The Irvin Boom – adapting proven sugar cane industry weed management technology for dryland broadacre agriculture

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Summary The Irvin boom is a specialised shield-less boom comprised of stabilised nozzle platforms fitted with single or dual trailing legs for guidance between crop rows. In the past it has only been promoted for weed management in sugar cane. The shield-less character and the ability to use in-crop makes this boom appealing as a potential alternative to expensive shielded spray booms for use in broadacre dryland wide row (>1 m) crop situations. Five field trials have been conducted in central Queensland in sorghum and chickpea to determine the suitability and effectiveness of the Irvin boom using paraquat as the in-crop directed contact herbicide. It has been evaluated in conjunction with inter-row tillage and shielded applications of paraquat for weed control, crop damage and crop yield effects, and impacts on retained (carryover) crop stubbles.

Results showed that paraquat applied through the Irvin boom effectively (>98%) controlled the weeds present in the majority of trials. It was just as good, if not better, than the shielded application and inter-row tillage treatments. The boom tracked through standing wheat stubble with minimal impact on that stubble. Crop damage was more noticeable with the Irvin boom. This injury did not significantly reduce yields in sorghum trials. However, chickpea damage was much greater and recovery did not occur. The implications of these results and future applications for the Irvin boom in broadacre cropping are discussed further.

Keywords Irvin boom, wide rows, inter-row, weeds, sorghum, chickpea, paraquat.

INTRODUCTION

The Irvin boom is a spraying system with the ability to follow the ground contour and track in-between crop rows for the directed, shield-less application of post-emergence herbicides. The boom is a series of stabilised platforms with up to six directed nozzles per unit. Each platform may have single or dual trailing legs. It was developed for application in sugar cane, and is widely used in Queensland and New South Wales.

Grain sorghum is the principal dryland summer crop grown in central Queensland. Recently there has been an extensive adoption of wide row (>1 m) planting configurations to reduce production risks by guaranteeing reliable yields during dry seasons, particularly on shallow cropping soils (Collins *et al*. 2006). This move combined with zero-till has placed increased pressure on herbicides to effectively control in-crop weeds since crop competition is negligible. This wide-rows trend is also being practiced in chickpea.

The ability to apply contact herbicides in-crop to the inter-rows without the need for shields, coupled with the banding of residual herbicides over the rows at planting, facilitates potential economic and environmentally-positive practice change. Banding greatly reduces the physical amount of residual herbicide subject to off-site movement via soil erosion and run-off since much less is being applied. The ability to use paraquat (Group L) in-crop for summer grass weed control also provides an alternative herbicide mode of action to assist with avoiding the development of resistance to the region's widely used and at-risk herbicides atrazine (Group C) and glyphosate (Group M).

Research has been conducted in central Queensland since 2005 to evaluate the suitability and effectiveness of Irvin boom technology in wide-row sorghum and chickpea.

MATERIALS AND METHODS

Five field trials, four in sorghum and one in chickpea, have been conducted on the Emerald Research Station. Levels of weed control, crop damage and grain yields have been assessed where paraquat has been applied using the Irvin boom compared with shielded spraying and inter-row tillage. Two of the sorghum trials had standing wheat stubble present, and in one of these the impact of the inter-row treatments on the stubble was assessed.

Sorghum trials Trials without the wheat stubble used complicated designs (randomised blocks of split-split plots with three replicates). Crop row spacings were main treatments, split for over-the-row atrazine banding at planting, with further sub-splitting for inter-row treatments (shielded spraying, Irvin boom and tillage). Plot size was 6 m × 15 m. Sorghum cv. MR Buster was planted at 45,000 plants ha^{-1} in early January (2005 trial) and early December (2006 trial). The inter-row treatments were applied mid-February (2005 trial) and late January (2006 trial). In both trials Gramoxone® (paraquat 250 g a.i. L^{-1}) was applied at 2 L ha^{-1}, with volume outputs of 180 and 250 L ha^{-1} for the shielded sprayer and Irvin boom respectively. The tillage treatment consisted of sweep tynes set to a depth of 50 mm and no closer than 100 mm to the crop rows.

The trials with wheat stubble used complete randomised block designs with four replicates. Sorghum (as above) was planted mid-January (2006 trial) and mid-December (2007 trial). Inter-row treatments (as above) were applied late February (2006 trial) and early February (2007 trial). Plot size was 4 m × 20 m. Gramoxone® was applied at 2 L ha^{-1} and volume output (200 L ha^{-1}) was the same for both the shielded sprayer and the Irvin boom. In both trials, standing wheat stubble across the trial area was measured prior to treatment application and was recorded as 3.9 (2006) and 3.2 t ha^{-1} (2007).

Visual percentage weed control and percentage crop injury assessments were made at 21 days after the inter-row treatment application (DAT). Grain yields were measured at maturity. In the 2007 trial, stubble was also measured within plots for quantity and percentage remaining upright at 21 DAT.

Chickpea trial A single trial (2006) utilised a complete randomised block design with four replicates. Chickpea cv. Jimbour was planted on 1 m rows at 275,000 plants ha^{-1} in mid-May. Pre-emergence herbicide (simazine) was banded (30 cm width) over all rows at planting except in the untreated controls. Inter-row treatments (shielded sprayer, Irvin boom and tillage) were applied in early July. Gramoxone® was applied at 2 L ha^{-1} at volume output of 180 L ha^{-1} for both the shielded sprayer and Irvin boom. Tillage was identical to that used in the sorghum trials.

Visual percentage weed control and percentage crop injury was measured at 22 DAT. Yields were measured at maturity.

Data All data were subjected to analysis of variance using Genstat statistical package (9th edition). LSD values are provided where the F tests were significant. For purposes of brevity and simplicity, this paper only presents the results associated with the inter-row treatments. Hence, data have been pooled for other treatments components (e.g. row spacing, atrazine banding).

RESULTS

Sorghum studies

Weed control: The Irvin boom was as good as, if not better than, the other treatments. In three of the four trials, weed control achieved with paraquat applied via the Irvin boom ranged from 98 to 100% (Table 1). In the remaining trial, this treatment only achieved 87% control, but reduced control levels were also recorded in the shielded application and the inter-row tillage treatments.

Crop damage and yield: Very low levels of crop damage (0.1 to 12.3%) were noted across treatments and trials (Table 1). In each trial, the Irvin boom produced the highest level of damage. This injury was transient as no significant yield differences were recorded in any trial.

Stubble impacts: In the 2006 trial with stubble (Table 1), the 3.9 t ha^{-1} residual wheat stubble present may have reduced the level of weed control achieved (80

Table 1. Impact of inter-row treatments on weed control, crop damage (at 21 DAT) and grain yield in four central Queensland sorghum trials.

Treatment	Weed control (%)	Crop injury (%)	Yield (kg ha^{-1})
Sorghum 2005			
Irvin boom	98	2.7	2691
Shield spray	97	2.4	2720
Tillage	97	0.1	2699
Nil	–	0.0	2654
LSD (P=0.05)	ns	1.4	ns
Sorghum 2006			
Irvin boom	100	4.1	1137
Shield spray	99	3.9	1054
Tillage	100	1.5	1103
Nil	–	0.0	1078
LSD (P=0.05)	ns	0.9	ns
Sorghum with stubble 2006			
Irvin boom	87	2.8	3175
Shield spray	80	1.9	3146
Tillage	91	2.0	3581
Nil	–	0.0	3027
LSD (P = 0.05)	ns	ns	ns
Sorghum with stubble 2007			
Irvin boom	100	12.3	2046
Shield spray	99	7.1	2111
Tillage	98	1.0	2265
Nil	–	0.0	2194
LSD (P = 0.05)	ns	7.8	ns

to 91%) across the treatments. However, in the 2007 trial where the mean stubble level was 3.2 t ha^{-1}, weed control was not compromised in any treatment. In this latter trial, the inter-row tillage treatment physically removed (dragged) most of the stubble from the plots (Table 2), and of that left behind, none remained upright. Both the Irvin boom and the shielded spray did not move any stubble. The majority remained upright with no more than 4% (non-significant) knocked over by the shielded sprayer.

Table 2. Impact of inter-row treatments on wheat stubble (21 DAT) remaining in the 2007 central Queensland sorghum trial.

Treatment	Stubble quantity (t ha^{-1})	Stubble remaining upright (% of total)
Irvin boom	3.22	20
Shield spray	3.19	17
Tillage	0.52	0
Nil	3.22	21
LSD (P = 0.05)	0.61	4

Chickpea study

Data were limited for chickpea as only one trial was conducted. Weed control in chickpea with paraquat applied via the Irvin boom was very effective (98%) (Table 3). Both the Irvin boom and the shielded spray treatments were significantly better than inter-row tillage. Unlike the sorghum, crop damage in chickpea by the Irvin boom treatment was greater and the crop was unable to recover, resulting in significantly reduced yields in this treatment.

Table 3. Impact of inter-row treatments on weed control, crop damage (at 22 DAT) and yield in the 2006 central Queensland chickpea trial.

Treatment	Weed control (%)	Crop injury (%)	Yield (kg ha^{-1})
Irvin boom	98	16.3	1207
Shield spray	99	0.0	1620
Tillage	93	0.0	1740
Nil	–	0.0	1626
LSD (P = 0.05)	2.6	4.0	202

DISCUSSION

The data presented support the suitability and effectiveness of the Irvin boom for the directed application of paraquat in broadacre dryland wide row cropping, particularly sorghum, without the need for shields. Inter-row weed control was very effective for the spectra (species not listed) encountered in all trials. Sorghum crop safety was not diminished where the Irvin boom was used.

The boom's use in chickpea is not supported due to unacceptable (non-recovery) crop damage and consequent yield reduction. Because the boom is shield-less, paraquat drifted onto chickpea plants. Paraquat is a contact herbicide and kills any green plant material it comes in contact with. Grass species, such as sorghum, have of a whorl of leaves wrapping the stem, hence contact by paraquat drift on these outer whorl-leaves is only likely to affect those leaves. In broad leaved plants like chickpea, paraquat contact on the stem is likely to create a partial 'ring-bark' effect which will adversely affect the growth of the entire plant.

The ability to apply paraquat without shields to the sorghum inter-row zone in lieu of blanket atrazine or shielded glyphosate applications presents an effective herbicide resistance avoidance strategy for high risk summer grass weeds.

There is potential to couple Irvin boom technology with Weed Seeker technology to further reduce the physical amount of herbicide applied in the inter-row. In doing so, costs will also be reduced. This marriage of technologies could provide significant economic and environmental benefits without compromising effective weed management or herbicide resistance avoidance strategies. Wide-row systems will be able to maintain stubble and continue to rely on strategically applied herbicides (banded residuals over crop rows with contacts applied in the inter-rows but only to zones where weeds are present). Opportunities to explore this further will be taken in central Queensland over the next five years.

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