EVALUATION OF CHILLING TOLERANCE IN COTTON GENOTYPES

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Abstract

Cotton production (quantity and quality) on the Texas High Plains is limited by the number of heat units available during the growing season. Producers, therefore, face a dilemma in their planting schedule. Early plantings to obtain good yield and fiber quality by having the crop mature early in the fall when temperatures are warm, risk poor stand establishment from cool spring soils. Later plantings, to ensure good stand establishment in warmer soils, risk poor yield and fiber quality from crop maturation in the cooler late fall conditions. Cold tolerant cotton genotypes would allow earlier planting; thus, allowing for more profit from reductions in seeding rates and obtaining greater yields of high quality fiber. This study was initiated to screen a number of commercial and experimental cotton genotypes for both early and late season cold tolerance and to identify or develop laboratory test(s) to identify this trait. The test will then be available to breeders to initially screen large numbers of breeding lines for this trait prior to field testing those lines that have been identified as cold tolerant. Two groups of seed were evaluated (one consisting of twenty-nine genotypes grown in a common environment and another group of sixteen genotypes produced in various locations) with various field, laboratory, and controlled environment tests. A good indicator of cold tolerance (one providing good separation between genotypes in both seed groups) was tested whereby seed were subjected to a 24 hour imbibition period in rolled foam pads at 5C (40F) then planted in sand at 18C (64F) and emergence counted after 21 days to determine a Cold Tolerance Rating (CTR).

Introduction

Cotton production (quantity and quality) on the High Plains of Texas is limited by the number of seasonal heat units available. Because cotton is a "cold sensitive" plant, producers are faced with a dilemma in their planting schedule. If producers plant late in the season (e.g. mid- to late-May) when soil temperatures are ideal for seedling emergence and stand establishment, they are faced with reduced fiber and seed quality resulting from maturation under the cool fall temperatures (Gipson et al., 1969). Conversely, if producers plant early in the season (e.g. mid- to late-April) so that crop maturation occurs under warmer fall conditions, seedling emergence and stand establishment are compromised due to the low early spring soil temperatures (Christiansen et al., 1969; Christiansen, 1964). If more cold tolerant (both early and late season) varieties of cotton could be developed, producers could utilize a longer growing season where good stand establishment would be obtained under cool spring temperatures in addition to the crops ability to mature under the later cool fall temperatures (Buxton et al., 1976). These traits would increase production and profit on the High Plains by decreasing seeding rates while obtaining ideal plant populations and proper spacing and increased quantity and quality of cotton produced from a longer growing season. This study was initiated to identify a laboratory test that could be used to screen for seed and seedling traits associated with both early and late season cold tolerance. Such a lab test could then be used by breeders to initially screen many lines for these traits under laboratory/greenhouse conditions, thus, allowing increased numbers of lines to be screened quickly in the lab instead of the costly and labor intensive traditional field trials.

Materials and Methods

Two groups of seed, one group of twenty-nine genotypes grown and evaluated for cold tolerance in 1995 at the Texas Agriculture Experiment Station north of Lubbock, TX (common production environment) and another group of sixteen commercial cultivars produced in different locations (different production environment) were used in this study to evaluate various laboratory tests in their ability to predict early and late season cold tolerance in the field. Three replications of 50 seed from both seed groups were planted in a controlled environment room in sand at a constant 64◦ F (18◦ C) to evaluate for early season cold tolerance (emergence and stand establishment). On June 13, 1996 three blocks were planted in the field at the Texas Tech Research Farm in New Deal, TX to evaluate for late season cold tolerance (yield, fiber development, and maturation). Data were then correlated with various laboratory tests to note any relationships.

Field parameters measured for early season cold tolerance were Emergence Rate Index (a measure of rate and total emergence) and Establishment Index-21 (a measure of the percentage of seeds planted resulting in established plants 3 weeks after planting). Field parameters measured to determine late season cold tolerance included yield (a measurement of lint production) and fiber properties (various measurements of fiber to determine quality and maturity).

Various laboratory tests were used to evaluate traits of both seed and seedlings from the entries. Germination and vigor properties of the entries were measured by conducting a

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Warm Germination Test (WGT), a Cool Germination Test (CCT), and the combination of these tests to calculate a Cool Warm Vigor Index (CWVI). The WGT is run with 100 seed under an 86/68◦ F (30/20◦ C) regime in rolled towels. After four days, normal seedlings 1.5 inches or longer were counted. A final 7 day count was also taken to determine percent germination. The CGT was conducted by placing 100 seed in rolled towels at a constant 64◦ F (18◦ C) temperature. Seedlings were counted 7 days later that met the same criteria as that of the WGT. The CWVI rating of the entries was calculated by numerically combining the WGT after 4 days and the CGT values.

Laboratory test to evaluate seedling responses after being subjected to extreme chilling temperatures during the seed's water imbibition (a critical period when damage from chilling occurs) included an Imbibitional Chilling Test (ICT). The ICT involved rolling three replications of 100 seed from each entry in germination towels that had been previously wetted and allowed to equilibrate to 40◦ F (5◦ C). The rolled towels were then placed in a cold chamber for 24 hours at 40◦ F to induce imbibitional chilling conditions. After 24 hours the rolled seed towels were transferred to another chamber set at 86◦ F for an additional 96 hours. The seed were then evaluated for the percentage of normal seedlings that germinated (radicle visible).

Seed leachate electrical conductivity was measured following a 24 hour imbibition period. Seed imbibition at chilling temperatures can result in cellular damage. The degree of damage can be assessed proportionally through determining the electrical conductivity of the leachate in a known volume of water. Three replications of five grams of seed from each entry were rinsed twice with 30 ml of deionized water. After rinsing, the seed were placed in 30 ml of 40◦ F water and allowed to soak for 24 hours. After 24 hours the water was decanted, allowed to equilibrate to room temperature, and electrical conductivity measurements taken. Readings were reported as EC 40◦ F.

The test resulting in the best separation among entries regardless of production area was a combination of a test involving imbibition and germination which we are calling a Cold Tolerance Rating (CTR) test. The test involves imbibing three replications of 50 seed from each entry in a 0.25"x13"x17" polyurathane foam pad containing 100 mls of 40◦ F (5◦ C) water for 24 hours. After the 24 hour imbibition period, the seed are planted in plastic boxes on a 1.5" layer of sand at field capacity and another 1.5" of dry sand covering the seed. Establishment is counted after 21 days at a constant 64◦ F (18◦ C) and corrected for viability to determine a Cold Tolerance Rating (CTR). This correction involves dividing the Establishment Index by the viability percentage (all seeds showing a radicle after 10 to 12 days under standard warm germination test conditions).

Results and Discussion

Several lab tests correlated with various field and chamber parameters at the 5% significance level, however, r^2 values were not high. Because of excellent separation among entries (Figures 1,2) seen from the CTR tests, we believe it will be a good test for breeders to screen for cold tolerance. The excellent separation from conducting the CTR is directly related to factors comprising the test. First the seed are subjected to an extremely cold 40◦ F (5◦ C) period of imbibition. Then the seed are required to germinate under a cool temperature (64◦ F/18◦ C) with mechanical resistance (sand) under the constraint of a time limitation (21 days). The CTR test is also relatively simple to run, relatively quick, and easy to interpret. It is recognized that because we are only screening for cold tolerance among genotypes, an entry should not penalized if some seed fail to germinate for reasons other than lack of cold tolerance, such as dead, immature, or mechanically damaged seed. Therefore, a correction factor to reduce the error should be used. This correction factor is determined by conducting a standard warm germination test and counting all seeds with a visible radicle after 10 to 12 days.

Acknowledgments

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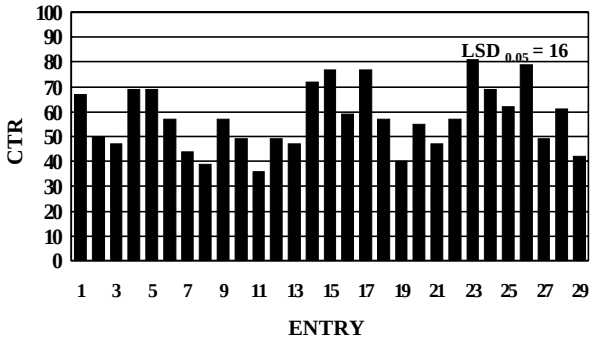

Figure 1. Cold Tolerance Rating of 29 entries of seed produced in a common environment

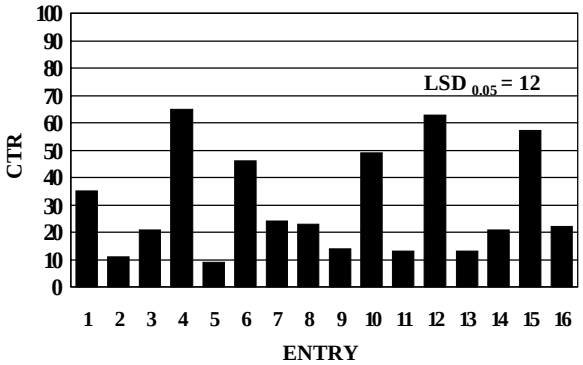

Figure 2. Cold Tolerance Rating of 16 entries of seed produced in different environments