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Influence of Night Temperature on Growth and Development of Cotton (*Gossypium hirsutum* L.). III. Fiber Elongation.[1]

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ABSTRACT

Four different night temperature regimes were maintained on two varieties of field-grown cotton *Gossypium hirsutum* L., during the 1964 and 1965 seasons. Elongation of fiber was found to be closely associated with both temperature and variety. As night temperature was lowered, fiber elongation rates decreased and fiber elongation periods increased for both varieties. Rate of elongation was not uniform over the entire elongation period, but was dependent upon fiber age and night temperature. Temperature coefficients of elongation decreased with increased fiber age and night temperature. Thus, the initial stages of fiber elongation were highly temperature dependent, while the latter stages tended to become temperature independent.

Additional index words: **Field growth chambers, Fiber growth rates, Temperature coefficients.**

COTTON (*Gossypium hirsutum* L.) fibers are single-celled outgrowths of epidermal cells of the seed. They originate at the time of, or very soon after, anthesis (1, 3). The fiber cell develops in two distinct phases. An initial period of cell elongation is followed by a period of secondary wall formation. Mature cotton fibers contain both a primary and a secondary wall. The primary wall is formed first and eventually constitutes a thin sheath on the outer surface of the mature fiber. Only the primary wall is present during the period of elongation[3] (1, 3, 5). Limited information is available which indicates a definite relationship exists between temperature and fiber elongation. In 1930 Hawkins and Serviss (3) reported that temperatures below the optimum for plant growth retarded fiber elongation. O'Kelly and Carr (7) found that decreasing the temperature from 21.8 to 14.7 C slowed fiber elongation. They obtained a Q_{10} of 63.3 for fiber elongation between 14.7 and 21.8 C. They attributed the high Q_{10} value to the fact that the lower temperature was very close to the minimum temperature required for fiber elongation. Hessler, Lane, and Young (4), working at Lubbock, Texas, noted that fiber length decreased as the season progressed, indicating a temperature deficiency for elongation. In Uganda, Morris (6) found the time required for fiber cells to attain maximum length varied only slightly from season to season, despite marked differences in rainfall and temperature. He did note, however, that the maximum length obtained was reduced under the cool temperatures. Stockton and Walhood (8), in a study of boll temperatures, found that as boll temperature increased above 32 C, fiber length was reduced.

There are indications that the rate of elongation may undergo a sudden decline for 2 to 3 days during some stage of the elongation period, followed by a subsequent resumption of the normal rate of elongation. This phenomenon was first observed by Hawkins and Serviss (3) in 1930 They noted that the rate of lint hair elongation suffered a temporary reduction between 9 and 15 days after anthesis in Pima and between 9 and 12 days in Acala. More recently, Morris (6) observed the same effect between 18 and 21 days after anthesis in three different cotton lines grown in Uganda. He suggests the reductions are associated with biochemical changes taking place in the lint hairs and seed at the time when secondary thickening of the fiber is initiated.

We are reporting a study undertaken to determine the influence of night temperatures on the rate and extent of fiber elongation.

EXPERIMENTAL PROCEDURE

Four night temperature regimes were maintained on field grown cotton during the 1964 and 1965 seasons. Night temperatures were controlled by use of polyethylene-covered growth chambers. The chambers had hinged tops which could be folded open during the day to expose the plants to the ambient environment. The chambers and experimental design have been previously described (2).

The night temperatures in the present work were 12.8, 15.5, 21.1, and 26.6 C in 1964; and 10.0, 15.0, 21.7, and 27.2 C in 1965. Temperature treatments were begun at first bloom, which occurred on July 22 in 1964 and July 10 in 1965, and continued until frost. 'Acala 1517 BR-1' and 'Paymaster 101-A' varieties were used in 1964, but in 1965 'Acala 1517 BR-2' was substituted for Acala 1517 BR-1.

The effect of temperature on fiber elongation was evaluated by means of length determinations made on fiber from bolls of various ages. Bolls were harvested at 5-day intervals until

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[3] Anderson, D. B. 1937. The primary wall of the cotton fiber. Abstract for program of North Carolina Academy of Science, May 7.

length became constant. Fiber length was determined as follows: A lock from a boll was placed in a beaker of boiling water for 2 to 3 minutes (for bolls 20 days old or older 2.5% HCl was used) to dissolve simple sugars and allow the seed with attached fiber to float free. The seed were then floated out on the convex side of a watchglass, the fiber made to stream out with a jet of water and length (cm) measured with a ruler (6). All measurements were made from the rounded side of the immature seed. Fiber of five to six seed per boll from four different bolls was measured and averaged for each determination.

RESULTS AND DISCUSSION

Fiber elongation varied with night temperature, variety, and season. The effect of temperature on elongation periods (number of days required to attain maximum length) of fiber and elongation rate for both varieties and seasons is illustrated in Fig. 1. In both varieties for both years, boll periods (the number of days from open bloom to open boll) decreased as night temperature increased. Boll periods were considerably shorter for Paymasted than for Acala in both seasons. Although differences in elongation periods between the two varieties were evident at all temperature levels, the greatest difference was associated with the lowest temperature level each season.

Elongation rates for different fiber age intervals for the two varieties in 1964 are shown in Table 1. Some definite trends are evident with rates varying according to temperature, variety, and boll age. In general, within a given age group, rate of fiber elongation of both varieties increased as night temperatures were raised. From 0-5 days after anthesis, little or no elongation occurred, depending on temperature. Between 5 and 10 days after anthesis, the rate of growth increased rapidly at the two higher temperatures, reaching a maximum between 10 and 15 days after anthesis. At the two low temperatures, elongation rates were very slow up to 10 days after anthesis. Maximum rate of growth was not attained until the 15- to 20-day period. Even then, the maximum rate attained at 12.8 C was considerably less than the rate at the three higher temperatures.

Table 1. The effect of night temperature on rate of Acala and Paymaster fiber elongation in 1964.

Days from bloom	Temperature, ° C: 12.8		15.5		21.1		26.6	
	A*	P	A	P	A	P	A	P
	mm/day							
0-5	0.0	0.0	0.0	0.0	0.2	0.2	0.4	0.4
5-10	0.2	0.2	0.6	0.4	1.2	1.0	1.4	1.2
10-15	1.0	1.0	1.4	1.2	2.4	2.0	2.4	1.8
15-20	1.6	1.6	2.2	2.4	1.0	0.8	0.8	1.0
20-25	1.2	0.6	0.8	0.2	0.4	0.2	0.2	
25-30	0.4	0.5						

* A = Acala. P = Paymaster.

Table 2. The effect of night temperature on rate of Acala and Paymaster fiber elongation in 1965.

Days from bloom	Temperature, ° C: 10.0		15.0		21.7		27.2	
	A*	P	A	P	A	P	A	P
	mm/day							
0-5	0.0	0.0	0.2	0.1	0.3	0.3	0.5	0.5
5-10	0.8	0.6	0.8	0.7	1.3	1.3	1.5	1.5
10-15	1.0	1.0	1.4	1.4	1.8	1.4	1.8	1.4
15-20	1.0	1.2	1.2	1.4	1.0	1.4	1.2	1.0
20-25	0.8	1.2	1.0	0.8			0.4	
25-30	0.6	0.4	0.8					
30-35	0.6							

* A = Acala. P = Paymaster.

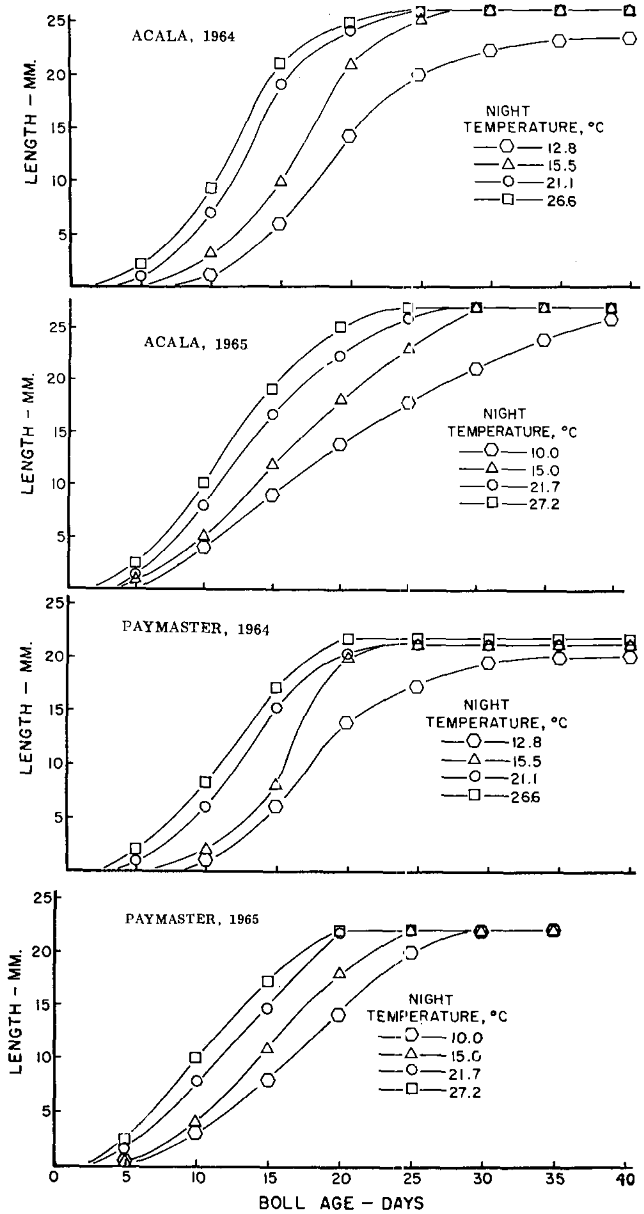

Fig. 1. The influence of night temperature on fiber elongation of Acala and Paymaster varieties, 1964 and 1965.

Elongation rates for the different fiber age intervals for 1965 are shown in Table 2. A comparison of the data in Table 1 and Table 2 reveals similar trends, although some differences are evident. In the early part of the boll period (0 to 10 days), elongation rates were higher in 1965 than in 1964. In 1965 the elongation rates at the two lower temperatures appeared to be essentially the same for the 10- to 15- and 15-to 20-day intervals, whereas, in 1964 elongation was much faster at the 15 to 20-day interval as compared to the 10 to 15-day interval for those temperatures. Maximum rates of elongation in 1965 were not as great as those obtained in 1964.

It is of interest to note that rate of elongation was not uniform over the entire elongation period. Rather, the rate of growth appeared to be dependent upon variety, fiber age and night temperature. Moreover,

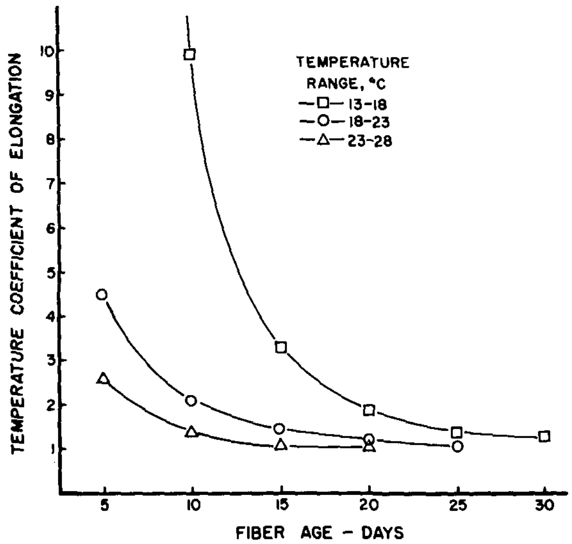

Fig. 2. The temperature coefficients of elongation for Acala fiber as influenced by night temperature.

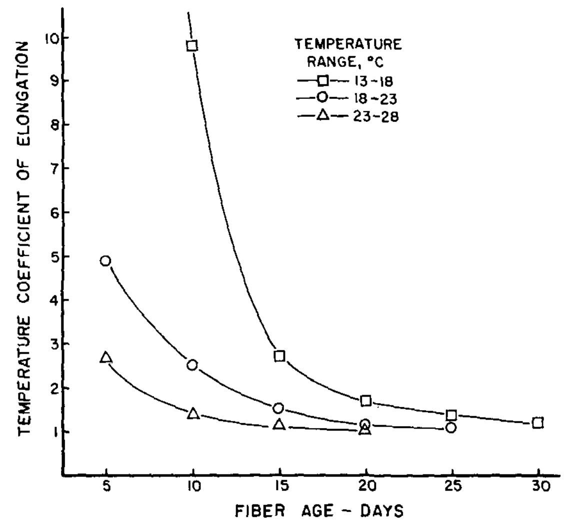

Fig. 3. The temperature coefficients of elongation for Paymaster fiber as influenced by night temperature.

during the period of maximum elongation, at the higher night temperatures, Acala fiber grew at a faster rate than Paymaster fiber. At the low temperatures there was no difference between varieties in maximum fiber elongation rate. The lowest temperatures at which the varieties attained their maximum elongation rates were 21.1 C for Acala and 15.0 C for Paymaster. At each temperature the rate of fiber elongation increased until a maximum was reached and then declined as the fiber attained its final length. This trend was noted in both years. Thus, fiber length is a product of the rate of elongation and length of the elongation period. Both rate and period are properties of the genetic potential of a given variety and their expression is influenced by the environmental conditions under which the variety develops.

The sudden decline in elongation rates observed by Hawkins and Serviss (3) and Morris (6) were not observed in this research. Such a phenomenon could have been easily masked, however, since length measurements were made on 5-day intervals in this work rather than on daily intervals as in the case of the previously cited researchers.

The temperature coefficients of fiber elongation calculated as a function of the different night temperature ranges and fiber ages provide further information on the relationship of temperature to fiber growth rates. The initial stages of fiber elongation are apparently highly temperature dependent, whereas, the latter stages tend to become temperature independent. This relationship is illustrated in Fig. 2 and 3 for Acala and Paymaster varieties respectively. From these figures, it is apparent that the rate of fiber elongation was extremely temperature sensitive up to 15 days age. Beyond 15 days age, however, the calculated temperature coefficients quickly approached 1 at temperatures between 18 and 28 C and after 18 days age were less than 2 in the range of 13 to 18 C. Thus, as temperature decreased, the fiber age level at which the rate of growth was limited by temperature, gradually increased.

CONCLUSIONS

It was shown that fiber elongation rates within a given season are dependent upon night temperature, variety, and fiber age. Maximum growth rates were obtained between 10 and 15 days after anthesis with night temperature levels of 21.1 C or above. During this period of maximum elongation. Acala fiber grew at a more rapid rate than Paymaster fiber. Paymaster attained its maximum fiber elongation rate at a lower temperature than did Acala.

At all temperature levels, Acala fiber continued to elongate after Paymaster fiber elongation had ceased. Thus, the fact that Acala produces longer fiber than Paymaster may result from its faster rate of elongation coupled with more lengthy elongation periods.

ACKNOWLEDGMENTS

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