Effects of Early-Season Adverse Conditions on Root Development and the Subsequent Stress

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RESEARCH PROBLEM

Low temperatures during the initial growth of cotton (Gossypium hirsutum L.) have detrimental effects on root and seedling growth. Cotton grown in the Mississippi River Delta is generally planted in cool and wet weather conditions that lead to slow germination, uneven emergence, and poor root growth. Genetic diversity exists among cotton cultivars and may be a source of tolerance to these conditions. This study examined the seedling root growth of four genetically diverse cotton cultivars under seven temperature regimes to determine growth response and genetic variability.

BACKGROUND INFORMATION

The optimum temperature for cotton root development is 28°C (McMichael, 1994). The base temperature is generally reported to be 15.5°C (Oosterhuis, 1990), while Ludwig (1932) revealed the minimum temperature for cotton germination to be near 12°C. However, low temperature during the initial growth stage is a problem that affects all cotton cultivars grown in the Mississippi Delta. The genotypic differences for root development between cotton cultivars can be examined to find a cultivar able to withstand cool temperatures and produce a vigorous root system for a more healthy plant and greater yield stabilization.

RESEARCH DESCRIPTION

This study was conducted at the Altheimer Laboratory at the University of Arkansas Agricultural Research and Extension Center in Fayetteville, Ark. A Conviron MP 3023 growth chamber (Controlled Environments LTD., Winnipeg, Manitoba, Canada) was used for the experiment with seven temperature regimes. The seven temperature

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regimes consisted of: 28EC (constant), 15EC to 20EC (night/day), 15EC to 25EC, 15EC to 30EC, 15EC to 35EC, 15EC to 40EC, and 15EC to 45EC.

Four diverse cultivars were chosen for this experiment. ‘Acala Maxxa’, grown primarily in California, is a cultivar with a high fiber quality and Pima lineage. ‘Stoneville 4892BR’ is grown primarily in the Mississippi River Delta, but stable under various climate conditions. Stoneville 4892BR also contains the stacked gene. ‘Tamcot Sphinx’ has been adapted to the climate of the high plains of Texas where excessively hot and cool temperatures are common. ‘Fiber Max 966’ grows large bolls with high fiber quality with a genetic make-up from Australia. The four cotton cultivars were used throughout the experiment and germinated in the same temperatures as the treatments used for the study. Two seeds of each cultivar were placed on each side of the paper wick “V” of one 18-cm x 16.5-cm growth pouch (CYG Seed Growth Pouch, West St. Paul, Minn.) with sterile tweezers. Each pouch received 50-ml half-strength Hoagland’s solution and was stored in the growth chamber. Each growth pouch was clamped to a 19-cm x 22-cm piece of cardboard with two mini binder clips. The pouches and cardboard backings were placed upright in a metal tray at random positions with dividers separating each pouch. Two trays contained a total of 20 pouches with ten replications for each of the four cultivars. Cotton seedlings were grown for 10 days before harvest. Daily measurements included root length and the number of lateral roots. At post harvest, the hypocotyl height was taken as well as the dry weight of the roots, cotyledon, and hypocotyl.

RESULTS AND DISCUSSION

The total tap root length of Stoneville 4892BR was between 60 and 40 mm in all temperature regimes after 10 days in a growth pouch. Starting at 15EC to 20EC with the maximum temperature increasing 5EC for every regime and concluding at 15EC to 45EC, Acala Maxxa, Tamcot Sphinx, and Fiber Max 966 had less consistent root growth throughout all temperature regimes. Preliminary results from this study showed that Stoneville 4892BR produced a linear response to increasing temperature for root length and root dry weight, while other cultivars produced a curvilinear response (data not shown). Temperature had little or no effect on dry weight of cotyledons in the first 10 days of cotton seedling development (data not shown).

During sub-optimal conditions, Acala Maxxa and Tamcot Sphinx’s root length followed a discernible growth curve with each reaching the peak approximately at mid-range of the temperature regime, Acala Maxxa at 15EC to 30EC and Tamcot Sphinx at 15EC to 35EC (data not shown). These results are consistent with the environments in which the cultivars were developed. Sphinx was bred for a higher temperature environment in Texas, while Acala Maxxa would be adapted to the more temperate climate in California. Stoneville 4892BR had a broad temperature response during the test and performed well at most temperature regimes. This was indicated by all growth lines of the regimes converging in close proximity on day ten (Fig. 1b) as opposed to the other three cultivars (Figs. 1a, 1c, and 1d). This shows that Stoneville 4892BR has stability over a broad array of climates. Fiber Max 966 root systems performed inconsistently.
through the temperature regimes and seemed to be more prone to disease than the other cultivars.

The optimal temperature regime of each cultivar in the study produced the most dry weight within a linear to curvilinear response. The response of Stoneville 4892BR indicated consistent growth through all temperature regimes (data not shown). Each cultivar throughout the temperature regimes produced similar amounts of cotyledon dry weight (data not shown). This indicated that temperature had little or no effect on the cotyledon in the first 10 days of cotton seedling development.

**PRACTICAL APPLICATIONS**

Root growth response to temperature exists among the four diverse cultivars, culminating in various root growth patterns in response to the temperature regimes. Stoneville 4892BR had the most sizeable root growth over the entire range of temperature regimes while Tamcot Sphinx had the most predictable growth pattern with peak growth at 15°C to 35°C. Root dry weight was proportional to root length among cultivars. Cotyledon dry weight exhibited no association with root length or root dry weight. With a genetic difference between the cultivars, perhaps a gene can be found that will lead to a tolerance to cooler weather and an earlier planting date possible for cotton.

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**LITERATURE CITED**

Ludwig, C.A. 1932. The germination of cotton seed at low temperatures. J. Agricultural Research 44.


Fig. 1. Effect of six temperature regimes on daily root length of four cultivars grown in growth pouches with half-strength Hoagland’s solution.