Aerial application of Magister in rice using the Bickley boom

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Summary A novel aerial boom configuration, now called the Bickley boom after the designer, was developed specifically for application of pesticides into flooded rice bays. It consists of two large bore nozzles mounted on droppers one either side of the plane. In flying tests, the Bickley boom reduced drift by 70–80% at 100 metres downwind compared to the best multiple solid stream CP nozzle configuration. The reduction was consistent whether applying a total spray volume of 10 L ha^{-1} or 20 L ha^{-1}.

Four aerial trials in unreplicated commercial rice bays were carried out in the rice season of 2000/2001 to determine the safety to rice and control of grass weeds by Magister® (480 g L^{-1} clomazone as an EC) or Ordram (960 g molinate L^{-1} as an EC) alone and tank mixed with Taipan® (300 g L^{-1} benzofenap as an SC). These treatments were applied through the Bickley boom in comparison to Magister applied by ground SCWIIRT (Soluble Chemical Water Injection In Rice Technique). Off-target effects were assessed by use of potted roses and water sensitive papers at 25 m intervals up to 100 metres downwind of treated bays. A drift retardant agent, Sanag 41-A©, was added to the aerial Magister treatments to further reduce the likelihood of drift.

Magister applied through the Bickley boom was as efficacious on barnyard grass *Echinochloa* spp. and as safe to rice as Magister applied as a ground SCWIIRT. Activity and safety of Magister were maintained whether applied in a total spray volume of 10 L ha^{-1} or 20 L ha^{-1} through the Bickley boom. Drift, as measured by bleaching effects on roses and capture on water sensitive paper, was generally confined to the first 25 metres downwind even in situations where cross winds of up to 19 km h^{-1} prevailed.

Keywords Magister, Bickley boom, aerial, application, drift, off-target.

INTRODUCTION

The majority of herbicide applications in rice are made by aircraft equipped with booms mainly fitted with multiple solid stream nozzles (McCaffery *et al.* 2000). The minimum volume for aerial application specified on most herbicide labels used in rice is 20 L ha^{-1}. The high flying speed of today's crop spraying aircraft results in a high degree of atomisation of the spray solution which is normally applied over the entire surface of the water in the rice bay. These factors increase the number of fine droplets which can result in off-target deposition in neighbouring sensitive horticultural crops or sensitive environments. A lower proportion of applications into permanent water are made by four wheel motor bikes and less frequently by helicopter which use total volumes of 5 L ha^{-1} to spray the pesticide under low pressure into the flooded bay whilst traversing 20 to 30 m swaths. The technique is called SCWIIRT (Taylor 1994) and is increasing in popularity due to lower application costs per hectare than aerial application and ability to spray alongside sensitive horticultural crops.

The rice aerial industry is under increasing pressure to minimise drift and off-target effects and to contain or reduce application costs. Fortunately the common method of growing and treating rice in Australia offers scope to change application practices. This is because herbicides and insecticides are mostly applied into permanent water where they subsequently re-distribute due to effects of wind and currents. The precedent has been set by the concept of ground SCWIIRT. Adapting this concept to aerial application appears logical but paradigms govern every day operations and challenges to accepted norms tend to be rare.

Magister® is a herbicide commercialised in 1999 by Crop Care/FMC for control of barnyard grass and suppression of silver top grass (*Leptochloa fusca*) in rice when applied into the flood water. Magister is a Group F herbicide which adds a new mode of action for control of grass weeds in rice. Clomazone causes bleaching in susceptible plants and because of the possibility of drift from aerial application resulting in off-target effects the application methods on the first label were limited to ground or helicopter SCWIIRT and to dripping Magister into flood water as the bay was filled. This precluded the use of Magister in the major part of the rice market. The advent of the Bickley boom raised the possibility of using it to apply Magister by air.

MATERIALS AND METHODS

Development of the Bickley boom Flying tests of various boom and nozzle configurations fitted to an Air Tractor 502B were conducted at Jerilderie in 2000. The reference boom as used by Field Air for rice work was fitted with 24 CP solid stream nozzles (no deflection) at 40% wing span. This delivered a spray volume of 20 L ha^{-1}. Reducing the number of nozzles enabled a lower volume of 10 L ha^{-1} to be applied. The Bickley boom, (conceived and developed by Bickley Thomas, Field Air, Finley) consisted of two nozzles, one either side of the plane mounted on short droppers approximately 40 cm long just outside the first boom hanger. Altering the bore of the nozzle enabled spray volumes of 10 L ha^{-1} and 20 L ha^{-1} to be applied. The rearward facing nozzles were angled so that in flight they were parallel to the airstream. Water plus dye was the standard solution applied. Several tests also included Sanag 41-A drift retardant at 30 g 100 L^{-1}. Treatments were replicated 1–3 times.

Spray patterns and recovery were evaluated by SprayCheck P/L, Orange, NSW using the WRK DropletScan™ string and water sensitive paper collection method and software for analyses (WRK, Incorporated 5703 Saddlerock Road Manhattan, KS 66502). This system has been found to accurately and rapidly characterise spray outputs in the field (Wolf *et al.* 1999). The string system utilises the fluorescent dye, Rhodamine WT as a tracer. The collection media was a 1 mm diameter cotton string stretching across the flight line to a point 70 m up wind of the first pass. The aircraft was flown over the string in a back to back pattern three times moving into wind on each pass. Swath width was approximately 25 m. The DropletScan system utilises water sensitive cards to measure droplet size (VMD) and number, per cent coverage and application recovery rates. Horizontal down wind deposition data was collected at 25 m intervals 1 m above the ground using single water sensitive cards attached to poles and angled at 45° from vertical. Spray deposition was also collected on two vertical towers 10 m high at 50 m and 100 m downwind from the first pass using water sensitive paper at 1 m intervals. Weather data were recorded during each flight.

Field trials with Magister and the Bickley boom A total of four trials were conducted in the rice season of 2000/2001 under NRA permit in commercial rice bays in the Murray Valley and the MIA. The main objective was to test labelled rates of Magister plus Sanag® 41-A drift retardant, 60 g L^{-1} and of Ordram applied in spray volumes of 10 and 20 L ha^{-1} through the Bickley boom in comparison to ground SCWIIRT applications of Magister in a spray volume of up to 5 L ha^{-1} using 4WD ag bikes. There were two trials done to this protocol, one in the MIA near Griffith, the other in the eastern Murray Valley near Deniliquin. Some of these treatments were also repeated in two other trials in the same two locations. The other trials were all applied through the Bickley boom in a spray volume of 10 L ha^{-1} and tested the compatibility of Magister and Ordram with Taipan L ha^{-1}. Treatments consisted of single unreplicated bays of 2.3 to 5.7 ha in area. Rates of all herbicides were appropriate to the situation. Treatments were applied into permanent flood pre- or up to a month post-sowing, rice stages were up to 3-leaf and barnyard grass up to 3-leaf.

Figure 1. One side of a commercial Bickley boom mounted on an AT 502 showing single dropper, check valve and nozzle.

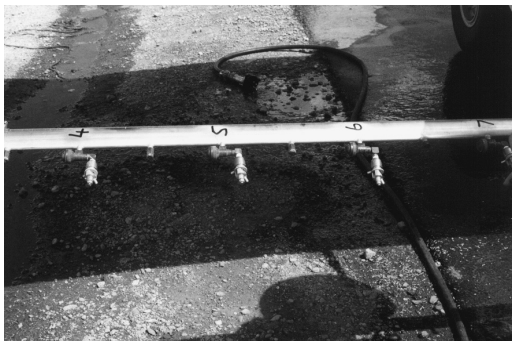

Figure 2. Section of one side of a standard aerial boom showing three CP solid stream nozzles.

Ag Tractor AT-502B planes fitted with prototype Bickley booms were used to apply the aerial treatments of Magister and Ordram in the four trials.

Aerial application was made as low as possible aiming for a wheel height of 2 m. Swath widths of

Table 1. Mean drift in L ha^{-1} measured at distances (m) downwind on water sensitive cards mounted 1 m above ground. Temperature mean 21°C (18–24°C), RH 50.4% (45–54 %), wind 7.1 km h^{-1} (2–12 km h^{-1}).

Boom	L ha^{-1}	0	25	50	75	100
CP	10	35.8	8.9	0.5	0.5	0.3
CP	20	37.5	16.2	4.1	1.6	0.6
Bb	10	3.3	2.3	0.6	0.2	0.1
Bb	20	11.1	2.6	0.7	0.4	0.2
Bb + 41-A	10	12.0	4.5	0.8	0.5	0.2
Bb + 41-A	20	3.3	3.8	0.5	0.2	0.1

CP = multi solid stream CP nozzle boom.
Bb = Bickley boom.

approximately 25 m were flown. In one trial in the MIA, only one side of the boom was operating so half swath widths were flown to compensate.

Water sensitive papers and potted roses as sensitive indicator plants were set up at 0, 25, 50, 75 and 100 m directly downwind of some of the bays treated with Magister to capture off-target drift. At all distances, water sensitive papers were mounted on holders at approximately 1 m above the nominal water height facing the wind. At 50 and 100 m, additional papers were set up at 2 m height. Potted roses were either placed on a bank or mounted on stakes above the water where an untreated bay was downwind of the bay being monitored. The roses were only put into position immediately before the bay was treated and removed soon after to a clomazone free environment to reduce the likelihood of vapours causing symptoms. The water sensitive papers were sent to Spray Check Pty Ltd for quantification of drift.

RESULTS

Performance of the Bickley boom The drift results obtained from the flying tests and expressed as L ha^{-1} are shown in Tables 1 and 2. The values reported at 0 m may be higher than the actual application rate due to horizontal movement of spray droplets from the multiple passes onto the target.

Field trials with Magister and the Bickley boom Refer to Tables 3 to 5.

DISCUSSION

Performance of the Bickley boom The drift data presented in Table 1 indicates that the Bickley boom operated at 10 L ha^{-1} and 20 L ha^{-1} reduced downwind drift measured at 100 m by 79% and 73% compared to the corresponding spray volumes delivered through the multi CP boom. The drift captured on the 10 m high

Table 2. Drift in L ha^{-1} measured at 50 m and 100 m downwind on water sensitive papers mounted 10 m above ground.

Boom	L ha^{-1}	50	100
CP	10	1.1	0.4
CP	20	3.2	1.0
Bickley boom	10	0.5	0.1
Bickley boom	20	1.0	0.2
Bickley + 41-A	10	0.8	0.2
Bickley + 41-A	20	0.9	0.3

CP = multi solid stream CP nozzle boom.

Table 3. Surviving barnyard grass (BYG) panicle counts in 2 trials (10 and 20 L ha^{-1}) and four trials (10 L ha^{-1}) in Murray Valley and MIA, 2001.

Treatment	Spray volume L ha^{-1}	BYG m^{-2} mean	BYG m^{-2} mean
Magister Bickley	10	9.5	5.1
Magister Bickley	20	7.5	
Ordram Bickley	10	13.5	7.3
Ordram Bickley	20	15.5	
Magister SCWIIRT	5	16.5	8.8

Mean of 50 × 0.25 m^2 quadrats per bay.

Table 4. Off-target drift captured on water sensitive cards in an aerial trial with a cross wind of 19 km h^{-1} in Murray Valley, 2001.

Treatment	Distance downwind m	L ha^{-1}	No. of drops	VMD µm
Magister applied	0	0.5	17	173
through Bickley	25	0	3	125
boom in a spray	50	0	0	0
volume of	75	0	0	0
10 L ha^{-1}	100	0	0	0

Table 5. Off-target drift captured on potted roses in an aerial trial in Murray Valley, 2001.

Treatment	Distance downwind m	% bleaching 9 DAT
Magister applied	0	24
through Bickley	25	25
boom in a spray	50	5
volume of	75	12
10 L ha^{-1}	100	10
Untreated	–	3

DAT = Days After Treatment.

towers in Table 2 showed almost identical reductions of 77% and 79% in favour of the Bickley boom at 10 L ha^{-1} and 20 L ha^{-1}. At 50 m the improvement was 56% and 69% respectively.

The inclusion of Sanag 41-A appeared to offer some further reduction in drift at the 20 L ha^{-1} spray volume but not at 10 L ha^{-1}. The rate chosen, 30 g L^{-1} was at the lower end of the label range which may not have increased viscosity of the spray solution sufficiently.

Additional parameters measured in the flying tests with the Bickley boom were dropper length, operating pressure, boom height and nozzle orientation. Increasing the dropper length longer than 30–40 cm did not offer further reductions in drift and compromised ground clearance. Spraying at higher rather than lower pressures appeared to reduce drift presumably due to reductions in shear impact of airflow and subsequent secondary shattering of droplets. Flying at 1–2 m markedly reduced drift compared to flying at 4 m heights. Ensuring the rearward facing nozzles were oriented parallel to the airstream when in flight offered the best reduction in drift.

The irregularity of the spray pattern from the Bickley boom was at first confronting. Deposit CV were in the order of 260% compared to 30–40% from the reference CP nozzle boom. The Bickley boom resulted in two discrete peaks approximately 8m apart under the aircraft with the output from each nozzle concentrated in bands 1–2 m width. However at a swath width of 25 m this would result in a maximum distance of 15 m between recurring treatment strips which was not considered to be a problem given the ability of herbicides like Magister, Ordram and other herbicides to redistribute in water.

Field trials with Magister and the Bickley boom

The surviving counts of barnyard grass in Table 3 were much higher than desirable because in the MIA trial poor water management late in the crop life allowed subsequent germinations to flourish. However the mean data show that Magister applied by air through the Bickley boom was the most efficacious with little difference when applied in either spray volume. The reason for the lower activity of the SCWIIRT treatment of Magister is unclear. Magister has demonstrated greater robustness on barnyard grass than Ordram which was reflected in these trials. An early inspection of bays treated with the Bickley boom revealed uniform weed control was achieved across bays indicating that both Magister and Ordram alone and tank mixed with Taipan redistributed throughout the bay following application through the Bickley boom.

Grass weed data from the trial testing the compatibility of Magister or Ordram plus Taipan when applied with the Bickley boom are not shown since there were no surviving grass weeds found in any treatment.

Rice safety was not affected when either Magister or Ordram were applied through the Bickley boom at either spray volume. Slight striping was evident in a bay treated with Magister plus Taipan but the bleaching soon disappeared and rice yields of over 11 t ha^{-1} were achieved with this treatment. The absence of bleaching of rice which can occur with Magister indicates that

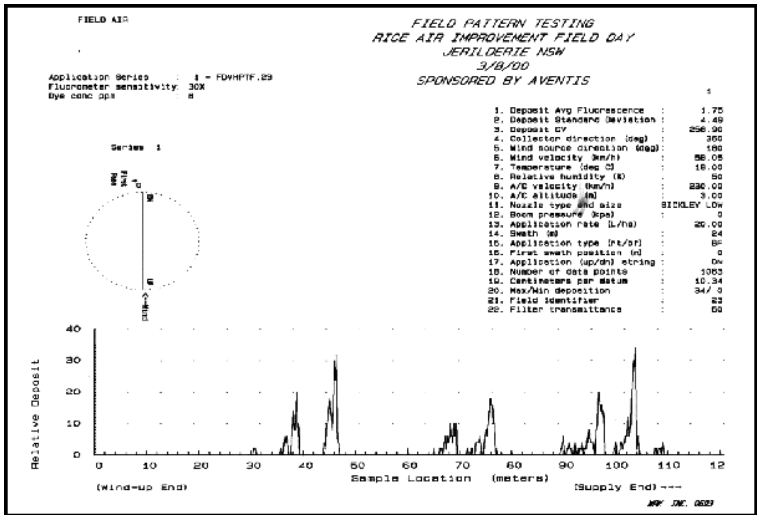

Figure 3. Actual spray distribution from three passes over the collection string of a plane fitted with a prototype Bickley boom flying 30 m swaths, Jerilderie, 2000. Analysed using WRK string methodology.

the concentrated bands resulting from Bickley boom application were no more likely to cause effects than a ground SCWIIRT application.

The drift data from the trial in Table 4 was generated with a cross wind of a very constant 19 km h^{-1} which is at the upper limit for good aerial application. The absence of droplets beyond 25 m indicates that the spray cloud from the Bickley boom descended rapidly which was evident to the naked eye. The water sensitive cards from the two trials in the MIA were contaminated in handling thus rendering them unreliable for analyses by the DropletScan method. The potted rose data in Table 5 tends to support the water sensitive card data since the plants showing marked bleaching were located at 0 m and 25 m. The lesser symptoms on plants at the further distances are believed to be an artefact due to the fact that when the pots were taken away for maintenance they were all placed in a common box for watering and either vapour or soil transfer of the very mobile clomazone contaminated them. The symptoms on the untreated pots tend to support this. In two other trials where potted roses were used, strict attention to isolation during the post treatment phase resulted in symptoms only on roses situated at 0 m in one trial and at 0 m and at 25 m in the other. In these trials wind speeds were 12.5 and 16 km h^{-1} respectively.

As a result of these trials, Magister was registered for aerial application in rice in a minimum volume of 10 L ha^{-1} with the proviso that it could only be applied through the Bickley boom to the specifications listed on the label and that Sanag 41-A drift retardant, 60 g L^{-1} must be added. This was one of the first aerial application routes for clomazone approved in the world by FMC Corporation.

In the 2001/2002 Australian rice season, it is estimated that a third to a half of the increased volume of Magister sold was applied with the Bickley boom. There were no reported cases of off-target drift, rice injury or efficacy complaints associated with aerial application by this method.

A permit was granted by the NRA with the support of chemical companies and the rice industry to allow use of the Bickley boom and a lower minimum application volume of 10 L ha^{-1} for application of the other herbicides and insecticides registered for application into the flood water for the 2001/2002 season. The Bickley boom was produced commercially by Field Air, Ballarat but other versions conforming to the specifications were also manufactured and used with success.

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