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Determining Lock Tenacity in Pima Cotton[1]

E. F. Young, Jr.[2]

ABSTRACT

These investigations were initiated to develop a technique for estimating storm resistance under field conditions in Pima cotton (*Gossypium barbadense* L.). A 500-g force gauge was used for field determination of lock tenacity. Lock tenacity was measured for fully open bolls. The pull of the lock was made parallel to the suture opening when the gauge was held horizontally. The most consistent readings were obtained from bolls located in the upper two-thirds of the open-boll zone. Storm resistance was overestimated if diseased locks or bolls not fully open were measured.

Field estimates of lock tenacity of several Upland cotton (*G. hirsutum* L.) cultivars were close to earlier laboratory estimates. Highly significant differences in lock tenacity among Pima cultivars and consistent ranking of cultivars over experiments showed that they differ genetically for lock tenacity. The force gauge effectively measures the trait in a breeding program.

Additional index words: ***Gossypium barbadense*** **L.,** ***Gossypium hirsutum*** **L., Storm resistance, Genotype × environment interaction.**

THERE is considerable interest in once-over harvesting of cotton in the irrigated areas of Texas, New Mexico, Arizona, and California. Extra-long staple American Pima (*Gossypium barbadanse* L.) is produced in these areas, but this species has a low level of storm resistance, a characteristic not well suited to once-over harvesting.

In 1969, Pima yield tests in New Mexico could not be harvested until after exposure to snow and high wind. By visual estimates, two strains in these tests resisted storms moderately well, whereas the seed cotton of most other strains was strung out badly or had dropped to the ground. Because strains appeared to differ for this trait, a study was initiated to develop a technique for getting field estimates of storm resistance among Pima cottons.

LITERATURE REVIEW

In the laboratory, Jones and Ray (5) studied stormproofness on snapped bolls of Upland cotton. The peduncle was attached to a 500-g weight placed on a direct-reading scale. A battery clip, attached to a lock of seed cotton, was then pulled upward. A pull of 500 g (minus the minimum scale reading) as the lock was pulled from the bur was then recorded as the pull in grams required to remove the lock. Choudhury (3) used a resistance strain gauge for measuring the dynamic force required to extract locks from the bur. He found that cultivars differed in the amount of work required to remove the lock, and that dynamic

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[2] Research Agronomist, ARS-USDA; 10601 North Loop Road, El Paso, TX 79927.

Table 1. Mean lock tenacity, range, and frequency distribution for 18 strains and cultivars in the Upland stripper test at El Paso, Texas, in 1970.

Strains and cultivars	Lock tenacity, g			Frequency distribution							
	Mean	Range Low	Range High	0 to 50	51 to 100	101 to 150	151 to 200	201 to 250	251 to 300	301 to 350	351 to +
Stripper Cala-S	220.3 a*	88	466		1	4	4		3	2	1
Tamcot 24	175.5 ab	79	398		3	5		5		1	1
Lockett 4789	158.9 bc	55	290		4	3	5		3		
Tamcot 788	156.4 bcd	87	240		1	6	7	1			
Dunn 56C	155.5 bcd	54	340		5	3	2	3	1	1	
Lambright X-15-3	142.3 bcde	40	215	1	4	2	5	3			
Lambright X-15-5	129.6 bcde	56	341		8	4		1	1	1	
Tamcot SP-21	128.7 bcde	75	282		4	7	2	1	1		
Paymaster 111	125.4 bcde	35	212	2	2	7	3	1			
MDR-H4 68-237	125.1 bcde	68	200		5	6	4				
Dunn 118	123.9 bcdef	67	189		5	5	5				
Lambright X-15-3A	102.5 cdef	50	162	1	7	6	1				
Tamcot SP-37	101.6 cdef	43	215	2	7	5		1			
MDR-Hr 68-237	99.4 cdef	47	175	1	8	4	2				
Lankart 3840	97.1 cdef	44	215	2	7	4	1	1			
Coker 4104	93.9 def	26	155	1	6	6	2				
Tamcot SP-23	91.1 ef	37	150	2	8	5					
Stoneville 7A	60.0 f	30	103	6	8	1					
Totals	126.6	26	466	18	93	83	43	17	9	5	2
C.V.	57.3%										

* Cultivar means followed by the same letter are not significantly different at 0.05 level of probability.

force was negatively correlated with the angle of carpel opening and mechanical harvesting efficiency. He concluded that the method helped to measure storm resistance in Upland cotton. Also, Wilkes (6) observed that harvesting efficiency decreased as storm resistance increased. Friesen (4) reported that the following factors influence lock removal from the boll: 1) fibers clamped in convolutions formed in the carpel wall during dehiscence, 2) fibers pinched in the base of the bur, 3) diseases affecting the fiber and carpel wall, 4) friction between the fiber and carpel wall, 5) protrusions along the boll suture, and 6) a mucous-type substance left on the fiber acting as a gluing agent.

MATERIALS AND METHODS

Lock tenacity is defined here as the grams of force required to remove a lock of seed cotton from the bur of a fully open boll. A 500-g force gauge with a maximum-hold attachment (2) was used for measuring lock tenacity. The force gauge was fitted with a 3.8 cm alligator-nosed, electric quick connection (5) for clamping and pulling the seed cotton from the bur. After the connection was attached to the lock, the force guage was reset to zero and a steady pull allowed the cotton plant to hold the boll in a stable position.

For evaluating cultivars in replicated tests, one reading was made from the middle of the open-boll zone on each of five randomly chosen plants per plot. All tests were randomized complete blocks. The Upland stripper test at El Paso, Texas, included 18 entries with three replications in 1970. The Pima test included five entries with four replications in 1970 and 1971 at Fabens, and El Paso, Texas, and at Las Cruces, New Mexico. In 1972, boll position on the plant was studied for six Pima strains and cultivars by readings taken at three positions—top, middle, and bottom thirds of the open-boll zone. This technique was used on five randomly chosen plants in each plot for three replications at El Paso, Texas.

RESULTS AND DISCUSSION

Preliminary Investigations

A period of trial and error preceded most of the work. These first efforts showed that the force gauge should be used at a constant angle (preferably horizontal) for repeatable measurements. Tilting the gauge downward produced higher readings, and tilting it upward produced lower ones. Evaluations should be confined to those bolls that allow the pull to be made parallel to the plane of the suture opening; otherwise, friction will raise the readings. Sampling bolls at various positions on the plant suggested that fully open bolls near the middle of the fruiting zone give the most consistent indication of lock tenacity. Locks that separated, rather than coming out entirely, were considered to give valid readings if there was no evidence of boll damage. This criterion was needed because fewer than 10% of the pulls removed entire locks on several of the Upland stripper entries. The factors that obviously contributed to storm resistance were: fibers pinched in the base of the carpels, protrusions along the carpel wall, and carpel placenta convolutions. Sampling diseased and damaged bolls resulted in misleading storm resistance determinations.

Table 2. Mean squares for lock tenacity in the Pima test for main effects and interactions among them.

Source	Df	Mean squares
Replications (R)	3	1,839
Years (Y)	1	90
R × Y	3	571
Locations (L)	2	1,135
Y × L	2	4,564**
R × Y × L	12	448
Cultivars (C)	4	15,782**
C × Y	4	940
C × L	8	628
C × Y × L	8	637
R × C × Y × L	72	605
C.V.		40.6%

** Significant at the 0.05 and 0.01 levels of probability, respectively.

Table 3. Mean lock tenacity for five Pima strains and cultivars, 2 years, and three locations.

Strains and cultivars	Years 1970	Years 1971	Over years
	Fabens, Texas		
E-1087	77.0 a*	69.9 a	73.5 a
E-1125	74.5 a	56.6 ab	65.6 a
E-3	51.6 b	49.6 b	50.6 b
Pima S-3	52.1 b	54.6 b	53.4 b
63-B-466	52.4 b	44.9 b	48.6 b
	El Paso, Texas		
E-1087	81.7 a	88.5 a	85.1 a
E-1125	73.2 a	60.0 b	66.6 b
E-3	64.7 b	58.9 b	61.8 bc
Pima S-3	45.7 c	60.5 b	53.1 cd
63-B-466	59.0 bc	45.8 b	52.4 d
	Las Cruces, New Mexico		
E-1087	70.0 a	86.3 a	78.1 a
E-1125	54.2 b	64.9 b	59.5 b
E-3	52.1 b	66.6 b	59.3 b
Pima S-3	49.0 b	50.5 b	49.7 c
63-B-466	45.6 b	57.1 b	51.3 bc
	Over Locations		
E-1087	76.2 a	81.5 a	78.9 a
E-1125	67.3 b	60.5 b	63.9 b
E-3	56.1 c	58.3 b	57.2 c
Pima S-3	48.9 c	55.2 bc	52.1 cd
63-B-466	52.3 c	49.2 c	50.8 d

* Means within each data set followed by the same letter are not significantly different at 0.05 level of probability.

Table 4. Mean lock tenacity and frequency distribution for five Pima strains and cultivars over three locations and 2 years.

Strains and cultivars	Lock tenacity (g) frequency distribution										
	10.0 to 24.9	25.0 to 39.9	40.0 to 54.9	55.0 to 69.9	70.0 to 84.9	85.0 to 99.0	100.0 to 114.9	115.0 to 129.9	130.0 to 144.9	145.0 to 159.9	160.0 to +
E-1087	2	4	17	27	20	21	19	5	1	4	
E-1125		10	34	40	19	7	6	3			1
E-3	1	24	37	34	10	8	3	2		1	
Pima S-3	3	35	38	25	13	1	2	1	1	1	
63-B-466	2	29	45	29	8	5	2				

Upland Stripper Test

The force gauge technique was applied to Upland cotton in the field to compare this technique (for ultimate use on Pima cotton in the field) with earlier efforts in the laboratory to measure storm resistance in Upland cotton. At El Paso, Texas, in 1970, 18 entries in the Upland stripper test were evaluated for lock tenacity (Table 1). The test included several non-stripper (i.e., picker) types such as 'Stoneville 7A' and 'Coker 4104.' 'Stripper Cala-S,' with a Macha-type boll (1), had a significantly higher mean lock tenacity than all but one other entry, 'Tamcot 24.' Both of these cultivars had a wide range of lock tenacity values. Stoneville 7A showed the lowest mean lock tenacity and the narrowest range for this characteristic of all entries in the test. Lock tenacity values found in the field closely agreed with the readings for similar boll types found by Jones and Ray (5). Most of the entries with intermediate tenacity were stripper types with high levels of storm resistance. All entries, except Stripper Cala-S, can be harvested with a spindle-picker, although harvest efficiency reduces as the level of lock tenacity increases. The frequency distributions appear to be skewed toward low lock tenacity.

Pima Tests

The mean squares (Table 2) showed highly significant differences among cultivars and for the year × location interaction. All other main effects and interactions were nonsignificant. Because neither the years nor locations effects were significant, lock tenacity was not significantly influenced by the years or locations concerned. Neither those mean squares nor the year location interactions have a specific genetic interpretation. But, because the interactions between years and locations was significant, a major effect might be detected some years at some locations. Significant differences among cultivars suggest genetic potentials that can be used by crossing and selecting. Because none of the interactions involving cultivars were significant, evaluation of cultivars in one environment should be effective.

'E-1087' consistently produced the highest value for each year-location combination (Table 3), having significantly higher lock tenacity than all other cultivars except 'E-1125' at El Paso, Texas, in 1971 and at Fabens, Texas, in both years. Comparing the 1970 El Paso Pima and stripper test data, the storm resistance of E-1087 and E.1125 appears the same as that of Tamcot 24, and that of 'E-3' and '63-B-446' appears the same as that of Stoneville 7A. The lock tenacity frequency distributions (Table 4) for each cultivar are skewed toward the lower readings with an average of 58% of the readings located below the mean. The tendency

Table 5. Influence of boll position on the lock tenacity of six Pima strains and cultivars in 1972.

Boll position on the plant	E-2	E-3	P-21	P-23	Pima S-3	Pima S-4	Means
Top-third	60.1 a*	59.0 a	47.6 a	44.9 a	47.1 a	60.9 a	53.3 a
Middle-third	47.5 ab	44.1 ab	51.1 a	44.8 a	45.3 a	64.8 a	49.6 a
Bottom-third	32.7 b	40.1 b	39.6 a	39.5 a	43.3 a	58.4 a	41.9 b
Mean	46.7	47.7	46.1	43.0	44.5	61.4	
C.V.	42.7%						

* Means for each cultivar followed by the same letter are not significantly different at the 0.05 level of probability.

toward skewed distributions and high coefficients of variation (Tables 1, 2, and 5) indicate that large numbers of observations are required for reliable estimates of storm resistance.

Boll Position

This experiment was conducted to further evaluate the findings of the preliminary investigations on the relationship of boll position on the plant and lock tenacity. At a given node on fruiting branches, bolls are set from the bottom to the top of the plant; and boll opening has essentially the same sequence as boll set. The lower bolls on the plants are exposed to longer periods of weathering, which tends to lower lock tenacity. 'E-2' and E-3 showed significant differences in lock tenacity between the bottom third and the top third of the plant (Table 5). Although the differences were not significant, the other cultivars showed the same trend. The performance of these six Pima cultivars supports the observation that sampling in the upper two-thirds of the open-boll zone would probably give the most consistent estimate of lock tenacity. However, sampling in the lower third would show storm resistance better, because these are the bolls that have been most exposed to weathering.

REFERENCES

1. Brown, H. B., and J. O. Ware. 1958. Cotton. 3rd ed. McGraw Hill Book Company, Inc., New York.
2. Chapman, W. E. 1972. How the strength of attachment of fibers to cottonseeds affects ginning performance and fiber qualities. Beltwide Cotton Prod. Res. Conf. Nat. Cotton Council, Proc. (Memphis). p. 54-56.
3. Choudhury, M. S. U. 1963. Use of recording resistance strain gauge equipment in measuring dynamic force required to extract cotton locks from the burrs. Unpublished M.S. Thesis. Texas A&M University, College Station.
4. Friesen, J. A. 1968. Factors affecting removal of cotton from the boll. Am. Soc. Agr. Eng. 11:529-531.
5. Jones, D. L., and L. L. Ray. 1953. Genetic studies of the stormproof type boll in American Upland cotton. Agronomy Abstr. Amer. Soc. of Agron., Madison, Wis. p. 90.
6. Wilkes, L. H. 1965. Use of strain gauge equipment for determining storm resistance and harvesting efficiencies of cotton varieties. Presented at the Southeast and Southwest Regional Meetings, Am. Soc. of Agr. Eng. Mimeo, p. 4.