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Influence of Chilling Upon Subsequent Growth and Morphology of Cotton Seedlings[1]

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LITTLE information is recorded concerning the influence of unfavorably low temperatures above freezing upon subsequent growth of a subtropical heat-loving plant species such as cotton, *Gossypium hirsutum* L. Most chilling injury research has attempted to determine the immediate effects of subfavorable temperature, with little reference to the influence of chilling upon future growth at favorable temperatures. The results of such research are usually reported in life or death terms. A recently published study (5) reported that growth of cotton seedlings was reduced immediately following chilling. Radicle injury symptoms were described which were thought responsible for seedling growth inhibition. In that report a 5° C. temperature was noted as more injurious than 10° C. Earlier reports by Arndt (1) and Camp and Walker (3) have established 15° C. as near the minimum for germination and growth of cotton. Arndt (2) reported the optimum temperature range for growth is 30–33°. Sellschop and Salmon (6) investigated the influence of chilling upon several species including cotton. Severe leaf necrosis was incited by chilling cotton 48 hours at 2–4° C. Root development was inhibited by chilling 3-week-old plants of cowpea, *Vigna sinensis* (Torner) Savi. No report has presented evidence of long-term growth patterns following chilling nor evidence of an additive influence of time increments of chilling.

The present investigation sought to demonstrate the immediate and long-term effects of different increments of low temperature upon cotton seedling development.

MATERIALS AND METHODS

Seed source and germination method. The seed was of M-8 strain; a double-haploid derived from Deltapine 14 variety. The seed quality, vigor, and genetic purity were excellent. Seedcoats were removed to eliminate variation in germination induced by differential water absorption commonly encountered. The hulled seed were germinated between two 12 $\times$ 18 inch germination papers which were rolled and covered with a waxed paper. Each roll was wet with 60 ml. of distilled water. Twenty-five seeds were placed in each roll. The temperature in the incubators was maintained at the proper level within $\pm$0.25° C.

Experiment series A. The objective of this series was to determine the influence of length of chilling upon early seedling development rate.

Seed in previously described rolls were subjected to an initial 24-hour period at 31° C. to initiate germination. The rolls were subsequently placed at 10° C. for 0, 1, 2, 3, 4, and 5 days. Initiation of chilling treatments was so timed that all seed completed the chilling period simultaneously. The rolls were returned to 31° and seedling development measured by the rate of cotyledon dry weight transfer method (4) which measures the rate of dry weight transfer from the cotyledons to the axial parts of the seedling. Three replications were used of a randomized block design setup for orthogonal polynominal regression analysis. The experiment was repeated three times.

Experiment series B. The objective of this series of tests was to ascertain the normality of postemergent growth of seedlings chilled prior to emergence. The chilling treatments of Series A were duplicated except that a control, 1-, 2-, 3-, and 4-day chilling treatments were included in one experiment, and a control, 2-, 4-, and 6-day chilling treatments in a second. After chilling in paper rolls, the seedlings (radicle about 1 cm. long) were planted 1 inch deep in 10-inch pots. The soil mixture contained equal volumes of sand, sandy loam, and peat moss. It was autoclaved prior to use. Three pots per treatment were planted with 12 seedlings per pot. Sixteen replications were used in a randomized-block design. One week after planting the plants were thinned to the 9 best seedlings in each pot. The plants were watered as necessary by subirrigation.

In the first experiment of Series B 2 and 4 weeks after planting in the greenhouse, 3 seedlings were cut at the soil line from each pot for dry weight determinations. First true leaf width was determined after two weeks as a supplemental measure of plant development. Height after 2 and 4 weeks, length of hypocotyl above the soil after 4 weeks, and length of first internode were also measured in the second test as supplemental measures of seedling development.

RESULTS

Experimental Series A results show that chilling appears to have a directly linear-additive influence upon early seedling development (Figure 1). Linear regression of chilling was 5.2% reduction in dry-weight transfer per day of chilling. The chilled seedlings were shorter and showed increased radicle necrosis with increased chilling.

The longer term greenhouse studies (Series B) revealed considerable growth inhibition by chilling. In essence, the chilling seemed to slow the development of the entire plant (Figure 2). Emergence from the soil (as seen in Figure 2 at 1 week), dry weight of the tops, height, width of the first true leaf and elongation of the hypocotyl were all inhibited quantitatively by added increments of chilling (Figures 2, 3). Root development was likewise

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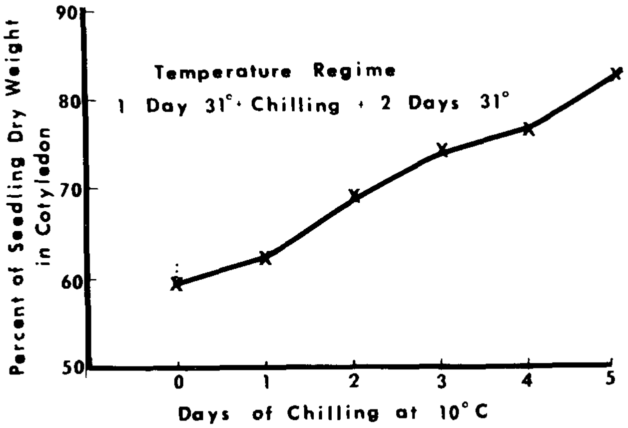

Figure 1. Influence of length of chilling period upon subsequent rate of seedling development in cotton.

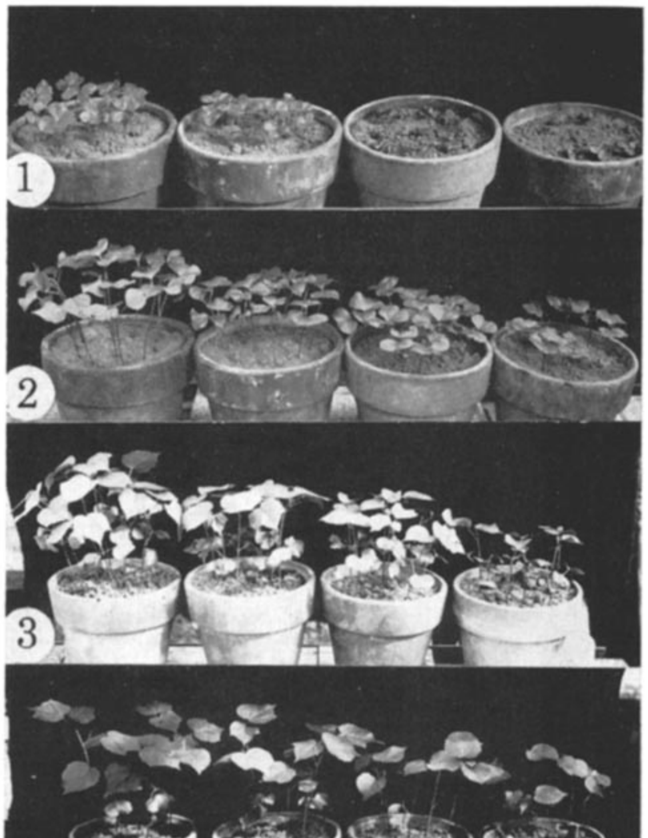

Figure 2. Influence of chilling upon development of cotton seedlings during 4 weeks growth (1=1 week, 2=2 weeks, etc.). Treatments from left to right were: control, 2, 4, and 6 days of chilling at 10° C.

retarded (Figure 4b). Normally the radicle continued to elongate but the volume of root was reduced. The shape of the first true leaf was distorted (Figure 4a). Subsequent leaves were normal. The length of the first internode above the cotyledons was likewise near normal.

The treatment effect on plant growth persisted throughout the four weeks as shown in Figure 2. The general appearance of the cold-treated plants was normal.

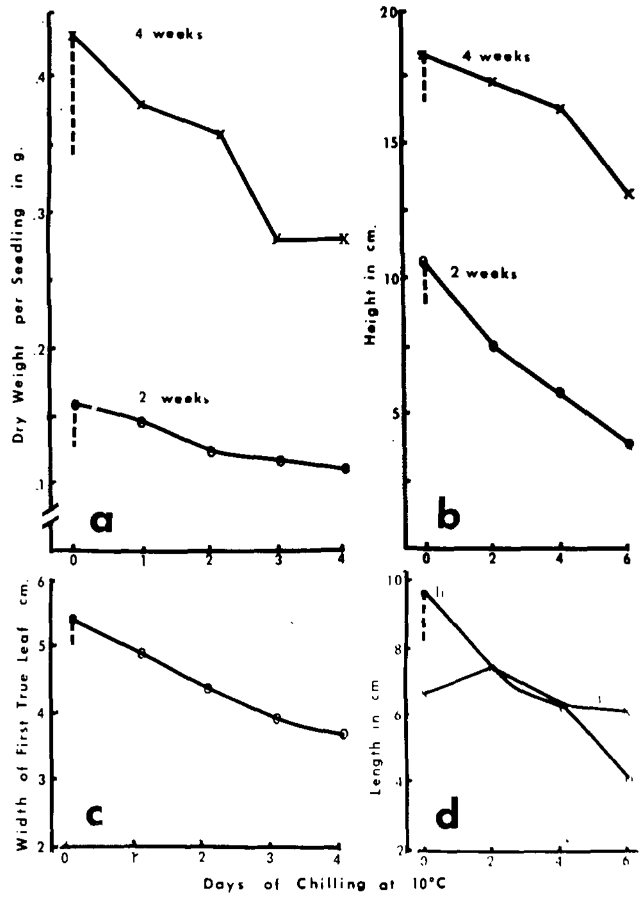

Figure 3. Influence of chilling upon: a. Dry weight of seedling (tops) after 2 and 4 weeks growth; b. Height of seedlings after 2 and 4 weeks growth; c. Width of first true leaf after 2 weeks growth; and d. Elongation of hypocotyl (h) and first internode (i) after 4 weeks growth. Dotted lines represent LSD at 5% level of probability.

DISCUSSION

The results tend to support the idea that a general growth suppressant develops as a consquence of chilling. The fact that the duration of the chilling period is additive suggests that something (a toxin) builds up, or an essential substance is destroyed. Since our previous research (5) has shown that serious injury to the radicle cortex is induced by chilling, it is possible that the reduced rate of seedling development is a consequence of reduced root system effectiveness. The present results tend to negate this idea somewhat since there was morphological evidence of systemic chilling influence, e.g., first true leaf abnormalities, leaf width ,and reduced hypocotyl growth (Figures 3, 4). When height and dry weight differences at 2 and 4 weeks are compared it appears that growth rates are similar for controls and chilled plants. Also as previously noted, the elongation of the first internode, and morphology of the second true leaf are normal in chilled seedlings. All of this suggests that (a) chilling injures tissue present at the time of incidence (radicle hyocotyl and first leaf primordia), (b) seedling development suffers a lag due to this injury, and (c) if the seedling survives the injury subsequent growth may resume at a normal rate.

The general influence of the time factor in chilling is additive. No doubt a lethal threshold exists, beyond which

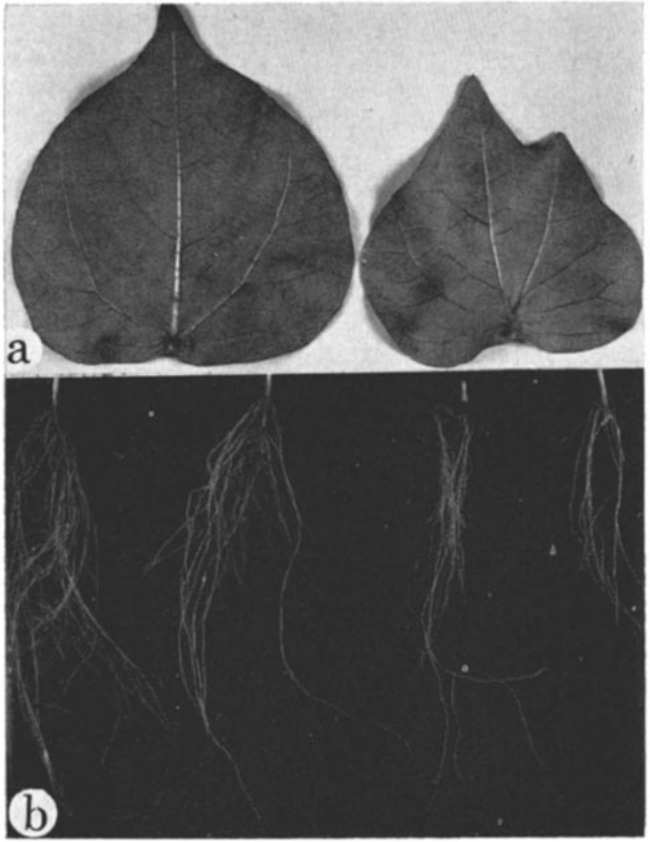

Figure 4. Influence of chilling upon: a. First true leaf development and morphology; left, no chilling, right, 4-day chilling; b. Root developument after 2 weeks; left to right, no chilling, 2-, 4-, and 6-days chilling.

plants are not merely inhibited but are killed. An economic or agronomic threshold also must exist beyond which seedling development is so generally inhibited that growth patterns will be severely altered, or yields reduced.

Chilling injury might conceivably be of serious consequence if seedling disease or other adversities of the environment also exert an influence. The shortened hypocotyl might cause difficulties with herbicidal oil application and cultivation practices.

SUMMARY

Laboratory and greenhouse growth studies of the influence of chilling (10° C.) upon germinating cottonseed show that length of cold period is additive in inhibiting subsequent seedling growth at favorable temperatures.

Seedling development in terms of dry weight accumulation, height, and width of first true leaf were reduced by early chilling. Root development, first true leaf morphology and hypocotyl elongation were adversely influenced.

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