LABORATORY TESTS USED TO SCREEN FOR 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. Thirty two genotypes were planted on April 12 and June 9 to identify early and late season cold tolerance, respectively, in field situations. Field parameters were then correlated with lab tests conducted on seed and seedlings. The EC 40° F and Pouch Germination tests correlated with several field parameters at the 5% significance level, but r^2 values were low. We believe that variables other than temperature masked results in the field and are responsible for the low r^2 values. Therefore, a cold temperature room has recently been obtained for future testing that allows for control of all variables as temperature is changed to better identify a suitable screening test.

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

Fourteen commercial cultivars and eighteen experimental lines were used in this study to evaluate various lab tests in their ability to predict early and late season cold tolerance in the field. Four replications of the 32 entries were planted at the Texas Agriculture Experiment Station in Lubbock, TX on April 12, 1995 to evaluate for early season cold tolerance (emergence, stand establishment, and stand survival) and again on June 9, 1995 to evaluate for late season cold tolerance (yield, fiber development, and maturation). Field 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), Establishment Index-4 (a measure of the percentage of seeds planted resulting in established plants 4 weeks after planting). Field parameters measured to determine late season cold tolerance included Percent Open Bolls (a measurement of earliness), Yield (a measurement of lint production), and the fiber properties of lint micronaire, length, and strength (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 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

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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) and a Pouch Root Growth test (PRG). 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 (4° 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). Another laboratory evaluation of seedling response to chilling was the Pouch Root Growth test (PRG). The PRG test was conducted by placing 5 seed in pouches that were subjected to the same temperature regime as that of the ICT (24 hours at 40° F and 96 hours at 86° F). Root length and shoot length were then measured. Also evaluated from this study were the percentage of normal seed that germinated and is reported as the Pouch Germination test (PG). The study consisted of five replications.

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 imbibe for 24 hours. After 24 hours the water was decanted and electrical conductivity measurements taken. Readings were reported as EC 40° F.

Results and Discussion

Several lab test correlated with various field parameters at the 5% significance level. EC 40° F and the Pouch Germination tests correlated with six and four field parameters, respectively (Table 1). Although several correlations were significant, r^2 values were low (Figures 1,2,3,4). While a high correlation between lab data and field data was not observed, we do believe that a lab test exists which can screen for early and late season chilling tolerance in cotton genotypes. It is believed that electrical conductivity measurement of leachate from seed exposed to chilling during imbibition is a good indicator of chilling tolerance. The low r^2 values were likely due to other uncontrolled field variables or variables other than temperature which may have masked the results. Therefore, a cold temperature room has recently been obtained and will be used in future testing.

Acknowledgments

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Table 1. Correlation of laboratory and field data for the early planting date (April 12) and late planting date (June 9) to determine early and late season cold tolerance, respectively.

		FIELD						
LAB	P DATE	ERI	EI-4	POB	YIELD	MIKE	LEN	STREN
CGT	1	0.20	0.26	0.05	0.40*	0.13	-0.13	0.11
	2	0.33	0.31	-0.02	0.51**	0.32	0.15	0.29
CWVI	1	0.21	0.16	-0.06	0.23	-0.13	-0.07	0.03
	2	0.23	0.17	-0.05	0.45**	0.08	0.18	0.09
EC 40°F	1	-0.08	-0.31	-0.17	-0.39*	-0.42*	-0.16	-0.42*
	2	-0.55**	-0.61**	-0.15	-0.23	-0.10	-0.29	-0.51**
ICT	1	0.19	0.13	0.03	0.10	-0.02	-0.02	0.11
	2	0.17	0.13	0.05	0.53**	-0.19	0.17	0.02
PRG	1	-0.21	-0.19	-0.16	-0.09	-0.24	0.14	-0.05
	2	0.00	0.00	0.04	-0.14	-0.14	0.12	-0.08
PG	1	-0.07	-0.01	0.42*	0.32	0.36*	-0.36*	-0.31
	2	0.08	0.08	0.28	0.54**	0.13	-0.26	-0.22

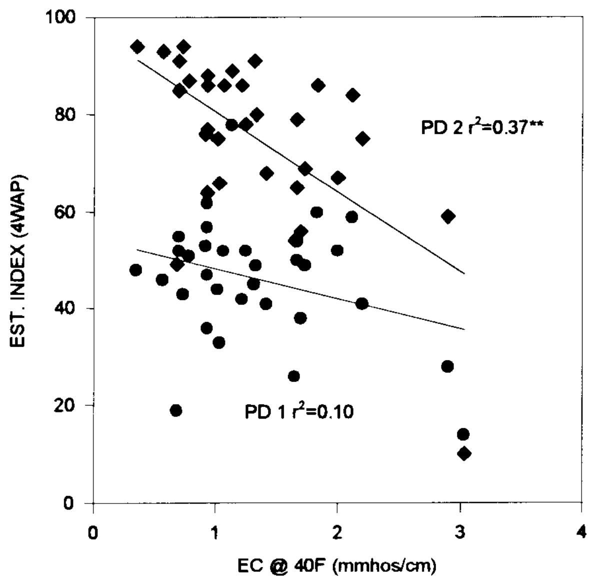

Figure 1. Regression: EI-4 vs. EC 40 F

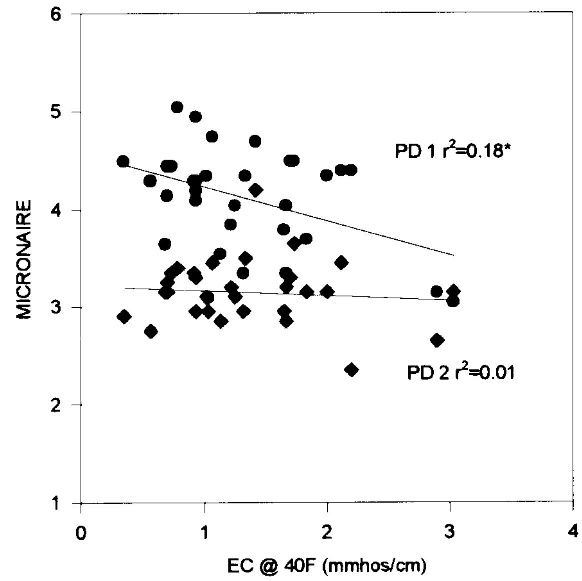

Figure 3. Regression: Mike vs. EC 40 F

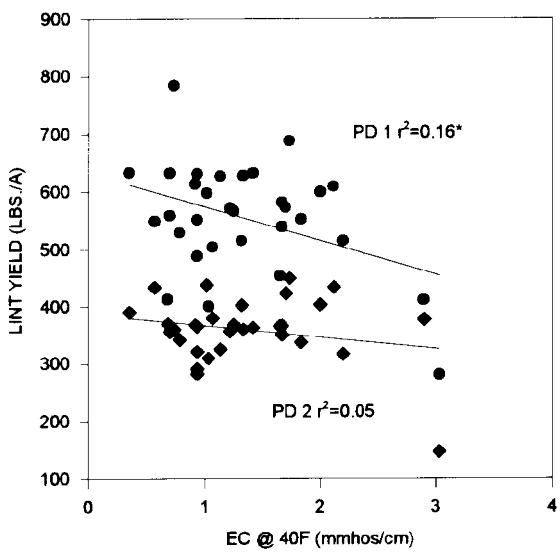

Figure 2. Regression: Yield vs. EC 40 F

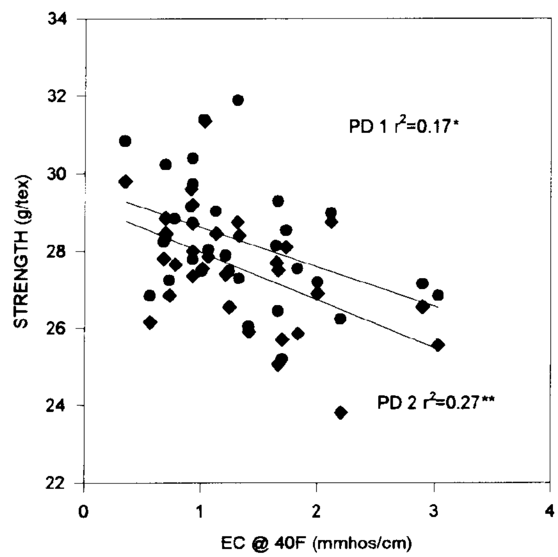

Figure 4. Regression: STR vs. EC 40 F