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Overview of recent research into ultra-narrow row cotton in Australia

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Main: Planting with UNR planter at Narrabri. Photo: CSIRO

Small, left to right: UNR Responsive Management Experiment 2007-08, Merrowie, Hillston. Photos: Malcolm Pritchard

Introduction

Typically cotton in Australia is planted in rows spaced one metre apart. Historically this spacing was the narrowest spacing that would facilitate the use of draft animals. When tractors started to mechanise production, rows were kept at one metre for hand picking, then when harvesting was mechanised, rows needed to be at least 91cm apart to accommodate equipment.

Ultra-narrow row (UNR) systems (rows spaced <40 cm apart) were first developed in the United States in the 1950's and 1960's, for cotton production in areas with limited growth and low yield potential (short growing seasons, dryland situations, poor soils, etc). Since then advances in technologies such as growth regulators (e.g. Pix), transgenic varieties for improved insecticide and weed management, precision planters, narrow row spindle harvesters, and positive commercial experience generated renewed interest in narrow row production.

In theory UNR cotton (with more plants/m^2) should lead to earlier maturity without sacrificing yield. This would come about from having fewer early bolls on maturing plants and the higher plant population would compensate for less bolls per plant.

Other perceived advantages included earlier and more efficient light interception (as canopy closure would occur sooner) and that the smaller plants in UNR are less vegetative and will allocate a greater proportion of resources to bolls. In practice, this earliness has been difficult to achieve consistently in UNR trials both in Australia and the US.

Research was required to understand the complexity of UNR especially given the higher yield potential in Australia. Research led by Dr. Rose Brodrick studied UNR systems in detail over seven years (2001-2008) to determine how it differed in its growth and development to conventional 1 m spaced systems. The aim was to provide growers with guidelines for determining the appropriate plant population (row and plant spacing), and agronomic practices (e.g. water, N and Pix) to optimise yield and quality. All experiments used transgenic Bollgard II, Roundup Ready varieties.

> Ready for harvest: 1 m rows in foreground, UNR in background at Narrabri, NSW. Photo: CSIRO

What did we learn?

Compared to conventional 1 m spacings, UNR did not mature earlier in Australian systems, because fruiting site development was slowed in response to early plant competition impeding the opportunity for early fruit maturity. This response occurred much earlier and much more often than was previously thought. Yield however, was marginally higher in UNR (although highly variable) and this was achieved by having more bolls per area from the increased population. Bolls were smaller but the greater number of bolls in UNR compensated this. The use of Pix and changes in early season crop management for water and nutrition did not improve UNR yields. Primary fibre quality properties were unaffected in UNR systems, although grades can be reduced with stripper harvesters.

> Rose Brodrick checking plant establishment in row spacing experiments in Narrabri. Photo: CSIRO

UNR Comparisons with 1 m Spacings

Numerous field experiments were conducted to compare 1 m row spacing with 38 cm and 25 cm spacings over four regions and seven seasons to assess growth, maturity, yield and quality of cotton. Apart from one experiment these were all planted on 2 m beds. In addition, some experiments had extra treatments added to investigate management effects on UNR, such as variety (early maturing, Bollgard II, cluster type), the use of Pix, and the use of additional nitrogen and water. Management effects are discussed in the section on agronomy of UNR.

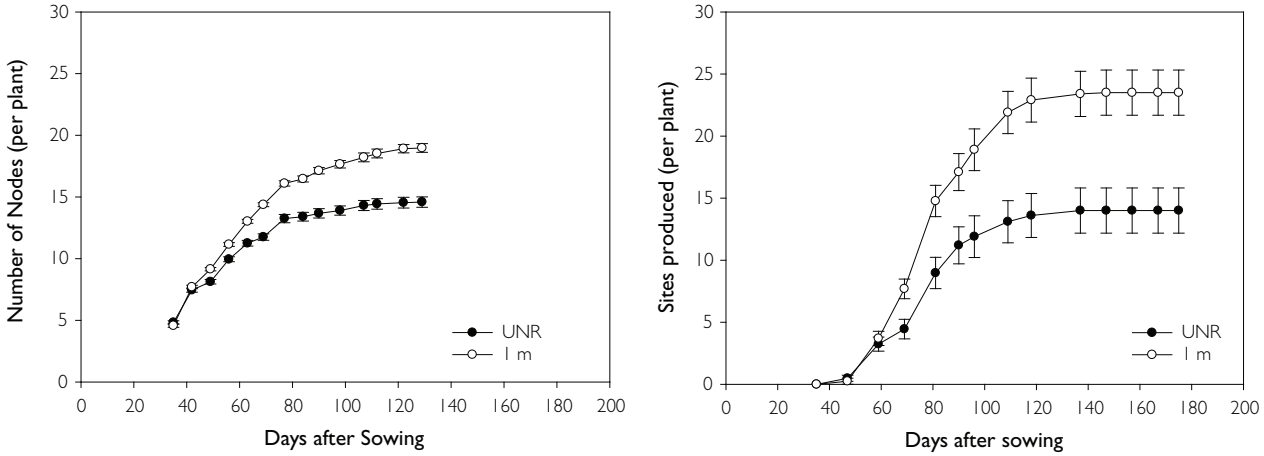
> Table: Summary table of yield and maturity differences from comparisons of UNR and 1m row spacings in four regions over seven years. X is no difference; up arrow means that treatment named had better yield or was earlier.

Year	Location	Row Configuration	Additional Management Treatment	Yield	Maturity
01/02	Narrabri	25cm, 1 m	Early Maturity/Normal Variety	×	×
02/03	Narrabri	25cm, 1 m	Cluster/Normal Plant Type	×	×
02/03	Breeza	25cm, 38 cm, 1 m	Twin row	×	×
02/03	Hillston	25cm, 38cm, 1 m		×	×
03/04	Narrabri	25cm, 38cm, 1m	No Pix vs. Pix Bollgard II vs.Non Bollgard II	×	×
03/04	Hillston	25cm, 1m	No Pix vs. Pix	×	×
04/05	Narrabri	25cm, 38cm, 1m	Bollgard II vs.Non Bollgard II	×	×
05/06	Narrabri	25cm, 38cm, 1m	Responsive Management	×	×
05/06	Hillston	38cm, 1m	Responsive Management	×	×
05/06	Hay	38cm, 1m	Responsive Management	↑ UNR	×
06/07	Narrabri	25cm, 38cm, 1m	Extra Early Irrigation Extra N Applied Extra N and Early Irrigation	×	×
07/08	Narrabri	25cm, 38cm, 1m		↑ Conv.	↑ UNR
07/08	Hillston	38cm, 1m		↑ UNR	×

UNR Growth and Development

A key finding of this research is that competition for resources between plants occurs very early (before flowering) and is much higher than expected in UNR plantings. This stress results in slower node development resulting in fewer fruiting sites (see Figure). For UNR plants to mature earlier, early node production and fruiting site production rates need to be similar to conventionally 1 m spaced crops.

The increased competition between plants in UNR also leads to smaller boll size (average of 9% in 25 cm and 4% in 38 cm) and lower final fruit retention on individual plants. Yield was not impacted as the smaller boll size was more than compensated by the increased plant population raising final boll numbers in UNR spacings (average of 21% in 25 cm and 7% in 38 cm).



> Node and fruiting site development per plant of 25 cm UNR and 1 m spaced cotton. Note that both node and fruiting site development slowed much earlier in the UNR plants compared with the 1 m space cotton.

Crop Maturity, Yield and Quality

Maturity

There was little evidence that narrow row spacings affected maturity (days after sowing to 60% open bolls). When data from all experiments was analysed together neither 25 cm or 38 cm spaced rows had earlier crop maturity compared to the 1m spaced rows. Only on one occasion in the 2007/08 season in Narrabri was crop maturity earlier. The 25 cm or 38 cm spacings were significantly earlier by 3 and 3.8 days respectively.

Yield

When UNR was compared with 1 m spacing for yield it was statistically higher on only two occasions. However when data from all experiments was combined and analysed the 25 cm row spacing was the only row spacing that differed from 1 m spacing (7% on average higher in UNR). This was due to increased boll numbers in the 25 cm UNR spaced crops. There was no improvement in yield of 38 cm spacing compared to the 1 m spacing.

Fibre Quality

Across all experiments there were no differences between the row spacings in terms of fibre quality.

> Ready for harvest UNR (38cm) responsive management experiment 2007-08, Merrowie, Hillston. Photo: Malcolm Pritchard

Agronomy of UNR

Plant populations

Two experiments were also undertaken to determine if arranging plants to give a more equidistant arrangement gave a yield or maturity advantage. 1m spaced rows were compared with 38 cm and 25 cm spaced rows which were sown to establish populations equivalent to 12, 24, 36 (only in 25 cm rows) plant m^{-2}. Overall the stability of cotton's yield and maturity response was maintained, with no consistent difference across inter- or intra-row spacings. Again, no differences in fibre quality were measured.

The only exception was higher lint yield in the 12 plants m^{-2} plant population in the 38 cm row spacing in the first experiment suggesting that there may be a yield advantage with more equidistant arrangement of plants; however, this relationship was not confirmed in the second experiment or in any of the other treatments.

Importantly, these experiments found that there were no consistent relationships between increased plant densities with 38 cm and 25 cm row spacings. Not having to use higher plant densities significantly reduces the costs of UNR cotton production. Seed costs using current recommended densities of 12 plants m^{-2} is only 3.82 % ($88.80 ha^{-1}) of the total variable cost of cotton production compared with 7.43 % ($177.6 ha^{-1}) and 10.75 % ($266.4 ha^{-1}) for 24 plants m^{-2} and 36 plants m^{-2} respectively.

However, like other recent plant population research in 1 m spaced rows has reinforced the importance of getting even plant establishment. Therefore in areas where establishment can be difficult, lowering the sowing rate could result in patchy establishment and lower yields.

> UNR crop at Narrabri ready for harvest. Photo: CSIRO

Pix

The use of Pix in UNR did not improve yield. While maturity was earlier in UNR with Pix it had a similar effect on the 1 m spacing treatments.

Nutrition and Irrigation

These studies found that early plant competition in narrow systems limited yield potential and negated early maturity benefits. In an attempt to overcome this plant stress early, a large scale experiment in Narrabri with 38 cm and 1 m row spacing was undertaken to determine whether specific management practices could be developed to raise yields and provide earlier crop maturity. Treatments included applying prior to first square, an extra 60 kg/ha N, an extra irrigation, and an additional treatment with both extra N and water to both 38 cm and 1 m rows. The results of this experiment showed both extra early irrigation and nitrogen did not benefit the 38 cm crop. The only effect measured was an increase in yield in the 1 m crop from an extra irrigation. Importantly these results indicate that increasing early inputs did not alleviate the competition stress between plants which is most likely a result of more complex physiological processes (e.g. competition for space and light).

Varieties

There were no differences in the response of Bollgard II varieties to UNR measured in these experiments. Other experiments compared Bollgard II to conventional varieties, cluster type varieties and extremely early varieties to normal varieties, and none performed better or differently in the UNR spaced crops compared to the 1 m spaced crops.

Responsive Management Comparisons

Four 'responsive management' experiments were developed in consultation with growers and extension officers to assess impact of commercial on-farm management at a larger scale on UNR. Experiments were conducted at Hillston (repeated in two seasons), Hay and in Narrabri. These experiments were designed to allow 38 cm and 1 m crops to be managed as required. This allowed for Pix or additional nutrients to be applied (monitored by vegetative growth rates, and plant nutritional status). In addition these treatments were also compared to a "normal" management regime that was applied similarly across both row spacings.

Across all four experiments the narrow row spacing did not require different nutrient or growth regulator management. Differences between the row spacing only occurred in Hay for yield, however there were concerns that the 1 m spacing treatment had been unfairly biased as an inter-row cultivation may have caused damaged to plant roots.

Overview of Seven Years of Research

- Narrow row systems (25 cm and 38 cm) did not consistently improve yield, quality, or cause earlier maturity.
- Plant population differences from both changes in inter- and intra row spacing had little or no consistent response on yield, quality or maturity.
- The addition of earlier and higher inputs of water and nitrogen did not overcome plant competition effects that delay maturity in narrow row spacings.
- Different Pix management was not required between conventional and narrow row systems. Pix did not help raise yields of narrow row systems.
- No differences were identified in the response of non-Bollgard II and Bollgard II varieties to changes in plant population (including row spacing).
- UNR systems did not respond to varieties with different plant types (e.g. cluster fruiting), maturity or fruit retention when compared to 1 m spaced systems.
- Uniform plant population is vital for achieving optimum yield.

Other issues to consider

- A quality precision planter is needed.
- Good bed formation is important.
- Poor subbing at the centre of beds can occur despite irrigation allowed to run.
- There are limited numbers of contractors with narrow row pickers. Picking can therefore be delayed.
- Picking efficiency was less in high yielding crops.
- Picking was delayed for longer after rain as there is less air flow through the crop. Cutting after harvest can also be more difficult as plants are not dry.
- Shorter picking days can result as cotton needs to be about 9% moisture for effective picking in narrow rows compared with 12% for 1 m spacing.
- Narrow row systems can involve higher initial seed costs.
- Inter-row cultivation is limited to furrows under UNR systems. Chippers can also find it difficult to remove weeds effectively.
- Need to disc soil post harvest as root cutting is not possible after UNR.

Management Recommendations

- Management considerations for narrow row are not different to 1 m row spacing.
- Intangible issues need considering.
- No change in management for high fruit retention Bollgard II crops.
- Choose a variety that is regionally adapted.
- Uniform plant establishment is critical to maximise yield.

Conclusion

From such detailed research it can be concluded that although the 1 m spacing systems may have evolved to meet practical and mechanical requirements, cotton's growth habit allows it to be grown across a range of row and plant spacings. For growers considering narrower row spacings, this research has provided management suggestions. A key message is that uniform plant establishment is vital, whichever row configuration/plant population is adopted.

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