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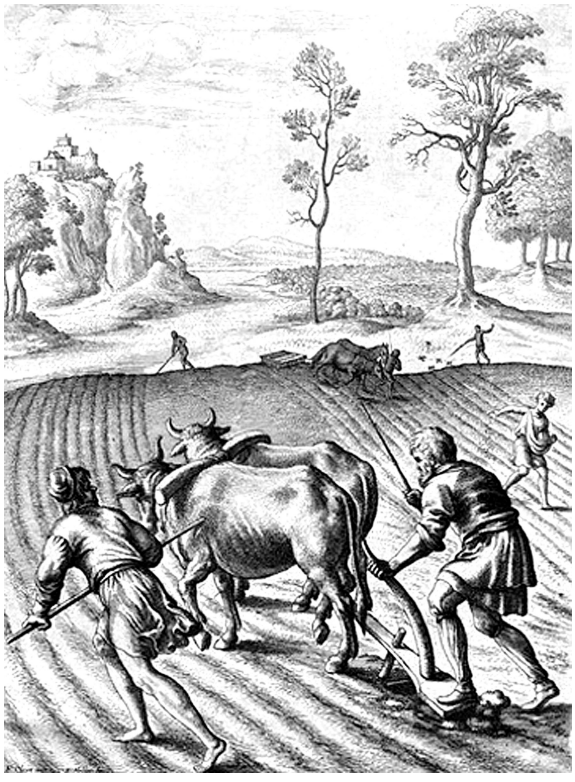

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Predicting Cotton Seedling Emergence for Cold Tolerance: *Gossypium barbadense*

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Abstract: A total of 9 genotypes from *G. barbadense* were screened at 5 different tests to determine the best screening test to predict field emergence. Warm germination percentage was measured at 30°C and ranged from 87.5 to 99.2%. Cool germination percentages were measured at 13, 15 and 18°C. Multiple regressions were used to determine degree of association between variables. Predicting field emergence with combinations of 30 and 18°C tests (difference between 30 and 18°C) was better than other tests alone. No significant relation was found between field emergence percentages and 15 and 13°C germination percentages.

Key words: Cotton, *Gossypium barbadense*, cold stress, screening

INTRODUCTION

Because cotton is a cold sensitive plant, producers are faced with a dilemma in their planting schedule. They confuse for uncertainty in the seed quality or the environment by planting extra seed. If producers plant late in the season 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 (Kittock *et al*., 1987). Thus, the inability to plant to an optimum stand makes cotton production more difficult and costly. Conversely, when the producers plant early in the season 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 and Thomas, 1969). On the other hand, early planting had yield improvement to the normal planting if it is not stressed by cold (Bange and Milroy, 2004). So, having good quality cotton seed that is somehow tolerant to cold stress is an important issue in many breeding programs.

McDonald (1980) defined seed vigor as those properties which determine the potential for rapid, uniform emergence and development of normal seedlings under a wide range of field conditions. Several attempts have been made to define those properties. These include weight relationships (Christiansen, 1962), biochemical test (Speed *et al*., 1996) and classification according to radicle growth rate. Cool germination test at 18°C were used by several researchers to test cold tolerance of different genotypes (Savoy, 2005; Smith and Varvil, 1984; Tolliver *et al*., 1997; Durummond and Savoy, 1996). Metabolic chill test and imbibitional chill tests on sand are also used to test cold tolerant varieties with cold tolerance rating (Duesterhaus *et al*., 2000; Schulze *et al*., 1997).

Kerby *et al*. (1989) concluded that predicting field emergence with Cold+Warm% was better than either component alone. They also used HU values 5 and 10 days after planting to explain as much variation in field emergence as seed quality. When HU 5 days after planting, C+W% and the interaction between the two were considered in multiple regressions, 68.5% of the variation in field emergence explained.

Bourland (1992) indicated that standard germination test results are often a poor indicator of emergence if suboptimum conditions are experienced and only vigorous seed emerge. The cool germination test provides an indication of vigor, but at 18°C slight variations in temperature may cause large differences in germination.

Physiological zero for cotton has been described to 15°C. This minimum temperature appears to affect essentially all phases of cotton growth and development. In most of the cotton planting areas of Turkey, planting occurs when the night temperatures are well below this minimum temperature requirement. Optimum planting date for the region is around May 15th. Advisable planting date for GAP region starts around April 20th. For this reason minimum soil temperature falls below the 15°C. Early plantings when soils were cool generally reduced yields of upland cotton, but these conditions had little detrimental impact on Pima cotton (Kittock *et al*., 1986).

In the GAP region, major cotton growing region in Turkey, planting usually performed after April 20th and most of the time goes first or second weak of May. If more cold tolerant 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).

Identification and use of high quality planting seed is a priority of cotton growers in Turkey and in the world as well. Screening for cold tolerance in the field is sometimes not easy due to bad whether conditions in addition to soil born diseases affecting germination and stand establishment. Using the most predictable laboratory screening technique for cold tolerance will help to save time and increase the efficiency of selection. The purpose of this study was developing a model to predict field emergence from laboratory experiments to relate cold tolerance for *G. barbadense* cultivars. A high cool germination percentage identifies genotypes that may be planted under a wider range of field conditions than genotypes with lower cool germination results has been suggested. Results from this experiment are used by growers as a tool for scheduling plantings, determining seeding rates and determining seed vigor.

MATERIALS AND METHODS

Field test: Two hundred seed of each genotype were planted on each raw on April 7, 2005. This date was used to determine the response of seeds to low temperature stress. Seeding depth was 25 mm. Optimum planting date for the region is around May 15th. Stand counts were recorded once a week for a month after the planting date. Four counts were made from April 7 to May 4th. Soil temperature in the experimental area was averaged 12°C at 5 cm depth.

The experimental design was a randomized complete block with 2 replications. Rows were 12 m length and 70 cm apart each other. Soil type was alluvial. Soil moisture was adequate and irrigation was not required for seedling emergence. Field parameter measured for early season cold tolerance was field emergence percentage (total percent germination).

Laboratory test: Various laboratory tests were used to evaluate of both seed and seedling from the entries. Standard, 30°C and cool, 18°C, germination percentages as defined by AOSA procedures were determined. The tests were conducted on four replications of 50 seed, which were planted on moistened germination towels (two on bottom, two on top) then rolled. Rolled towels were place upright in a less-then air tight container to prevent towels from drying too rapidly, to maintain high humidity and to provide proper aeration to germinating seeds. These containers were placed in germination equipment capable of maintaining 18°C. The duration of the test was seven days for 18°C and 4 days for 30°C. A final 7 day count was also taken to determine percent germination for 30°C. At this time one count of normal seedlings that had a combined hypocotyl and root length of 3.75 cm (1.5 inch) or longer were made. The root-hypocotyl measurement was made from the point of cotyledon attachment to the tip of the radicle. Standard germination, defined as percent of healthy seedlings reaching 38 mm after 7 days at 30°C on paper towels. Combinations of 18 and 30°C tests were also calculated.

Four replications of 50 seed were subjected to a 24 h imbibition period in rolled foam pads containing 100 mL of 5°C water then planted in a controlled environment room in sand at a constant 18°C to evaluate for early season cold tolerance (Schulze *et al*., 1997). Seeds were planted in plastic boxes on a 3.8 cm layer of sand at field capacity and another 3.8 cm of dry sand covering the seed. Germination counts were made 7th, 14th and 21st days after planting the seeds. Sand was autoclaved before use for planting.

Cool, 13 and 15°C, tests were conducted as standard germination test. Counts for 13°C germinations were made 7th, 14th and 21st day after planting. Seedlings having hypocotyl length greater than 1, 2 and 2 cm were counted at day 7, 14 and 21 days, respectively. Normal seedlings that had a combined hypocotyl and root length of 3.75 cm (1.5 inch) or longer were made at 15°C germination percentages after 7 days of planting.

Multiple regression analysis was used to relate laboratory germinations to field emergence percentages.

RESULTS AND DISCUSSION

Nine *G. barbadense* genotypes were screened for cold tolerance in the laboratory and field to predict field emergence percentage from laboratory germination and emergence percentages. 13, 15, 18°C (both in paper towels and in sand) and 30°C germination conditions were evaluated in addition to the combinations of 18 and 30°C germination percentages calculated.

Germinations at 15 and 13°C were not a good predictor of field emergence with sufficient precision to allow growers to plant to a stand for *G. barbadense* since no significant relationship was detected between them. Buxton *et al*. (1976) found that Pima cotton (*G. barbadense*) gave similar results at 15 or 25°C. It could be better to test *G. barbadense* cultivars using higher temperatures than 15°C. No significant relations were also found between field emergence and 18+30°C germinations percentages. Eighteen degree centigrade germination and emergence especially combination with 30°C germination percentages are more conservative estimate of field emergence (Table 1). Subtracting 18°C germination percentages from 30°C germinations (30-18°C) of day 7 are the best predictor of field emergence at 7, 14 and 21 days

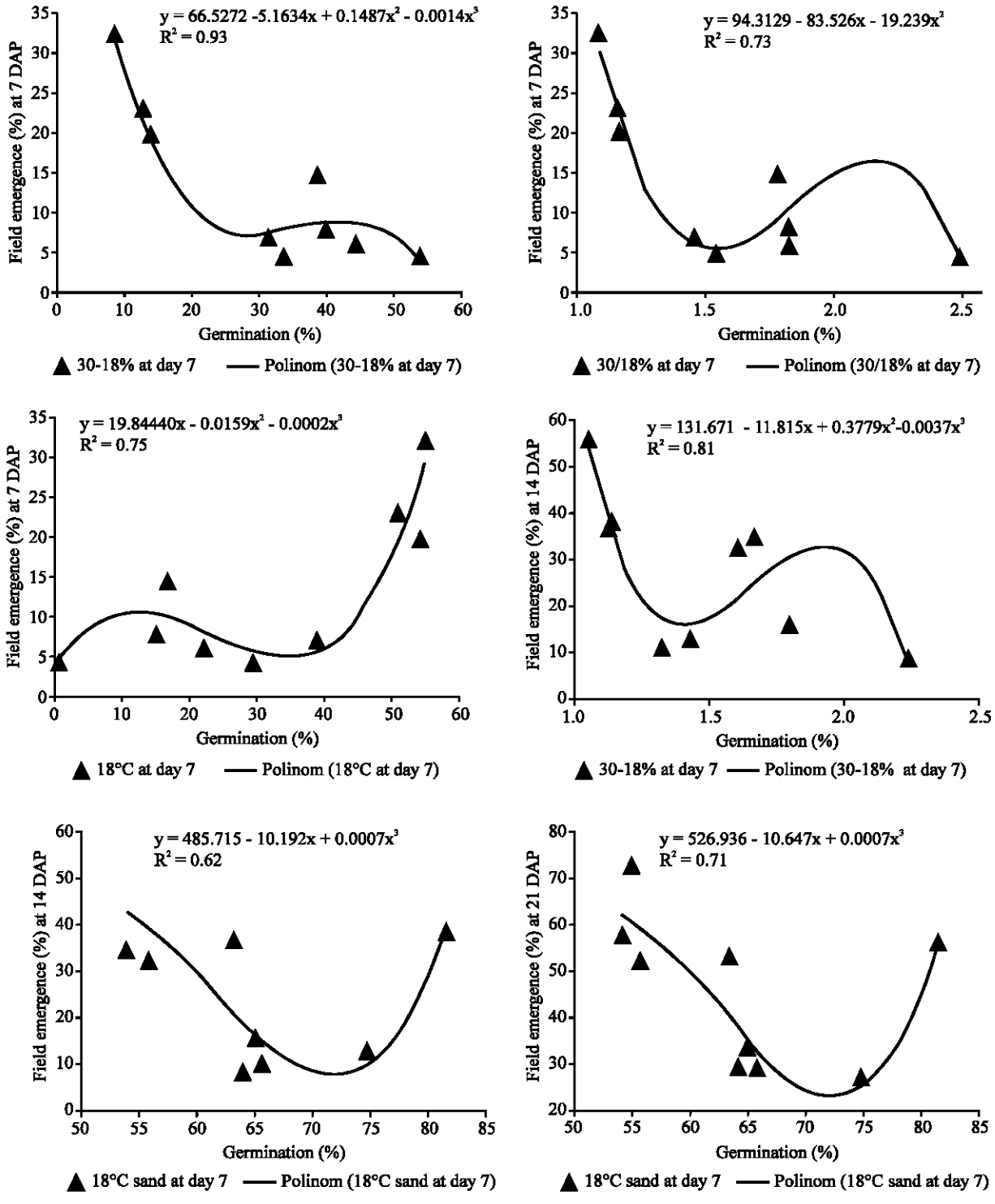

Fig. 1: Field emergence percentages as predicted by 18, 30, 30-18 and 30/18°C germination percentages at 7, 14 and 21 Days After Planting (DAP)

Table 1: Comparison of independent variables against percent field emergence at 7, 14 and 21 days after planting

Field emergence (%)	Independent variables and days		R^2	p-value	Regression equation
Day 7	18°C germination percentage on paper (Day 7 counts)	Linear	0.57	*	$y = -14.726 + 0.4578x$
		Quadratic	0.72	*	$y = 46.8216 - 1.7135x + 0.0179x^2$
		Cubic	0.75	*	$y = 19.8440 - 0.0159x^2 + 0.0002x^3$
	30°C germination percentage on paper (Day 4 counts)	Quadratic	0.75	*	$y = -1896.5 + 43.9076x - 0.2508x^2$
		Cubic	0.75	*	$y = -1896.5 + 43.9076x - 0.2508x^2$
	30-18°C germination percentage on paper (Day 4 counts)	Linear	0.68	**	$y = 27.5201 - 0.5741x$
		Quadratic	0.81	**	$y = 36.8282 - 1.6665x + 0.0224x^2$
		Cubic	0.90	**	$y = 54.0124 - 5.0143x + 0.01797x^2 - 0.0021x^3$
	30-18°C germination percentage on paper (Day 7 counts)	Linear	0.76	**	$y = 29.8484 - 0.5407x$
		Quadratic	0.85	**	$y = 39.0273 - 1.4087x + 0.0150x^2$
		Cubic	0.93	**	$y = 65.5272 - 5.1634x + 0.1487x^2 - 0.0014x^3$
	30/18°C germination percentage on paper (Day 4 counts)	Linear	0.53	*	$y = 41.3451 - 18.795x$
		Quadratic	0.69	*	$y = 108.660 - 107.47x + 27.5924x^2$
		Cubic	0.69	*	$y = 108.660 - 107.47x + 27.5924x^2$
	30/18°C germination percentage on paper (Day 7 counts)	Linear	0.55	*	$y = 39.1950 - 16.135x$
		Quadratic	0.73	*	$y = 94.3129 - 83.526x + 19.2392x^2$
		Cubic	0.73	*	$y = 94.3129 - 83.526x + 19.2392x^2$
Day 14	18°C emergence percentage on sand, (Day 7 counts)	Cubic	0.62	*	$y = 485.715 - 10.192x + 0.0007x^3$
	30-18°C germination percentage on paper (Day 4 counts)	Linear	0.53	*	$y = 47.7760 - 0.8323x$
		Cubic	0.81	*	$y = 102.056 - 10.709x + 0.4361x^2 + 0.0055x^3$
	30-18°C germination percentage on paper (Day 7 counts)	Linear	0.57	*	$y = 50.7723 - 0.7714x$
		Cubic	0.81	*	$y = 131.671 - 11.815x + 0.3779x^2 - 0.0037x^3$
Day 21	18°C emergence percentage on sand, (Day 7 counts)	Quadratic	0.70	*	$y = 733.796 - 20.188x + 0.1450x^2$
		Cubic	0.71	*	$y = 526.936 - 10.647x + 0.0007x^3$
	30-18°C germination percentage on paper (Day 7 counts)	Linear	0.45	*	$y = 66.5641 - 0.6817x$

*, Significant at 0.05; **, Significant at 0.01

and 21 days after planting. Regression equation for the field emergence at 7 days after planting is $y = 65.5272 - 5.1634x + 0.1487x^2 - 0.0014x^3$. Thus, counting hypocotyl-root length after 7 days the tests started could explain much of the variation in the field. The 18°C germination alone accounted for 75% of the variation in field emergence of day 7. On the other hand, the 18°C emergences in sand alone accounted for 62 and 71% of the variation for day 14 and 21 after planting, respectively.

Kerby *et al*. (1989) found that the difference or the ratio between 30 and 18°C germination percentages are not a good indicator of field emergence for *G. hirsutum* as opposed to our findings for *G. barbadense* genotypes.

The difference between 18 and 30°C germination percentages (30-18°C) accounted for 93, 81 and 45% of the variation in field emergence for 7, 14 and 21 days after planting, respectively. This indicates that *G. barbadense* cultivars emerge faster under cool temperatures and could be presented by laboratory tests. On the other hand, the ratio of 18 and 30°C (30/18°C) accounted for 73% of the variation in field emergence for day 7 counts after planting (Table 1). The 30-18°C of day 4 accounted for 90 and 81% of the variation at day 7 and 14, respectively, while 30/18°C accounted for 69% of the variation in field emergence at day 7 after planting.

Acid delinted and not damaged, selected seeds were used for this study. Variations in soil temperature might cause biases in prediction of field emergence as noted by Buxton *et al*. (1976). For this reason environmental factors need to be taken into account in order to plant to a stand. Graphical representation of regression equations were given in Fig. 1. The predicted value of field emergence increases as 30-18°C values increases (Fig. 1).

In both 30-18°C and 30/18°C are the parameters that greater percentage of the variation in field emergence can be explained (Table 1). This appears to offer the potential to allow cotton growers to determine if planting conditions are favorable and adjust planting rates according to 18 and 30°C test results. These data demonstrate that cotton farmers planting *G. barbadense* cultivars can adjust seeding rates and plant to a stand across a range of acceptable planting temperature if they know the 18 and 30°C germination percentages.

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