Assessing the feasibility of GM cotton in the Ord River Irrigation Area: tillage systems for late wet season sowing.

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Abstract

The possible reintroduction of cotton into the Ord Valley has necessitated a change from wet to dry season production to avoid key insect pests. Research has found that good yields are achievable with minimal insecticide usage with genetically modified Bollgard?II? varieties using locally developed IPM. However, the capacity to sow commercial scale areas earlier and avoiding a late wet season (March to mid-April) is a potential constraint to the system.

In 2004 and 2005, an early sowing system (ES) involving permanent beds, a cover crop, watering-up and minimum tillage, was compared with a) the conventional system (CS) of cultivation, bed formation plus pre-irrigation, and b) reduced tillage (RT), with limited cultivation of the beds and watering-up. Varieties with and without genetic modification for resistance to glyphosate (Roundup Ready?) were compared in each system.

ES and RT with or without Roundup Ready? varieties permitted sowing before April 15, 18 to 20 days earlier than CS with similar costs. The ES and RT lint yields were significantly higher than CS in 2004. In 2005 there was no yield difference, possibly due to all treatments being sown before mid-April and the better growing conditions that followed for all treatments. Effective weed control was achieved in all systems. Roundup Ready? technology, although permitting effective weed management maybe of limited value as the window for application of glyphosate early in cotton growth was small (17 d). The importance of seed bed and weed management during the wet season fallow was also highlighted in this study.

Key Words

Minimum tillage, glyphosate, Roundup Ready?, tropics.

Introduction

The research described here forms part of a broader study to assess the feasibility of reintroducing cotton into the Ord River Irrigation Area (ORIA). Cotton production was terminated in the ORIA in 1975 due to poor fibre quality and insecticide resistance in *Helicoverpa armigera*, which were symptoms of a production system that in hindsight failed to recognise the ecological limitations of the environment. Research over the past 10 years has evaluated a novel production system in which cotton is grown during the dry season (March to October) to avoid key insect pests. Combined with IPM, Bt transgenic Bollgard II? varieties and pre-emptive resistance management, insecticide usage has been reduced to less than 5 sprays per season, with acceptable fibre quality and yields similar to the Australian average (Strickland et al. 1998; Strickland et al. 2003).

However, agronomic research and has shown that the new growing season is tight and sowing must occur after March 1 but prior to April 15 to minimise insect pest numbers, avoid rain at picking and maximise yield (Yeates and Bange 2003). Moreover, to ensure commercial scale areas can be picked before wet season rains, the majority of the cotton needs to be planted during March. Trafficability during March is constrained by heavy clay soils that are still drying following the wet season, and highly variable rainfall (Yeates et al. 1996).

Currently land preparation in the ORIA relies on cultivation because it has evolved for crops such as maize and chickpeas that are sown after mid April when the chance of rain is low. The current system relies on pre-irrigation to geminate weed seeds that have built up in the prior wet season fallow. Herbicides are used to kill weeds prior to, or soon after sowing.

Research was initiated to evaluate early sowing systems for cotton that use less tillage and don't rely on pre-irrigation for weed management, so that earlier sowing can be achieved. In addition, the value of genetically modified Roundup Ready? varieties with resistance to glyphosate was evaluated with conventional varieties to assess their contribution to achieving earlier sowing. The relative value of this technology in terms of herbicide usage and costs were also assessed.

Methods

The experiments were located at the Frank Wise Institute, 13 km NW of Kununurra WA, (15°S, 128°E). The soil was a Cununurra clay (Parberry et al. 1968). Two replicated experiments were conducted during the 2004 and 2005 dry seasons. A plant population of 8 to 10 plants per m of row was established using a row configuration of 2 rows per bed separated by 80 cm and 1 m between rows in adjacent beds; irrigation furrows were between beds. The Bt transgenic (Bollgard II?) variety Sicala 40B was compared with its Bt transgenic and glyphosate resistant equivalent (Roundup Ready?) Sicala 40BR. Plots were 12 - 48 rows wide by the length of the field (280m and 200m in 2004 and 2005 respectively). Insect pests were managed by scouting twice weekly and insecticide spray decisions were made according to established thresholds. Fertiliser, 200 kg/ha N, 40 kg/ha P, 17 kg/ha S and 5kg/ha of Zn, was banded at or prior to sowing, 15 cm below and 5cm outside the seed row. Seed cotton was machine harvested from the centre rows of each plot. Lint yield was calculated by ginning a 1kg sub-sample with a 10 saw gin. The tillage treatments are summarised in Table 1.

Table 1: Details of the tillage systems compared. (For Roundup Ready? treatments in ES and RT glyphosate replaces residual herbicide (pendimethalin) and is applied when cotton ≤ 4 nodes).

Tillage System	Management Components
Early Sowing (ES)	*Wet season:* Permanent beds, cover crop or previous crop stubble, glyphosate / knockdown herbicide in February to kill cover crop and weeds. *Cotton season:* Fertilise/clean furrows, sow, knockdown herbicide, residual herbicide, water up.
Reduced Tillage (RT)	*Wet season:* As above except weed cover on beds which is killed before seeding. *Cotton season:* As above except cultivate prior to sowing.
Conventional (CS)	*Wet season:* Re-establish beds for weed control. *Cotton Season:* Cultivate, fertilise, power harrow, pre-irrigate, cultivate, sow, residual herbicide.

In 2004 the stubble from the previous winter grain sorghum crop was retained on the surface of the beds at the start of the wet season in all treatments. In 2005 the previous dry season crop was chickpea which was cultivated in early December with beds retained in ES and RT.

Results and Discussion

In 2004 and 2005 the ES and RT systems permitted sowing prior to April 15, 18 to 20 days before the conventional system (Table 2). The earlier sowing could be attributed to a combination of permanent

beds reducing the need for aggressive cultivation of wet sub soil, and watering up. In 2005 sowing was possible in mid-March for the ES and RT systems and the mulch cover prevented bed slumping following 130mm of rain post sowing.

There was no difference in lint yield with or without Roundup Ready?, hence the tillage system yields are pooled in Table 2. Lint yields of the CS and RT were similar to the Australian average for 2004 and 2005. In 2004 lint yields were significantly lower for CS due to the later sowing. The growing season included 10 consecutive nights < 10?C (average 14?C) during early flowering, and this, combined with unseasonal rain, contributed to an early *Alternaria spp.* infection that damaged young leaves. There were no yield differences in 2005 due to sowing before April 15 combined with warmer than average night temperatures with only 1 night < 12?C.

Table 2: Sowing date and lint yield for the tillage treatments.

Tillage	Sow date		Lint Yield (kg/ha)	
	2004	2005	2004	2005
Early Sowing	April 10	March 15	1918	2157
Reduced Tillage	April 10	March 15	1898	2202
Conventional	April 28	April 4	1503	2281
$LSD_{0.05}$			157	NS

Effective weed control was achieved in all tillage systems. The relative cost of the tillage systems was $110/ha or less (Table 3), which is small compared to total variable growing cost of $2400/ha. The RT without RR was the same cost or up to $75 less than the CS, while the cost of ES varied between the seasons (Table 3), due to the differences in wet season cover management. Using Roundup Ready? varieties increased the relative costs by $39/ha due to the difference between the licence fee and the saving in herbicide cost.

Table 3: The cost ($/ha) of tillage and weed control relative to CS. Costs include management of the wet season cover crop or fallow. (Roundup Ready? = RR)

Tillage Method	2004	2005
ES without RR	-110	+41
ES with RR	-71	+80
RT without RR	-38	-75

RT with RR	+1	-36

The difference in the herbicide treatments and cultivations between the seasons reflected the timing of rain and a weedier paddock in 2005 (Table 4). Of interest is the greater herbicide use during the wet season fallow/cover crop than in-crop. This is due to the same weed species growing in the wet and dry seasons, hence a need to manage the weed seed bank over the wet season, (and this is not cotton specific). The cover crop in 2005 reduced the need for wet season herbicides in ES, while additional herbicide treatments were required in RT to prevent seed set in the weed fallow.

The use of transgenic Roundup Ready[?] did not change the total number of herbicide treatments, as glyphosate applied post emergence removed the need for the residual herbicide pendimethalin (Table 4). In fact glyphosate was used in all tillage systems. Due to rapid crop growth, Roundup Ready[?] had the disadvantage of requiring glyphosate treatment within 17 days of sowing to avoid crop damage.

The majority of herbicides applied were knockdown and not confined to glyphosate, with the Group L (paraquat, diquat), Group G (oxyfuorfen) and Group I (2,4-D amine) herbicides applied pre-sowing (Table 4). This is desirable from a resistance management perspective and demonstrates that effective weed control can be achieved in different tillage systems without relying on glyphosate alone.

Table 4: Cultivation and herbicide summary including the wet season fallow/cover crop prior to sowing cotton. The number of herbicide treatments at/or post sowing are shown in brackets.

Tillage System	Cultivations#	Total Herbicide Treatments	Glyphosate Treatments	Pendimethalin Treatments	Other Herbicide Groups used^
			2004		
ES – RR	1	4 (2)	2	1	L, G
ES + RR	1	4 (2)	3	0	L, G
RT – RR	2	3 (2)	2	1	G
RT + RR	2	3 (2)	3	0	G
CS	2	4 (2)	2	1	L, G
			2005		
ES – RR	3*	3 (2)	1	1	L, G
ES + RR	3*	3 (2)	2	0	L, G

RT – RR	2	4 (1)	3	1	I, G
RT + RR	2	4 (1)	4	0	I, G
CS	5	2 (1)	2	1	I, G

Fertilisation and planting are not included as they were the same in each system.*Includes mulching of cover crop.^ I and H were applied in glyphosate mixes and L alone.

Conclusions

ES and RT with and without Roundup Ready[?] varieties permitted sowing before April 15, 18 to 20 days earlier than conventional systems, with similar costs and producing the same or higher yield. Roundup Ready[?] varieties, although permitting cost effective weed management and a diversification of herbicide groups, were of limited value due to the need for the glyphosate treatment to be applied within 17 days of sowing. The importance of seed bed and weed management during the wet season fallow was highlighted in this study.

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