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Year Effects on Partitioning of Dry Matter into Cotton Boll Components[1]

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ABSTRACT

The distribution of dry weight in cotton boll walls, seeds, and fibers was investigated through the boll developmental period for one flowering date each year in 1979 and 1980. Previous experiments on patterns of fiber development encountered large environmental variation, so this experiment with four diverse cottons was undertaken to measure the effect of years on dry weight distribution into boll components. There was a large difference between years in temperature and moisture, with 1980 being hot and dry. Associated with differences in weather between the years was a large difference in dry weight distribution and boll development. In 1980, cotton matured in 88% of the time, individual boll dry weight was reduced 25%, boll wall dry weight per boll was reduced 17%, seed dry weight per boll was reduced 15%, and fiber dry weight per boll was reduced 41% compared to 1979. In addition, bolls developed in 1980 had fewer but larger seeds and fewer but larger fibers than in 1979. Total lint yield was reduced only 7% in 1980 vs. 1979, so more bolls were produced in 1980. At the individual boll level, the differences between years had the greatest effect on fiber dry weight. The effect on fiber dry weight per boll demonstrated the vulnerability of fiber development to environmental variation.

Additional index words: **Fiber, Seed, Boll wall, Boll development, Environmental effects.**

COTTON (*Gossypium* spp.) is grown for the production of fibers on its seed that are used as a major raw material for the spinning and weaving industries of the world. The physical properties of these fibers determine both the speed and efficiency with which they can be processed and the end uses of the fabrics produced. Physical properties of cotton fibers vary among the cultivated species and among cultivars within the species. Studies of the mature cotton fiber have resulted in the description of certain of its physical properties and development of instrumentation for measurement of fiber quality for use in genetic improvement programs and processing industries (Mayne, 1966).

The economic importance of cotton fibers stimulated investigations of their development and chemical composition (Balls, 1915, 1928; Benedict et al., 1973; Berlin and Ramsey, 1970; Delmar et al., 1977; Hawkins and Serviss, 1930; Lang, 1938; Morris, 1962; O'Kelly and Carr, 1953; Schubert et al., 1973). Many studies of fiber development were concerned with environmental events that occur during development and how they influence the harvested fiber (Gibson and Joham, 1968a, b; Gipson and Ray, 1969, 1970; Hesketh and Low, 1968; Leffler, 1976; Turner et al., 1979). However, little is known about the precise developmental events that produce desirable fiber properties.

We began experiments to investigate fiber development in cotton growing in the field, to determine the developmental patterns of cottons with differing fiber properties, and to identify those unique developmental events that relate to inherent differences in fiber properties (Kohel and Benedict, unpublished; Schubert et al., 1973). We found that while we could clearly describe the general patterns of fiber development, we could not identify the subtle variations in development that resulted in the unique differences of the mature fibers. Detection of these differences was prevented by the large environmental variation. We concluded that a greater understanding of the partitioning of dry matter into the major components of the boll might provide better insight and guidance into understanding the problems associated with studies of cotton fiber development. This paper reports the results of a study designed to measure year effects on dry weight distribution in developing bolls of cotton (*Gossypium hirsutum* L.).

MATERIALS AND METHODS

We selected four cottons to provide a range in boll and fiber types. 'Stoneville 213' was selected because it had relatively small bolls and seed, medium fiber length with good fiber properties, and full-season maturity. 'Acala 1517–70' was selected because it had relatively large bolls and seeds, long fiber length for an Upland cotton with excellent fiber properties, and relatively late maturity at College Station. The two other entries 'Tamcot SP-37' and DSR 1X4–27–66, an experimental strain developed by G. A. Niles, Texas Agricultural Experiment Station, had medium sized bolls and seed and early maturity. Tamcot SP-37 differed from DSR 1X4–27–66 in that it had medium fiber length with a lower micronaire value, whereas DSR 1X4–27–66 had short fiber length, low lint percentage, and the earliest maturity of the four entries.

Routine cultural practices, which included pest control practices, were followed to provide full performance potential. In 1979 the season was wet and warm and no irrigation was required. The 1980 season was dry and hot and required frequent irrigation. The two seasons represented the extremes of temperature and moisture usually encountered at College Station.

The four entires were grown in plots consisting of 13 and 16 rows (7.5 × 1.0 m) in 1979 and 1980, respectively, and replicated four times. Test site was at the TAMU-TAES Brazos River Farm on a Ships, clay (very-fine, mixed, thermic Udic Chromusterts) soil. When all entries had begun to bloom rapidly, set bolls were removed from 10 rows of each plot to remove the effects of substrate competition within each plant, and enough flowers were tagged on one day to provide bolls for sampling throughout the developmental period. Flowers were tagged 16 July 1979 and 8 July 1980. In 1979 bolls were sampled twice a week. In 1980 bolls were sampled weekly after the first 2 weeks. Three bolls were sampled per entry per replication, except that five bolls were sampled for the first 2 weeks. Only undamaged bolls with four locules were sampled. Boll samples were separated into wall, seed, and fiber components. Both the fuzz and fiber cells were removed together from

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Table 1. Dry weight of components at weekly intervals during cotton boll development and average temperature for week prior to measurement in 1979 and 1980.

Days from anthesis	Wall per boll 1979	Wall per boll 1980	Seed per boll 1979	Seed per boll 1980	Seed per seed 1979	Seed per seed 1980	Fiber per boll 1979	Fiber per boll 1980	Fiber per seed 1979	Fiber per seed 1980	Maximum daily 1979	Maximum daily 1980	Minimum daily 1979	Minimum daily 1980
	g				mg		g		mg		C			
0	0.04	0.03	0.01	0.01	0.3	0.2	0.00	0.00	0.0	0.0	33	38	23	24
7	0.38	0.36	0.08	0.11	2.5	5.2	0.06	0.05	2.1	2.5	33	38	23	24
14	1.12	1.06	0.61	0.81	24.3	38.3	0.24	0.24	8.5	11.9	31	38	23	24
21	1.48	1.42	1.07	1.37	39.4	67.7	0.90	1.06	34.0	52.2	33	37	23	24
28	1.45	1.38	1.35	1.77	52.5	83.2	1.61	1.52	62.6	71.5	32	37	22	23
35	1.56	1.41	1.92	2.19	68.0	106.6	2.36	1.75	83.8	86.1	33	35	22	24
42	1.49	1.40	2.25	2.65	81.4	118.1	2.73	1.49	95.9	65.7	33	36	21	24
49	1.20	1.13	2.45	2.30	91.0	107.7	2.30	1.39	85.0	65.0	33	39	22	23
56	1.39		2.70		96.6		2.35		82.4		32		21	

Table 2. Yield, agronomic traits, and number of seeds per boll of mature cotton harvested in 1979 and 1980.†

Year	Lint yield‡	Seed cotton per boll§	Lint percentage§	Seed index§	Fiber length§ 2.5% span length	Fiber length§ 50% span length	Fiber strength§	Micronaire value§	Seed¶
	kg/ha	g	%	g	mm		kN.m/kg		no.
1979	1471 ± 238	4.76 ± 0.15	39.28 ± 0.71	8.19 ± 0.18	25.9 ± 0.00	12.4 ± 0.00	180.0 ± 0.39	4.38 ± 0.005	29.06 ± 0.72
1980	1363 ± 119	3.20 ± 0.30	35.12 ± 0.59	10.23 ± 0.21	27.9 ± 0.05	12.9 ± 0.02	199.8 ± 1.76	4.42 ± 0.003	21.39 ± 0.59

† Analysis of variance showed significant difference among entries for all characters, significant difference between years except for micronaire value and total seed cotton, and no year by entry interaction except for micronaire value, lint percentage and seed cotton per boll.
‡ Lint yield estimated from seed cotton harvested from plot at maturity.
§ Determined from a 25 boll sample.
¶ Determined from mature bolls sampled in developmental measurements.

Table 3. Growth rates, mature dry weights, and duration of linear grow phases of cotton boll components in 1979 and 1980.

Component	Rate during linear growth phase 79	Rate during linear growth phase 80	Rate for entire developmental period 79	Rate for entire developmental period 80	Weight at maturity 79	Weight at maturity 80	Linear growth phase 79	Linear growth phase 80
	mg/day				g		days post anthesis	
Wall per boll	76.8 ± 5.5	72.2 ± 6.4	24.8	23.2	1.39 ± 0.052	1.13 ± 0.074	0-21	0-21
Seed per boll	63.1 ± 2.5	70.4 ± 3.8	48.2	46.9	2.70 ± 0.118	2.30 ± 0.206	6-46	4-37
Avg per seed	2.1 ± 0.1	3.5 ± 0.3	1.7	2.2	0.10 ± 0.003	0.11 ± 0.007	4-45	5-36
Fiber per boll	104.6 ± 5.7	91.9 ± 14.8	42.0	28.3	2.35 ± 0.079	1.39 ± 0.092	14-37	13-28
Avg fiber per seed	3.7 ± 0.2	3.4 ± 0.6	1.5	1.3	0.08 ± 0.003	0.06 ± 0.002	13-38	11-34

the fresh sample with forceps (Gipson and Joham, 1968a, b; Benedict et al., 1973). The number of seeds per boll were recorded, and the components were oven-dried and weighed. The dry weights were expressed as the mean per boll and per seed. The developmental time was expressed as days after anthesis.

The rows not included in the boll sampling procedure, three in 1979 and six in 1980, were harvested at maturity. The center one row in 1979 and two rows in 1980 were harvested for total yield. At the same time a 25 boll sample was taken to determine boll size, seed size, lint percentage, and fiber properties.

In general, the dry weight of the boll components follow a sigmoidal curve over time. Linear regression was used to estimate the rate of dry weight change during the phase of rapid linear increase. Linear regression was also used to represent the beginning and final phase of the developmental period. The interception of these regression lines with the rapid linear phase was used to estimate the beginning and end of the rapid linear phase of development.

RESULTS

The greatest impact on these investigations was the effect of years. The mean total dry weight per boll was 6.44 g in 1979 compared to 4.82 g in 1980. The period of boll maturation was 56 vs. 49 days in 1979 and 1980 (Table 1). Total yield of lint was 1471 and 1363 kg/ha in 1979 and 1980, respectively (Table 2). Thus, in 1980 cotton bolls matured in 88% of the time, total boll dry weight was 75% of the size, and lint yield was still 93% of that in 1979.

These summary data indicate the magnitude of the effect of the environment between the 2 years, and they are consistent with observations on the effects of temperature (Gipson and Joham, 1968a, b; Gipson and Ray, 1969, 1970; Hesketh and Low, 1968). In some cases there were significant differences in entry and entry × date effects within each year and these will be discussed in a separate report. In this paper we will concentrate on how year differences influenced partitioning into the components of the boll.

Boll Wall

Boll wall development was similar in both years (Table 1). The rate of change was greater, but not significantly so, in 1979 during the linear phase of development and over the entire developmental period (Table 3). The boll wall began its rapid linear growth from the day of anthesis, and this linear phase was estimated to end at 21 days. The larger boll wall weight in 1979 can be attributed to the slightly greater rate of development during the linear phase and the continued slow development beyond the rapid linear phase. Differences in boll wall dry weight were not as great as those of the total boll. In 1980 total boll dry weight was reduced 25% and boll wall weight was reduced only 17% as compared to 1979.

Seed

The amount of dry matter partitioned into seed per boll was reduced 15% in 1980 compared to 1979 (Table 1). The rate of dry weight increase during the rapid linear phase of development was significantly greater in 1980, and this linear phase began at day 4 vs. day 6 in 1980 and 1979, respectively (Table 3). The major difference was that the linear phase ended earlier in 1980 compared to 1979, day 37 vs. 46, respectively.

A similar pattern existed for the dry weight of individual seeds (Table 1). In 1980 26% fewer seed were set per boll (Table 2), so although less dry matter was distributed to seed per boll, fewer but larger seed were produced in 1980 than in 1979. The rate of increase in seed weight during the linear phase was 66% greater per seed and 11% greater per boll in 1980 than in 1979 (Table 3).

Fiber

The greatest difference between years in the partitioning of dry weight in the boll was expressed in fiber development (Table 1). Partitioning of dry weight into fiber on a per boll or per seed basis was similar for the linear phase. The rapid linear phase began at about the same time and the rates of dry weight increase were not significantly different (Table 3). However, the rapid linear phase stopped much earlier in 1980 than in 1979. Fiber dry weight per boll decreased 41% in 1980, and this decrease was the greatest of any boll component. The reduction in fiber dry weight was reflected in the agronomic properties of reduced seed cotton per boll and a lower lint percentage (Table 2).

DISCUSSION

The study of dry weight partitioning during boll development in 1979 and 1980 demonstrates that fiber was the most sensitive boll component in its response to the environment. Dry weight partitioning into the individual boll components of wall, seed, and fiber was 22, 42, and 36% in 1979 and 23, 48, and 29% in 1980, respectively. This response would indicate that studies of fiber development would be subject to intraseasonal environmental variation, and that, in field evaluations of fiber development, it would be difficult to detect small differences that might be reflected in mature fiber physical properties.

The results of this study were consistent with previous studies of the effects of temperature on the development of cotton bolls and its components, but an important observation from the current study is that fewer seeds were developed per boll in 1980 than 1979. We had no direct measure of the number of fibers formed per seed; however, mature fiber properties do provide an estimate of relative fiber numbers. The physical properties of mature fibers in 1980 (Table 2) show that the fibers were longer and stronger. Therefore, in 1980, less total fiber dry weight and more dry weight per fiber would mean that fewer fibers were formed per seed. The effect of the 1980 environment, compared to 1979, was to decrease the number of seed per boll and fiber per seed that developed, increase the rate of dry weight accumulation in seed, decrease the rate of dry weight accumulation in fibers, and reduce the length of the developmental period.

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