Hill, R. E., and Z. B. Mayo. 1974. Trap-corn to control corn rootworm. J. Econ. Entomol. 64:748-750.

Ortman, E. E., D. C. Peters, and P. J. Fitzgerald. 1968. Vertical-pull technique for evaluating tolerance of corn root systems to northern and western corn rootworms. J. Econ. Entomol. 61:373-375.

Owens, J. C., D. C. Peters, and A. R. Hallauer. 1974. Corn rootworm tolerance in maize. Environ. Entomol. 3:767-772.

Rogers, R. R.. W. A. Russell, and J. C. Owens. Expected gains from selection in maize for tolerance to corn rootworm. Environ. Entomol. (in press).

INFLUENCE OF LINT PERCENTAGE ON YIELD, BOLL, AND FIBER CHARACTERISTICS IN ACALA STRAINS OF UPLAND COTTON[1]

William T. W. Woodward and Norman R. Malm[2]

ABSTRACT

Yield, boll, and fiber characteristics were studied in low, intermediate, and high lint percentage groups of Acala strains of upland cotton (*Gossypium hirsutum* L.). Three genotypes were used to represent each group. The three groups did not differ significantly in yield of seed cotton or seed, but the high lint percentage group produced significantly more lint yield, lint/plant, lint/boll, lint/seed (lint index), and fiber elongation than did the low lint percentage group. The high lint percentage group produced significantly less seed/boll, seed cotton/boll, and five-lock bolls and smaller seed (seed index) than the low lint percentage group. Seed, lint, and seed cotton yield were highly correlated as were those three characters with bolls/m^2.

***Additional index words:* *Gossypium hirsutum* L., Phenotypic correlations, Fiber quality.**

IN a cotton (*Gossypium hirsutum* L.) breeding program designed to improve seed production, it is important to understand the relationships between yield, boll, and fiber characteristics. Negative associations would tend to prevent the simultaneous improvement of two traits, while positive associations would suggest that rapid progress could be made for both.

Lint percentage was highly correlated with yield in several previous studies (1, 4, 6, 8). Miller et al. (8) reported genetic correlations of 0.74, 0.79, and 0.87 between lint percentage and lint yield in three segregating populations. A genetic correlation of 0.84 was reported by Al-Jibouri et al. (1). Meredith and Bridge (4) found a genetic correlation of 0.70 for both an intermated population and a segregating F_3 population. In a similar study with populations produced by intercrossing, Miller and Rawlings (6) found a genetic correlation of 0.67. In recurrent selection programs, Miller and Rawlings (7) noted that lint percentage had a positively correlated response with selection for yield. Meredith and Bridge (5) reported significant increases in both lint percentage and yield as a result of three cycles of selection for lint percentage. Bridge et al. (2) compared obsolete and current cultivars of upland cotton and found a close association between yield and lint percentage.

Several studies have shown no correlation between lint yield and lint percentage. Singh et al. (9) studied advanced generation strains originating from seven diverse crosses and found no association between lint percentage and yield. Butany et al. (3) observed interrelationships between characters in material which evolved from within a segregating population and also found no significant correlation. Thomson (10) found no association between the two traits in F_1 material from a diallel cross of American and African cotton cultivars.

High lint percentage has been an important selection criterion for cotton breeders for many years in their attempts to achieve higher lint yield. The study reported here was made to determine phenotypic correlations between lint percentage and components of lint and seed yield. In addition, the possibility of simultaneously improving both lint and seed yield was studied.

MATERIALS AND METHODS

Nine strains of Acala type with a wide range of lint percentage were chosen. These were arbitrarily classified as high, intermediate, and low for lint percentage based on data from the previous year. All except 'Acala 1517-70' were strains from the breeding program with good yield potential and high quality fiber. Most of the strains were of exclusively Acala 1517 parentage. Non-Acala 1517 parentage involved in four strains was 'Pee Dee 2165,' 'Hopicala.' and K3131. Only one strain (Hopicala × 'Del Cerro 153') had no Acala 1517 parentage. Several of these strains have been used extensively as sources of Verticillium wilt tolerance, high quality fiber, and good plant type. Acala 1517-70 is an upland cultivar grown mostly in New Mexico, and the leading cultivar grown at this time.

Acid-delinted seed was used to plant four replications in a randomized, complete block design on 8 May 1973, at the Plant Science Farm near Las Cruces using 6.1-m single-row plots, with 96.5 cm between rows. Plants were thinned to 15-cm spacing. Two sample areas of 1 m^2 were used within each plot for yield, boll, and fiber determinations. The experiment was irrigated during the season, fertilized with 133 kg N/ha and 45 kg P/ha, and harvested by hand on 24 October and 23 November.

Lint percentage was determined by weighing the lint ginned from a sample of seed cotton and expressing it as a percentage. Seed cotton, lint, and seed yield were averaged for two sample areas in each plot and are reported in g/m^2. Lint/plant and number of seeds/plant were determined by dividing the material harvested in each sample area by the number of plants in m^2 area. Number of bolls/m^2 were recorded at harvest time to also obtain lint/boll, seed/boll, and seed cotton/boll in g.A 100-boll sample was counted in each plot before boll opening to determine the percentage of five-lock bolls. Seed index was measured as g/100 fuzzy seeds and lint index as g lint/100 seeds. Fiber length was measured as 50 and 2.5% span length on a digital fibrograph and expressed as mm. Uniformity index was calculated as the ratio of (50% span length/2.5% span length) × 100. Micronaire was measured and expressed in standard micronaire units. Fiber strength (T_1) is reported in millinewtons per tex (mN/tex), and elongation (E_1) in units as measured on a 3.2 mm gauge stelometer.

RESULTS AND DISCUSSION

As indicated in Table 1, the lint percentage groups averaged 39.0, 36.4, and 33.4 lint percentage, respectively. The data presented demonstrate that the lint percentage groups did not differ significantly in yield of seed cotton or seed, but the high lint percentage group produced significantly more lint per square

[1] Journal Article 562, New Mexico Agric. Exp. Stn., Las Cruces, NM 88003. Received 6 June 1975.

[2] Former graduate student (now graduate assistant, Oregon State Univ., Corvallis, OR 97330) and professor, respectively. Dep. of Agronomy, New Mexico State Univ., Las Cruces, NM 88003.

meter than did the low lint percentage group. Bridge et al. (2) also noted that cultivars exhibiting increased yield potential had higher lint percentages. The intermediate lint percentage group produced a numerically intermediate lint yield per unit area. but it was not significantly different from either the high or low lint percentage groups. Although the low lint percentage group yielded poorly as a group, Strain 2460 produced the most lint, seed, and seed cotton/m² of all entries. Yields were 153 g lint/m², 298 g seed/m², and 439 g seed cotton/m².

The high lint percentage group also produced significantly more lint per plant, lint per boll, and lint per seed (lint index) than the low lint percentage group. The low lint percentage group produced more seed and seed cotton per boll and more bolls with five locks than the high group, but it had fewer, though not significantly fewer, bolls per unit area. The low lint percentage group had a greater seed index than the high or intermediate lint percentage groups.

The mean lock size for the high, intermediate, and low lint percentage groups was 0.48, 0.46, and 0.43 g of lint, respectively. In terms of seeds per lock, the values were 0.75, 0.80, and 0.85 g, respectively. The only significant difference in fiber properties was the greater fiber elongation value for the high lint percentage group.

Phenotypic correlations among 15 selected characters are shown in Table 2. Some caution should be exercised in the genetic interpretation of these correlations since they include an environmental as well as a genotypic component. In the materials used in this study, there were no significant negative associations between seed yield and any of the other characters studied. A strong positive correlation was found between seed and lint yield (0.86**, 7 df). These results suggest that lint and seed yield can be improved concurrently without detrimental effects on fiber of other characters in the material studied. One significant negative correlation was found with lint percentage, g seed/boll (—0.76*), indicating that selection for high lint percentage will result in lower seed weight/boll.

The method of breeding for higher lint and seed yield at the same time appears more effective if greater selection pressure were placed on bolls/m² rather than on lint percentage. Lint percentage was significantly correlated with only lint yield/m² (0.69*), but not with seed or seed cotton yield/m². The yield-components most strongly correlated with lint yield were g lint/plant (0.96**), g seed/plant (0.89**), and bolls/m² (0.95**). Seed yield was most strongly correlated with g lint/plant (0.74*), g seed/plant (0.95**), and bolls/m² (0.93**). The most effective selection tool to indirectly increase yield appears to be bolls/m² since the correlations with lint, seed, and seed cotton yield were 0.95**, 0.93**, and 0.97**, respectively.

Significant positive correlations of yield-components with fiber characters were all associated with 2.5% span length. These were seed index (0.86**), g seed/boll (0.72*), and g seed cotton/boll (0.68*).

In summation, it appears that the best ways to indirectly increase seed yield in this material are to select for seed cotton yield (0.97**), lint yield (0.86**), lint/plant (0.74*), seed/plant (0.95**), and bolls/m² (0.93**). The best way to indirectly increase lint, seed, and seed cotton yield simultaneously is to select for bolls/m² (0.95**, 0.93**, and 0.97**, respectively).

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

Table 1. Yield, boll, and fiber character means for lint percentage groups.

Character	Lint percentage group: High	Intermediate	Low
Lint percentage	39.0 a*	36.4 b	33.4 c
Lint yield, g/m²	132 a	117 ab	106 b
Seed yield, g/m²	209 a	209 a	213 a
Seed cotton yield, g/m²	340 a	326 a	315 a
Lint/plant, g	20.9 a	17.7 ab	15.9 b
Seed/plant, g	33.1 a	31.6 a	32.2 a
Lint/boll, g	2.1 a	2.1 a	1.9 b
Seed/boll, g	3.3 c	3.6 b	3.9 a
Seed cotton/boll, g	5.4 b	5.7 a	5.8 a
Bolls/m²	67 a	61 a	58 a
5-lock bolls, %	45.2 b	54.3 a	57.7 a
Lint index, g/100 seeds	7.9 a	7.0 b	6.4 c
Seed index, g/100 seeds	12.5 b	12.5 b	13.0 a
2.5% Span length, mm	30.0 a	30.2 a	30.7 a
Uniformity index, %	47.8 a	47.3 a	46.5 a
Micronaire, units	4.0 a	3.9 a	4.1 a
Fiber strength, mN/tex	246 a	247 a	251 a
Fiber elongation, units	6.8 a	5.8 b	5.4 b

* Means within a row followed by a different letter are significantly different at the 0.05 protection level by Duncan's multiple range test.

Table 2. Phenotypic correlation coefficients measuring associations between selected yield, boll, and fiber characters.

Character	Lint yield	Seed yield	Seed cotton yield	Lint/ plant	Seed/ plant	Lint/ boll	Seed/ boll	Seed cotton/ boll	Bolls/ m²	Lint index	Seed index	2.5% span	Micronaire	Strength
Lint percentage	0.69*	0.23	0.45	0.74*	0.31	0.60	−0.76*	−0.45	0.50	0.94**	−0.43	−0.60	−0.11	−0.34
Lint yield, g/m²		0.86**	0.96**	0.96**	0.89**	0.39	−0.39	−0.25	0.95**	0.56	−0.33	−0.46	−0.18	−0.34
Seed yield, g/m²			0.97**	0.74*	0.95**	0.09	−0.01	−0.06	0.93**	0.09	−0.18	0.23	−0.14	−0.29
Seed cotton yield, g/m²				0.87**	0.96**	0.24	−0.19	−0.15	0.97**	0.31	−0.26	−0.35	−0.18	−0.32
Lint/plant, g					0.86**	0.43	−0.45	−0.28	0.87**	0.64	−0.34	−0.43	−0.20	−0.22
Seed/plant, g						0.15	−0.08	−0.08	0.92**	0.19	−0.19	−0.21	−0.18	−0.14
Lint/boll, g							0.02	0.43	0.12	0.80**	0.39	0.04	−0.55	−0.06
Seed/boll, g								0.90**	−0.36	−0.56	0.79*	0.72*	−0.18	0.37
Seed cotton/boll, g									−0.35	−0.17	0.89**	0.68*	−0.39	0.35
Bolls/m²										0.32	−0.41	−0.47	−0.11	−0.33
Lint index, g/100 seed											−0.10	−0.33	−0.25	−0.16
Seed index, g/100 seed												0.86**	−0.45	0.46
2.5% Span length, mm													−0.25	0.56
Micronaire, units														0.07

*,** Significant at the 0.05 and 0.01 levels (7 df) of probability, respectively.

REFERENCES

1. Al-Jibouri, H. A., P. A. Miller, and H. F. Robinson. 1958. Genotypic and environmental variances and convariances in an upland cotton cross of interspecific origin. Agron. J. 50:633-636.
2. Bridge, R. R., W. R. Meredith, Jr., and J. F. Chism. 1971. Comparative performance of obsolete varieties and current varieties of upland cotton. Crop Sci. 11:29-32.
3. Butany, W. T., M. Singh, and R. B. Mehra. 1966. Interrelationships between some characters in *hirsutum* cotton. Indian J. Genet. 26:262-268.
4. Meredith, W. R., Jr., and R. R. Bridge. 1971. Breakup of linkage blocks in cotton, *Gossypium hirsutum* L. Crop Sci. 11:695-698.
5. ———, and ———. 1973. Recurrent selection for lint percent within a cultivar of cotton (*Gossypium hirsutum* L.). Crop Sci. 13:698-701.
6. Miller, P. A., and J. O. Rawlings. 1967a. Breakup of initial linkage blocks through intermating in a cotton breeding population. Crop Sci. 7:199-204.
7. ———, and ———. 1967b. Selection for increased lint yield and correlated responses in upland cotton, *Gossypium hirsutum* L. Crop Sci. 7:637-640.
8. ———, J. C. Williams, Jr., H. F. Robinson, and R. E. Comstock. 1958. Estimates of genotypic and environmental variances and covariances in upland cotton and their implications in selection. Agron. J. 50:126-131.
9. Singh, R. B., M. P. Gupta, B. R. Mor, and D. K. Jain. 1968. Variability and correlation studies on yield and quality characters in *hirsutum* cotton. Indian J. Genet. 28:216-222.
10. Thomson, N. J. 1971. Heterosis and combining ability of American and African cotton cultivars in a low latitude under high-yield conditions. Aust. J. Agric. Res. 22:759-770.

RELATION OF FLAG SMUT INCIDENCE TO SPIKE TYPE IN WHEAT ISOLINES[1]

R. E. Allan and J. A. Pritchett[2]

ABSTRACT

Incidence of flag smut [*Urocystis agropyri* (Preuss) Schroet.] was indirectly related to the club spike trait in F_6 and F_7 isolines of the population 'Suwon 92'/8* 'Omar' (*Triticum aestivum* L. em Thell.). Paired comparisons between isolines showed that the club types averaged 3.0 and 12.2% more smut than lax types at two different field sites in 1971. The club sib was equal to or more heavily smutted than the lax sib in 31 of the 40 comparisons. The club lines averaged 10.5% more smut than their lax sibs in a replicated test in 1973. The relationship between the *C* allele and increased severity of flag smut appeared to be indirect, since no linkage or pleiotropism was detected between the two characteristics from observations on two crosses. In addition, percentage of flag smut was not significantly different between the two spike types at one site. The *C* allele reduces rates of seedling growth and emergence, and delayed emergence may increase the opportunity for the wheat seedling to become infected by the pathogen. Club genotypes can potentially suffer greater losses from flag smut than lax genotypes. In the development of club cultivars, breeders should especially emphasize high, stable flag smut resistance.

Additional index words: **Genetic background, Compactum gene, Plant growth rate, Correlated response, Disease loss, *Triticum aestivum* L. em Thell., *Urocystis agropyri* (Preuss) Schroet.**

EACH year, flag smut [*Urocystis agropyri* (Preuss) Schroet.] damages soft-white club winter wheat (*Triticum aestivum* L. em Thell.) cultivars 'Omar' (CI 13072) and 'Paha' (CI 14485) in Klickitat County, Wash., and Wasco County, Ore., according to the records and observations of C. J. Peterson and R. F. Line (unpublished). No old or new club cultivars grown in the Pacific Northwest have high flag smut resistance. Allan (1) used wheat isolines and found that the semidwarf trait indirectly increased susceptibility to flag smut. He suggested that the delayed emergence typical of semidwarf wheats probably offered increased opportunity for infection to occur by the pathogen. The club or *C* gene also reduces rate of emergence (2), and delays seedling growth (3). The club trait is reported to be controlled by a single gene located on chromosome 2D (7). Since flag smut is particularly damaging to club cultivars, the objective of this study was to establish and describe the relationship between presence or absence of the *C* allele to severity of flag smut infection, by use of wheat isolines.

MATERIALS AND METHODS

The host test material consisted of 20 paired club and lax F_6 isolines and 19 lax and 19 club F_7 isolines of the population 'Suwon 92'/8* Omar. The lax spike allele was contributed by Suwon 92 (CI 12666) and the club spike allele by Omar. Trials were conducted at one or two sites near Bickleton, Wash., during 1971, 1972, and 1973. The wheat was sown 7 to 9 cm deep in early September with a semi-automatic planter. About 8 g seed were sown in a row 1.5 m long. The 1971 tests consisted of a single replication of paired club and lax F_6 isolines derived from F_4 lines that were heterozygous at the *C* locus. Members of each pair were sown in adjacent rows at each site. The 1973 test consisted of 19 lax and club F_7 isolines, derived from F_6 lines used in the 1971 study, sown in a randomized, complete block design of five replications at one site. Between 195 and 210 F_3 lines of two crosses with club flag smut susceptible and lax flag smut resistant parents were grown in field tests in 1972, to ascertain the genetic relationship between spike type and flag smut reaction. To record the percentage of smut 7 to 14 days after anthesis, we counted smutted and nonsmutted tillers per row. Smutted tillers were expressed as a percentage of total tillers, and the values were transformed into angles (arcsin $\sqrt{\%}$) (6) before analysis.

RESULTS AND DISCUSSION

The paired F_6 club isolines had 3.0 (29.8 vs. 32.8%) and 12.2% (36.5 vs. 48.7%) more smutted tillers than their lax sib lines in 1971 (Table 1). The difference was not significant at site 1, however. The percentage of smutted tillers of the lax and club lines overlapped, but club types produced the highest levels of smut. The ranges in percentage of smut for lax and club lines were 19 to 45 and 17 to 54 (Site 1), and 20 to 52 and 35 to 65 (Site 2), respectively. The club member of the pair had more flag smut in 10 and 18 of 20 comparisons for sites 1 and 2, respectively (Table 1).

The difference in severity of smut between F_7 isolines of the two spike types was highly significant in 1973 ($F = 89.7$, $P < 0.01$), with the lax lines averaging 44.2 vs. 54.7% smutted tillers for club types (Table 2). The incidence of smut for the two spike types overlapped slightly, with ranges of 33 to 50% and 47 to 58% for lax and club isolines, respectively. The range in smutted tillers for individual lax lines generally was greater than that of club lines (Table 2). The difference in spread between low and high values for the

[1] Cooperative investigations of the ARS-USDA, and College of Agriculture Research Center, Washington State Univ., Pullman, WA 99163. Scientific Paper No. 4378, Project 1467. Received 21 Apr. 1976.

[2] Geneticist and agricultural research technician, respectively, ARS-USDA, Pullman, WA 99163.