

## Variety development for dryland conditions

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### Introduction

Even though the Australian cotton industry is based on a high input irrigated system, there is an increasingly significant area of dryland cotton. Over the last few years there has been increased interest, by researchers and growers alike, in trying to gain the maximum amount of yield from the limited water that is available to them. This limited water occurs both in dryland systems, and in irrigated systems where water allocation from storages is reduced due to low dam levels.

Morphological characters have been utilised in many crops to improve water stress tolerance. Recently, physiological measures such as carbon isotope discrimination have been used to select for greater plant 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 two million hectares of raingrown or partially irrigated cotton, which generally adopt an early maturity strategy to avoid late season 'terminal' drought. When compared with Australian conditions, the Texas High Plains has a shorter growing season.

With this project we have two major objectives in mind:

1. To determine the range of genetic differences for WUE among commercial Australian and Texan cultivars, and decide on reliable methods for identifying differences in the field.
2. To measure the heritability of traits important for WUE of field-grown cotton, and include the information and genetic material into the existing CSIRO breeding program.

This paper reports on three seasons of trials which compare cultivar performance under dryland 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. Some yield results are also reported from the breeding strategy carried out in this project. The importance of earliness of maturity and okra leaf type under dryland 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 (ACCT), usually with 48 entries with five replicates of each cultivar. Each plot had an area of 45 m<sup>2</sup>. 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).

**Table 1: Cultivars tested in all experiments.**

Cultivar	Leaf type	Maturity	<i>Verticillium</i> (% plants infested)
Siokra L23	O	8	26
Siokra V-15	O	7	10
Siokra 1-4	O	6	36
Siokra S-324	O	5	38
Sicala V-2	N	8	8
Sicot 189	N	9	11
CS 8S	N	6	11
DP 90	N	8	31

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.*).

leaf types. At each location the two highest average yielding cultivars were okra leaf types (Figure 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.

Considerable research has focused on examining the physiological differences between the okra and normal leaf types. Our research has confirmed results from the USA where okra leaf plants had consistently greater canopy photosynthesis per unit leaf area compared with normal leaf plants. Lower stomatal conductances were also found for okra compared to its normal leaf isolate, this, coupled with greater photosynthetic rates gave the okra leaf types 40% greater leaf WUE (CO<sub>2</sub>/H<sub>2</sub>O) over the normal leaf isolines. This increase in leaf

## Results and discussion

Figure 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. Averaged over the four sites, okra leaf cultivars yielded 5.2% more than normal

productivity and efficiency is likely to be an important contributor to the yield advantages observed in these large scale trials.

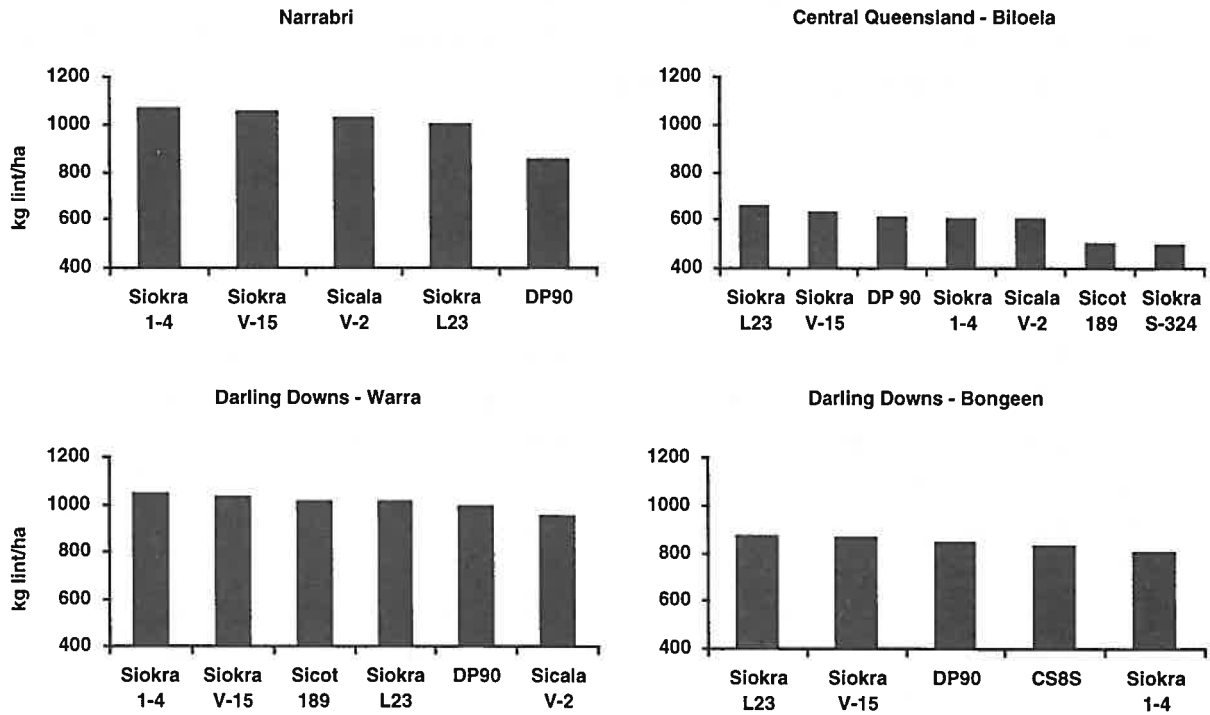


Figure 1: Three year mean lint yields for Narrabri, Central Queensland (Biloela) and two Darling Downs sites (Warra and Bongeen).

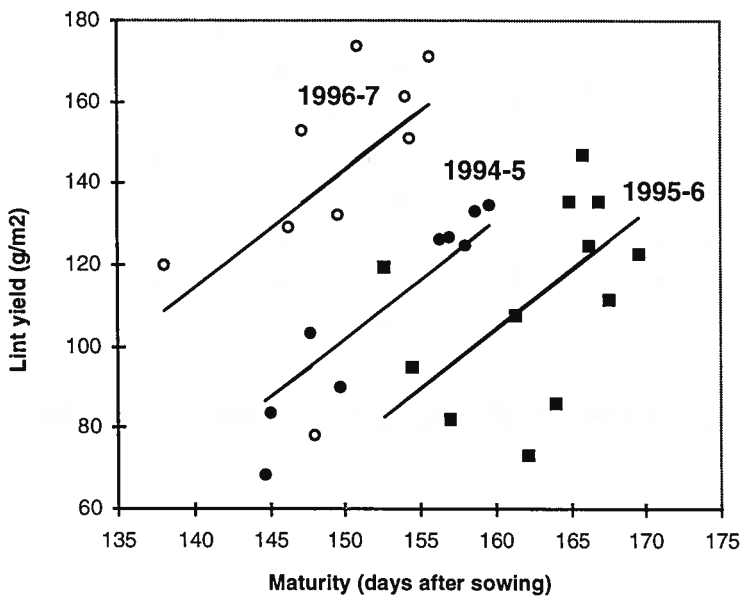


Figure 2: Lint yield vs maturity of the cultivars grown at ACRI over three seasons.

Figure 2 describes the relationship between cultivar maturity and lint yield when the cultivars were grown at ACRI. In all seasons the later maturing cultivars performed best. The regression indicated that the lines have the same slope each season but shift to the left or right predominantly due to the amount of rain heat units received during the growing season. The fitted regression lines indicate that for every one day increase in

cultivar maturity there is a 29 kg/ha increase in lint yield. Obviously this yield increase would only continue while the cultivar maturity is less than the available season length. There was good general consistency in cultivar rank between small and large scale trials (Figure 3). At Narrabri and Bongeeng, 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). This factor along with rotation crops of non-host species, reduces the severity of disease under raingrown cotton cropping compared with irrigated cropping. There was good agreement at Biloela between the two scales of trial size.

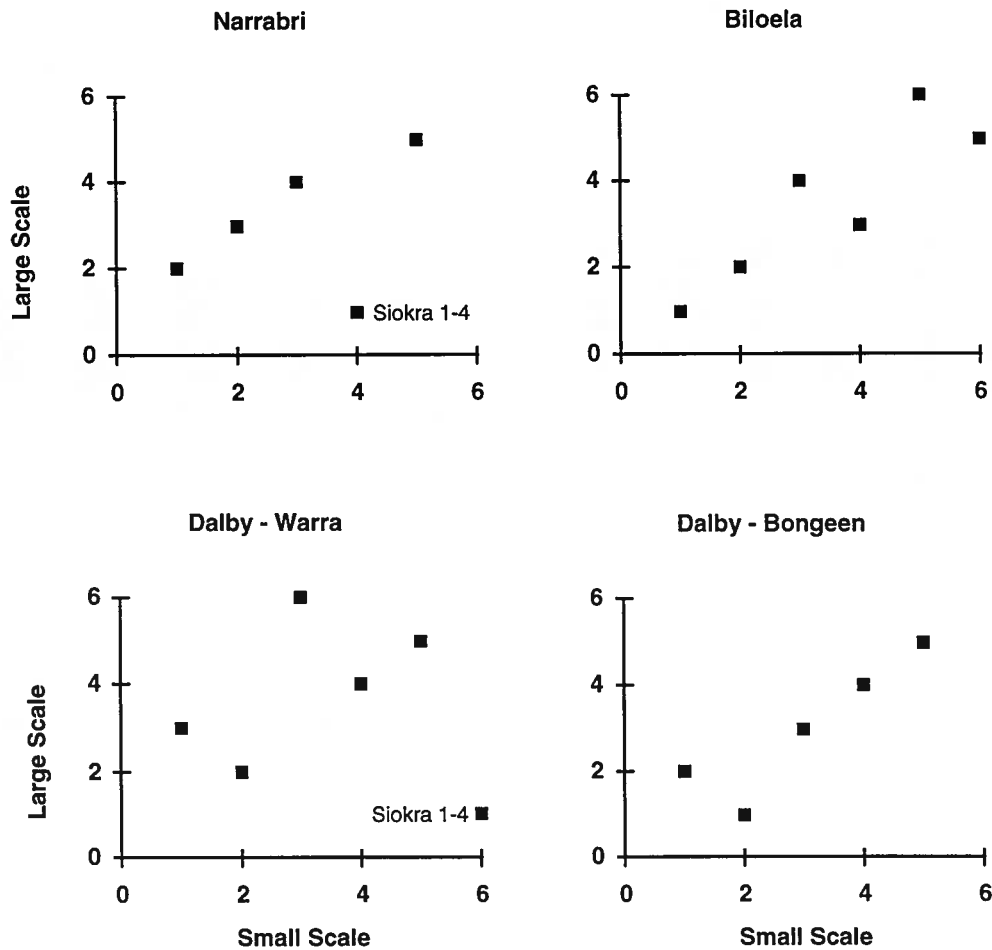


Figure 3: Comparison between small and large scale experiments of varietal ranking for yield.

As part of this effort to produce varieties better adapted to dryland conditions, progeny testing was carried out using a number of lines, both from this WUE project and the general breeding program. Table 3 shows the results of a dryland trial conducted in the 1997/8 season indicating the improved performance of some of these lines over two controls, Siokra L-23 and Stoneville 474.

**Table 3: Cultivar yields from genotypes selected under dryland conditions**

Genotype	Lint yield	Rank in trial
92238-255	562	1
92238-318	562	2
92238-395	536	3
88201-343-939	535	4
92238-556	532	5
92238-601	529	6
94228-65	518	7
Siokra L-23	492	14
Stoneville 474	352	40

## Conclusions

1. 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.
2. Earliness of maturity was not associated with raingrown performance. These experiments were for normal sowing dates, late sowings may require early maturing cultivars.
3. 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  $\times$  environment interactions for raingrown cotton are necessary to more effectively identify selection environments.

## Acknowledgments

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