Assessing cultivar cold tolerance using germination chill protocols – preliminary studies

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Summary

The potential for chilling conditions in many Australian cotton growing regions during early growth and development stages demonstrates the need for assessing cold tolerance of cultivars. Preliminary studies have been initiated to assess a range of simple techniques to detect cold tolerance between cultivars. Early results have been positive in detecting some differences between cultivars. The laboratory germination test where seeds are germinated at temperatures of 14 °C for 4 days showed some potential for providing an indication of differences in germination and early establishment.

Introduction

Cotton (*Gossypium hirsutum* L.) is sensitive to cold conditions during germination and establishment. Chilling injury can occur in cotton seeds and reduce germination and emergence whenever the temperature drops below a range of 15°C to 20°C for a few hours during the first few days of germination (Lauterbach *et al.* 1999, Cole and Wheeler 1974). The average frequency of cold shocks (minimum temperature ≤11°C) in major Australian cotton producing regions during the early growth of cotton (15th September – 30th November) ranges from 40 at Hillston (NSW) to 4 in Emerald (QLD) (Bange and Milroy 2004). This emphasises the importance of developing understanding of the differences in cultivars with cold tolerance or management practices that will avoid the potential cold periods during early cotton growth thus allowing for better crop establishment and in severe cases reduce the costly need to replant.

Although some work has been carried out on American cultivars, few germination chill experiments have been carried out on modern Australian cultivars to assess their potential for cold tolerance. Studies have been initiated to develop methodologies to assess chilling and cold tolerance at germination and early growth and establish whether there is variation in Australian cultivars. In identifying cultivars that may offer cold tolerance it may offer opportunities for future breeding efforts and for growers to select these cultivars specifically for these traits to mitigate chilling damage. Here we present some preliminary assessment of data assessing only a few of the techniques that we are investigating. Studies are continuing to assess a broader range of approaches to assess variation in cold tolerance of cultivars.

Materials and methods

Measurements were conducted at the Australian Cotton Research Institute (ACRI) and at the University of Sydney using germination incubators on ten cotton cultivars (Table 1).

Table 1: Cotton cultivars used to assess techniques to detect differences in cold tolerance.

- Sicala 350B
- Sicot 81
- Sicot 289RR
- Siokra V-18
- Pima A-8
- Sicot 71
- Sicot 75
- TL
- Namcala
- DP16

There were four replicates for each cultivar and the experiments were repeated in two locations (Narrabri and Sydney). Seeds were germinated at four differing temperatures 14ºC, 18ºC (cool germination test), 22ºC and 30ºC (warm germination test). Germination percentages where determined after 4, 7 and 10 d. In addition ten seedlings were selected randomly and the length from the hook of the hypocotyl to the tip of the radicle was also measured.

A cool-warm vigour index test was calculated using the 18ºC and 30ºC germination percentages taken at 4 and 7 d. The germination percentages were added together and divided by two to provide a cool-warm vigour index for each cultivar. Research has indicated that a combination of the warm germination test and the cool germination test are a more reliable indicator of field performance (Hake et al. 1996, Smith and Varvil 1984, Buxton et al. 1977).

The techniques described above were then correlated to field data of seedling vigour, which assessed the number of true leaves on ten plants per plot (averaged over four plots) 31 d. after planting at Myall Vale, Narrabri (NSW). Only six of the ten cultivars were tested in the field study. Germination tests were analysed using analysis of variance (ANOVA) and regressions with the Genstat statistical program.

Preliminary results

Preliminary results have suggested that there may variability in cultivar cold tolerance (Table 2, Figure 1). It is interesting that DP16 (95.25) had a higher cool-warm vigour index than Namcala (87.50). Namcala was originally developed in New Mexico, USA with a climate ranging from arid to semi-arid, and average summer temperatures ranging from 26ºC at high elevations to around 33ºC with maximum temperatures of up to 50ºC (Constable G.A., pers. comm..). DP16 was first developed in Mississippi, USA, where the climate is cooler and more humid. Hence, DP16 seedlings may be more adapted to chilling conditions during germination and establishment than Namcala which originated from a hotter, dryer climate.

We also see that some of the tests show some relationship with the number of true leaves 31 d after sowing indicating that the tests may reflect tolerance that translates into differences in the field (Figure 2). Work in continuing to assess a broader range of germination tests to see whether they have the potential to detect differences in cultivar cold tolerance. We are also investigating techniques that will account for seed viability due to differences in seed age.

Table 2: Warm germination, cool germination and cool-warm vigour index for selected cultivars

Cultivar	**Cool warm vigour index**	**Cool germination test (%)**	**Warm germination test (%)**
DP16	95.25	92.00	98.50
Sicala 350 B	93.00	90.50	95.50
Siokra V – 18	90.50	89.50	91.50
Sicot 71	90.50	90.50	90.50
Sicot 75	90.50	88.50	92.50
Sicot 81	89.00	88.50	89.50
Pima A – 8	88.75	85.00	92.50
TL	88.50	87.00	90.00
Namcala	87.50	85.50	89.50
Sicot 289 RR	86.00	81.00	91.00
L.s.d at $P = 0.05$	3.66	-	4.99
F test	$P < 0.001$	Not significant	$P < 0.05$

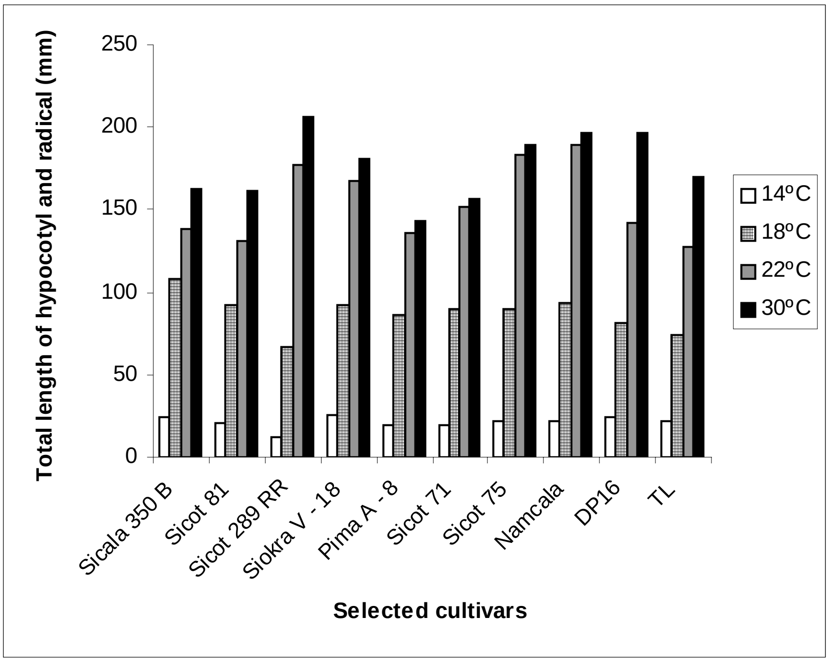

Figure 1: The effect of temperature on hypocotyl and radicle length after 10 days.

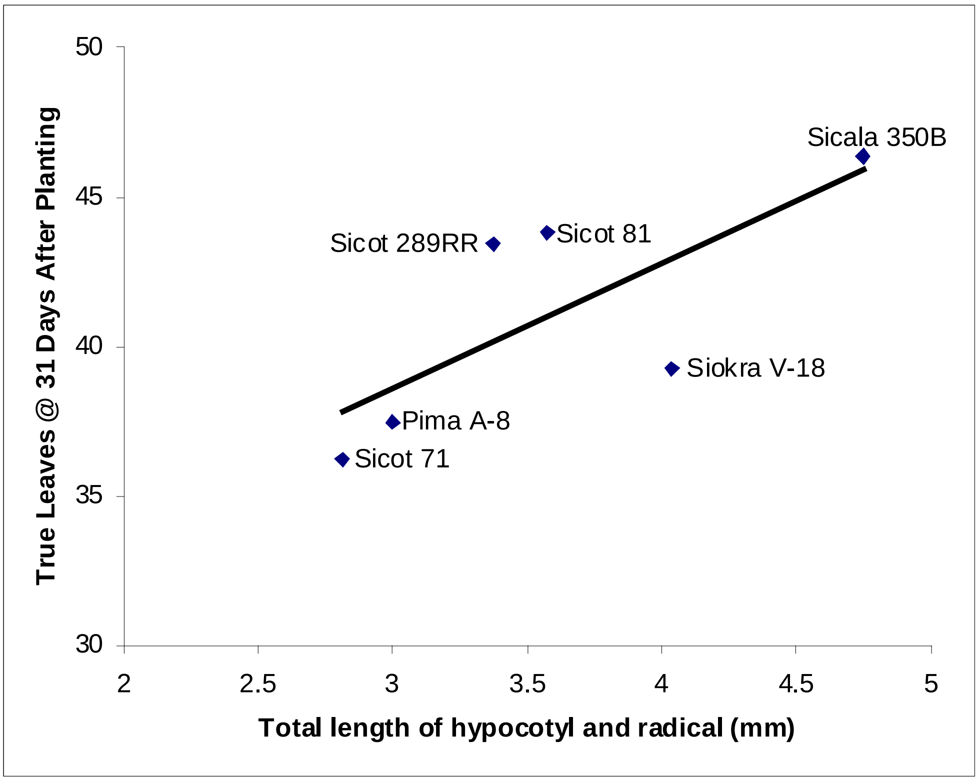

Figure 2. Relationship between total length of hypocotyl and radical (mm) after 4 days at 14 °C (laboratory test) and the number of true leaves at 31 days after planting (in the field).

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