Published May, 1969

Fiber Elongation Rates in Five Varieties of Cotton (*Gossypium hirsutum* L.) as Influenced by Night Temperature[1]

J. R. Gipson and L. L. Ray[2]

ABSTRACT

Five cotton varieties were grown in the field under four different night temperature regimes (10, 15, 20, and 25 C). The influence of temperature on the rate and extent of fiber elongation was studied. Temperatures below 20 C reduced fiber length; and generally, the reduction was greater in varieties having the longer fibers. Lowering night temperature increased the fiber elongation period and slowed the fiber growth rate. The temperature coefficients of elongation indicated the rate of elongation for all varieties was extremely temperature-sensitive up to 15 days age. Beyond 15 days age, however, the coefficients of elongation quickly approached one, indicating temperature independence.

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

WITH cotton, the important product of commerce is the seed-coat hairs commonly referred to as lint or fiber. Properly, the term "cotton" is restricted to commercial crop plants which produce spinnable lint. Therefore, any factors which affect the growth and development of the seedcoat hair cells are of primary importance to cotton production.

The hair cells, or fibers, are differentiated from epidermal cells and begin to grow at, or shortly after, anthesis. The development of the fibers takes place in two distinct stages. In the first stage, the elongation or linear growth phase, the cell contents are enclosed by only a primary wall. The second stage is characterized by secondary cell wall deposition. In a mature fiber, the secondary wall is almost pure cellulose and relatively thick, providing the extraordinary strength required of a textile fiber.

Both temperature and variety influence the rate of fiber elongation. Most of the work relating temperature to elongation has been of a general nature, with cotton grown under different climatic conditions. As early as 1930, Hawkins and Serviss (3) found that temperatures suboptimum for plant growth also retarded fiber elongation. Hessler, Lane, and Young (4) found that fiber length decreased as the season progressed, indicating a temperature deficiency for elongation. In Uganda, Morris (5) noted that maximum fiber length was reduced under cool seasons as compared with warm seasons. In a greenhouse experiment, O'Kelley and Carr (6) found that as temperature was decreased from 21.8 to 14.7 C, the rate of fiber elongation was drastically reduced. They obtained a coefficient of elongation of 63.3 in this temperature interval, and assumed the high value was a result of the lower temperature (14.7 C) approaching the minimum temperature required for fiber elongation. Gipson and Joham (2), in a 2-year study involving controlled night temperatures on two varieties of field-grown cotton, found the rate of elongation to be closely associated with both night temperature and variety. Their work indicated the initial stages of fiber elongation were highly temperature dependent, while the latter stages tended to become temperature independent.

This study continued the work of Gipson and Joham (2) to further define the fiber elongation capabilities of divergent varieties under varying night temperatures.

METHODS AND MATERIALS

Five varieties of cotton growing in the field at the Texas A&M University Agricultural Research and Extension Center at Lubbock in 1967 were subjected to four different night temperature regimes. The varieties used were 'Acala 1517 BR-2,' 'Stoneville 7A,' 'Lankart 57,' 'Stripper 31,' and an experimental strain, CA 491.

Different night temperatures (10, 15, 20, and 25 C) were maintained using a modification of the field chambers used in previous experiments (1, 2). The chambers were mounted on wheels and tracks to facilitate movement on and off the treated plots (the chambers previously used were stationary and had hinged tops which were opened during the day and closed at night). The two higher temperatures (20 and 25 C) were maintained with gas-fired furnaces and the two lower temperatures (10 and 15 C) with air conditioners.

The treatments were initiated about a week after the first blooms appeared on the earliest fruiting variety, C.A. 491, and continued throughout the fruiting and boll development period. Each day at approximately sunset the chambers were rolled over the plots and temperature control maintained throughout the night. The following morning, shortly after sunrise, the chambers were rolled off the plots to expose the plants to the normal environment throughout the daylight hours.

Fiber length was measured, beginning with 5-day-old bolls and continuing at 5-day intervals until the fibers attained their maximum length. To determine fiber length a lock from a boll was placed in a beaker of boiling water (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 watch glass, the fiber made to stream out with a jet of water and length measured with a centimeter rule. All measurements were made from the rounded side of the immature seed. Fiber of five to six seed per boll from three to four different bolls were measured and averaged for each determination, with the exception that five bolls were used to determine final length.

RESULTS AND DISCUSSION

Maximum fiber length was a function of both variety and night temperature (Table 1). Within varieties, a decrease in temperature below 20 C reduced

Table 1. Effect of night temperature on the fiber length of five varieties of cotton.

Variety	Temperature, C 10	15	20	25
	Mean length, mm.*			
Acala 1517 BR-2	25	26	28	28
Stoneville 7A	23	24	25	25
Lankart 57	22	22	23	23
Stripper 31	21	21	22	22
C.A. 491	20	21	21	21

* Each mean based on 5 determinations. Pooled SD = 0.22.

[1] Approved by the Director of the Texas Agricultural Experiment Station as Technical Article No. 7555. Research supported in part by grants from the Cotton Producers Institute and Plains Cotton Growers, Inc. Received Oct. 28, 1968.

[2] Assistant Professor and Associate Professor, respectively, Texas A&M University Agricultural Research and Extension Center, Lubbock 79401.

fiber length. The extent of the reduction appeared to be related to the staple length potential of the different varieties. The long fiber varieties, Acala and Stoneville, were affected to a greater extent than were the three short fiber varieties. Temperature exerted a much greater effect on fiber elongation periods (the number of days from anthesis to maximum fiber length) than on the final length. Fiber elongation periods for all varieties and temperature levels are shown in Table 2. These were interpolated from the fiber elongation curves in Fig. 1. The elongation period was positively correlated with fiber length at the highest temperature, 25 C. However, the variety with the shortest fiber, i.e. C.A. 491 had the longest fiber elongation period at the two lower temperatures. Thus, the shortest elongation period (21 days at 25 C) and the longest elongation period (38 days at 10 C) both occurred with the same variety, C.A. 491.

The rate of fiber growth provides further information on the influence of temperature on fiber development. These rates were calculated from the final fiber length (Table 1) and the fiber elongation period (Table 2) and are shown in Table 2. Low temperature decreased the fiber growth rate in C.A. 491 to a much greater extent than in the other four varieties. Between 25 and 10 C, the reduction in mean fiber elongation rate was 44% for C.A. 491, 34% for Stoneville 7A, 29% for Acala 1517 BR-2, 23% for Lankart, and only 20% for Stripper 31. At high temperatures (20 and 25 C), fiber of the varieties with the longest staple potential (Acala and Stoneville) grew faster than the short staple varieties, but under low temperature (10 C), the shortest fibers of Lankart 57 and Stripper 31 grew as fast as the longer fibers of Acala and Stoneville.

Fiber elongation patterns for the five varieties at the different temperatures are shown in Fig. 1. Essentially no fiber elongation occurred during the first 5 days following anthesis. Between the 5th and 10th day, however, rate of growth accelerated rapidly at 20 and 25 C; and some growth was recorded at 10 and 15 C. This delay in the onset of fiber elongation caused by low temperature was found also by Gipson and Joham (2). Maximum growth was obtained between the 10th and 20th day following anthesis. At the higher temperatures peak growth rates were usually reached quicker than at the lower temperatures. A significant reduction in peak growth rate at the lower temperature was noted with the C.A. 491 variety. As fiber approached its maximum length, growth rates were again reduced. In general, only small differences in fiber elongation patterns (Fig. 1) occurred between 20 and 25 C; but distinct differences were noted between the other temperature levels. Thus, low temperature affects fiber elongation by delaying the onset of fiber growth and to a lesser extent by decreasing the rate of fiber growth.

Further evidence that low temperature effects are the greatest in the early stages of fiber growth is found in the temperature coefficients of fiber elongation (Fig. 2). The coefficient of elongation is defined as the ratio of the rate of growth constants at two temperatures five degrees apart. It is a measure of the temperature coefficient of the reaction rate. With all varieties and at all temperature ranges, rather high values were obtained in the early stages of growth,

Table 2. Effect of night temperature on the fiber elongation periods and on mean elongation rates.

Variety	Temperature, C							
	10	15	20	25	10	15	20	25
	Days				mm/day			
Acala 1517 BR-2	35	30	30	28	.71	.87	.93	1.00
Stoneville 7A	35	30	26	25	.66	.80	.96	1.00
Lankart 57	31	27	27	23	.77	.83	.85	.92
Stripper 31	30	26	26	22	.70	.81	.85	.88
C.A. 491	38	35	26	21	.53	.60	.81	.95

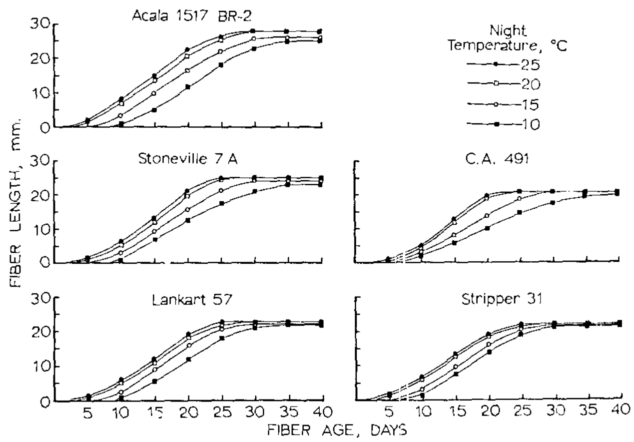

Fig. 1. Fiber elongation curves of five varieties for four temperature regimes.

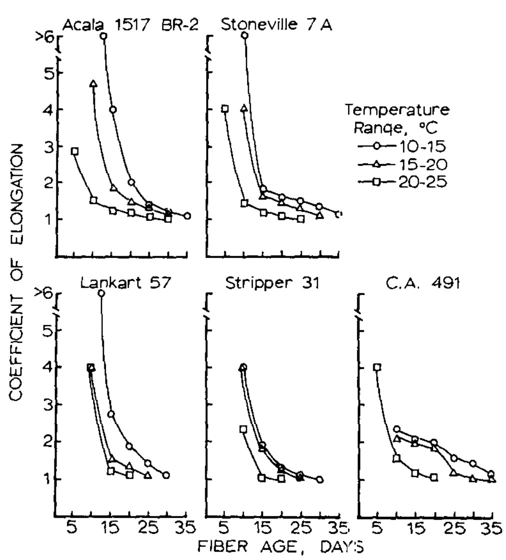

Fig. 2. Temperature coefficients of elongation of five varieties for three temperature ranges.

indicating that rate of elongation was extremely temperature dependent during the early phases. In the temperature range of 20 to 25 C, the coefficients of elongation tended to approach 1 within 15 days after anthesis. A value of 1 would be associated with minimal temperature dependence. In the range of 15 to 20 C, about 25 days were required for the temperature coefficients to drop to a value near 1 in the short fiber varieties and about 30 days in the long fiber varieties. In the 10 to 15 C range, an additional 5 days were required. Thus, from the temperature coefficients, it is apparent that the initial stage of fiber elongation are highly temperature dependent, whereas the latter stages tend to become temperature independent.

The results of this study substantiate the previous findings of Gipson and Joham (2) and provide further evidence that varieties differ in the degree of the temperature effect on fiber elongation. It further leads one to expect that favorable fiber elongation rates at low temperature would be a valuable adaptive variety characteristic in areas where minimal temperatures adversely affect production or fiber quality.

LITERATURE CITED

1. Gipson, J. R., and H. E. Joham. 1968. The influence of night temperature on growth and development of cotton (*Gossypium hirsutum* L.). I. Fruiting and boll development. Agron. J. 60:292-295.
2. ——— and ———. 1969. The influence of night temperature on growth and development of cotton (*Gossypium hirsutum* L.). III. Fiber elongation. Crop Sci. 9:127-129.
3. Hawkins, R. S., and G. H. Serviss. 1930. Development of cotton fibers in the Pima and Acala varieties. J. Agr. Res. 40: 1017-1029.
4. Hessler, L. E., H. C. Lane, and A. W. Young. 1959. Cotton fiber development studies at suboptimum temperatures. Agron. J. 51:125-128.
5. Morris, D. A. 1962. Elongation of lint hairs in upland cotton in Uganda. Emp. Cot. Gr. Rev. 39:270-276.
6. O'Kelley, J. C., and P. H. Carr 1953 Elongation of the cotton fiber p. 55-68. *In:* W. E. Loomis, (ed.) Growth and differentiation in plants. Iowa State College Press.