CRIS - 9	26.5	27.5	28.5	-	27.5	46.4	46.0	46.5	-	46.3	97.3	97.9	97.8	-	97.7
Okra, T. Jam x CRIS - 127	26.3	26.8	27.1	27.0	26.8	47.2	48.2	47.4	46.0	47.2	98.8	99.1	98.9	99.2	99.0
Rode okra x CRIS - 129	25.7	25.4	26.7	24.5	25.6	45.8	46.0	46.3	45.7	46.0	98.7	99.0	98.8	99.1	98.9
Super okra x CRIS - 52	26.3	26.0	27.5	27.1	26.7	48.0	46.3	48.3	46.2	47.2	97.8	98.0	98.9	98.1	98.2
Experimental mean	26.3	26.4	27.6	25.9	26.8	46.1	45.5	47.1	45.1	46.1	97.5	98.2	97.9	98.3	97.9

LSD (0.05); For main plots, Fibre length; 1.8, Uniformity ratio; 1.9, Fibre strength; 2.1. LSD (0.05); For sub-plots, Fibre length; 1.1, Uniformity ratio; 0.8, Fibre strength; 1.3. DAP; Days after planting + Some averages excluded Super-okra populations.

year 2000. The plot size was 45′ x 15′. The distance between rows and plants were kept at 2.5′ and 9.0″, respectively. For recording the data, 15 random plants of specified leaf types from each genotype in a replication were tagged and treated as index plants. Earliness was recorded as number of open bolls divided by the total bolls obtained after 140 days of planting calculated in %. The yield was recorded in g per plant and lint in % calculated as the proportion of seed and lint per plant. Fibre length was measured in millimeter, fibre uniformity as the ratio of 25.0 and 50.0% span length and fibre strength in lbs/sq inch.

Results and Discussion

Ten different cross combinations with four different leaf morphologies were compared for six important traits of cotton and the results summarized are presented in Table 1, 2 and 3. For yield per plant, the genotypes differed significantly and the combination BH - 41 x NIAB - 78, on average over populations, gave maximum yield of 95.3 g. Among the leaf types, averaged over the populations (populations and genotypes hereafter will be used inter changeably) Sub-okra types gave higher yields (92.0) followed by normal leaf (73.9 g), however, Super-okra leaf ranked poor (45.0 g). These results suggested that Sub-okra populations produced 19.7% more yield than the normal leaf. There was no genotype x leaf shape interaction for any trait because all the leaf shapes behaved similarly within the genotypes. The yield superiority of Sub-okra over normal leaf was also supported by Meredith and Randy (1987) and Meredith *et al* (1996). A high yielding variety, Siokra, with Okra leaves, for the first time was introduced commercially into Australia (Thomson 1985). Jones *et al* (1978) and Soomro *et al* (1998) also observed that Okra leaf plants out yielded normal leaf cultivars by 5.0 and 4.4% respectively. The genotypes have ginned differently and the highest lint% (36.9) was obtained by BH - 41 x CRIS - 121 and the lowest (33.8%) was obtained by BH - 41 x NIAB - 78. For leaf type, averaged over genotypes, Sub-okra ginned similar to normal and better than the Okra and Sub-okra leaves (Tables 1 and 3). El-Zik and Thaxton (1993) also reported non-significant difference in lint percentage between Sub-okra and normal leaf genotypes. The percent of bolls opened after 140 days of planting averaged over population varied significantly (Table 1) where population Super-okra x CRIS - 9 opened maximum number of bolls (89.7%). Among the leaf types averaged over populations, all the mutant leaf populations were earlier than the normal leaf, nonetheless Super-okra which had comparatively more open canopy than other leaf shapes was earliest of the all (92.9%).

The open canopy of mutant leaves probably has contributed more towards light interception into the plant canopy Table 1. Jones (1982) observed that mature Okra leaf plants have about 40.0% less foliage than normal leaf, thus permit 70.0% more sun light to penetrate the canopy. Meredith *et al* (1996) suggested that earliness is indicated by yield at first harvest and also observed that Sub - okra isolines yielded significantly higher than normal leaf at first harvest, however, at second harvest the yield differences were not different between the leaf types. Genotypes varied significantly for fibre length where population BH - 41 x NIAB - 78 recorded longer fibre (27.5 mm). The leaf types averaged over genotypes also differed significantly and Sub-okra populations averged longer fibre (27.6) mm) than the normal and other mutant leaf populations Table 2. The Super-okra however, produced rather smaller fibre (25.9 mm) probably due to less food reserve and smaller leaf lobbing consequently have affected the fibre to grow longer. El-Zik and Thaxton (1993) recorded similar results where Okra leaf produced longer fibre than the normal leaf. The populations differed significantly in fibre uniformity where Super-okra x CRIS -52 and Okra, T. Jam x CRIS - 127, were at par with each other but both populations gave equally more uniform fibre than other populations Table 2. Among the leaf types Sub-okra populations averaged significantly more uniform fibre (27.1%) than the normal and other mutant types. However, the lowest uniformity ratio was recorded in Super-okra populations (45.1%). Again this could be attributed to less food reserve in Super-okra leaves, consequently retarded the fibre growth and eventually uniformity ratio. Contrary to our findings, El-Zik and Thaxton (1993) observed no significant difference between the normal and mutant leaves for fibre uniformity. The populations produced significantly variable fibre strength and the cross BH - 41 x CRIS - 121 expressed the maximum strength of 98.7 lbs/sq inch (Table 2), however, among the leaf types, no significant difference was recorded.

Table 3
Comparison of mutant leaves with the normal leaf for various traits

Trait	Leaf types		
	Okra	Sub-okra	Super-okra
Seed cotton yield	=	<	>
Earliness	>	>	>
Lint%	<	=	<
Fiber length	<	>	<
Uniformity ratio	<	>	<
Fiber strength	>	=	>

=; Declared non-significant when the difference was smaller than the LSD (0.05) value, >; Declared significantly higher when the difference was equal or higher than the LSD (0.05) value, <; Declared significant lower when the difference was equal or less than the LSD (0.05) value.

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