Varietal characteristics for adaptation of cotton (*Gossypium Hirsutum* L.) to raingrown conditions

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Abstract

Three year means of large scale seed company trials indicated that okra leaf was a desirable character associated with yield under raingrown conditions. Early maturity was not a desirable character. Small scale experiments indicated a similar ranking. Deviations were associated with disease susceptible cultivars grown in small scale trials at sites with a greater than normal incidence of verticillium wilt. It was concluded that there is scope for greater selection pressure for cotton yield under raingrown conditions.

Key words: Raingrown cotton, leaf shape, crop maturity, plot size.

The Australian raingrown cotton industry has increased from minor areas ten years ago, to over 80,000 ha in northern NSW and southern Qld. This increased interest has been economically motivated, as the gross margin of cotton is greater than wheat or sorghum.

In 1972, the CSIRO Cotton Research Unit commenced a cotton breeding program at Narrabri NSW which has produced high yielding, locally adapted varieties, with particular emphasis on producing varieties suited to irrigated conditions.Given the increased frequency of irrigation restrictions and the expansion of raingrown cotton production, there is now greater impetus for selection of varieties more suitable for raingrown conditions.

Morphological characters have been utilised in many crops to improve water stress tolerance. Recently, physiological measures such as carbon isotope discrimination (1) have been used to select for greater water use efficiency. Earliness of maturity is often utilised as a trait for increasing yield or yield stability under raingrown conditions. In Texas (USA) there are over 2 million hectares of raingrown or partially irrigated cotton, which generally adopt an early maturity strategy to avoid late season 'terminal' drought (8). When compared with Australian conditions, the Texas High Plains has a shorter growing season when measured in heat units (5).

This paper reports on three seasons of seed company cultivar trials, that compare cultivar performance under raingrown conditions. Because a breeding program needs to develop trial programs which identify genotypes for commercial practice, comparison of relative varietal performance is made with small scale raingrown experiments from the CSIRO breeding program. The importance of earliness of maturity and okra leaf type under raingrown conditions are examined.

Methods

Each season, Cotton Seed Distributors (CSD) conduct large scale raingrown cultivar trials in all the major cotton growing areas of Australia. Entries in these trials vary between regions. They include the most popular CSD cultivar in the region, a standard CSD cultivar, a Deltapine nominated cultivar as well as one or two lines from CSIRO nearing commercial release. These trials were set out in a 'nearest neighbour' design, with a control cultivar planted between each treatment. Each cultivar had a planted area of about 4.5 ha. CSIRO also conducts small scale cultivar experiments each season in most of the major growing regions, usually with 48 entries. The experiments were laid out in a latinized alpha- design with five replicates of each cultivar. Each plot had an area of 45 m^2. All crops were managed with standard commercial practices. The characteristics of the cultivars discussed in this paper are presented in Table 1. The small and large scale sites are not always in close proximity to one another, which may confound interpretation. The small scale site on the Darling Downs was at Dalby and has been compared with the large scale sites at Warra (45 km north-west) and Bongeen (48 km south-east).

Results and discussion

Table 1: Cultivars tested in all experiments.

Cultivar	Leaf type	Maturity	*Verticillium* (% plants infested)
Siokra L23	O	8	25.6
Siokra V-15	O	7	10.3
Siokra 1-4	O	6	36.0
Siokra S-324	O	5	38.0
Sicala V-2	N	8	8.2
Sicot 189	N	9	10.7
CS 8S	N	6	11.1
DP 90	N	8	31.4

Leaf type: O=okra leaf, N=normal leaf; Maturity: (relative scale, 1=very early, 10=very late) calculated from date of 60% boll opening when grown at Narrabri (P. Reid, *pers comm.*); and percentage of plants infested with *Verticillium* when grown at Narrabri (S. Allen, *pers comm.*).

Table 2: Mean monthly rainfall (mm) for the three trial years compared with 100 year average (italics) for the three regions.

	Narrabri	Dalby	Biloela
Oct	45	64	57
	53	*58*	*107*
Nov	59	49	38
	58	*73*	*99*
Dec	93	115	79
	66	*93*	*67*
Jan	136	61	79
	81	*84*	*51*
Feb	55	106	76
	63	*78*	*73*
Mar	39	40	91
	58	*65*	*99*
Total	427	434	420
	379	*451*	*496*

Fig. 1 presents the means of varieties that were entered in the CSD large scale trials for the three seasons 1994/95 to 1996/97. The general yield level under raingrown conditions of 1000 kg lint/ha at Narrabri and Darling Downs is about 60% of irrigated yields, and 600 kg lint/ha at Biloela is about 36% of irrigated yields.? The lower relative yield at Biloela reflects the higher evaporative demand and lower summer rain (Table 2). Averaged over the four sites, okra leaf cultivars yielded 5.2% more than normal leaf types. At each location the two highest average yielding cultivars were okra leaf types (Fig. 1). The lowest yielding cultivars at Biloela and Bongeen were also okra leaf types, indicating that the okra leaf character has to be combined with adaptation for a site and season together with high yield potential to be an effective performer. Okra leaf is an old and common mutant present in cotton, characterised by deeply cleft and narrowly lobed leaves. Interest in the character has come from reduction in boll rot in humid environments (4) and in host plant resistance to some insect pests (3, 9, G. Fitt, *pers. comm*.). Despite these advantages, the only place where any significant area of okra leaf cottons are grown commercially is in Australia, with up to 50% of total plantings (9). Considerable research has focused on examining the physiological differences between the okra and normal leaf types.? Peng and Krieg (6) reported that okra leaf plants had consistently greater canopy photosynthesis per unit leaf area compared with normal leaf plants. Lower stomatal conductances were also reported for okra compared to its normal leaf isoline (7, 10), this, coupled with greater photosynthetic rates gave the okra leaf types 40% greater leaf WUE (CO_2/H_2O) over the normal leaf isolines? (7). This increase in leaf productivity and efficiency is likely to be an important contributor to the yield advantages observed in these large scale trials.

There was no consistent association between cultivar maturity and yield. At Biloela, there was a trend toward later season cultivars having the best yield. However, the association within a site and especially across sites between yield and maturity was not significant in the large scale trial data set. More detailed studies have actually shown a significant positive relationship between yield and maturity, with later types being superior (W. Stiller, unpub.).

There was good general consistency in cultivar rank between small and large scale trials (Fig. 2). At Narrabri, Siokra 1-4 (labelled in the graphs) had poor performance in small scale trials due to high infestation with verticillium wilt. This cultivar has very low tolerance to that disease (Table 1). There was good agreement at Biloela between the two scales of trial size. The Bongeen site agreed closely, but the

Warra site was less consistent with the small scale experiment at Dalby. Incidence of verticillium possibly resulted in the poor performance of Siokra 1-4 at Warra. Irrigation is known to encourage the build-up of verticillium wilt in the soil (2). This factor along with rotation crops of non-host species, reduces the severity of disease under raingrown cotton cropping compared with irrigated cropping.

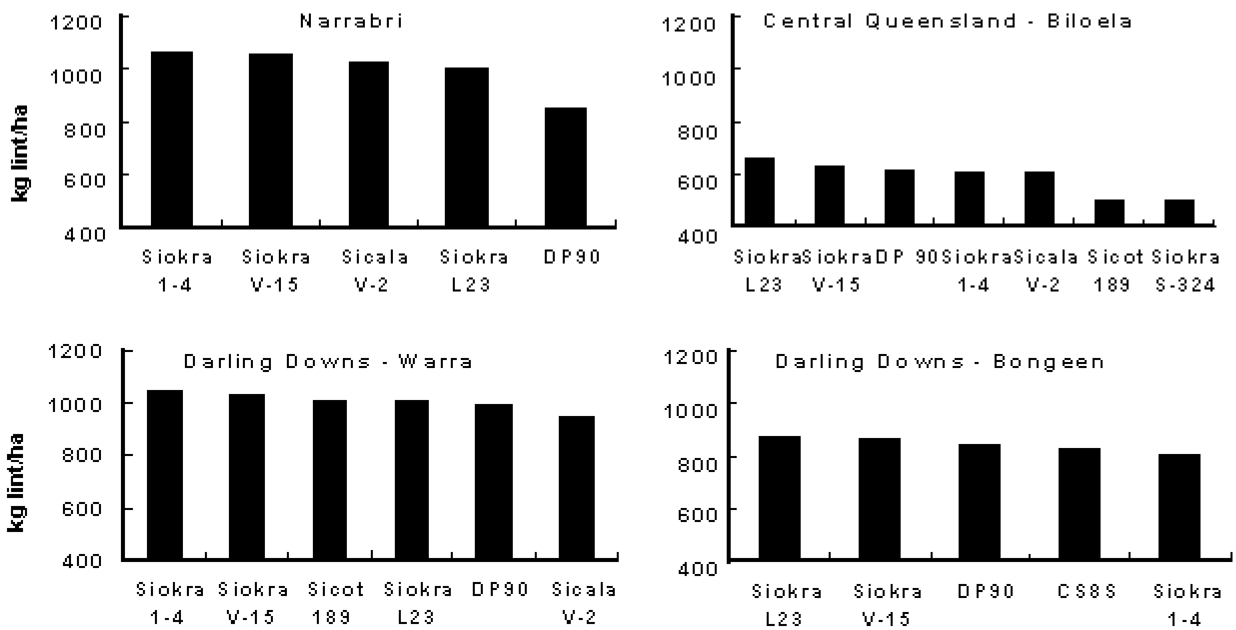

Figure 1

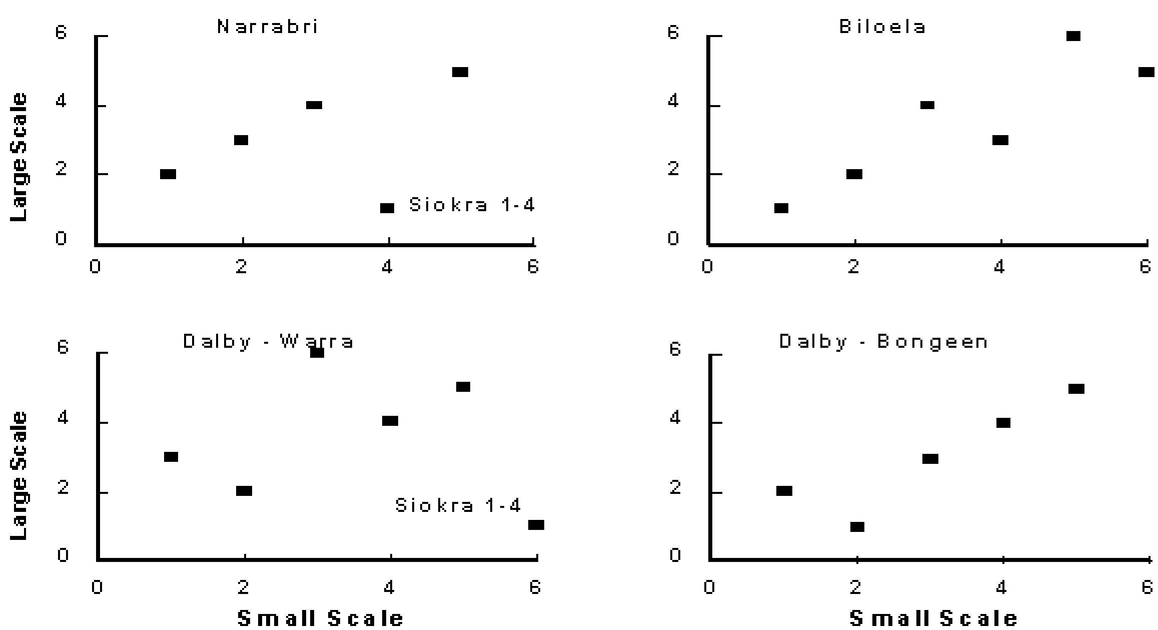

Figure 2

Conclusions

• The okra leaf trait combined with high adaptation and yield potential conferred good performance under raingrown conditions. This result is consistent with physiological measurements. If morphological characters such as okra leaf type provide improved performance under raingrown conditions, there may be potential for placing selection pressure on other physiological characters such as photosynthesis, transpiration efficiency and carbon isotope discrimination.

• Earliness of maturity was not associated with raingrown performance. These experiments were for normal sowing dates, late sowings may require early maturing cultivars.

• Small scale experiments were able to identify better raingrown genotypes so long as disease incidence was known at each site. It is possible that more experimentation to investigate genotype x environment interactions for raingrown cotton are necessary to more effectively identify selection environments.

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References

1. Condon, A.G., Richards, R A., and Farquhar, G.D. 1987. *Crop Sci.* **27,** 996-1001.

2. El-Zik, K.M. 1985. *Plant Dis*. **69,** 1025-1031.

3. Jenkins, J.N. 1994. *Proc. World Cotton Res. Con*f. Brisbane. pp. 359-372.

4. Jones, J.E. 1982. *Proc. Beltwide Cotton Prod. Res. Conf.* Memphis TN. pp 93-99

5. McMahon, J., and Low, A. 1972. *Cott. Gr. Rev.* **49,** 39-49.

6. Peng, S., and Krieg, D.R. 1991. *Agron. J*. **83,** 704-708.

7. Pettigrew, W.T., Heitholt, J.J., and Vaughn, K.C. 1993. *Crop Sci.* **33,** 1295-1299.

8. Richmond, T.R., and Ray, L.L. 1966. *Crop Sci*. **6,** 235-239.

9. Thomson, N.J. 1994. *Proc. World Cotton Res. Conf.* Brisbane. pp. 393-401.

10. Wells, R., Meredith, W.R., and Williford, J.R. 1986. *Plant Physiol.* **82,** 635-640.