Cotton varieties – optimising quality

Warwick Stiller, Greg Constable and Peter Reid
CSIRO Cotton Research Unit, Narrabri, NSW 2390

Summary

A raising of the quality base and increasing levels of discounts impact significantly on the profitability of dryland cotton. CSIRO has research in place that not only aims to improve the yield of dryland cotton varieties, but also fibre quality and disease resistance. Fibre length is the quality trait that is most influenced by the water stress that dryland crops experience at some point during the season, but micronaire is also influenced to a degree. Data is presented on some commercial varieties well suited to dryland production, as well as some examples of future varieties that may be released over the next few years.

Introduction

One aim of our cotton breeding program is to produce cultivars for dryland production systems that have a good quality package, high yield potential and enhanced water use efficiency in addition to tolerance to water stress. With the continuing interest in producing dryland cotton, we have expanded our breeding efforts to specifically address this production system and evaluate different selection criteria in screening breeding populations for enhanced performance under dryland conditions.

The soil types used for dryland cotton typically have a high water holding capacity, but rainfall can be unreliable. Thus a dryland cotton cultivar needs to withstand extended periods of water stress and then be able to utilize rain when it occurs. Late-maturing, relatively indeterminate cultivars have been shown to best meet these requirements and those with the okra leaf trait have also been successful. Anything that can be done to improve stress tolerance, or alleviate the effects of stress, should improve both yield and quality.

Physiological traits associated with water use efficiency or stress tolerance have rarely been used in plant breeding. This is due to difficulties associated with measuring these traits on large numbers of plants, low heritabilities and complex relationships between these traits and yield (Hall *et al.* 1994). In recent years carbon isotope discrimination (Δ) has shown promise as in winter crops an indirect measure of plant transpiration efficiency (Farquhar *et al.* 1982; Farquhar and Richards 1984) and we have incorporated some screening for this trait in our breeding program.

Factors in selecting a dryland variety

Yield and maturity

To survive periods of water stress, plants use one of two main strategies. With the first, the plants *escape* water stress by completing their life cycle before serious water deficit occurs. In the semi-arid dryland cotton areas of the United States, emphasis has been placed on early maturing varieties. The problem with this however, is that a negative relationship often exists between yield and earliness. Longer season plants perform differently, and are said to have drought *resistance*. This is achieved by maintaining water uptake while reducing water loss. In Australia, significant rainfall can occur throughout the growing season, with some years being nearly ideal for production. However, this rain often falls sporadically, and towards the middle or end of the season. To take advantage of favourable years, varieties that can utilise rain when it falls, together with sufficiently high yield potential are required. In part, a longer season cultivar is able to perform better under this situation due to the tendency to start fruiting later and hence to stay vegetative longer. This allows roots to develop further and explore a larger volume of soil. Roots in the lower zone are also less susceptible to drought than those in the upper zone. This greater root system allows the plant to avoid stress by maintaining water uptake. The plant requires as much time as possible to make use of all rainfall events, without 'cutting out'. This is in full season environments, and the same long season varieties would not perform well in a short season area. However, in short season areas it is still important to have a variety capable of using all of the available season and not restrict the ability to utilise late rain. Of course late planting requires a shift to earlier maturing varieties.

Fibre length

Economically, length is the most important quality trait of a dryland variety. Because plant turgor is required to lengthen the developing fibre, any stress during the first 20 days after flowering (elongation phase) can impact fibre length (Hearn 1976). Every day of water stress (>60% deficit) an individual boll experiences during this phase can reduce fibre length by up to 0.03"/day.

To minimise the risk of staple discounts, varieties should be chosen that have inherently long fibre length. While the length of most varieties is reduced by a similar amount given the same amount of stress, our research has shown that there can be a variety interaction. This means that some varieties can have slightly less reduction in staple relative to others under dryland *eg* Siokra V-16 and Sicot 80 types. These tend to be the varieties that consistently perform better in terms of dryland yield. We propose that the combinations of maturity, plant type and fruiting dynamics that have a positive influence on yield also positively influence fibre length.

Fibre strength

Fibre strength is largely unaffected by dryland conditions. However, severe water stress resulting in a large number of immature fibres can reduce fibre strength. This would normally only occur in a situation where the crop had a moderate to good fruit load and the conditions turned very dry toward the end of the season. Obviously, very poor conditions through the entire season could also result in reduced fibre strength.

All varieties that are recommended for dryland should have adequate strength so discounts should be rare.

Micronaire

On average, the micronaire of a variety is increased under dryland conditions compared with irrigated. Our data indicates that this increase can be as high as 0.4 of a unit. However, there are circumstances where the opposite will occur. If a crop has experienced favourable conditions for much of the season and has a moderate to high fruit load, a very dry finish can result in a significant number of bolls with immature fibre. This immature fibre will reduce the micronaire of the crop. Under most situations though, the plant will manage its fruit load and any surplus resources (water, nutrients etc.) will be allocated to secondary thickening of fibres. This results in increased micronaire.

Choosing a variety with suitable micronaire for dryland is challenging. An inherent micronaire of 4.0 – 4.1 usually provides enough buffer against both high and low micronaire situations. However, there will always be occasions, due to environmental conditions and management, when these varieties will incur a micronaire discount. For that reason, growers should spread their risk if they are concerned about micronaire discounts. Siokra V-16BR has a slightly lower micronaire and Sicot 289B has a slightly higher micronaire.

Current commercial dryland varieties

There is an excellent range of varieties available with all trait combinations that are suited to dryland production. Most of these have a fairly similar long term yield average, but performance obviously depends on individual regions and sites. Table 1 details the dryland variety in each trait group that has the longest fibre length based on long term means (excluding premium types). Obviously growers need to look at trial results for their specific regions in making variety decisions.

Table 1: Longest staple dryland variety in each of the trait groups based on long term means.

Conventional	Siokra 24
Roundup Ready	Siokra V-16RR
Bollgard II	Siokra 24B
Bollgard II/Roundup Ready	Siokra V-16BR

Premium fibre types

The ultimate way of minimising fibre discounts from dryland cotton is to grow a premium fibre variety. Currently there is only one variety available in this category – Sicala 350B, but it is expected that more will be available in the future with different trait combinations. Across all dryland trials, both small and large scale, this variety has yet to have any of its fibre properties fall into the discount range. Table 2 shows an example of a trial on the Darling Downs in 2004-5 where Sicala 350B was the only variety not to incur any discounts. There is also potential for an additional bonus, that is under excellent growing conditions a genuine premium fibre may be produced and the opportunity to gain a premium above base price.

Unfortunately, there is also a downside to growing these types. Sicala 350B averages 10% lower yield under dryland than the major current varieties. This has varied from almost no yield reduction (usually at low yield levels) to 15% at higher yield levels

Table 2: Fibre quality of Sicala 350B compared to the major transgenic dryland varieties – one site Darling Downs 2004-5.

	Length	Strength	Micronaire
Sicot 80B	1.05	30.4	4.6
Siokra 24B	1.05	28.5	5.1
Siokra V-16BR	1.06	28.4	4.3
Sicot 289BR	1.04	30.6	4.5
Sicala 350B	**1.11**	**31.2**	**4.2**

Dryland varieties – a look to the future

CSIRO has a significant emphasis on developing new varieties in all trait groups with improved yield and quality under dryland conditions. This is not a simple task and there are many challenges to overcome. Firstly, the negative correlations that exist between yield and many of the quality parameters ensure that simultaneous improvement of both yield and quality is more of an incremental process than rapid gains. The need for improved fusarium resistance in dryland varieties has also slowed progress, as many of the types that were suited to dryland production were susceptible to this disease. While the impact of fusarium in dryland production systems has been negligible, the threat of the disease worsening together with the need for seed production under irrigation has resulted in an objective to raise the F.rank of dryland varieties. We have been successful in addressing each of these objectives in various combinations, but substantial work still needs to be done to ensure the ideal combination of yield, quality and disease resistance is met.

We are also continuing development of premium fibre types in for both dryland and irrigation. The main focus of this work is to raise the yield of these types while retaining (or improving) the fibre quality that we already have.

Table 3 shows four examples of conventional lines that we have in development. In most cases the combination of traits still requires further development; CSX225 – greatly improved yield, similar fibre quality to standard varieties, but lower than desirable F.rank; CSX892 – no real improvement in yield or fibre quality (slightly higher mic) but much improved F.rank; CSX855 – an example of a premium type, still behind on yield, excellent quality but lower than desirable F.rank; CSX262 – a line that provides a good combination of yield, quality and F.rank.

Table 3: New conventional dryland lines in development – three site dryland means 2004-5

	Relative yield	Length	Strength	Micronaire	F.rank
Siokra 24	*97*	*1.10*	*31.6*	*4.3*	*102*
Sicot 81	*103*	*1.09*	*31.2*	*4.6*	*114*
CSX225	116	1.09	30.2	4.6	75
CSX892	103	1.09	30.6	4.7	186
CSX855	94	1.15	35.3	4.6	87
CSX262	106	1.10	31.1	4.4	101

Due to the low adoption of conventional varieties across the industry, it is expected that there will be relatively few new conventional varieties released. All promising conventional lines are entered into the transgenic program to produce varieties with various combinations of transgenic traits. For 2006 planting Sicot 80BRF, which has shown good adaptation to dryland situations, will be released. Over the next few years there will be a larger suite of dryland varieties to choose from particularly in the Bollgard® II and Bollgard® II / Roundup Ready Flex® (BRF) trait groups.

References:

Farquhar GD, O'Leary MH, Berry JA (1982) On the relationship between carbon isotope discrimination and the intercellular carbon dioxide concentration in leaves. *Australian Journal of Plant Physiology* **9**, 121-137.

Farquhar GD, Richards RA (1984) Isotopic composition of plant carbon correlates with water use efficiency of wheat genotypes. *Australian Journal of Plant Physiology* **11**, 539-552.

Hall AE, Richards RA, Condon AG, Wright GC, Farquhar GD (1994) Carbon isotope discrimination and plant breeding. In 'Plant Breeding Reviews'. (Ed. J Janick) pp. 81-113. (John Wiley & Sons: New York, NY)

Hearn AB (1976) Response of cotton to nitrogen and water in a tropical environment. III Fibre quality. *Journal of Agricultural Science, Cambridge* **86**, 257-269.