Effect of 1 m and 1.5 m row spacing on yield and fibre quality of upland cotton (*Gossypium hirsutum*) in Warren, NSW, Australia

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Compaction by machinery traffic increases soil strength and reduces soil porosity, which hinders root growth, moisture and nutrient uptake. GPS-auto steer and modification of machines to 3 m wheel centres can minimise field compaction. Conventional 1 m cotton does not accommodate 3 m wheel centres, so row spacing can be altered to alleviate this issue. The aim of this study was to test the hypothesis: is cotton yield and fibre quality in wide 1.5 m row the same as conventional 1 m rows? There were two experiments at Auscott Warren farm; a randomised block design field experiment with nine replicates of 1 m and 1.5 m row treatment and a paddock scale experiment which was two large field blocks of 1 m and 1.5 m row treatments. 1.5 m cotton was 10 cm taller than 1 m cotton. The 1 m cotton yielded 1.8 bales/ha and 3.6 bales/ha higher than the 1.5 m cotton in the machine picked and handpicked replicated experiment, respectively. Yield of 1 m cotton mainly came from fruiting nodes 1-8, position 1, whereas yield in 1.5 m cotton mainly came from vegetative branches. There was a strong positive correlation ($R^2 = 0.99$) between the number of bolls/m2 and yield. In the 1.5 m cotton there were minor improvements in fibre quality compared with the 1 m cotton. Gross margins of the two row configurations were very similar. Reduced water use of 1.5 m cotton allows for more hectares to be grown and potentially a more profitable farming system. Future research should quantify water use to improve grower decision making.

Key words
Controlled traffic, Gossypium hirsutum, irrigation, row configuration, wide row

Introduction

Row spacing can play a large role in performance of dryland and irrigated crops. In dryland situations wide row spacing and skipped rows can be used as a management technique to minimise production risk in dry years but compared with closer row spacing can limit top end yields in favourable conditions (Whish *et al*. 2005). Narrow row spacing increases yield in more favourable rainfed environments and in irrigated environments by increasing crop leaf area and associated light interception (Brodrick *et al*. 2010). The vast majority of irrigated cotton in Australia is grown in solid configuration, on 1 m row spacing. The traditional row spacing in Australia of 1 m does not accommodate 3 m wheel centres and a controlled traffic system at Auscott Warren. Altered row spacing including wide row (1.5 m) or narrow row (0.75 m) cotton can facilitate a controlled traffic system on 3 m wheel centres. There has been a considerable research into Ultra Narrow Row (<0.4 m), narrow row (0.75 m) (Brodrick *et al*. 2010) and 1 m cotton, but little is known about the performance of irrigated wide row (1.5 m) cotton. This study will investigate the hypothesis: is cotton yield and fibre quality in wide 1.5 m row the same as conventional 1 m rows? The aim of the study is to compare the yield and fibre quality of wide row (1.5 m) and conventional (1 m) cotton grown under irrigated conditions.

Materials and methods

There were two main components of this study at Auscott Warren farm (31°47'25" S 147°44'17" E, 195 m above sea level), a replicated plot experiment and a paddock scale whole block experiment. Auscott Warren is located 11 km south west of Warren in the central west area of NSW, Australia. The area is considered semi–arid, receiving an average rainfall of 490 mm per annum, which is evenly split between summer and winter, of which 236 mm fall on average during the cotton growing season (October – February). Hot summers (mean daily maximum 33.4°C, and minimum 19°C) and mild winters (mean daily maximum 15.6°C and minimum 3.4°C) are typical of the area. Self-mulching grey Vertosols dominate the irrigated areas of the farm.

The replicated plot experiment was a randomised block experimental design with 9 replicates. All experiments used the variety Sicot 74BRF (Bollgard II™ Roundup Ready Flex™). At harvest maturity, just prior to defoliation, plant height and harvest index (ratio of fruit to vegetative dry biomass) were measured.

The cotton from each linear metre was handpicked and grouped into different fruiting segments of the plant. Fibre quality parameters were measured using the High Volume Instrument (HVI).

The paddock scale experiment was conducted on a large 17.5 ha block that was divided into two whole blocks of 8.75 ha each for the 1 m, and the 1.5 m row configuration treatments, which were separately machine harvested. The harvested seed cotton from each block was ginned separately to provide an infield broad scale comparison between 1 m and 1.5 m row spacing. Both the handpicked and machine picked yields were recorded in bales/brown ha and bales/green ha (227 kg lint bales). The term brown ha refers to the total area taken to grow the wide row crop in hectares, whereas the term green ha refers only to the area covered by plant rows and does not account for the additional space between the rows. Brown hectares are generally used in the Australian cotton industry as it represents the actual area required to grow the crop. Data were analysed using analysis of variance (ANOVA) and regression in Genstat v16.

Results and discussion

Cotton yield

Final heights were 92 cm for 1 m and 102 cm for 1.5 m cotton. This is consistent with other work where Ultra Narrow Row cotton (< 0.4 m) plants were considerably shorter and smaller compared with 1 m rows (Brodrick et al. 2010). In the machine picked fields, the 1 m cotton out yielded the 1.5 m cotton by nearly 2 bales/ha, a 16% yield difference (227 kg lint per bale) (Fig. 1). A similar trend emerged with the handpicked data where the 1 m cotton out yielded 1.5 m by 3.6 bales/ha (23%). In the segment picked cotton, yield on the 1 m row spacing was confined to mainly first position fruit on fruiting nodes 1-8, and some vegetative fruit (Fig. 2a). In contrast yield on the 1.5 m spacing was mainly derived from vegetative branches, along with a smaller contribution from fruiting nodes 1-8 (Fig. 2b).

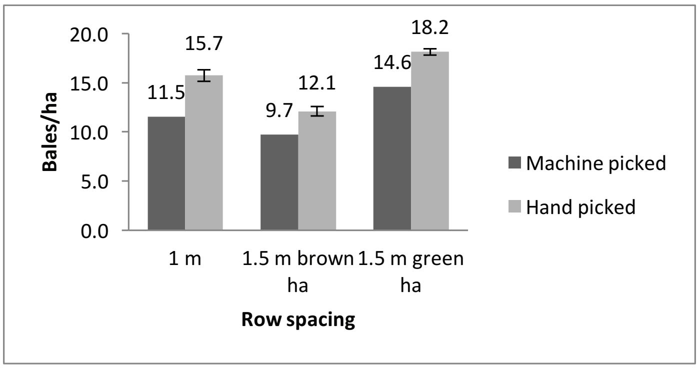

Figure 1. Cotton lint yields harvested (227 kg bales) by machine and by hand from cotton grown on 1 m and 1.5 m row spacing. The term brown ha refers to the total area taken to grow the wide row crop in ha, whereas the term green ha refers only to the area covered by plant rows. Error bars represent standard errors of the mean.

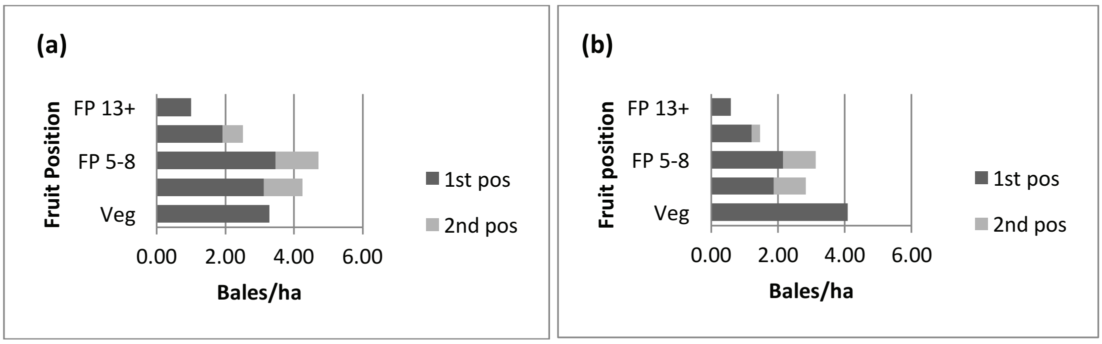

Figure 2. Yield (bales/ha) of hand picked cotton separated into fruiting branch positions (FP) (227 kg lint bales) for (a) 1 m row spacing and (b) 1.5 m row spacing (yield/brown ha)

There was a very strong linear correlation between the number of bolls per m2 and yield (R2 = 0.99) for both 1 m and 1.5 m cotton (see Fig. 3). This agrees with Worley *et al*. (1974) and Jones *et al*. (2014) working in South Carolina and Texas U.S.A., respectively (Worley *et al*. 1974; Jones *et al*. 2014). Furthermore bolls/m2 is considered the primary factor to historical yield increases in Australian cotton (Constable*et al*. 2001).

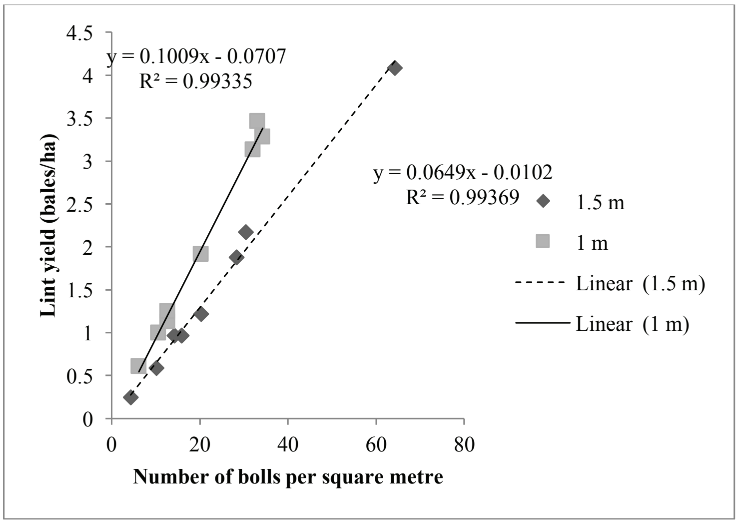

Figure 3. Relationship between the number of bolls (per m2) and yield (in 227 kg bales/ha) across all segments.

Fibre quality

Overall there were no considerable differences in fibre quality between the two row configurations. Both 1 m and 1.5 m cotton exceeded the parameters set by the Australian cotton industry of >1.125 inches fibre length and >29 g/tex fibre strength, respectively (Bange *et al*. 2009). There were slight changes in fibre quality in the segment picks. Fibre length was consistently longer and less variable in the 1.5 m cotton compared with 1 m cotton ($P < 0.031$) (Fig. 4). The 1 m cotton showed considerable variation in fibre length throughout the different fruiting branch positions. The 1.5 m cotton was consistently approximately 1.25 inches, whereas the 1 m cotton was approximately 1.2 inches and shorter in the vegetative branches (1.18 inches). Fibres from the 1.5 m cotton were slightly stronger than 1 m cotton ($P < 0.020$). The 1.5 m cotton consistently took >31 g/tex to break, whereas the 1 m cotton was not as strong at <31 g/tex except for the vegetative fruiting positions (<30 g/tex) (Fig. 5). This improved fibre quality in wider row spacing could indicate less water stress during fibre elongation and is one of the major drivers of using this in rainfed systems (Bange *et al*. 2005). There may also have been less synchronous demand for carbohydrates in the wider row spacing indicated by the differences in fruit distribution.

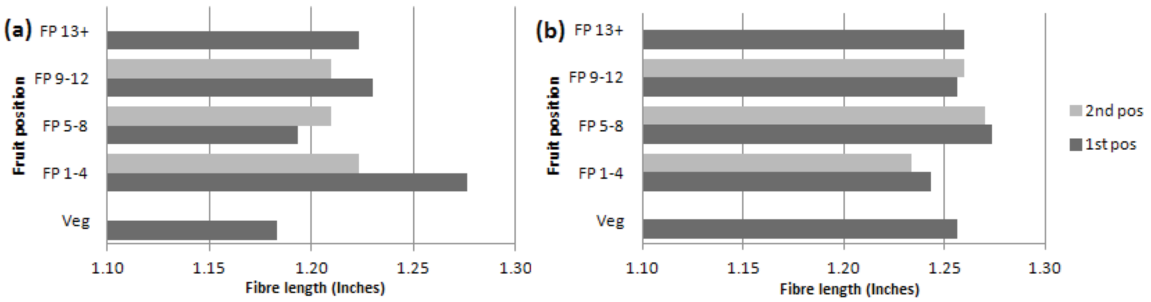

Figure 4. Fibre length (inches) of hand picked cotton in separate fruiting branch positions (FP); (a) 1 m row and (b) 1.5 m row spacing. Fibre length was measured in decimal inches by the High Volume Instrument (HVI) (1 inch = 25.4 mm).

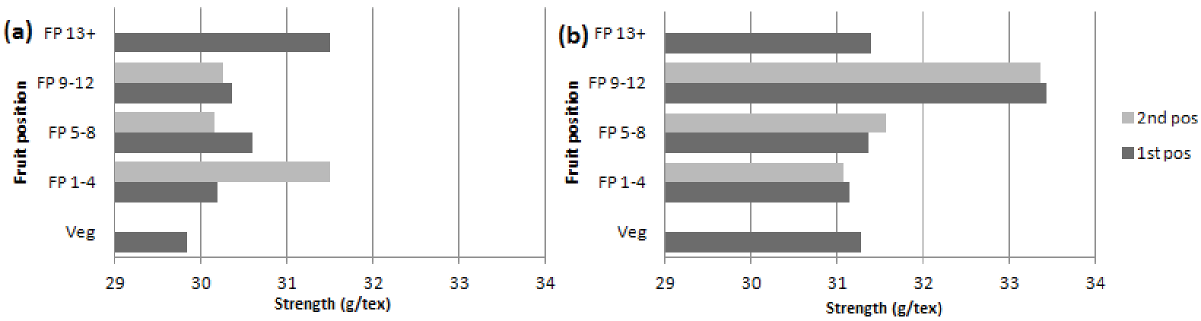

Figure 5. Fibre strength (g/tex) of hand picked cotton in separate fruiting branch positions (FP) in (a) 1 m row and (b) 1.5 m row spacing.

Estimated water use provided by Auscott showed that the 1.5 m cotton used 30% less water (7.27 ML/ha), compared with the 1.0 m cotton (10.43 ML/ha). The water saving of 3.2 ML/ha played a role in reducing costs of 1.5 m cotton to compensate for the reduction in yield compared with 1 m cotton and this saved water would allow for more hectares of cotton to be grown and overall a more profitable farming system. Estimated gross margins showed that both row configurations produced a similar gross margin of $2,000 per ha (detailed calculations not presented). Although yields were higher with 1 m row, 1.5 m row had reduced costs due to savings in irrigation water ($474 /ha) and technology fees ($133 /ha). Technology fees are charged based on the actual green hectares grown, i.e. 100% of the fees are applicable for 1 m row, while only 66.7% of fees are applicable for 1.5 m cotton and skip row spacing as cotton plants represent only 2/3 of the total land area. In the 2014/2015 cotton season, Auscott Warren has installed Mace meters to measure total water applied and capacitance probes to measure crop water use in each row configuration. More precise quantification of crop water use is essential for estimating water use efficiency.

Conclusions

The 1 m cotton out yielded the 1.5 m cotton by 1.8 bales/ha (16%). There was a small improvement in fibre quality in the 1.5 m cotton compared with the 1 m cotton, however in both treatments all fibre parameters exceeded the industry requirements. Handpicked segments revealed that the majority of the fruit in 1 m cotton came from position 1 of fruiting branch positions 1-8 whereas in the 1.5 m cotton a high proportion of fruit came from the vegetative fruiting branches. Gross margins of the two systems were remarkably similar at $2,000/ha. Future research needs to quantify water use to provide more information to improve decision making.

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