DEVELOPMENT OF MAR COTTON GERMPLASM WITH MORPHOLOGICAL MUTANT TRAITS

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Abstract

Higher levels of resistance to insects, plant pathogens, and abiotic stresses are needed in cotton cultivars to enhance plant health and increase yield. The multi-adversity resistance (MAR) program has been successful in transferring and developing cotton germplasm with morphological mutant traits known to impart host resistance to pests. The performances of two okra-leaf strains, OSIKRHQWIH-2-94 and OHGPILBHQH-1-96, and a frego bract strain RCBCLCQPIH-1-95 were similar to the commercial cultivars for yield and fiber quality. Progress in yield was not as great in the nectariless, glandless and red-plant color strains. The MAR strains, especially the okra-leaf and frego bract, have simultaneous genetic gains for many traits, and will provide new sources of host-plant resistance to cotton insects and plant pathogens.

Introduction

Controlling pests is becoming more critical for maintaining plant health throughout the growing season and for profitable cotton production. Increased levels of resistance to biotic and abiotic stresses are needed in cotton to enhance plant health. The multi-adversity resistance (MAR) cotton genetic improvement program continues to make a steady and significant progress in developing cottons with broad resistance to pests and abiotic stresses such as drought, in addition to increased yield potential and improved fiber quality (Bird, 1982; El-Zik et al., 1988, 1991; El-Zik and Thaxton, 1989, 1992; Thaxton et al., 1990; Thaxton and El-Zik, 1994a, 1996).

A number of morphological mutant traits are associated with host plant resistance to insects and plant pathogens in cotton. No single trait provides adequate resistance to all pests. The association of several morphological traits with resistance to insects and diseases have been reviewed (El-Zik and Frisbie, 1985; El-Zik and Thaxton, 1989; Jenkins, 1976, 1982, 1986; Jones, 1972, 1982; Maxwell, 1980; Schuster, 1980; Wilson and George, 1982, Thaxton and El-Zik, 1994b, Meredith et al., 1996).

Pubescent (hairy) plant types are used for resistance to jassids in Africa and India, and to fleahopper, Lygus spp. and thrips. Conversely, cotton plants without these hairs (glabrous) offer resistance to tobacco budworm, bollworm, and pink bollworm by incurring much less egg laying, and to whitefly. The glabrous trait also is associated with reducing trash content of fiber.

The nectariless trait provides resistance to plant bugs (cotton fleahopper, tarnish plant bug, and Lygus bug), and to the pink bollworm, tobacco budworm and bollworm. Many adult insects prefer to feed and lay eggs on cottons that have extra floral nectaries (Adjei-Maafo and Wilson, 1983; Henneberry et al., 1977; Lukefahr and Rhyne, 1960; Schuster et al., 1976). Nectaries also provide a port of entry for some pathogens. The threshold population level at which application of insecticide was required for pink bollworm control was delayed two weeks in Arizona when nectariless cultivars were used (Wilson and Wilson, 1976). The level of seed damage by pink bollworm also was reduced significantly.

Mature okra-shaped leaf plants have about 40% less foliage than normal leaf plants which permits 70% more light to penetrate (Andries et al., 1969). This open canopy causes a greater mortality of immature boll weevils than in normal leaf cotton, because the increased temperature and decreased relative humidity desiccate the insect after the soil surface and plant parts become dry (Reddy, 1974). Wilson and George (1982) reported okra-shaped leaf to be a pink bollworm resistance trait. The open canopy also reduces boll rot (Reddy, 1974). Okra-shaped leaf cotton usually is associated with accelerated fruiting rates and early maturity when evaluated under an early season insect control program (Andries et al., 1969; Jones, 1982). Plants with okra-shaped leaves also produce fiber with less trash.

The frego bract trait is associated with a high level of resistance to the boll weevil (Jones, 1972). Jenkins (1976) reported that frego bract caused a 50% reduction in boll weevil damaged squares compared with normal bract, and that cotton strains with this trait required 46% less insecticide. Cotton strains with frego bract are early maturing in the absence of early season insects, and also reduce the incidence of boll rot damage in humid areas (Jones, 1972). Bracts from the cotton plant are a component of cotton dust and may contribute to byssinosis. Frego bract also helps in producing fiber with less trash.

Frego bract in glabrous and hairy types, and in both normal and okra-shaped leaf types has been reported to reduce yield. In certain genetic backgrounds, frego bract also is associated with an increase in susceptibility to plant bugs and to fleahopper damage, causing delayed fruiting and maturity in addition to reducing yield (Jones, 1972; Thaxton et al., 1985). Thaxton et al. (1985) reported that genetic associations of the traits glabrous, okra-shaped leaf and frego bract with unfavorable traits either have been or are being broken in the MAR germplasm.

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Red plant color was one of the first morphological traits recognized in conferring significant degrees of nonpreference to the boll weevil. This trait also confers resistance to cotton aphids. Certain red plant MAR strains recently were observed to confer resistance to the whitefly and to root pathogens causing Verticillium wilt and Phymatotrichum root rot (El-Zik and Thaxton, unpublished data).

Most morphological traits have not been bred into widely adapted cultivars. The exception is the SIOKRA okra-leaf cultivars which are widely grown in Australia. In addition, two nectariless cultivars are being grown in limited acreage in the United States, and a super-okra, smooth leaf cultivar has been developed for whitefly control in the Sudan of Africa. The MAR program has been successful in transferring and combining several of the morphological traits in MAR germplasm. Bird et al. (1974, 1977), Bird and Percy (1979), and Thaxton and El-Zik (1994b) reported on developing MAR cottons with morphological traits. This paper reports recent research and progress in developing new advanced MAR germplasm with the mutant traits frego bract, nectariless, okra-shaped leaf, and red plant color in glabrous and hairy plant types.

Materials and Methods

Field tests were conducted in Texas in 1997 at five locations (Weslaco, Corpus Christi, College Station, Temple and Chillicothe). Plots were single rows, 30 feet long and rows were 40 inches apart. Genotypes were grown in a randomized complete block design with four replications. Plots were harvested sequentially at two dates to determine lint yield and earliness. Fiber quality was determined by the International Textile Research Center, Texas Tech University, utilizing the HVI double line.

Entries in the tests included the MAR mutant strains, and advanced MAR-7 strains and cultivars. The four glandless strains were GCGL2GCLBH-1-96, GCGL2GCLBH-2-96, GCNHLEBS-1-88, GNLBG8CN5-1-96, and the two glandless cultivar checks Rogers LG-102 and Tamcot GCNH. The two nectariless strains were NLG8CDGP6H-1-95 and NLG8QWGPIH-1-95. Eleven okra-leaf strains were tested: OC3PICLBGS-1-95, OCBCLCDCBS-1-96, OCBCLPD24S-1-96, OCDCB2UCLH-1-96, OCDCB2UCLS-1-96, OHGPILBHQH-1-96, OHGPILBHQH-2-96, OHGPILBHQH-3-96, OLBHQPD22S-1-96, OPD23CBCLS-1-96 and OSIKRHQWIH-2-94. The two frego bract strains were RC5BCCUBQS-1-93 and RCBCLCQPIH-1-95. The three red-plant color strains were MLBCBUHG2H-1-91, MLBGUCLBGH-1-95 and MLBHGCULBH-1-91. The MAR-7 strains used as comparison checks were two elite MAR-7 strains that are possible cultivar releases, CABU2HGC8H-2-91 and CUBQHGRPIS-1-92, and the Tamcot CAB-CS (glabrous) and Tamcot Sphinx (pubescent) cultivars. These mutant traits were integrated into glabrous and hairy genotypes. The last letter in the strain designation indicates whether the strain is pubescent (H) or glabrous (S).

Analyses of variance were performed for each location and averaged over locations. When measured traits had a significant F value ($P<0.05$), means were separated using Fisher's least significant difference (LSD) procedure.

Results and Discussion

Lint Yield and Earliness

Averaged over the five morphological traits tests in 1997, lint yield ranged from 575 lb/a for the red plant color MLBGUCLBGH-1-95 to 963 lb/a for Tamcot Sphinx (Table 1). Yields of three okra-leaf strains, OHGPILBHQH-1-96, OHGPILBHQH-3-96 and OSIKRHQWIH-2-94 were similar to Tamcot Sphinx. The okra-leaf strain OHGPILBHQH-1-96 produced the highest yields at Weslaco and in the Brazos Valley near College Station, and was second to Tamcot Sphinx at Corpus Christi. Lint yield of the frego bract strain RCBCLCQPIH-1-95 was similar to the elite MAR strain CABU2HGC8H-2-91 and significantly higher than Tamcot CAB-CS. The glandless strains were equal to Tamcot CAB-CS in yield. Overall the okra-leaf strains performed exceptionally well while the nectariless and red plant color strains produced the lowest yields.

Significant differences were obtained for earliness among strains with a range from 52.3% for the okra-leaf strain OSIKRHQWIH-2-94 to 89.5% for an okra-leaf strain OHGPILBHQH-2-96 with a mean over locations of 71.7% (Table 2). All of the okra-leaf strains with the exception of OSIKRHQWIH-2-94 which was significantly later, the nectariless strain NLG8CDGP6H-1-96, and the red-plant color strain MLBGUCLBGH-1-95 were significantly earlier than Tamcot Sphinx. The glandless strain GCGL2GCLBH-1-96 was the latest maturing strain in the tests. Most of the strains were not significantly different from Tamcot CAB-CS in earliness.

Fiber Quality Traits

Fiber quality traits of the morphological strains and checks are presented in Tables 3-8, and ranked in the order of lint yield. There was no significant difference for fiber length among the locations, however, cotton grown in the Brazos Valley produced the longest fibers. Averaged over four locations (Weslaco, Corpus Christi, Brazos Valley and Temple), fiber length ranged from 1.05 inches for the glandless check Rogers LG-102 to 1.20 inches for the okra-leaf strain OLBHQPD22S-1-96, with an overall test mean of 1.15 inches (Table 3). The glandless strains had the shortest fibers with the exception of GCGL2GCLBH-1-96.

Fiber uniformity ranged from 82.8 at Weslaco to 85.3 in the Brazos Valley, with the entry x location interaction being non-significant (Table 4). The two sister okra-leaf strains,

OHGPILBHQH-1-96 and OHGPILBHQH-2-96 had significantly higher uniformity values than most of the strains and cultivar checks. Two okra-leaf sister strains, OCDCB2UCLS-1-96 (glabrous) and OCDCB2UCLH-1-96 (pubescent), and the older glandless strain GCNHLBEBS-1-88 had the lowest uniformity.

Fiber strength of the MAR strains and cultivars was higher in 1997 than in previous years with an overall mean of 31.6 g/tex (Table 5). Mean fiber strength ranged from 29.1 g/tex at Weslaco to 34.7 g/tex in the Brazos Valley. The location x genotype interaction was not significant. Fiber strength ranged from 28.0 g/tex for an older glandless strain GCNHLEBS-1-88 to 35.6 g/tex for the okra-leaf strain OHGPILBHQH-2-96 and 35.3 g/tex for its sister line OHGPILBHQH-1-96 which were significantly stronger than Tamcot Sphinx, a high strength cultivar (33.1 g/tex). Overall, fiber strength of the mutant strains were significantly stronger than the checks Tamcot GCNH, Rogers LG-102 and Tamcot CAB-CS.

Fiber elongation ranged among the locations from 5.7 at Weslaco and Temple to 6.2 at Corpus Christi and the Brazos Valley (Table 6). Averaged over locations, elongation ranged from 5.3 for GCNHLEBS-1-88 to 6.4 for three strains, CUBQHGRPIS-1-92, RC5BCCUBQS-1-93 (frego bract), and NLG8CDGP6H-1-93 (nectariless). Two okra-leaf strains OCDCB2UCLS-1-96 and OCDCB2UCLH-1-96, and the glandless strain GCNHLBEBS-1-88 had the lowest elongation.

Significant differences occurred for micronaire among the locations and genotypes (Table 7). Micronaire ranged from 3.5 at the Corpus Christi location to 4.8 at the Brazos Valley location with the location x genotype interaction being significant. Micronaire for the okra-leaf strains OSIKRHQWIH-2-94 and OHGPILBHQH-2-96 was higher or equal to that of Tamcot Sphinx among the locations. The glandless strain GCGL2GCLBH-1-96, okra-leaf strains OPD23CBCLS-1-96 and OCBCLCDCBS-1-96 produced the lowest micronaire among the locations. Most of the morphological strains had micronaire values higher than Tamcot CAB-CS.

In addition to improving yield, the MAR program continues to develop germplasm with the mutant traits with high fiber quality. Table 8 summarizes fiber quality traits for the 1997 morphological tests over four locations. There were significant difference among the genotypes for fiber quality. Three okra-leaf strains: OHGPILBHQH-1-96, OHGPILBHQH-3-96 and OSIKRHQWIH-2-94 and the frego-bract strain RCBCLCQPIH-1-95 produced the highest lint yield in addition to high fiber quality. Fiber quality of the mutant strains was higher or equal to the fiber of Tamcot Sphinx. The earlier released strains, Tamcot GCNH and Rogers LG-102 had the lowest fiber quality, in addition to OCDCB2UCLS-1-96, OCDCB2UCLH-1-96, and GCNHLEBS-1-88.

The performance of the new MAR morphological mutant strains in comparison with Tamcot Sphinx and Tamcot CAB-CS is summarized in Table 9. Substantial progress has been achieved in integrating the okra-leaf trait, producing yield and having fiber quality similar to or higher than Tamcot Sphinx, especially the OSIKRHQWIH-2-94 and OHGPILBHQH-1-96 strains. The frego bract strain, RCBCLCQPIH-1-95, produced yields and had fiber quality similar to the Tamcot cultivars. Progress in yield was not as great for the nectariless, glandless and red-plant color strains. Yield of these strains need to improve in order to be competitive with Tamcot Sphinx. However, fiber quality traits of these strains are equal to with a lower micronaire value than Tamcot Sphinx. The new okra-leaf and frego bract strains will provide an excellent source for morphological mutants for host plant resistance to insects and plant pathogens, and will be useful to breeders in genetic improvement programs, benefiting the cotton growers and industry.

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References

Adjei-Maafo, I. K., and L. T. Wilson. 1983. Factors affecting the relative abundance of arthropods on nectaried and nectariless cotton. Environ. Entomol. 12:349-352.

Andries, J. A., J. E. Jones, L. W. Sloane, and J. G. Marshall. 1969. Effects of okra leaf shape on boll rot, yield and other important characters of Upland cotton, *Gossypium hirsutum* L. Crop Sci. 9:705-710.

Bird, L. S. 1982. Multi-adversity (diseases, insects and stresses) resistance (MAR) in cotton. Plant Dis. 66:173-176.

Bird, L. S., F. M. Bourland, J. E. Hood, and D. L. Bush. 1974. Adversity-multi-disease resistant okra leaf and frego bract cottons. Proc. Beltwide Cotton Prod. Res. Conf., Cotton Improv. Conf. 27:95-97.

Bird, L. S., F. M. Bourland, R. G. Percy, J. E. Hood, and D. L. Bush. 1977. Additional progress in developing okra leaf, frego bract and glabrous multi-adversity resistant cotton. Proc. Beltwide Cotton Prod. Res. Conf., Cotton Improv. Conf. 29:107-110.

Bird, L. S., and R. G. Percy. 1979. Advancements in developing multi-adversity (disease, insects and stress) resistant glandless and glanded, okra leaf, frego bract and glabrous cottons. Proc. Beltwide Cotton Prod. Res. Conf., Cotton Improv. Conf. 31:230-232.

El-Zik, K. M., and R. E. Frisbie. 1985. Integrated crop management systems for pest control and plant protection. *In* N.B. Mandava (ed.), CRC Handbook of Natural Pesticides: Methods. Vol. I: Theory, Practice, and Detection. CRC Press Inc., Boca Raton, FL. pp. 21-122.

El-Zik, K. M., P. M. Thaxton, T. P. Wallace, and C. G. Cook. 1988. Improvement in fiber quality, yield potential, and resistance to pests of MAR cottons. Proc. Beltwide Cotton Prod. Res. Conf., Joint Session: Cotton Disease Council and Cotton Improv. Conf. 48:554-560.

El-Zik, K. M., and P. M. Thaxton. 1989. Genetic improvement for resistance to pests and stresses in cotton. *In* R. E. Frisbie, K. M. El-Zik, and L. T. Wilson, (eds.), Integrated Pest Management Systems and Cotton Production. John Wiley & Sons, New York, N.Y. pp. 191-224.

El-Zik, K. M., P. M. Thaxton, and R. A. Sequeira. 1991. Genetic gains in resistance to pests in the MAR Germplasm. II. Insects. Proc. Beltwide Cotton Prod. Res. Conf., Cotton Improv. Conf. 43: 545-549.

El-Zik, K. M., and P. M. Thaxton. 1992. Simultaneous improvement of yield, fiber quality traits, and resistance to pests in MAR cottons. Proc. Beltwide Cotton Prod. Res. Conf., Cotton Improv. Conf. 44:560-563.

Henneberry, T. J., L. A. Bariola, and D. L. Kittock. 1977. Nectariless cotton: effect on cotton leaf perforator and other insects in Arizona. J. Econ. Entomol. 70:797-799.

Jenkins, J. N. 1976. Boll weevil resistant cottons. Boll Weevil Suppression, Management and Elimination Technology. USDA/ARS S-71. pp. 45-49.

Jenkins, J. N. 1982. Present state of the art and science of cotton breeding for insect resistance in the southeast. Proc. Beltwide Cotton Prod. Res. Conf., Cotton Improv. Conf. 34:117-125.

Jenkins, J. N. 1986. Host plant resistance: advances in Cotton. Proc. Beltwide Cotton Prod. Conf., 1986:34-41.

Jones, J. E. 1972. Effect of morphological characters on cotton insects and pathogens. Proc. Beltwide Cotton Prod. Res. Conf., Cotton Improv. Conf. 24:88-92.

Jones, J. E. 1982. The present state of the art and science of cotton breeding for leaf morphological types. Proc. Beltwide Cotton Prod. Res. Conf., Cotton Improv. Conf. 34:93-99.

Lukefahr, M. J., and C. Rhyne. 1960. Effects of nectariless cottons on populations of three lepidopterous insects. J. Econ. Entomol. 53:242-244.

Maxwell, F. G. 1980. Advances in breeding for resistance to cotton insects. Proc. Beltwide Cottton Prod. Res. Conf., Cotton Insect Res. and Control Conf., 33:141-147.

Meredith, W. R., W. T. Pettigrew, and J. J. Heitholt. 1996. Sub-Okra, Semi-Smoothness, and Nectariless Effect on Cotton Lint Yield. Crop Sci. 36:22-25.

Reddy, R. S. C. 1974. Effects of three leaf shape genotypes of *Gossypium hirsutum* L. and row types on plant microclimate, boll weevil survival, boll rot and important agronomic characters. Ph.D. dissertation. Louisiana State University, Baton Rouge, LA. 184 pp.

Schuster, M. F. 1980. Insect resistance in cotton. *In* M. K. Harris (ed.), Biology and Breeding for Resistance to Arthropods and Pathogens of Agricultural Plants. Texas Agric. Exp. Stn. MP-1451. pp. 101-112.

Schuster, M. F., M. J. Lukefahr, and F. G. Maxwell. 1976. Impact of nectariless cotton on plant bugs and natural enemies. J. Econ. Entomol. 69:400-402.

Thaxton, P. M., K. M. El-Zik, and L. S. Bird. 1985. Influence of glabrous and hairy plants, leaf and bract types of near-isogenic cotton lines on lint yield, earliness, and fiber quality. Proc. Beltwide Cotton Prod. Res. Conf., Cotton Improv. Conf. 37:81-84.

Thaxton, P. M., K. M. El-Zik, and C. G. Cook. 1990. Genetic gains in yield, earliness, and fiber quality in the MAR hybrid pools. Proc. Beltwide Cotton Prod. Res. Conf., Cotton Improv. Conf. 42:77-80.

Thaxton, P.M. and K.M. El-Zik.. 1994a. Genetic enhancement of MAR cottons for resistance to insects and pathogens, yield and fiber quality. Proc. Beltwide Cotton Prod. Res. Conf., Cotton Improvement Conf. 46:658-661.

Thaxton, P.M. and K. M. El-Zik. 1994b. Development of MAR cotton germplasm with morphological mutant traits. *In:* G.A. Constable and N.W. Forester (eds) Challenging the Future: Proceeding of the World Cotton Research Conference. pp. 244-250.

Thaxton, P. M. and K. M. El-Zik.. 1996. Genetic advance in new multi-adversity resistnace (MAR) cotton germplasm. Proc. Beltwide Cotton Prod. Res. Conf., Cotton Improv. Conf. 48:601-611.

Wilson, F. D., and B. W. George. 1982. Effects of okra-leaf, frego-bract, and smooth-leaf mutants on pink bollworm damage and agronomic properties of cotton. Crop Sci. 22:798-801.

Wilson, R. L., and F. D. Wilson. 1976. Nectariless and glabrous cotton: effect on pink bollworm in Arizona. J. Econ. Entomol. 69:623-624.

Table 1. Mean lint yield for MAR cotton strains and cultivars in the 1997 morphological mutant traits test over five locations (Weslaco, Corpus Christi, Brazos Valley, Temple and Chillicothe).

MAR Strain/Cultivar	Weslaco	Corpus Christi	Brazos Valley	Temple	Chillicothe	Mean Over Locations
	lb/a	lb/a	lb/a	lb/a	lb/a	lb/a
Tamcot Sphinx ck	866**	1022**	783**	1183*	899**	963**
OHGPILBHQH-1-96	775	969	1001	1153	797	943
OHGPILBHQH-3-96	884	875	974	984	908	923
OSIKRHQWIH-2-94	809	873	926	1075	692	882
CABU2HGC8H-2-91	677	817	xx	1063	837	849
ROGERS LG-102 ck	873	823	702	935	769	829
RCBCLCQPIH-1-95	715	833	619	1214	641	824
OHGPILBHQH-2-96	682	808	844	900	891	820
OCBCLCDCBS-1-96	830	913	719	838	749	818
OPD23CBCLS-1-96	741	794	758	953	729	801
OLBHQPD22S-1-96	692	766	800	842	856	787
CUBQHGRPIS-1-92	730	799	xx	833	764	782
OCDCB2UCLH-1-96	777	878	790	745	633	771
Tamcot CAB-CS ck	743	747	774	787	725	756
GCNHLEBS-1-88	708	733	736	862	712	753
GCGL2GCLBH-2-96	581	800	748	908	672	745
OCBCLPD24S-1-96	625	759	762	783	784	739
GCGL2GCLBH-1-96	551	756	513	1159	587	731
RC5BCCUBQS-1-93	601	620	893	929	624	731
Tamcot GCNH ck	627	740	536	947	719	724
GNLBG8CN5S-1-96	524	735	844	826	597	704
NLG8CDGP6H-1-95	593	615	738	765	702	679
OCDCB2UCLS-1-96	573	769	760	701	517	667
NLG8QWGPIH-1-95	619	544	854	696	666	666
OC3PICLBGS-1-95	582	542	789	800	519	646
MLBCBUHG2H-1-91	444	503	987	626	517	600
MLBHGCULBH-1-91	431	523	829	711	473	587
MLBGUCLBGH-1-95	479	582	737	600	498	575
Mean	669	755	785	886	723	756
LSD (*P*=0.05)†	165	110	150	234	152	88
C.V. %	18	10.4	11.6	18.8	14.9	18

Location x cultivar interaction was not significant.
** Significant at the 0.01 probability level.
† Least significant difference between two means within a column.

Table 2. Mean percent earliness for MAR cotton strains and cultivars in the 1997 morphological mutants test at three locations and averaged over locations.

MAR Strain/Cultivar	Corpus Christi	Brazos Valley	Temple	Mean Over Locations
	%	%	%	%
Tamcot Sphinx ck	55.0**	80.9**	48.7**	61.5**
OHGPILBHQH-1-96	81.7	93.9	70.3	82.0
OHGPILBHQH-3-96	82.8	88.6	77.2	82.9
OSIKRHQWIH-2-94	46.6	76.3	34.1	52.3
CABU2HGC8H-2-91	67.9	---	63.1	65.5
ROGERS LG-102 ck	65.6	82.2	59.2	69.0
RCBCLCQPIH-1-95	56.7	84.1	42.8	61.2
OHGPILBHQH-2-96	90.9	92.6	85.0	89.5
OCBCLCDCBS-1-96	82.9	83.4	74.6	80.3
OPD23CBCLS-1-96	92.7	85.8	70.9	83.1
OLBHQPD22S-1-96	80.9	94.2	82.7	85.9
CUBQHGRPIS-1-92	74.6	---	52.9	63.8
OCDCB2UCLH-1-96	72.8	92.6	78.1	81.2
Tamcot CAB-CS ck	64.4	91.3	58.9	71.5
GCNHLEBS-1-88	68.6	62.5	43.7	58.3
GCGL2GCLBH-2-96	64.1	74.9	50.9	63.3
OCBCLPD24S-1-96	84.5	91.5	79.8	85.3
GCGL2GCLBH-1-96	43.3	60.8	41.0	48.4
RC5BCCUBQS-1-93	54.1	83.7	45.1	61.0
Tamcot GCNH ck	70.3	75.4	53.5	66.4
GNLBG8CN5S-1-96	68.0	55.0	46.1	56.4
NLG8CDGP6H-1-95	74.6	86.8	67.6	76.3
OCDCB2UCLS-1-96	82.1	93.8	76.1	84.0
NLG8QWGPIH-1-95	65.6	88.1	54.9	69.5
OC3PICLBGS-1-95	80.9	93.9	78.5	84.4
MLBCBUHG2H-1-91	66.3	89.6	60.5	72.1
MLBHGCULBH-1-91	51.6	77.0	59.3	62.6
MLBGUCLBGH-1-95	65.0	88.5	76.9	76.8
Mean	69.8	83.4	61.9	71.7
LSD (*P*=0.05)†	9.1	9.7	13.1	10.6
C.V.%	9.3	7.1	15.0	10.5

Location x cultivar interaction was not significant.
** Significant at the 0.01 probability level.
† Least significant difference between two means within a column.

Table 3. Mean fiber length for MAR cotton strains and cultivars in the 1997 morphological mutants test at four locations and averaged over locations.

MAR Strain/Cultivar	Mean Over Locations	Weslaco	Corpus Christi	Brazos Valley	Temple
	inches	inches	inches	inches	inches
Tamcot Sphinx ck	1.13**	1.11**	1.16**	1.14**	1.11**
OHGPILBHQH-1-96	1.18	1.16	1.21	1.19	1.15
OHGPILBHQH-3-96	1.16	1.15	1.19	1.19	1.11
OSIKRHQWIH-2-94	1.19	1.17	1.21	1.23	1.14
CABU2HGC8H-2-91	1.10	1.10	1.11	---	1.08
OHGPILBHQH-2-96	1.16	1.14	1.18	1.17	1.13
ROGERS LG-102 ck	1.09	1.08	1.11	1.11	1.05
OCBCLCDCBS-1-96	1.16	1.12	1.18	1.21	1.12
RCBCLCQPIH-1-95	1.18	1.17	1.19	1.21	1.15
OPD23CBCLS-1-96	1.15	1.13	1.18	1.17	1.11
OLBHQPD22S-1-96	1.20	1.15	1.23	1.23	1.17
CUBQHGRPIS-1-92	1.13	1.13	1.17	---	1.10
OCDCB2UCLH-1-96	1.13	1.11	1.15	1.18	1.08
Tamcot CAB-CS ck	1.16	1.11	1.18	1.22	1.13
GCNHLEBS-1-88	1.14	1.11	1.15	1.18	1.10
OCBCLPD24S-1-96	1.17	1.12	1.21	1.21	1.12
GCGL2GCLBH-2-96	1.19	1.16	1.21	1.24	1.15
RC5BCCUBQS-1-93	1.17	1.12	1.19	1.21	1.14
Tamcot GCNH ck	1.10	1.07	1.12	1.15	1.06
GCGL2GCLBH-1-96	1.16	1.14	1.19	1.20	1.12
GNLBG8CN5S-1-96	1.13	1.09	1.17	1.16	1.08
NLG8CDGP6H-1-95	1.18	1.16	1.20	1.20	1.14
NLG8QWGPIH-1-95	1.14	1.11	1.17	1.17	1.10
OCDCB2UCLS-1-96	1.14	1.09	1.17	1.17	1.12
OC3PICLBGS-1-95	1.15	1.12	1.17	1.18	1.14
MLBCBUHG2H-1-91	1.15	1.10	1.16	1.21	1.12
MLBHGCULBH-1-91	1.17	1.15	1.18	1.21	1.12
MLBGUCLBGH-1-95	1.16	1.12	1.20	1.20	1.12
Mean	1.15	1.12	1.18	1.19	1.11
LSD (*P*=0.05)‡	0.02	0.03	0.30	0.04	0.03
C.V.%	1.89	2.00	1.60	1.40	2.10

Location x cultivar interaction was not significant.

** Significant at the 0.01 probability level.

† Fiber analysis performed by the International Center for Textile Research, Texas Tech University.

‡ Least significant difference between two means within a column.

Table 4. Mean fiber uniformity for MAR cotton strains and cultivars in the 1997 morphological mutants test averaged over four locations (Weslaco, Corpus Christi, Brazos Valley, and Temple.)

MAR Strain/Cultivar	Mean Over Locations	Weslaco	Corpus Christi	Temple	Brazos Valley
Tamcot Sphinx ck	84.8**	83.5**	85.2**	85.0**	86.0**
OHGPILBHQH-1-96	86.1	85.5	86.6	86.0	86.8
OHGPILBHQH-3-96	85.5	84.1	86.1	85.3	87.5
OSIKRHQWIH-2-94	85.4	84.9	85.8	85.1	86.8
CABU2HGC8H-2-91	84.3	83.9	85.3	83.8	---
OHGPILBHQH-2-96	85.3	84.4	85.7	84.9	87.0
ROGERS LG-102 ck	83.1	81.9	83.7	82.5	85.4
OCBCLCDCBS-1-96	83.1	82.3	83.0	83.2	84.9
RCBCLCQPIH-1-95	83.0	81.6	83.9	83.3	83.9
OPD23CBCLS-1-96	83.6	82.8	83.9	83.4	85.2
OLBHQPD22S-1-96	83.8	82.2	84.5	84.8	84.0
CUBQHGRPIS-1-92	85.2	84.1	86.0	85.4	---
OCDCB2UCLH-1-96	82.8	81.5	83.3	82.7	84.7
Tamcot CAB-CS ck	83.6	82.1	83.6	84.3	85.3
GCNHLEBS-1-88	82.3	81.0	83.3	81.8	83.6
OCBCLPD24S-1-96	84.0	82.9	84.7	83.7	85.3
GCGL2GCLBH-2-96	83.0	82.0	83.3	82.9	85.0
RC5BCCUBQS-1-93	83.8	82.8	84.6	84.1	83.3
Tamcot GCNH ck	83.2	81.5	84.0	83.4	84.7
GCGL2GCLBH-1-96	84.0	82.5	84.9	84.2	85.1
GNLBG8CN5S-1-96	83.5	82.0	84.1	83.6	85.1
NLG8CDGP6H-1-95	84.5	83.4	84.4	84.7	86.4
NLG8QWGPIH-1-95	84.0	82.9	84.4	83.9	85.3
OCDCB2UCLS-1-96	82.8	80.2	83.5	83.8	85.0
OC3PICLBGS-1-95	84.0	82.8	84.6	84.1	84.8
MLBCBUHG2H-1-91	83.7	82.0	84.4	84.0	85.4
MLBHGCULBH-1-91	84.5	84.1	84.9	83.9	86.1
MLBGUCLBGH-1-95	84.5	83.3	85.4	84.6	85.4
Mean	84.0	82.8	84.5	84.0	85.3
LSD (*P*=0.05)‡	0.7	1.4	1.2	1.3	2.1
C.V.%	1.1	1.2	1.0	1.1	1.2

Location x cultivar interaction was not significant.

** Significant at the 0.01 probability level.

† Fiber analysis performed by the International Center for Textile Research, Texas Tech University.

‡ Least significant difference between two means within a column.

Table 5. Mean fiber strength for MAR cotton strains and cultivars in the 1997 morphological mutants test at four locations and averaged over locations.

MAR Strain/Cultivar	Mean Over Locations	Weslaco	Corpus Christi	Brazos Valley	Temple
	gms/tex	gms/tex	gms/tex	gms/tex	gms/tex
Tamcot Sphinx ck	33.1**	30.2**	32.6**	35.6**	34.1**
OHGPILBHQH-1-96	35.3	33.6	34.3	39.1	34.3
OHGPILBHQH-3-96	32.4	31.5	31.7	35.5	30.9
OSIKRHQWIH-2-94	34.0	31.3	34.3	38.0	32.5
CABU2HGC8H-2-91	30.8	30.0	30.0	---	32.4
OHGPILBHQH-2-96	35.6	33.6	34.8	40.2	33.7
ROGERS LG-102 ck	29.3	27.1	28.5	33.4	28.2
OCBCLCDCBS-1-96	31.5	28.9	31.7	35.4	29.9
RCBCLCQPIH-1-95	30.3	27.5	30.3	33.8	29.4
OPD23CBCLS-1-96	30.6	28.6	29.9	33.7	30.1
OLBHQPD22S-1-96	32.0	29.9	31.8	34.3	31.8
CUBQHGRPIS-1-92	31.8	30.1	32.1	---	33.1
OCDCB2UCLH-1-96	31.1	28.1	31.9	34.8	29.5
Tamcot CAB-CS ck	29.6	27.0	29.2	32.3	29.8
GCNHLEBS-1-88	28.0	25.8	28.5	30.5	27.1
OCBCLPD24S-1-96	31.9	29.0	33.4	34.0	31.2
GCGL2GCLBH-2-96	30.6	28.7	30.3	33.6	29.8
RC5BCCUBQS-1-93	31.7	29.7	31.1	35.2	30.9
Tamcot GCNH ck	28.4	26.7	28.2	32.3	26.4
GCGL2GCLBH-1-96	31.1	28.5	31.7	33.6	30.7
GNLBG8CN5S-1-96	31.5	28.3	31.7	35.0	30.8
NLG8CDGP6H-1-95	32.9	31.2	32.1	35.8	32.4
NLG8QWGPIH-1-95	32.0	29.8	32.4	34.3	31.3
OCDCB2UCLS-1-96	30.3	26.3	30.7	33.3	30.8
OC3PICLBGS-1-95	32.3	29.8	31.5	35.5	32.3
MLBCBUHG2H-1-91	30.4	26.4	31.1	34.2	30.0
MLBHGCULBH-1-91	32.0	30.4	30.9	34.2	32.4
MLBGUCLBGH-1-95	31.4	27.9	32.2	34.0	31.5
Mean	31.6	29.1	31.4	34.7	31.0
LSD (*P*=0.05)‡	0.9	2.0	1.7	3.4	2.0
C.V.%	4.7	4.8	3.8	4.8	4.5

Location x cultivar interaction was not significant.

** Significant at the 0.01 probability level.

† Fiber analysis performed by the International Center for Textile Research, Texas Tech University.

‡ Least significant difference between two means within a column.

Table 6. Mean fiber elongation for MAR cotton strains and cultivars in the 1997 morphological mutants test at four locations and averaged over locations.

MAR Strain/Cultivar	Mean Over Locations	Weslaco	Corpus Christi	Brazos Valley	Temple
Tamcot Sphinx ck	6.1**	6.0**	6.3**	6.0**	5.9**
OHGPILBHQH-1-96	6.3	6.2	6.4	6.6	6.1
OHGPILBHQH-3-96	6.1	6.1	6.3	6.3	5.7
OSIKRHQWIH-2-94	6.0	6.0	6.2	6.6	5.8
CABU2HGC8H-2-91	6.0	6.1	6.2	---	5.9
OHGPILBHQH-2-96	6.2	6.2	6.4	6.5	6.0
ROGERS LG-102 ck	5.9	5.7	6.3	6.2	5.5
OCBCLCDCBS-1-96	5.5	5.0	6.0	6.1	5.0
RCBCLCQPIH-1-95	6.0	5.8	6.3	6.2	5.9
OPD23CBCLS-1-96	5.6	5.4	6.1	5.9	5.3
OLBHQPD22S-1-96	6.0	5.9	6.1	6.1	5.9
CUBQHGRPIS-1-92	6.4	6.5	6.5	---	6.3
OCDCB2UCLH-1-96	5.4	5.1	6.0	6.0	4.9
Tamcot CAB-CS ck	6.0	5.8	6.3	6.2	5.8
GCNHLEBS-1-88	5.3	4.9	5.6	5.9	5.0
OCBCLPD24S-1-96	5.9	5.5	6.4	6.0	5.7
GCGL2GCLBH-2-96	5.6	5.3	5.9	6.0	5.4
RC5BCCUBQS-1-93	6.4	6.2	6.4	6.9	6.2
Tamcot GCNH ck	5.9	5.8	6.2	6.6	5.4
GCGL2GCLBH-1-96	6.2	6.0	6.4	6.4	6.1
GNLBG8CN5S-1-96	6.1	5.7	6.5	6.5	5.9
NLG8CDGP6H-1-95	6.4	6.3	6.5	6.6	6.4
NLG8QWGPIH-1-95	5.9	5.7	6.2	6.1	5.7
OCDCB2UCLS-1-96	5.5	4.9	5.9	5.8	5.5
OC3PICLBGS-1-95	5.7	5.6	5.9	6.0	5.6
MLBCBUHG2H-1-91	5.6	5.3	6.0	6.1	5.4
MLBHGCULBH-1-91	6.2	6.0	6.4	6.3	6.2
MLBGUCLBGH-1-95	6.0	5.8	6.4	6.2	5.8
Mean	5.9	5.7	6.2	6.2	5.7
LSD (*P*=0.05)‡	0.2	0.4	0.2	0.5	0.4
C.V.%	4.4	4.9	2.6	4.2	5.3

Location x cultivar interaction was significant.

** Significant at the 0.01 probability level.

† Fiber analysis performed by the International Center for Textile Research, Texas Tech University

‡ Least significant difference between two means within a column.

Table 7. Mean fiber micronaire for MAR cotton strains and cultivars in the 1997 morphological mutants test at four locations and averaged over locations.

MAR Strain/Cultivars	Mean Over locations	Weslaco	Corpus Christi	Brazos Valley	Temple
Tamcot Sphinx ck	4.8**	5.0**	4.4**	5.0**	4.7**
OHGPILBHQH-2-96	4.8	4.9	4.3	5.2	4.7
OSIKRHQWIH-2-94	4.9	4.8	4.6	5.1	5.0
OC3PICLBGS-1-95	4.5	4.7	3.8	4.9	4.6
OCBCLPD24S-1-96	4.5	4.7	3.6	4.9	4.6
OHGPILBHQH-1-96	4.5	4.6	4.0	5.0	4.4
NLG8CDGP6H-1-95	4.3	4.0	3.4	5.2	4.7
OHGPILBHQH-3-96	4.4	4.2	3.8	5.0	4.7
ROGERS LG-102	4.4	4.2	3.6	5.2	4.4
CUBQHGRPIS-1-92	4.2	4.2	3.8	---	4.5
GNLBG8CN5S-1-96	4.3	4.1	3.4	5.0	4.5
NLG8QWGPIH-1-95	4.3	4.2	3.5	4.9	4.4
Tamcot GCNH ck	4.3	3.8	3.6	4.9	4.7
CABU2HGC8H-2-91	4.0	4.2	3.6	---	4.1
MLBCBUHG2H-1-91	4.2	4.1	3.4	4.9	4.4
OCDCB2UCLH-1-96	4.1	3.9	3.4	4.8	4.2
RC5BCCUBQS-1-93	4.2	4.1	3.5	4.7	4.6
GCGL2GCLBH-1-96	4.0	3.9	3.5	4.4	4.3
OLBHQPD22S-1-96	4.2	4.1	3.4	4.8	4.3
Tamcot CAB-CS ck	4.0	3.9	3.2	4.6	4.1
MLBGUCLBGH-1-95	4.0	4.0	3.3	4.6	4.1
MLBHGCULBH-1-91	4.0	3.6	3.4	4.7	4.2
OCDCB2UCLS-1-96	4.0	3.8	3.2	4.7	4.4
RCBCLCQPIH-1-95	4.1	4.1	3.5	4.4	4.2
GCNHLEBS-1-88	3.8	3.7	3.2	4.1	4.3
OCBCLCDCBS-1-96	3.8	4.0	3.1	4.4	3.8
GCGL2GCLBH-2-96	3.7	3.6	3.1	4.2	4.0
OPD23CBCLS-1-96	3.8	3.8	2.9	4.4	3.9
Mean	4.2	4.1	3.5	4.8	4.4
LSD (*P*=0.05)‡	0.2	0.4	0.2	0.3	0.3
C.V.%	5.7	7.0	5.0	3.3	5.0

Location x cultivar interaction was significant.

** Significant at the 0.01 probability level.

† Fiber analysis performed by the International Center for Textile Research, Texas Tech University.

‡ Least significant difference between two means within a column.

Table 8. Mean fiber quality traits for MAR cotton strains and cultivars in the 1997 morphological mutants test averaged over four locations (Weslaco, Corpus Christi, Brazos Valley, and Temple.)

MAR Strain/Cultivar	Fiber Traits (HVI)†				
	Length U.H.M.	Uniformity	Strength	Elongation	Micronaire
	inches		g/tex		
Tamcot Sphinx ck	1.13**	84.8**	32.8**	6.1**	4.7**
OHGPILBHQH-1-96	1.17	86.1	34.8	6.3	4.4
OHGPILBHQH-3-96	1.16	85.5	31.9	6.1	4.3
OSIKRHQWIH-2-94	1.18	85.4	33.5	6.0	4.8
RCBCLCQPIH-1-95	1.17	83.0	29.8	6.0	4.0
CABU2HGC8H-2-91	1.10	84.3	30.8	6.0	3.9
ROGERS LG-102	1.09	83.1	28.7	5.9	4.2
OCBCLCDCBS-1-96	1.15	83.1	30.9	5.5	3.8
OPD23CBCLS-1-96	1.14	83.6	30.1	5.6	3.6
OHGPILBHQH-2-96	1.15	85.3	34.9	6.2	4.7
OCDCB2UCLH-1-96	1.12	82.8	30.5	5.4	3.9
CUBQHGRPIS-1-92	1.13	85.2	31.7	6.4	4.2
OLBHQPD22S-1-96	1.19	83.8	31.6	6.0	4.0
Tamcot CAB-CS ck	1.15	83.6	29.2	6.0	3.8
GCNHLEBS-1-88	1.13	82.3	27.6	5.3	3.8
GCGL2GCLBH-1-96	1.16	84.0	30.8	6.2	3.9
GCGL2GCLBH-2-96	1.18	83.0	30.2	5.6	3.7
RC5BCCUBQS-1-93	1.16	83.8	31.2	6.4	4.1
OCBCLPD24S-1-96	1.16	84.0	31.6	5.9	4.4
GNLBG8CN5S-1-96	1.12	83.5	30.9	6.1	4.1
Tamcot GCNH ck	1.09	83.2	27.8	5.9	4.1
OCDCB2UCLS-1-96	1.13	82.8	29.8	5.5	3.9
NLG8CDGP6H-1-95	1.17	84.5	32.4	6.4	4.2
OC3PICLBGS-1-95	1.15	84.0	31.8	5.7	4.4
NLG8QWGPIH-1-95	1.13	84.0	31.6	5.9	4.2
MLBCBUHG2H-1-91	1.14	83.7	29.8	5.6	4.1
MLBHGCULBH-1-91	1.16	84.5	32.0	6.2	3.9
MLBGUCLBGH-1-95	1.14	84.5	30.7	6.0	3.9
Mean	1.14	84.0	31.0	5.9	4.1
LSD (*P*=0.05)‡	0.16	0.7	1.1	0.2	0.2
C.V.%	1.89	1.1	4.7	4.4	5.7

* The location cultivar interation was significant for elongation and micronaire.

** Significant at the 0.01 probability level.

† Fiber analysis performed by the International Center for Textile Research, Texas Tech University.

‡ Least significant difference between two means within a column.

Table 9. Summary performance of MAR cotton strains with mutant morphological traits in comparison with Tamcot Sphinx.

TRAIT	MAR mutant				
	Okra-leaf	Frego bract	Nectari-less	Gland-less	Red plant
Lint yield	>,=	=	<	<,=	<
Earliness	>,=	=	>	=	=
Fiber:					
Length	>	>,=	>,=	=	=
Uniformity	=	=	=	=	=
Strength	=,>	=	=	=,<	=,<
Elongation	=	=	=	=	=
Micronaire	=,<	<,=	<,=	<,=	=,<