SCREENING COTTON VARIETIES FOR TOLERANCE TO WATER-LOGGED SOIL CONDITIONS

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Abstract

The high economic potential makes cotton a desirable crop outside of the soils it was native to, which means it sometimes encounters flooding conditions. Cotton is poorly adapted to water-logged soil conditions, considered to be one of the major problems for cotton producers world wide. The objective of this research was to identify differences among the tolerances of modern cotton varieties to flooded soil conditions. A Sharkey clay soil at the University of Missouri Lee Farm in Pemiscot County, Missouri was used for the evaluation. Five seeds of each variety were hand planted in hills spaced 48 inches apart on raised beds on 38 inch rows. A levee of soil was established around the experiment to retain flood water. Each variety was replicated four times in a randomized complete block experimental design. Floods were established to a depth of 8 inches and maintained for at least 72 hours twice during July of both years. The plants were allowed to reach physiological maturity and the resulting cotton was harvested by hand. Differences were observed among cotton varieties in the ability to withstand water-logged soil conditions. More study is needed to identify varieties that perform satisfactorily under flooded soil conditions, if any exist. Furthermore, with the short time that most varieties are commercially marketed, screening methods will be needed in the variety development programs to allow producers to obtain varieties that will produce acceptable yields under such conditions.

Introduction

The high economic potential makes cotton a desirable crop outside of the soils it was native to, which means it sometimes encounters flooding conditions. Cotton is native to the arid upland areas of southern Mexico. It is genetically adapted to an arid climate and well drained soils. It is poorly adapted to water-logged soil conditions (Hearn, 1969). Cotton plants do not develop functional aerenchyma, which supply oxygen to the roots during water-logged soil conditions (Leonard and Pinckard, 1937). Root growth is also very sensitive to water-logging. Huck (1970) found that root growth stopped shortly after of the onset of anoxic conditions. Water-logged soils are considered to be one of the major problems for cotton producers world wide.

One of the challenges that cotton producers face is the uncertainty of the timing and amount of precipitation during the crop year (Constable and Hearns, 1981). Cotton is generally cultivated on well drained soils. However within most fields some areas are not as well drained. This problem is amplified on heavy clay soils (e.g. Sharkey series, very fine, montmorillonitic, thermic Vertic Haplaquept) which lack adequate internal drainage (Dunn et al., 2001). These soils are commonly furrow irrigated, making the potential for water-logging even greater. Factors which may increase the frequency and length of water-logging in furrow irrigated soils include excessive field length, inconsistent grading, inadequate field slope, improper bed form, and excessive rain fall following irrigation.

The cotton yield potential of Sharkey soils in Missouri is 2/3 to ¾ of more traditional cotton soils (Phipps, 2004). This is in contrast to other cotton producing areas of the world where heavy clay soils are among the most productive (Hearn and Fitt, 1992). Investigations by at the University of Missouri-Delta Center indicated that cotton lint yields on heavy clay soils could be increased with an aggressive irrigation scheduling (Dr. Bobby Phipps, unpublished data). Research in Australia has produced mixed results as to the effect of duration and timing of water-logging on cotton yields. Hodgson (1982) found that timing of water-logging was not as important as duration of the water logging event. In contrast, Bange et al., (2004) found that timing was important, with maximum yield reductions occurring when the event occurred at First Square. These differences in response were attributed to genetic differences in the cotton cultivars used in each evaluation.

The objective of this research was to identify differences among the tolerances of modern cotton varieties to flooded soil conditions.

Methods and Materials

This report covers the first two years of a three year study. In 2006, 61 varieties of cotton (51 commercial and 10 plant introduction) were evaluated for their ability to withstand prolonged flooded soil conditions. In 2007, 56 commercial varieties were evaluated. For purposes of this report only the 31 varieties common to both years are considered. These varieties are listed in Table 1. For complete information on all varieties evaluated please contact the authors.

Table 1. Two-year (2006 and 2007) average seed cotton yields and one year percent of non-flooded yield potential (2007) for commercial cotton varieties evaluated at Portageville, MO.

	Variety	Two-year average seed cotton yield (lb/plot)		% of non-flood yield potential (2007)	
1	DP 147 RF	0.04	a	13.4	b
2	ST 5242 BR	0.04	a	16.8	b
3	DG 2100 B2RF	0.04	ab	38.3	a
4	ST 5599 BR	0.04	abc	7.6	b
5	FM 9063 B2F	0.04	abcd	20.8	ab
6	PHY 310 R	0.03	abcde	9.3	b
7	FM 9058F	0.03	abcdef	5.0	b
8	DG 2242 B2RF	0.03	abcdefg	4.4	b
9	DP 515 BG/RR	0.03	abcdefgh	8.5	b
10	DP 444 BG/RR	0.03	abcdefgh	5.7	b
11	DP 164 B2RF	0.02	abcdefgh	8.2	b
12	ST 5327 B2RF	0.02	bcdefgh	9.1	b
13	ST 4554 B2RF	0.02	bcdefgh	7.8	b
14	DP 167 RF	0.02	bcdefgh	4.8	b
15	DP 143 B2RF	0.02	bcdefgh	7.9	b
16	DG 2520 B2RF	0.02	bcdefgh	0.0	b
17	CG 3020 B2RF	0.02	bcdefgh	0.0	b
18	ST 4357 B2RF	0.02	cdefgh	8.6	b
19	PHY 370 WR	0.02	cdefgh	0.5	b
20	FM 9060F	0.02	cdefgh	0.0	b
21	DP 445 BG/RR	0.02	cdefgh	1.6	b
22	DP 117 B2RF	0.02	cdefgh	6.8	b
23	CG 4020 B2RF	0.02	cdefgh	2.2	b
24	CG 3520 B2RF	0.02	cdefgh	9.2	b
25	ST 5283 RF	0.02	defgh	0.0	b
26	ST 4664 RF	0.02	efgh	4.8	b
27	PHY 425 RF	0.01	efgh	2.0	b
28	ST 4427 B2RF	0.01	fgh	4.6	ba
29	PHY 485 WRF	0.01	fgh	1.4	b
30	DP 455 BG/RR	0.01	gh	0.0	b
31	DP 432 RR	0.00	h	1.9	b
	CV %	80.2		185.5	

† Values followed by the same letter were not significantly different at the P=0.1 level.

A Sharkey clay soil (very fine, montmorillonitic, thermic Vertic Haplaquept) located at the University of Missouri Lee Farm in Pemiscot County, Missouri was used for this evaluation. The varieties were cultivated on raised beds on 38 inch rows. Five seeds of each variety were hand planted in hills spaced 48 inches apart. A levee of soil was established around the experiment to retain flood water (Figure 1). Each variety was replicated four times in a randomized complete block experimental design. In 2007 a non-flooded reference block with each variety represented was planted according the same specifications as above. Yield data from this reference block was used to calculate percentage of non-flooded yield potential obtained under flooded conditions.

Figure 1. Flood and non-flood area for cotton variety screening, Portageville, MO 2007.

The evaluations were planted on May 16, 2006 and May 15, 2007. In 2006 on July 12 a flood was established to a depth of 8 inches and maintained for 72 hours. A second flood was established on July 24 and maintained for 96 hours. In 2007 floods were established to a depth of 8 inches on July 9 and July 30. Both of these floods were maintained for 72 hours. The plants were allowed to reach physiological maturity. On November 14, 2006 and November 15, 2007 the resulting cotton was harvested by hand. The weight of seed cotton obtained from each hill was weighed and recorded. The small amount of seed cotton obtained from each hill was not sufficient to gin.

Two-year yield data, 2006 & 2007, was analyzed in SAS (SAS, 1997). The data were transformed using a log function to meet assumptions of normality. Non transformed data are presented. One year data, 2007, for percent of non flooded yield potential was analyzed in ARM (Gylling Data Management, INC. 2002).

Results and Discussion

Significant differences were found among varieties for seed cotton yields during both years. Analysis of variance showed no interaction between variety and year (Table 2), suggesting that the response may not be affected by environmental differences from season to season. The numerically greatest two-year seed-cotton yields were found with the varieties DP 147 RF and ST 5242 BR with 0.05 lb per plot. Additionally, 11 varieties produced seed-cotton yields that were statistically equivalent but numerically less than the top yielding variety.

Table 2. Analysis of variance for cotton yields from 2006 and 2007

Variable	Pr < F
Variety	0.0175
Year	0.0404
Variety*Year	0.6788

There were also statistical differences in the percentage of seed cotton yield relative to the non-flooded reference block (2007 data only). The variety DG 2100 B2RF produced the greatest percentage of potential yield of 38.3%. One other variety, FM 9063 B2F, had a percentage that was statistically equivalent but numerically less. Four varieties had yield greater than 10% of their non-flooded yield potential.

These data suggest that there is a varietal difference in the tolerance of cotton plants to flooded soil conditions. However, only 13% (4 of 31) of the varieties that were tested for two years retained at least 10% of the yield of non-flooded plants grown on the same soil type, and only one variety retained more than one-quarter of the non-flooded yield. More study is needed to identify varieties that perform satisfactorily under flooded soil conditions, if any exist. Furthermore, with the short time that most varieties are commercially marketed, screening methods will be needed in the variety development programs to allow producers to obtain varieties that will produce acceptable yields under such conditions.

Conclusions

Differences were observed among cotton varieties in the ability to withstand water-logged soil conditions. Eventually, it may be possible to exploit these differences in developing cotton management systems for soil prone to water-logging, however, the large amount of variability in the data makes definitive conclusions difficult at this time. More study is needed to identify varieties that perform satisfactorily under flooded soil conditions, if any exist. Furthermore, with the short time that most varieties are commercially marketed, screening methods will be needed in the variety development programs to allow producers to obtain varieties that will produce acceptable yields under such conditions.

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