LIGHT ENVIRONMENT OF THE DEVELOPING BOLL AFFECTS COTTON FIBER LENGTH

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Abstract

Various field management systems influence the quantity of photosynthetic light and the far-red to red ratio (FR/R) in light reflected to developing cotton bolls. Previous studies have shown that an increased FR/R results in longer stems and longer cells within those longer stems. Since the cotton fiber is a single elongated cell, we hypothesized that the FR/R reaching the developing boll could influence elongation of fibers. Spaced plants were grown in trickle-irrigated field plots covered with different colored plastic sheets, which reflected different quantities of FR/R up to developing bolls. Fiber lengths were evaluated by AFIS procedures. Soil covers that reflected higher FR/R resulted in longer fibers that were also thinner. Evaluation of fiber physical and chemical characteristics relevant to strength and dye holding ability have been initiated. Relevance of these findings to field management of cotton production is that the FR/R reaching developing bolls is influenced by FR reflected from nearby green leaves (population density), dead plant residue (conservation tillage), and even color of the soil surface.

Introduction

Canopy architecture and the interception of photosynthetically active light have received considerable attention. However, the spectral distribution of light acts through photomorphogenic pigments, such as phytochrome, within growing plants to regulate where the photosynthate is allocated and used (Kasperbauer, 1988).

The ratio of far-red (just beyond visible red) to red light (FR/R) regulates the photoequilibrium between the two forms of phytochrome, and that ratio regulates how a plant develops. For example, seedlings that receive a high FR/R ratio develop longer and thinner stems (which contain longer cells) than plants that receive a low FR/R ratio (Downs et al., 1957; Nakata and Lockhart, 1966). The same stem elongation pattern is observed whether the FR/R ratio received by the plant is supplied in a controlled environment, a greenhouse or a field (Kasperbauer, 1992). Under field conditions the FR/R ratio can be changed by the number and nearness of other plants (green leaves reflect much FR) or by the FR/R ratio reflected from different colored soil surfaces (Kasperbauer, 1992). Thus, the FR/R ratio can be managed and it affects morphological characteristics of the parts that are developing when the ratio is received.

The objective of our study was to determine whether length and diameter of cotton fibers can also be affected by the FR/R ratio received while they develop on the plant.

Materials and Methods

Stem Elongation Response

Cotton seedling stem elongation responses to FR/R ratio were tested in a controlled environment where seedlings received low or high FR/R ratios at the end of each day from date of emergence. Other seedlings emerged and grew in a greenhouse over white or red soils, which reflected low or high FR/R ratios, respectively.

Fiber Responses

For cotton fiber studies, plants were grown in trickle-irrigated field plots that were covered with painted plastic mulches to obtain different reflected light spectra. All plants received full incoming sunlight. There were three replicate plots for each mulch color. Colors were green, red, white and aluminum. Green and red reflected high FR/R ratios. White and aluminum reflected more photosynthetic light but lower FR/R ratios. Plants were spaced 30 inches apart in rows that were 40 inches apart in order to increase the probability that developing bolls would receive light reflected from the different colors.

Seed cotton was harvested on the same date ± 1 day from all open bolls that were 12 to 15 inches above the soil surface. One hundred seeds with fiber attached were carefully separated (from each of the 3 reps of each of the 4 colors) and brushed to extend the fibers. Three measurements were made by hand from each of the 100 seeds per color per rep.

Subsamples used for the AFIS measurements were drawn from the same 12 samples.

Results and Discussion

Stem Elongation Response

Stem elongation response of cotton seedlings to FR/R ratio is shown in Table 1. Seedlings exposed to the high FR/R last each day developed longer and thinner stems. Effects of high FR/R were reversed by exposure to low FR/R, indicating photoreversible control of morphogenesis by phytochrome within the seedings.

Seedings grown in sunlight over white or red soil (which reflected different FR/R ratios and amounts of photosynthetic light) had quite different stem lengths. The red soil reflected a higher FR/R ratio, and seedlings developed longer stems over the red soil.

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Fiber Responses

Lengths of fiber developed on spaced plants grown in trickle-irrigated field plots over green, red, white and aluminum soil covers (mulches) are shown in Table 2. All bolls sampled for this comparison developed 12 to 15 inches above the colored surfaces, and they opened on the same date ± 1 day. Notice that green and red reflected the higher FR/R ratios and cotton fibers were longest. These hand measurements measured the longest fibers and did not attempt fiber diameters.

Length and diameter values obtained by AFIS procedures for fiber subsampled from the samples described above were analyzed by ANOVA, and summarized in Table 3. Values for fibers grown over the two high FR/R reflecting surfaces (green and red) did not differ from each other at the 5% level of significance for any of the measured parameters. Similarly, most of the values for white and aluminum (the two low FR/R reflectors) did not differ from each other at the 5% level. For brevity, values in Table 3 are for fibers grown over red (high FR/R) and aluminum (low FR/R).

Discussion

It has been known for many years that the FR/R ratio received by developing seedling stems can influence cell length, and a cotton fiber is a single elongated cell. Also, studies of chemical composition reported by the senior author as early as 1970 showed that various organic compounds in seedling stems (and other organs) are influenced by the FR/R ratio received during elongation (Kasperbauer and Hamilton, 1984; Kasperbauer et al., 1970).

The physical results obtained in this study support the hypothesis that the FR/R ratio received by developing cotton bolls during fiber elongation can influence length and diameter of the fiber. Studies of fiber chemistry and its influence on fiber strength, dye holding properties, etc., are presently in the discussion stage. If the chemical results are as evident as the physical data presented above, the information is relevant in field management of cotton fiber development.

Conclusions

Increased photosynthetic light received in reflection from the white and aluminum surfaces did not result in longer fibers.

The same elevated FR/R ratio that acts through the phytochrome system to influence cell length and thickness in developing stems can also influence length of a developing cotton fiber, which is an elongated cell.

The phytochrome system is known to influence chemical composition of developing plant stems, and it is hypothesized that cotton fiber chemistry can also be influenced by the FR/R ratio received during fiber development.

References

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Table 1. Cotton seedling stem elongation responses to red (low FR/R ratio), far-red (high FR/R ratio) and FR followed immediately by R to test photoreversible control as evidence of phytochrome involvement.

	End-of-day FR/R ratio		
	Low	High	High, Low
Hypocotyl (in)	2.47 a	4.80 b	2.53 a

Seedling hypocotyls were measured 10 days after emergence.

Table 2. Approximate reflected FR/R ratios and mean lengths of cotton fiber grown on plants in full summer sunlight over different colored surfaces.

	Color of reflector on soil surface			
	Green	Red	White	Aluminum
FR/R ratio*	1.3	1.2	1.0	1.0
Fiber length (in)†	1.46	1.38	1.21	1.26

* In upwardly reflected light. All plants received full incoming sunlight.
† Measurements were from seed to tip of longest fibers. There were 3 such measurements on each of 100 seeds per each of 3 reps per color. Fiber length data are means for 900 measurements.

Table 3. AFIS-derived characteristics of cotton fiber that developed in field plots over red versus aluminum soil covers.

AFIS parameter	Color of reflector on soil surface: Red (high FR/R)	Aluminum (low FR/R)	Signif. (P=0.05)
L(w)	1.12	1.05	*
L(w)cv	24.5	26.0	NS
SFC(w)	3.4	4.4	NS
UQL(w)	1.30	1.23	*
L(n)	0.99	0.93	*
L(n)cv	35.5	36.8	NS
SFC(n)	11.9	13.7	NS
UQL(n)	1.24	1.17	*
D(n)	13.3	14.0	NS
D(n)cv	34.1	32.1	NS
Perimeter	50.68	52.31	*

Notes: A(n) values were numerically (but not statistically) higher for fiber grown over white and aluminum (low FR/R) than over either red or green (higher FR/R). Micronafis was also numerically (but not statistically) higher over white than over red or green.