A SCREENING TEST FOR THE EVALUATION OF COLD TOLERANCE IN COTTONSEED GERMINATION AND EMERGENCE

B. Duesterhaus, [1] N. Hopper ,[1,2] J. Gannaway[2] and T.D. Valco[3]
[1]Texas Tech University, [2]Texas Agricultural Experiment Station; Lubbock, TX, and [3]Cotton Incorporated; Raleigh, NC

Abstract

The objective of this study was to develop a test to determine metabolic and imbibitional cold tolerance of cotton (*Gossypium hirsutum*) genotypes. Metabolic cold tolerance was determined by planting cotton seed in a sand media, exposing it to a constant temperature of 18^{O}C for 21 days, and then counting and adjusting the emergence percent for viable seed by dividing the emergence percentage by the warm germination percent. Imbibitional cold tolerance was determined by chilling the seed in moistened rolled foam pads at 5^{O}C for six hours, planting the seed in a sand media, exposing it to a constant temperature of 30^{O}C for 14 days, and then counting and adjusting the emergence for viable seed by dividing the emergence percent by the warm germination percent. Varieties whose imbibitional and metabolic emergence percents were both above 80% ranked as having excellent cold tolerance. If both emergence percents were from 65% to 80%, the variety ranked as having good cold tolerance. Varieties that had both imbibitional and metabolic emergence percents between 50% and 65% had fair cold tolerance, and if either emergence percent was below 50%, the variety had poor cold tolerance.

Introduction

Cotton (*Gossypium hirsutum*) development and production depends on many environmental factors. One important determinant is temperature, especially at planting. Temperatures below 20^{O}C at planting may cause chilling injury to seedlings and reduce stand establishment (Cole, 1974). Initial injury stems from the imbibition of cold water. Imbibition of 5^{o}C water for 12 hours can kill cottonseed (Christiansen, 1971). Secondary injury can occur 18 to 24 hours after the initiation of germination if temperatures remain below 18^{O}C (Christiansen, 1967). Therefore, varieties with enhanced cold tolerance are desired. Breeders currently screen new lines in field trials early in the season to help determine their cold tolerance; however, environmental conditions do not always allow for proper evaluation. Temperatures after planting are often difficult to predict. Therefore, a laboratory method to determine cold tolerance is needed. The objective of this study was to develop a laboratory method to determine a variety's overall cold tolerance by evaluating its cold tolerance to both metabolic and imbibitional chilling. In addition, this study evaluated the performance of 20 common varieties, most of which are grown on the Texas High Plains, using this test.

Reprinted from the *Proceedings of the Beltwide Cotton Conference*
Volume 1:596-599 (2000)
National Cotton Council, Memphis TN

Materials and Methods

The following 20 varieties were used in this study:

Altex Atlas	DP 5690	PM 2326 RR
Stoneville BG 4740	AFD Explorer	AFD Rocket
AFD 2525	Altex Express	Stoneville 239
DP 50	Holland 186	Suregrow 125
DP 2156	JH 126	Tejas
DP 2379	NuCotton 33b	Ute
DP 5415	PM 2200 RR	

Metabolic Chill Test

Three 50 seed replications of each variety were planted in plastic boxes (20 x 33 x 8 cm) on top of 3.8 cm (1.5 in.) of sterile sand previously wetted to field capacity. The seed were covered with 2.5 cm (1 in.) of dry sand and placed in a chamber at a constant temperature of 18^{O}C for 21 days. After 21 days, the Emergence Percent – Metabolic was calculated for each variety by determining the seedling emergence percentage and adjusting it for percent viable seed. The percent viable seed was determined by conducting a standard warm germination test on each variety as noted below.

Imbibitional Chill Test

From each variety, 150+ seeds were spread on and subsequently rolled in a polyurethane foam pad (34 x 42 x 1 cm). The pads were placed inside plastic tubes (33.5 cm long x 5 cm diameter) and soaked with 750 ml of 5^{O}C water. The tubes were drained of excess water and placed in a 5^{O}C chamber for six hours. After six hours, the seed were divided into three 50 seed replications and planted in sand using the same procedure as described above. The planted seed were then exposed in a chamber to a constant temperature of 30^{O}C for 14 days. After the 14 days, the Emergence Percent – Imbibitional was calculated for each variety by determining the seedling emergence percentage and adjusting it for percent viable seed.

Warm Germination Correction Factor

A standard warm germination test was conducted on the 20 varieties using four replications of 50 seeds each. The seeds were placed on wetted germination towels, rolled and placed into a germination chamber. Temperatures alternated between 30^{O}C for eight hours and 20^{O}C for 16 hours. After 10 days, seedlings with normal radicles 3.8 cm or greater in length were counted to determine the percent germination. Each variety's 10 day percent germination was divided into the corresponding variety's Emergence Percent – Metabolic and Emergence Percent – Imbibitional from the previous tests. This allowed the cold tolerance ratings to be determined

only on actual viable seed. These corrected values are used to determine the cold tolerance rating.

Imbibition

Ten grams of seed from each variety were distributed on the foam pads as described above. The foam pads were rolled, placed in the plastic tubes, and soaked with 750 ml of $5^{O}C$ water. The tubes were drained of excess water and placed in a chamber at $5^{O}C$ for six hours. After six hours, the seed were removed from the pad, blotted dry, and weighed again to determine the weight gain due to water imbibition. The moisture percentage is reported as the percent weight gain. The procedure was replicated three times.

Results and Discussion

From the Emergence Percent-Metabolic and Emergence Percent- Imbibition (Tables 1 & 2) of the 20 varieties, two way plots were produced (Figs. 1 & 2). These graphs indicate how each variety performed in each test with the x-axis representing the variety's corrected emergence in the imbibitional chill test and the y-axis representing the variety's corrected emergence in the metabolic chill test. The higher value on each axis indicates higher levels of cold tolerance to that chilling test. Overall cold tolerance for a variety is determined by its performance on both tests. Varieties with Emergence Percents from both tests 80 or above were classified as having excellent overall cold tolerance. Those with both Emergence Percents between 65 and 80 ranked as having good overall cold tolerance. If both Emergence Percents were between 50 and 65, a variety had a fair overall cold tolerance. A poor ranking was given to varieties that had either or both Emergence Percents below 50.

Emergence Percents for each variety from the metabolic and imbibition chill test were regressed on the corresponding variety's percent moisture increase after six hours of imbibition. This was to note if the imbibition rate was related to either type of chilling tolerance. The regressions of Imbibitional Emergence Percent with Imbibition (Figs. 3 & 4) had an R^2 of 0.40 in 1998 and an R^2 of 0.47 in 1999. This suggests that at least 40% of a variety's imbibitional chilling tolerance can be explained by imbibition rate. The regressions of Metabolic Emergence Percent with Imbibition (Figs. 5 & 6) were not significant, with R^2 values below 0.17 for each year. This suggests that little of a variety's metabolic chilling tolerance can be explained by its 6 hour imbibition.

The 20 varieties used in this study were evaluated using this test. The test values and ratings for each variety for 1998 and 1999 may be noted in Tables 1 and 2 (varieties not identified).

Acknowledgements

The authors would like to thank Cotton Incorporated for supporting this project. A special thanks goes to Dr. Norman Hopper for his advisement in this study. Also, thanks to Stacy Franklin, Katie Williams, and Dewayne Hovey for their assistance in conducting this study.

References

Christiansen, N.M. 1967. Periods of Sensitivity to Chilling in Germinating Cotton. Plant Physiology. 42:431-433.

Christiansen, M.N. 1971. Biochemical and Physical Responses to Chilling by Germinating Cotton. Proc. 1971 Beltwide Cotton Conference., pp. 71-72.

Cole, D.F. and J.E. Wheeler. 1974. Effect of Pregermination Treatments on Germination and Growth of Cottonseed at Suboptimal Temperatures. Crop Sci. 14:451-454.

Table 1. Emergence Percents (1998).

Variety	EP Met.	EP Imb.	Category
1	81.4	83.3	Excellent
2	81.0	82.5	Excellent
3	80.3	78.1	Good
4	75.9	82.3	Good
5	73.7	86.9	Good
6	73.4	81.3	Good
7	71.6	75.2	Good
8	71.4	78.0	Good
9	70.7	86.9	Good
10	69.7	75.7	Good
11	68.8	84.2	Good
12	67.7	76.8	Good
13	61.9	85.5	Fair
14	61.1	88.4	Fair
15	60.3	72.3	Fair
16	54.6	80.1	Fair
17	53.6	74.0	Fair
18	43.9	60.7	Poor
19	41.8	12.4	Poor
20	17.8	33.8	Poor

EP Met. = Emergence Percent – Metabolic

EP Imb. = Emergence Percent - Imbibitional

Variety order in above table is based on performance in the Cold Tolerance Screening Test and does not correspond to the variety order in Methods and Materials.

Table 2. Emergence Percents (1999).

Variety	EP Met.	EP Imb.	Category
1	84.7	85.2	Excellent
2	81.1	95.2	Excellent
3	77.9	89.1	Good
4	76.5	90.5	Good
5	72.0	82.8	Good
6	69.8	72.6	Good
7	69.2	69.2	Good
8	69.1	98.0	Good
9	69.1	90.1	Good
10	67.0	89.9	Good
11	63.3	89.1	Fair
12	62.2	77.0	Fair
13	60.6	58.3	Fair
14	59.5	71.0	Fair
15	57.5	100	Fair
16	56.8	87.2	Fair
17	64.4	22.3	Poor
18	49.8	75.8	Poor
19	48.6	92.4	Poor
20	44.4	72.7	Poor

EP Met. = Emergence Percent – Metabolic
EP Imb. = Emergence Percent - Imbibitional
Variety order in above table is based on performance in the Cold Tolerance Screening Test and does not correspond to the order in Methods and Materials.

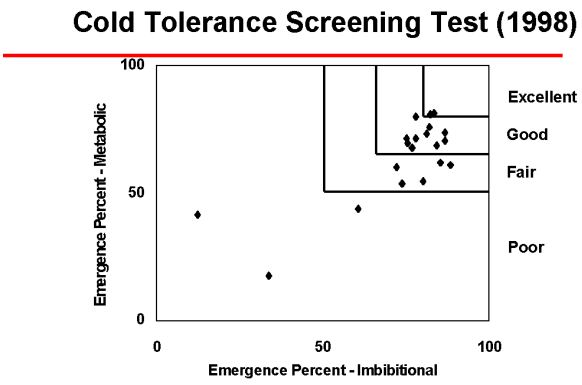

Figure 1.

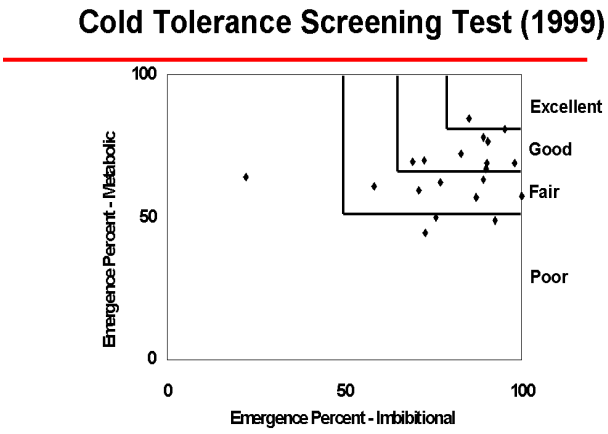

Figure 2.

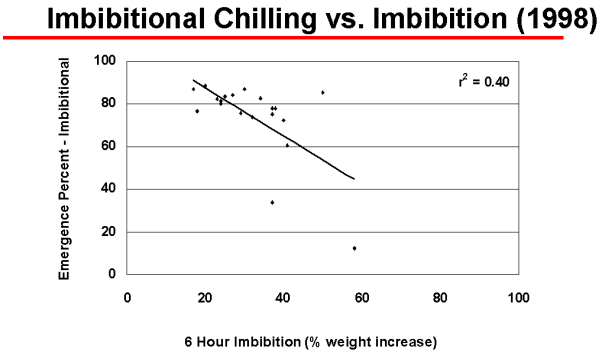

Figure 3.

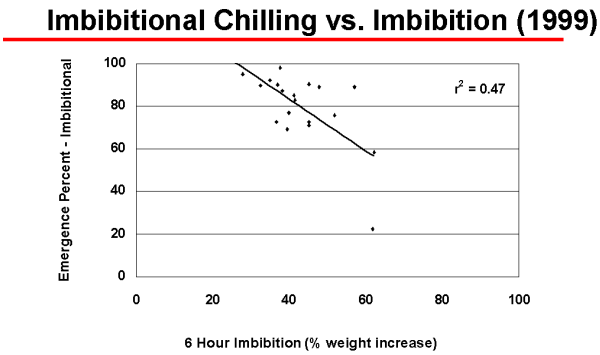

Figure 4.

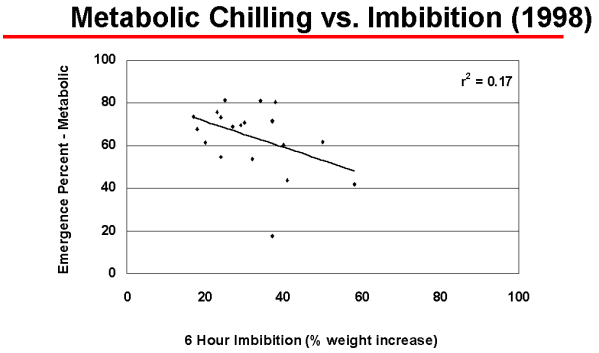

Figure 5.

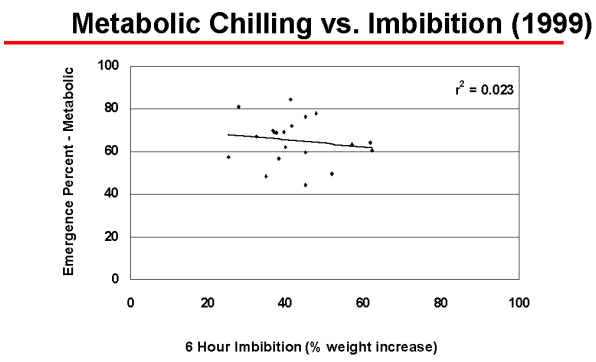
Metabolic Chilling vs. Imbibition (1999)
Emergence Percent - Metabolic
100
80
60
40
20
0
0
20
40
60
80
100
r^2 = 0.023
6 Hour Imbibition (% weight increase)

Figure 6.