Published May, 1983

Associations Between Bracts and Several Agronomic Traits in Cotton[1]

D. T. Bowman and J. E. Jones[2]

ABSTRACT

Cotton (*Gossypium hirsutum* L.) bracts, as part of the trash in machine-harvested seed cotton, have been implicated in the brown lung disease, byssinosis, in mill workers. As part of two separate investigations into the genetic nature of bract surface area (cm^2 of bract area), genotypic and phenotypic correlations were calculated to determine linkages or associations with several agronomic traits. These field studies were conducted at Alexandria and Baton Rouge, La. on typic udifluvents and aquic fragiudaif soils, respectively. Significant positive associations in both studies between bract surface area and boll weight suggested little progress would be made in reducing the bract relative to the boll if only the bract surface area was considered. A better measure of heritable changes in bract surface area relative to boll weight may be the ratio of bract surface area/lint weight per boll. A low ratio of bract surface area/lint weight per boll would denote a low bract trash potential and may denote a low byssinosis potential. The ratio bract surface area/lint weight per boll appeared to be positively associated (genotypically) with 50% span length, and negatively associated with fiber micronaire and lint percent. These associations would suggest that parents with high lint percent and parents with small bracts should be selected. The potential problem with fiber length and micronaire should be considered in breeding cottons for low bract trash potential.

Additional index words: Byssinosis, *Gossypium hirsutum L.*

BYSSINOSIS is a major problem in the cotton industry (2). In researching the factors creating the dust problem in textile mills, bracts from the cotton (*Gossypium* spp.) plant have been found to contribute a substantial portion of the trash in machine-harvested cotton (4, 8). Bracts have been suggested as the active agent in the cotton dust involved in byssinosis (1). With this in mind, it has been suggested that cotton breeders should develop cottons with minimum bract surface area (7).

Inheritance studies of bract surface area (3) revealed that additive gene effects were primarily responsible for bract surface area. Dominance contributed to the inheritance of this trait, but epistasis could not be detected.

As part of these two separate studies, phenotypic correlations in both studies and genotypic correlations in one study were calculated between bract surface area and several agronomic traits. This report seeks to explain the results of these investigations and the implications in breeding for reduced bract surface area.

MATERIAL AND METHODS

Study One

The first study consisted of an unreplicated random population of F_3 lines. Only phenotypic associations were determined. The plant materials were derived from a cross involving HR-26-Sm, a cotton with small, flared bracts, and Stoneville 7Ane, BC_7, a cotton with bract surface area more typical of modern Uplands. HR-26-Sm is an F_5 generation line developed by M. J. Lukefahr from a cross between small bracted *G. hirsutum* race stock T718 and La. 213-19556, an inbred line of 'Stoneville 213.' Lukefahr further crossed HR-26-Sm (plant 2) with Stoneville 7Ane, BC_7, a breeding line obtained from W. R. Meredith. The F_1 seed were kindly furnished to us by M. J. Lukefahr in 1976.

In 1978, 83 random F_3 progenies obtained from selfpollinated F_2 plants were planted in unreplicated single-row plots, 5.5 m long with 12 hills per plot and approximately two plants per hill. The only restriction on selection of parental F_2 plants was the

[1] Contribution from the Dep. of Agronomy, Louisiana Agric. Exp. Stn., Baton Rouge, LA 70802. Received 10 May 1982.

[2] Former research associate (presently assistant professor, Crop Science Dep., North Carolina State Univ., Raleigh NC 27650), and professor, Dep. of Agronomy, Louisiana Agric. Exp. Station, Baton Rouge, LA 70803.

availability of at least 20 self-fertilized seed. Twenty bracts, one per plant, were collected from each plot. The bracts were collected from the first, second, or third mature boll on the sympodial branches in the middle of the plant. Bract surface area was measured on a Hayashi Denko Area Meter, Model AAm-5[3] in centimeters^2. A random 25-boll sample was collected from each plot to determine boll weight, lint percent, and fiber properties.

Study Two

The second study consisted of a seven-parent diallel using the following lines or cultivars:

1. Mo Bw 51849
2. 'LSS' (Pak) M71-010
3. NCJ-9 (B-5) 23790-1796-1167-657
4. 4S-180 (Greece) - 1766-1149-636
5. La. DSIS 12513-245-1667-1015
6. Coker NF 73-809-060
7. La. 16ne 24-1-845-103-63-57

These lines ranged in bract surface area from 4.1 cm^2 for parent 1 to 8.7 cm^2 for parent 7.

Due to limited number of parents and the manner in which they were selected, this study does not constitute a random sample of all Upland cotton cultivars and breeding lines.

Diallel crosses were made at the Perkins Road Agronomy Farm in Baton Rouge, La., in the summer of 1977 and 1978 and in the greenhouse during the winter of 1978 and at Iguala, Mexico, during the winter of 1977. Reciprocal full sibs were bulked. The experiments were conducted at the Perkins Road Agronomy Farm in Baton Rouge and at the Dean Lee Agricultural Center in Alexandria, La., in 1978 and 1979. The soil types at Alexandria and Baton Rouge are Norwood silt loam (Typic Udifluvents) and Olivier silt loam (Aquic Fragiudalf), respectively.

The populations studied were the 21 F_1s and the 21 F_2s. The experiments were conducted in a randomized, complete block design with four replciations at each location with the exception of Baton Rouge in 1978 where data were obtained from three replications. Plots were single rows 5.5 or 6.0 m long and 1.0 m apart. Twenty-four hills, spaced approximately 0.5 m apart with two plants per hill, were planted in each plot. The plots were bordered on each end by 1.5 to 1.8 m of red-leaf cotton. The red-leaf plants used as borders and as fillers within plots were removed after maturity and prior to harvest. A minimum of one border row was planted on each side of the experiments at both locations.

Cultural practices regarding fertilization, cultivation, and pest control normally used for cotton production were performed at both locations.

Twenty-four bracts per plot, one per plant, were collected in the same manner as in Study One. A 24-boll sample was collected from each plot to determine boll and fiber properties which included 2.5% and 50% span length, uniformity ratio, T_1 fiber strength, fiber micronaire, lint percent, boll weight, and lint weight per boll. Plots at Alexandria were harvested 11 Dec. 1978, and 14 Nov. 1979. Plots at Baton Rouge were harvested twice each season with harvests made 13 Oct. and 9 Nov. 1978, and 15 Oct. and 12 Nov. in 1979. Earliness at Baton Rouge was calculated from the first harvest as a percentage of the total harvest.

Both genotypic and phenotypic correlations were calculated between bract surface area and the ratio of bract surface area/lint weight per boll with all variables studied in the F_1 and F_2 generations.

Standard correlation coefficient formula was used to calculate phenotypic correlations in Study One. Genotypic and phenotypic correlations were calculated using the formula as described by Griffing (6) in Study Two. Tests of significance for the phenotypic correlation coefficients were based on degrees of freedom using Fisher's (5) Table VA.

All effects were assumed fixed.

[3] Mention of a trademark or a proprietary product does not constitute a guarantee or warranty of the product by the Louisiana Agric. Exp. Stn. and does not imply its approval to the inclusion of other products that may also be suitable.

Table 1. Phenotypic correlations between the traits bract surface area and the ratio bract surface area/lint weight per boll and several agronomic traits in Study One.

Trait	Bract surface area	Bract surface area/ lint weight per boll
	r	
50% Span length	0.14	0.16
2.5% Span length	0.12	0.05
Micronaire	0.10	−0.27*
T_1 strength	0.06	0.33**
Lint %	0.20	−0.44**
Boll weight	0.54**	−0.23*

*,** Significantly different from zero at the 0.05 and 0.01 levels of probability, respectively.

RESULTS AND DISCUSSION

In Studies One and Two, bract surface area was not phenotypically associated with 50% span length (Table 1), and in Study Two, only one of eight genotypic correlation coefficients would indicate any type of linkage or pleiotropism (Table 2).

Five of eight phenotypic correlation coefficients between bract surface area and 2.5% span length were nonsignificant in Study Two. This correlation was also nonsignificant in Study One; however, all coefficients were positive. Genotypic correlations between these two traits in both generations in Study Two were positive and sufficiently high enough to indicate some type of association. Genotypically, a reduction in bract surface area may be associated with shorter fibers, a very undesirable relationship.

None of the phenotypic correlation coefficients between bract surface area and uniformity ratio were significant and only two of eight genotypic correlation coefficients were over 0.50 in Study Two, even though all coefficients were in a desirable negative direction. Length uniformity was not examined in Study One.

The phenotypic correlation coefficients between bract surface area and micronaire generally were nonsignificant in both studies, but a significant negative phenotypic correlation was found in one environment of Study Two, Alexandria—1979, and the genotypic correlation coefficients in both F_1 and F_2 at this environment also suggested a negative association. Micronaire is highly influenced by environment, which may explain why high correlation coefficients were found only at one environment.

Generally, T_1 strength appeared to be negatively correlated phenotypically with bract surface area in the F_1 and F_2 generations in Study Two. This is in contrast to the nonsignificant phenotypic correlation coefficient in Study One. In Study Two, two genotypic correlation coefficients could not be calculated in the F_2 generation due to a large experimental error; five of the remaining six genotypic correlation coefficients were negative and generally high. Except for the highly significant positive phenotypic and the high positive genotypic correlations in the F_2 generation at Baton Rouge in 1979, the data of Study Two suggested a negative relationship between bract surface area and fiber strength. The differences in results from Study One and Study Two may be explained on the basis of two genetically different populations. Since the association in the second

Table 2. Phenotypic and genotypic correlations between bract surface area and several fiber and agronomic traits in Study Two.

	F_1				F_2			
	Alexandria		Baton Rouge		Alexandria		Batron Rouge	
Trait	1978	1979	1978	1979	1978	1979	1978	1979
	r							
50% Span length	0.11†	0.04	−0.07	0.19	0.04	0.12	−0.11	0.11
	0.31	0.24	0.19	0.32	0.12	0.89	0.17	0.30
2.5% Span length	0.36	0.51*	0.31	0.42	0.52*	0.47*	0.19	0.33
	0.43	0.69	0.72	0.66	0.59	0.66	0.58	0.52
Uniformity ratio	−0.19	−0.31	−0.26	−0.08	−0.30	−0.28	−0.30	−0.19
	−0.20	−0.42	−0.19	−0.21	−0.88	−0.57	−0.38	−0.35
Micronaire	−0.23	−0.51*	−0.01	−0.08	−0.24	−0.27	−0.16	0.05
	−0.21	−0.74	0.17	−0.14	−0.36	−0.50	−0.06	0.18
T_1 strength	−0.57**	−0.57**	−0.28	−0.60**	−0.53*	−0.59**	−0.31	0.64**
	−0.91	−0.78	−0.39	−0.86	-‡	−0.81	-‡	0.87
Lint percent	0.36	0.01	0.31	0.23	0.44*	0.14	0.05	0.10
	0.43	0.06	0.37	0.28	0.58	0.22	0.15	0.13
Yield	0.31	−0.13	0.08	−0.05	0.35	0.26	0.16	0.12
	0.55	-‡	0.25	−0.09	0.47	-‡	0.83	-‡
Earliness	-§	-§	-§	0.01	-§	-§	0.11	−0.15
	--	--	--	−0.01	--	--	0.50	−0.21
Boll weight	0.50*	0.49*	0.63**	0.62**	0.53*	0.53*	0.48*	0.69**
	0.67	-‡	0.81	0.84	0.68	0.87	0.85	0.83
Lint weight per boll	0.51*	0.28	0.63**	0.53*	0.54**	0.43*	0.32	0.51*
	0.65	0.67	0.65	0.66	0.67	0.65	0.56	0.58

*,** Significantly different from zero at the 0.05 and 0.01 levels of probability, respectively.
† Upper figure = phenotypic correlation coefficient. Lower figure = genotypic correlation coefficient.
‡ Unable to calculate genotypic correlation coefficient due to large experimental error.
§ Data were not collected for this trait.

Table 3. Phenotypic and genotypic correlations between the ratio bract surface area/lint weight per boll and several fiber and agronomic traits in Study Two.

	F_1				F_2			
	Alexandria		Baton Rouge		Alexandria		Baton Rouge	
Trait	1978	1979	1978	1979	1978	1979	1978	1979
	r							
50% Span length	0.32†	0.17	0.23	0.47*	0.26	0.07	−0.54**	0.37
	0.57	0.90	0.07	0.99	0.50	-‡	−0.68	0.75
2.5% Span length	0.11	0.02	−0.13	0.18	0.27	0.12	−0.49*	0.19
	0.08	0.05	0.07	0.31	0.21	0.26	−0.50	0.31
Uniformity ratio	0.24	0.14	−0.23	0.41	0.07	−0.02	−0.40	0.27
	0.40	0.21	0.02	0.64	0.32	0.11	−0.15	0.53
Micronaire	−0.22	−0.28	−0.38	−0.03	−0.37	−0.42	−0.67**	−0.35
	−0.08	−0.78	−0.29	−0.04	−0.70	−0.76	−0.60	−0.44
T_1 Strength	0.47*	−0.23	−0.33	−0.07	0.19	0.03	−0.58**	0.11
	−0.01	−0.41	−0.32	−0.09	0.17	0.10	-‡	0.07
Lint %	−0.56**	−0.72**	−0.55**	−0.66**	−0.68**	−0.60**	−0.71**	−0.74**
	−0.70	−0.63	−0.68	−0.85	−0.77	−0.76	-‡	−0.82
Yield	0.04	−0.12	0.10	0.01	−0.25	−0.14	−0.01	−0.11
	0.32	--	0.05	0.67	−0.32	−0.16	−0.74	-‡
Earliness	-§	-§	-§	0.38	-§	-§	−0.32	−0.50*
	-	--	--	-‡	--	--	−0.75	−0.63

*,** Significantly different from zero at the 0.05 and 0.01 levels of probability, respectively.
† Upper figure = phenotypic correlation coefficient. Lower figure = genotypic correlation coefficient.
‡ Unable to calculate genotypic correlation coefficient due to large experimental error.
§ Data were not collected for this trait.

study is desirable and the lack of association in the first study is neutral, breeders will likely not encounter problems in this area.

A significant positive phenotypic correlation coefficient between bract surface area and lint percent occurred only in the second study at Alexandria in 1978; most of the other correlations in both studies, though positive, did not approach significance.

All phenotypic correlation coefficients between bract surface area and yield in the second study were nonsignificant. However, three of five genotypic correlations, all occurring in 1978, were positive and substantial suggesting a possible breeding problem. Three other genotypic correlation coefficients could not be calculated due to a large experimental error.

Not enough data were collected for earliness to make conclusive statements regarding any association of this trait with bract surface area.

Bract surface area was positively correlated, phenotypically, with properties of boll weight in both studies and lint weight per boll in the second study. The consistently large genotypic correlation values also would suggest an

association. Thus, a reduction in bract size resulted in a corresponding reduction in boll weight and lint weight per boll, both of which are undesirable associations with regard to the problem of bract trash in machine-harvested seedcotton. Such correlations suggest that one would not make progress in reducing the bract surface area relative to the boll.

The ratio of bract surface area/lint weight per boll may be a more accurate measure of heritable changes in bracts relative to bolls. This ratio would reflect centimeters^2 of bract area per gram of lint. A low ratio of bract area to lint weight per boll would denote a low bract trash potential and may denote a low byssinosis potential.

In Study Two, 8 of 15 correlation coefficients between bract surface area/lint weight per boll and 50% span length were either significant or greater than 0.50 (Table 3). The same phenotypic correlation coefficient in Study One was nonsignficant (Table 1). To generalize, there doesn't seem to be a phenotypic association between the two traits. But five of eight genotypic correlation coefficients were positive and greater than 0.50; this possible association may present a problem to the breeder.

The traits of 2.5% span length and uniformity ratio did not appear to be associated with the bract surface area/lint weight per boll ratio in either study.

Phenotypic correlations were in a negative direction between the ratio bract surface area/lint weight per boll and fiber micronaire in both studies with significance detected in each study. Genotypically, the correlation coefficients were large and negative in all environments of the F_2 generation and in one environment of the F_1 generation (Table 3). The data suggest that, at least in the segregating generations, a reduction in the bract surface area/lint weight per boll ratio may result in an increased fiber micronaire reading. This is not necessarily a desirable association.

There was a highly significant positive association between T_1 strength and the ratio of bract surface area/lint weight per boll in the first study (Table 1), but no consistent association was detected between the traits in the second study even though two phenotypic correlation coefficients were significant (Table 3).

Lint percent was negatively associated with the ratio bract surface area/lint weight per boll in both studies. One could interpret this to mean that a reduction in the ratio of bract surface area/lint weight per boll results in an increased lint percent, but a more plausible interpretation may be that, in order to reduce this ratio, lint percentage must increase.

Yield did not appear to be associated with the ratio of bract surface area/lint weight per boll in the second study (Table 3). Phenotypic coefficients were nonsignificant and the two high genotypic coefficients were of contrasting signs. There were insufficient data to draw definite conclusions regarding a possible association with earliness although the data tended to be pointed to a favorable association.

Selection only for bract surface area may yield little progress with bract trash potential in machine-harvested seedcotton. A better measure may be the ratio of bract surface area/lint weight per boll. A reduction in this ratio may result in or may be a result of a genotypic reduction in 50% span length, an increased fiber micronaire, and an increased lint percent. The undesirable association involves fiber length. The association involving fiber micronaire may or may not be an undesirable association, depending on location and breeding objectives. Some change in micronaire can be tolerated if it does not exceed the mill requirements; this would require careful selection of parents in the breeding program and constant awareness that this problem exists. The correlation with lint percent would suggest using parents with high lint percent, as well as parents with small bracts, in a breeding program with the objective to reduce the ratio of bract surface area/lint weight per boll.

ACKNOWLEDGMENT

The authors thank Dr. M. J. Lukefahr, Entomologist, USDA-ARS, Weslaco, TX 78596, for furnishing F_1 seed used in the first study. The authors appreciate the advice and suggestions on the data analyses given by K. L. Koonce. The authors acknowledge the assistance of Jude Brand, Gregg Marshall, Roy Vidrine, William Day, Danny Aguillard, Doug Traylor, Billy Kingery, and Salvador Martinez in collection of field data and of Wilbur Aguillard, Rita Graham, Henrietta Jones, Margie Hudson, and Gladys Carmona in the determination of fiber properties.

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