Water extraction of solid and skip-row cotton

José Payero[1], Geoff Robinson[2], Graham Harris, and Dhananjay Singh[2]

[1] The University of Queensland, Queensland Alliance for Agriculture and Food Innovation (QAAFI), www.qaafi.uq.edu.au Email j.payero@uq.edu.au
[2] Queensland Department of Agriculture, Fisheries and Forestry (DAFF Queensland), 203 Tor Street, Toowoomba, QLD 4350. www.deedi.qld.gov.au Email graham.harris@deedi.qld.gov.au

Abstract
Australian cotton (*Gossypium hirsutum* L.) growers use different planting configurations as a strategy to minimise production risk in water-limited environments. Although there has been considerable research comparing yields between different row configurations, detailed information on associated water extraction is still lacking. The objectives of this study were to compare the water use, soil water extraction pattern, crop development and yield of dryland cotton planted on solid and single-skip row configurations. A replicated field experiment comparing the two configurations was conducted at Kingsthorpe, Queensland, in 2007-08. Soil water was measured weekly with the neutron probe method at 10 cm depth increments from three positions (P1, P2, and P3) with respect to the crop row. We found that the single-skip configuration had more water available in the top 105 cm during the vegetative development stage. Seasonal water extraction, however, was the same (about 128 mm) for both configurations, suggesting that both were water-limited and extracted all the soil available water. Since the seasonal rainfall was 271 mm, we estimated the seasonal water use at 399 mm, about half the grass-reference evapotranspiration. Because of the additional water available during the vegetative stage, the single-skip treatment grew about 10 cm taller than the solid treatment. The additional water, however, was not enough to produce significant differences in crop yield between the two configurations. These results show that the single-skip treatment did not save any water, but minimized risk of drought by producing more robust individual plants.

Key Words
Cotton, water use, soil water, row configuration

Introduction
Australian cotton producers use different row configurations, including solid, single skip, double skip, wide row, and alternate skip (Bange and Stiller, 2002). Although skip-row configurations, where individual rows are deliberately not seeded ie. "skipped" instead of solid configurations, are mainly used in dryland production, they are often used in irrigated crops when water is limited. Results of research comparing yields of solid to single skip and double skip cotton in Australia have been reviewed by Bange and Stiller (2002), and Gibb (1995). Although skip row configurations give up yield potential compared with solid planting when water is not severely limited, they reduce risk of crop failure when water is limited. Since production costs can be significantly reduced with skip row, especially for Bollgard II varieties with high seed cost, Gibb (1995) suggested that gross margins per unit area ($/ha) could actually increase with skip row compared to solid planting. Goyne and Hare (1999) reported increased gross margins for single and double skip rain-grown crops compared with solid planting. Under water limiting situations, additional income can also result from improved fibre quality from skip row configurations compared to solid planting (Goyne and Hare, 1999). Monsanto (2011) reported sensitivity analyses of gross margins of dryland cotton planted in different row configurations with respect to yield and crop price. The feasibility of skip-row configuration with respect to solid planting and the type of row configuration to be selected depends on a variety of factors, including the amount and distribution of water supplies (from rain and irrigation), soil type, weather conditions, and economic factors such as cost of production and crop price. Although in Australia there has been extensive research comparing row configurations, the focus has been mainly on yield and fibre quality. Accurate comparisons of water use, soil water extraction pattern, and crop development among cotton configurations are still lacking. The objectives of this study were to compare the water use, soil water extraction pattern, crop development and yield of solid and single-skip row configuration of dryland cotton.

Methods
This study was conducted in a heavy cracking-clay soil during the 2007-08 cotton season at the Agri-science Queensland's Kingsthorpe research station located in a sub-tropical climatic zone, about 20 km north-west of Toowoomba, Queensland. Two row configurations (Solid and Single-Skip) were compared as a split plot within the dryland treatment of a larger cotton irrigation experiment with three replications. Half of each dryland plot (13 m x 20 m) was kept as a Solid configuration and the other half as Single-skip (Figure 1).

The cotton hybrid Sicala 60 BRF, a Bollgard® II Roundup Ready Flex® variety, was planted on 12 Nov 2007 at 1-m row spacing and sowing density of 17 seeds/m. The conventional variety Sicot 43 RRF was planted as the refuge crop. In each configuration, three neutron tubes were installed in each plot, located at three positions with respect to the crop row, two in the plant line (positions P1 and P3) and one in the middle of the crop row (position P2) (Figure 1A). Neutron readings were taken about weekly (often twice a week) at 0.10 m depth increments to a depth of 1.4 m using a previously calibrated 503DR Hydroprobe (CPN International, Inc., Martinez, CA, USA). From these measurements, the total soil water in each depth increment *(TWin)* and the total soil water above a given soil depth *(TWto)* were calculated (both in mm). An EnviroStation (ICT International Pty Ltd, Armidale, NSW, Australia) weather station was installed next to the research plots, which recorded solar radiation, air temperature (maximum, minimum, and average), relative humidity, wind speed and rainfall. Daily and seasonal grass-reference evapotranspiration (ETo) was calculated from the weather data.

Figure 1. [A] Positions of neutron tubes in the solid and single skip cotton row configurations compared at Kingsthorpe during 2007-08, and [B] picture of the cotton crop showing the two row configurations.

Results

Comparison of total soil water in each depth increment (TWin)

Differences in TWin between the two configurations (Skip minus Solid) as a function of days after sowing (DAS) for four selected depths (25, 55, 105, and 135 cm) are shown in Figure 2. Positive differences indicate more water available for the skip compared with the solid configuration. Although differences were not significant, the skip configuration tended to have just slightly more water at the shallower depths (25 and 55 cm depths) while the solid tended to have more water deeper in the profile (105 and 135 cm depths). On average for all sampling dates, the skip configuration tended to have slightly more water in the top 100 cm while the solid tended to have more water deeper in the profile. Averaging all depths, at position P2, the tendency was for the skip to have slightly more water for the whole season, except for the first two sampling days (DAS 33 and 58). For positions P1 and P3, the tendency was for the skip to have slightly more water early in the season and less late in the season. Significant differences in *TWin* were sporadic for position P1. Most significant differences were detected at position P2, showing more water available for the skip configuration. The significant differences for position P2 concentrated in the top 85 cm of the soil profile, and mainly between 72 and 107 DAS. There were also significant differences at P2 between 140 and 144 DAS for the depth ranges of approximately 75 to 95 cm. At Position P3, there was significantly more soil water for the skip configuration between 58 and 65 DAS, mainly near the soil surface (top 35 cm). Under water-limiting situations, more water available for the skip row early in the season is expected to have promoted more vegetative growth, biomass and yield per plant compared with the solid configuration.

Comparison of total soil water above a given soil depth (TWto)

Differences in *TWto* between configurations by position and DAS are plotted in Figure 3. The skip configuration tended to have more water available during the crop development stages at position P1, but less water late in the season. At position P2, it tended to have more water in the profile for practically the entire season. At position P3, it had more water early in the season and less water after about 100 DAS. Statistical analysis resulted in significant differences in *TWto* between configurations at the three positions

(P<0.05). Significant differences resulted between 94 and 98 DAS at position P1, between 94 and 98 DAS at position P2, and between 58 and 65 DAS at position P3. No significant differences were detected below 105 cm depth for any of the positions. These results indicate that overall, the skip configuration had more soil water available from about 58 to 98 DAS. A maximum of about 15 mm more water was available to the skip configuration, which was mostly stored in the top 105 cm soil depth.

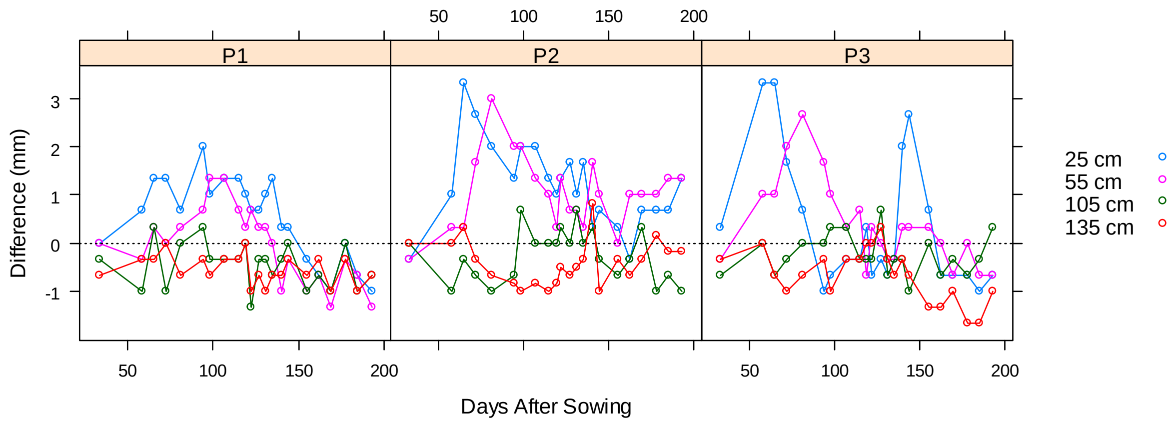

Figure 2. Difference (Skip minus Solid) in soil water between Skip and Solid cotton configurations by days after sowing and measurement position (P1, P2, and P3) in each 10-cm depth increment at 25, 55, 105 and 135 cm soil depths obtained at Kingsthorpe during 2007-08.

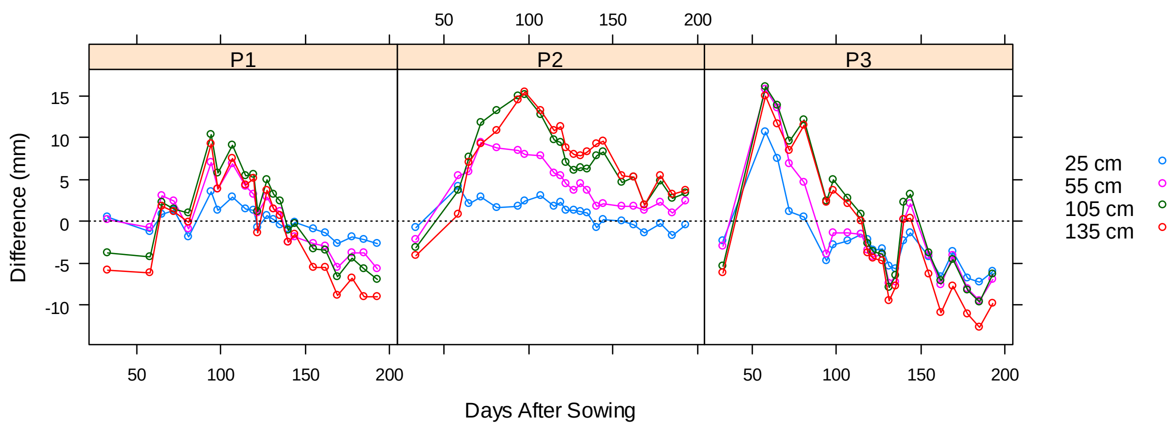

Figure 3. Difference (Skip minus Solid) in total soil water content between Skip and Solid cotton configurations by days after sowing and measurement position (P1, P2, and P3) above the top 25, 55, 105 and 135 cm soil depths obtained at Kingsthorpe during 2007-08.

Seasonal change in soil water and crop water use

Although there were small differences among positions, when all positions were averaged the seasonal change in *TWto* was the same for both configurations (128 mm) (Figure 4). Therefore, since there was 271 mm of seasonal rain and 128 mm of water extracted from the soil, an estimate of seasonal water use for the crop was about 399 mm (for both configurations).This seasonal water use represents about half of the seasonal ETo (ETo = 804 mm), which indicates that the crop was water stressed.

Crop development and yield

Cotton plants in the skip configuration grew significantly taller (about 10 cm taller) than those in the solid (Figure 5), which could be explained by the skip configuration having slightly more water available during the early and mid season, during the crop vegetative development stages. Even though the skip configuration produced taller plants, the solid configuration produced significantly higher dry biomass per unit area. The lint yield for the solid configuration averaged 6.2 bales/ha, while the skip averaged 5.2 bales/ha, but this difference was not significant due to high variability among replications.

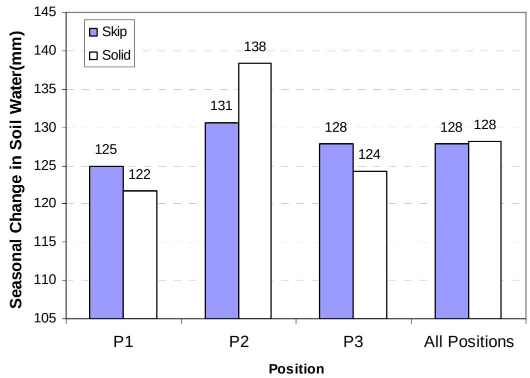

Figure 4. Comparison of seasonal change in soil water in the whole soil profile (to 135 cm) between configurations (skip and solid) and positions (P1, P2, P3) between the first and last sampling dates (days after sowing 33 to 193).

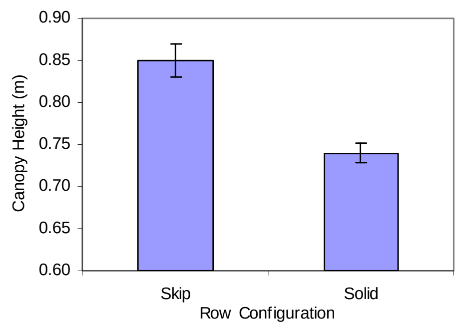

Figure 5. Maximum canopy height for cotton at Kingsthorpe during 2007-08. Error bars are standard error of the means.

Conclusion

This study compared single skip and solid cotton configurations under dryland conditions in a sub-tropical climatic zone. It was found that in general, the skip configuration tended to have more water available in the top 105 cm soil profile. This additional water was available between 58 and 98 days after sowing, during the vegetative development stage. The measuring position affected when the additional water was available. The additional water was available earlier in the season at position P3, which was available between 58 and 65 DAS, compared with positions P1 and P2 where the additional water was available later in the season (72 to 98 DAS). For the entire season, however, both configurations extracted the same amount of soil water (128 mm), which suggest that both configurations were water limited and extracted all the water that they had available. The 128 mm added to the seasonal rainfall of 271 mm allowed us to estimate the seasonal water use at about 399 mm, which was about half (49.6%) of the 804 mm seasonal ETo. Because of the additional water available between 58 and 98 DAS, the crop under the skip configuration grew about 10 cm taller. The additional water, however, was not enough to produce significant differences in crop yield between the skip and solid configurations.

References

Bange MP and Stiller W (2002). Agronomy, Australian dryland cotton production guide. Australian Cotton Cooperative Research Centre, Narrabri, Australia, pp. 41-52.

Gibb D (1995). Cotton production during drought. Cooperative Research Centre for Sustainable Cotton Production, Moree, Australia.

Goyne PJ and Hare J (1999). Improved understanding of cotton water use for better management in water limited environments: Annual Progress Report. Report. Queensland Department of Primary Industries and Fisheries/Farming Systems Institute, Hermitage.

Monsanto (2011). "Line up more profit with dryland cotton." Monsanto Australia e-news, Monsanto, Toowoomba, Australia, 1-4.