Published July, 1982

Measurement of and Correlations among Selected Seed Quality Factors for 36 Texas Race Stocks of Cotton[1]

Ted N. Shaver and Robert H. Dilday[2]

ABSTRACT

Five seed quality factors (gossypol, oil, protein, and kernel percentages, and seed index) were measured for 36 Texas race stocks of cotton (*Gossypium hirsutum* L.) and three controls. Linear correlation coefficients were then calculated for all possible combinations of the five traits taken two at a time to determine whether those traits were related in this material.

Texas race stocks were detected with significantly higher gossypol, oil, or protein percentages than the controls, but not with higher kernel percentages or seed indexes. Positive relationships were demonstrated between kernel and oil percentage ($r = 0.71$), kernel and protein percentage ($r = 0.62$), kernel percentage and seed index ($r = 0.62$), and protein percentage and seed index ($r = 0.48$). A negative relationship existed between seed index and gossypol percentage ($r = -0.47$). Gossypol level among the stocks was not related to the percentages of oil, protein, or kernel in the seed. In these stocks, increasing gossypol percentage for host plant resistance should not cause a reduction in quantity of oil or protein in the seed.

Additional index words: Gossypol percentage, *Gossypium hirsutum* L., Oil percentage, Protein percentage, Kernel percentage, Seed index.

THE potential of gossypol as a source of natural resistance to insect pests of cotton (*Gossypium hirsutum* L.), including the bollworm [*Heliothis zea* (Boddie)] and tobacco budworm [*H. virescens* (F.)], was recognized in the early 1900's by Quaintance and Brues (10). Subsequently, several laboratory and field tests have demonstrated the detrimental effects of gossypol on the growth and development of those two pests and others (1, 5, 6, 7, 8, 11). Dilday and Shaver (3) surveyed 256 wild cotton accessions to find new sources of high flowerbud gossypol and did find several which produced significantly higher levels than controls comparable to cultivars.

Since cottonseed quality generally increases with higher levels of protein and oil, but declines with increasing concentration of gossypol, 36 Texas race stocks, identified by Dilday and Shaver (3) as containing high concentrations of gossypol in their flowerbuds, and three controls were analyzed to measure the concentration of gossypol in their seed as well as their percentages of oil, protein, and kernel and their seed indexes and to determine whether those characteristics were related in this material.

MATERIALS AND METHODS

The cottonseed used in this study were grown near Tuxpan, Veracruz, Mexico in the winter of 1974–1975 because most of the materials in the Texas race stock collection exhibit a short-day photoperiodic flowering response and will not flower during the long-day growing season in Texas. Entries were planted in a randomized, complete-block experimental design replicated four times. Fourteen of the 21 entries which produced more than 1.30% flowerbud gossypol near Veracruz, Veracruz, Mexico in 1971–1972 (3) were included in this test. Also included were 22 entries of the Texas race stock collection which had shown promise as sources of resistance to the bollworm-tobacco budworm complex. 'Stoneville 213' (ST-213), 'Deltapine 16' (DPL-16), and TM-1 were included as controls. Each plot was two rows

[1]Cooperative investigation of the USDA-ARS and the Texas Agric. Exp. Stn., Texas A&M Univ., College Station, TX 77843. Received 1 May 1981.

[2]Research chemist, USDA-ARS, College Station, TX 77841 and research geneticist, USDA-ARS, Brownsville, TX 78520, respectively.

wide and 12.5 m long, and rows were 30 cm apart. There were about eight plants per meter within the rows. One row was left unplanted between adjacent entries.

Open bolls which matured within a 3-week period were harvested in March 1975, and their seed were ginned and acid-delinted. Seed were dried at 38 C in a forced-air oven to equalize moisture content among samples, and 10 g of each sample was weighed for oil analysis. Oil percentage of the seed was determined by nuclear magnetic resonance (NMR) in a Newport Quality Analyzer. Two analyses per replication were made for each entry.

Gossypol was determined using the method of Pons et al. (9) which measures total seed gossypol. Samples for this analysis were not dried and contained both seed coat and kernel. Two determinations per replication were made for each entry.

Protein content of the cottonseed samples was determined by Kjeldahl analysis using a 1.4 g sample per analysis. One analysis per replication was performed for each entry.

In addition to measurements of the major components of cotton seed, seed index (weight in grams of 100 acid-delinted seed) was calculated by weighing four 10-seed subsamples from each replicate. Each seed of those subsamples was then separated into seed coat and kernel to determine kernel percentage.

Linear correlations were calculated between the five parameters (percentages of gossypol, oil, protein, and kernel and seed index). Also, each parameter was subjected to an analysis of variance from which an L.S.D. ($\alpha = 0.05$) was calculated.

RESULTS AND DISCUSSION

Gossypol concentration in seed from the Texas race stocks ranged from 0.34% in Texas 1036 to 1.32% in Texas 497 (Table 1) with a mean of 0.74% over all entries. Gossypol concentration in seed of the controls (TM-1, DPL-16, ST-213) was fairly uniform (0.81, 0.72, and 0.73%, respectively). The L.S.D. ($\alpha = 0.05$) calculated from an analysis of variance was 0.30% gossypol, and only four of the race stocks contained more than the upper confidence limit of the mean gossypol level of TM-1. Those four entries were Texas 497 (1.32%), Texas 495 (1.19%), Texas 1161 (1.19%), and Texas 487 (1.16%). The mean seed gossypol content of the 14 lines grown near Veracruz in 1971–1972, which had contained greater than 1.30% flowerbud gossypol, was only 0.74; Texas 497 was the only one of those lines with a significantly greater level of gossypol than the controls. The seed gossypol content of two of the controls (DPL-16 and ST-213) was considerably less in this test than in seed produced at Brownsville, Tex. during the 1975 growing season. In the latter test, ST-213 and DPL-16 seed contained means of 1.25 and 1.19% gossypol, respectively, as compared to 0.73 and 0.72% herein. Cherry et al. (2) also found significant differences in seed gossypol content among four cultivars when grown at eight locations in Texas.

The percentage of seed oil in the 36 Texas lines ranged from a high of 25.6% in Texas 642 to 17.2% in Texas 301, with a mean of 21.1%. The three controls contained 21.0 to 22.4% oil, with a mean of 21.9%. Only one of the Texas entries (Texas 642, 25.6%) contained significantly more oil than the controls. Kohel (4) included 35 of these 36 Texas stocks (Texas 1146 not included) in his survey of seed-oil percentage among germplasm collections grown at Iguala, Guerrero, Mexico during the 1972–1973 winter season. His mean seed-oil percentage (i.e., 25.4%) for these 35 lines was considerable higher than the value we obtained. However, Cherry et al. (2) has also reported a large environmental source of variation in seed-oil content.

Table 1. Gossypol, oil, protein, and kernel percentages and seed index of cottonseed from 36 Texas race stock and three controls.

Entry	Gossypol	Oil	Protein	Kernel	Seed index
	%				g/100 seed
TM-1	0.81	22.4	21.2	60.9	8.1
DPL-16	0.72	22.4	23.6	60.3	8.7
ST-213	0.73	21.0	24.5	61.7	9.2
Texas 27	0.68	21.7	19.9	58.1	8.6
102†	0.74	21.2	23.7	62.2	6.4
110	0.50	21.1	21.4	63.3	10.4
114†	0.83	21.8	17.8	55.1	5.4
115†	0.83	20.8	22.1	59.6	6.3
119	1.10	22.7	25.2	64.5	7.2
144	1.05	22.5	20.2	60.6	6.1
152	0.94	22.1	26.4	63.4	8.0
165	0.72	19.6	21.4	56.0	6.3
187†	0.83	22.7	20.9	57.3	6.1
194	0.54	21.1	20.1	61.5	10.1
197†	0.58	21.6	20.2	57.9	7.4
216	0.74	22.6	21.9	58.2	7.4
231†	0.97	20.7	23.0	59.3	6.1
297†	0.58	19.7	24.2	62.4	9.1
301	0.49	17.2	20.3	51.4	7.2
318	0.52	19.3	23.4	56.7	8.0
461	0.49	20.5	23.2	60.8	7.0
481	0.83	22.1	19.8	59.0	6.1
487	1.16	19.6	21.3	54.0	5.6
490†	0.84	22.6	19.8	60.8	7.1
495	1.19	20.1	21.0	55.8	5.6
497†	1.32	19.5	19.7	52.2	5.0
605	0.37	20.5	23.2	61.1	8.7
642†	0.42	25.6	20.0	64.2	7.4
663†	0.56	20.0	19.4	54.1	6.1
664†	0.69	20.1	17.9	60.0	5.5
674†	0.49	20.2	21.9	58.9	7.9
707†	0.73	22.2	21.0	60.0	8.5
766	0.77	19.9	20.1	54.1	6.0
805	0.77	19.3	19.7	56.2	6.8
932	0.59	22.6	22.1	60.4	9.5
1036	0.34	18.3	18.4	52.5	5.5
1146	0.58	24.1	25.5	64.2	8.2
1150	0.83	19.9	17.5	55.2	5.5
1161	1.19	23.4	24.3	63.5	8.2
Mean	0.75	21.1	21.5	58.9	7.2
L.S.D. (α = 0.05)	0.30	2.8	4.0	4.8	1.5

† Texas race stock which exceeded 1.30% flowerbud gossypol in the study by Dilday and Shaver (3).

Protein content of the seed of Texas lines, as measured by the standard Kjeldahl method (conversion factor of N × 6.25), ranged from 17.5% in Texas 1150 to 26.4% in Texas 152 with a mean protein content of 21.9%. The three control lines ranged from 21.2 to 24.5% protein and averaged 23.1%. Although three of the Texas race stocks (Texas 119, Texas 152, and Texas 1146) contained a higher protein concentration than any of the control lines, the only significant increases in protein content were between those three lines and TM-1 (which contained only 21.2% protein).

The kernel accounted for more than 51% on the seed weight in all of the lines evaluated. The controls contained more than 60% kernel as did 16 of the 36 Texas race stocks. Seed index ranged from 5.0 for Texas 497 to 10.4 for Texas 110. Seed from the controls were fairly uniform, varying from 8.1 to 9.2.

Linear correlation coefficients among all possible com-

Table 2. Linear correlation coefficients among gossypol, oil, protein, and kernel percentages and seed index of cottonseed from 36 Texas race stocks and three controls.

	Oil, %	Protein, %	Kernel, %	Seed index
			r	
Gossypol, %	0.10	0.03	−0.11	−0.47**
Oil, %		0.26	0.71**	0.30
Protein, %			0.62**	0.48**
Kernel, %				0.62**

** Significantly different from zero at the 0.01 probability level.

binations of the five seed quality factors taken two at a time, as calculated from a linear regression analysis, are shown in Table 2. Significant positive correlations existed between kernel and oil percentage (r = 0.71), kernel and protein percentage (r = 0.62), kernel percentage and seed index (r = 0.62), and protein percentage and seed index (r = 0.48). A significant negative correlation (r = −0.47) was noted between seed index and gossypol percentage. Gossypol level among the lines studied was not associated with percentage of oil, protein, or kernel in the seed. Relationships within lines were not investigated and may be different from those among lines.

REFERENCES

1. Bottger, G. T., E. T. Sheehan, and M. J. Lukefahr. 1964. Relation of gossypol content of cotton plants to insect resistance. J. Econ. Entomol. 57:283–285.
2. Cherry, J. P., J. G. Simmons, and R. J. Kohel. 1978. Cottonseed composition of national variety test cultivars grown at different Texas locations. p. 47–50. *In* Proc. Beltwide Cotton Improvement Conf., Natl. Cotton Coun., Memphis, Tenn.
3. Dilday, R. H., and T. N. Shaver. 1976. Survey of the regional *Gossypium hirsutum* L. primitive race collection for flowerbud gossypol. USDA Res. Rep. ARS-S-80.
4. Kohel, R. J. 1978. Survey of *Gossypium hirsutum* L. germplasm collections for seed-oil percentage and seed characteristics. USDA Res. Rep. ARS-S-187.
5. Lukefahr, M. J., G. T. Bottger, and Fowden Maxwell. 1966. Utilization of gossypol as a source of insect resistance. p. 215–222. *In* Proc. 18th Annu. Cotton Improvement Conf., Natl. Cotton Coun., Memphis, Tenn.
6. ----, and J. E. Houghtaling. 1969. Resistance of cotton strains with high gossypol content to *Heliothis* spp. J. Econ. Entomol. 62:588–591.
7. ----, and D. F. Martin. 1966. Cotton-plant pigments as a source of resistance to the bollworm and tobacco budworm. J. Econ. Entomol. 59:176–179.
8. ----, L. W. Noble, and J. E. Houghtaling. 1966. Growth and infestation of bollworms and other insects on glanded and glandless strains of cotton. J. Econ. Entomol. 59:817–820.
9. Pons, W. A., Jr., R. A. Pittman, and C. L. Hoffpauir. 1958. 3-Amino-1-propanol as a complexing agent in the determination of total gossypol. J. Am. Oil Chem. Soc. 35:93–97.
10. Quaintance, A. L., and C. T. Brues. 1905. The cotton bollworm. USDA Bur. Entomol. Bull. 50.
11. Shaver, T. N., and M. J. Lukefahr. 1969. Effect of flavonoid pigments and gossypol on growth and development of the bollworm, tobacco budworm, and pink bollworm. J. Econ. Entomol. 62:643–646.