Research reports

A wedge shaped bluff plate air-assisted sprayer: III. High-speed, low volume herbicide spraying in dryland field cropping systems

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Summary
An air-assisted boom sprayer, consisting of a wedge shaped bluff plate placed in front of the nozzles, was used to apply herbicides in a spray volume of 20–30 L ha^{-1} at 30 km h^{-1} in field cropping situations. Low volume, fine, hollow cone and conventional flat fan nozzles were used in conjunction with the bluff plate. Results were compared to a conventional (non air-assisted) spray boom with flat fan nozzles. In several of the trials, a treatment was included using ultra-low-volume applications of herbicides, formulated in petroleum spraying oil and sprayed without water at 2–4 L ha^{-1} total spray volume using slotted rotary sleeve atomizers.

Thirteen herbicide efficacy trials were conducted in 1989 and 1990. Herbicides were applied to bare soil for pre-emergent weed control, to newly emerged weeds prior to sowing, to weeds early post emergence in the crop, and to pastures for seed set control (pasture topping) to control weeds in the crop for the following season. Herbicide efficacy in all situations was relatively consistent regardless of treatment (presence or absence of a bluff plate and nozzle type). Herbicides applied in petroleum oil at 2–4 L ha^{-1} without water gave similar or slightly reduced efficacy to conventional herbicide applications, and therefore warrant more detailed evaluation.

Earlier work with a simple bluff plate (Furness 1991), and work reported by Young (1996), established the ability of the bluff plate to virtually eliminate sideways spray drift even in windy conditions. Thus the main commercial advantages of the bluff plate sprayer are the ability to operate with consistent efficacy in a wide range of wind conditions, combined with a high work rate, (due to higher travel speeds and lower spray volumes). These features enable spray timing over large areas to be closer to the optimum for weed control.

Introduction
Problems with conventional, non air-assisted spray booms, the advantages of air-assisted spraying and the bluff plate concept were reviewed by Furness *et al.* (2001a). Studies on artificial targets using a wedge shaped bluff plate sprayer showed that it increased the amount of spray deposited on vertical targets compared to a conventional, non air-assisted spray boom, and overcame problems of poor impaction efficiency on short targets with a simple bluff plate sprayer (Furness *et al.* 2001a, Fulton and Furness 1988). Young (1996), also using artificial targets, compared spray deposition efficiency and uniformity, and drift, with a range of conventional and twin fluid nozzles on conventional spray booms, and with a range of covered and air assisted spray booms, including the wedge shaped bluff plate sprayer. He concluded that the wedge shaped bluff plate demonstrated the best overall performance under Australian field conditions of the sprayers tested. However, his opinion was that the current commercial bluff plate sprayers required some further refinements in design. It should be noted that his work was carried out after that reported in this series of papers, so built on the knowledge reported here.

Deposit studies with the wedge shaped bluff plate sprayer on lucerne plants similarly showed an increase in the amount of spray deposited (Furness *et al.* 2001b). However, the extra deposits occurred almost entirely in the upper canopy on the lower leaf surface, all other sites having similar deposit levels with both sprayers. Furness (1991) also showed that the conventional boom sprayer put most of the spray on upper leaf surfaces in calm conditions and that this decreased in windy conditions with a corresponding increase in deposits on the lower leaf surface. These differences in deposit patterns between a wedge shaped bluff plate sprayer and a conventional, non air-assisted spray boom may have implications for pesticide efficacy.

This paper reports and discusses results of herbicide efficacy trials with the wedge shaped bluff plate sprayer in a range of dryland cereal cropping systems using a range of pre and post emergent herbicides. The results are compared to those obtained with a conventional spray boom fitted with flat fan nozzles (non air-assisted). Preliminary trials using herbicides formulated in petroleum spraying oils and applied at ultra low volume (ULV), at 2-4 L ha^{-1}, using the slotted rotary sleeve atomizer behind the bluff plate, were also carried out. The development and advantages of a commercial wedge shaped bluff plate sprayer are also discussed.

Equipment and techniques
Details of the spray equipment used were described in detail by Furness *et al.* (2001a).

Herbicide trials
Thirteen herbicide trials (1–7 in 1989, 8–13 in 1990) were conducted to determine the effect of the bluff plate and nozzle type on weed kill in a wide range of typical dryland cereal cropping applications in southern Australia (Table 1.). The trials contained pre-emergent, early and mid post-emergent, and seed set control herbicides applied to a range of grassy and broad leafed weeds in a range of grassy and broad leafed crops. The treatments applied with each herbicide are listed in Table 2. Not all treatments were applied to all herbicide trials but all trials contained some bluff plate and some conventional hydraulic nozzle spray treatments. Full details of the herbicide trials, including sprayer treatments, herbicide, herbicide trade names, rates, crop, weed species, spraying dates, plot size and replication, location and conditions are given in Appendix 1.

Weed kill assessments
In treatments 1–7, actual counts of live weeds were made. Comparisons with the

Table 1. Herbicides evaluated with the bluff plate sprayer.

1. Chlorsulfuron for annual ryegrass control prior to seeding (wheat)[A]
2. Paraquat/diquat mixture for wild oat control before seeding (wheat,)[A]
3. Glyphosate for annual ryegrass control in newly emerged pasture (atypical situation)[A]
4. Fluazifop for the control of grass weeds in lupins[A]
5. Metasulfuron-methyl/MCPA mixture for the control of vetch in wheat[A]
6. Fluazifop for barley grass seed set control in clover pasture[A]
7. Metsulfuron-methyl for the control of broad leafed weeds in wheat
8. Paraquat/diquat mixture to desiccate a triticale crop (atypical situation)
9. Paraquat/diquat/MCPA mixture to control broad leafed weeds prior to sowing (wheat)
10. Bromacil for the control of broad leafed weeds in barley
11. Tralkoxydim for the control of wild oats in barley
12. Paraquat/diquat mixture for seed set control in annual ryegrass pasture[A]
13. Glyphosate for grass seed set control in pasture (pasture topping)

[A] Treatments for which results are presented.

Table 2. Treatments applied with each herbicide.

1. No bluff plate, flat fan nozzles (Albuz orange No 2)
   60 L ha^{-1} spray volume, spraying speed 15 km h^{-1}: (Fan60), (conventional)
2. No bluff plate, flat fan nozzles (Albuz orange No 2)
   30 L ha^{-1} spray volume, spraying speed 30 km h^{-1}: (Fan30)
3. Bluff plate with flat fan nozzles (Albuz orange No 2)
   30 L ha^{-1} spray volume, spraying speed 30 km h^{-1}: (Fan + BP)
4. Bluff plate with hollow cone nozzles (Spraying Systems TX 6)
   20 L ha^{-1} spray volume, spraying speed 30 km h^{-1}: (Cone + BP)
5. Bluff plate with slotted rotary sleeve atomizers (spinning vertically)
   20 L ha^{-1} spray volume, spraying speed 30 km h^{-1}: (SRSA + BP)

unsprayed control gave the proportion of weeds killed by the spray. The number of weeds present in the plots initially affected the number left after spraying and was a major source of variability. In treatments 8–13 a rating system was used for the amount of green (photosynthetic) tissue present. A rating of 0 was fully green (alive) and a rating of 7 had no green tissue present (dead). A rating of 7 was also regarded as dead. This system was rapid, permitting a larger number of trials to be carried out in a given time interval.

Results and discussion

A wide range of weed control strategies and herbicide types, typically used in dryland field cropping systems in southern Australia, were evaluated with the bluff plate sprayer.

Statistical analyses

Standard analyses of variance were applied to all trials. Results were variable with many coefficients of variation exceeding 25%. There were few significant effects and no strong or consistent pattern between sprayers. However, there were five significant rate × treatment interactions in the 22 tests. The cone + bluff plate (BP), especially with two passes in opposite directions, and to a lesser extent the SRSA + BP treatments had slightly steeper slopes, indicating greater effectiveness with increasing herbicide rate. Where repeated measurements per plot were carried out, the within plot variance was generally much lower than the between plot variance. More replicates would have given greater power in delivering clear outcomes but any differences would still undoubtedly have been small in magnitude.

Efficacy

All herbicides in all situations (with one exception, see below) whether pre-, early, mid or late post-emergent produced similar dose/response relationships regardless of the bluff plate or nozzle treatments and the crop or weed type, the effect being positively correlated to the herbicide dose per ha applied. Since all data showed similar trends, only seven examples are presented (Figures 1–7). Similar results were also obtained in trials conducted in 1988, which included the important pre-emergent herbicide trifluralin (Furness unpublished data). Hence, although deposit studies (Furness *et al.* 2001a and Furness *et al.* 2001b) indicated that the bluff plate treatments were applying more herbicide to the target, this did not result in increased efficacy. Herbicide efficacy can be affected by a number of other factors such as droplet size and impaction sites within the canopy (e.g. Moser *et al.* 1976, Wynen and Combellack 1989 and Moerkerk and Combellack 1989). Differences in these parameters could explain the lack of efficacy response to increased deposition in the bluff plate treatments. As noted above, five of the 22 trials indicated that the cone nozzle plus bluff plate and to a lesser extent slotted rotary sleeve atomizer (SRSA) plus bluff plate treatments had a tendency to produce slightly greater efficacy in some situations.

In several trials, a single herbicide rate was applied in some trials using the SRSA with the bluff plate at 2 L ha^{-1} spray volume, using oil as the sole herbicide carrier (i.e. no water involved). Results were more variable, with efficacy of a similar or slightly lower magnitude than the other treatments. The other (hydraulic) nozzles used could not apply such low volumes. These results indicate that oil based spraying using fine droplets with air assistance is worthy of further detailed study, as it could represent a major advance in spray application to field crops. Work on improving the uniformity of spray deposition and penetration into dense canopies would probably be required for reliable results.

In trial 3 (Figure 3), glyphosate was applied to newly emerged, dense pasture grasses (ryegrass) less than 2 cm tall heavily shaded by numerous large bare earth clods. In this situation, the standard non bluff plate treatments gave slightly superior efficacy to the bluff plate treatments. The differences were not significant but consistent, suggesting that with a larger sample size the differences would be significant. The possible difference was probably due to the unusual highly shaded situation of many of the weeds which were more exposed to a vertically falling droplet than one with a large sideways component to its trajectory as with the bluff plate. It is likely that the problem could be overcome by two passes in opposite directions, still applying the same dose per hectare. Two such passes would still be completed more quickly than with one standard non bluff plate treatment due to the higher travel speed and lower spray volume. Alternatively, it is likely that a higher volume nozzle with a greater mean droplet size at slower travel speeds would overcome the problem.

Advantages of bluff plate air assistance for commercial herbicide application

The drift reducing potential of bluff plate sprayers was established in earlier work with a simple bluff plate by Furness (1991) and with a wedge shaped bluff plate by Young (1996). Also, Geoff Esdaile, Manager, Livingston Farm, University of Sydney, Moree NSW, who started using a bluff plate sprayer in 1990, has claimed that the number of days or parts of days unsuited to spraying due to high winds was reduced from 20–30% to 5%). They have also observed that significant spray drift into susceptible crops has been eliminated. This has been particularly valuable for strip cropping with grassy and broad leafed crops in adjacent strips. These factors greatly increase the opportunity to

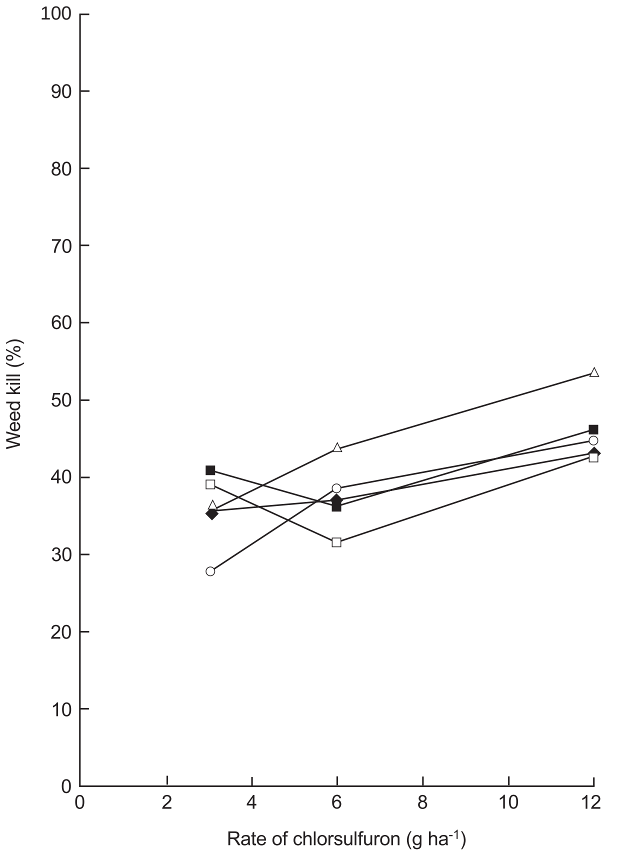

Figure 1. Comparison of a bluff plate and conventional boom sprayers: for pre-emergent grass weed control (ryegrass) in wheat (pre-sowing) with the herbicide chlorsulfuron. Fan 60 (◆); Fan 30 (■); Fan + BP (□); SRSABP (○); Cone + BP (△).

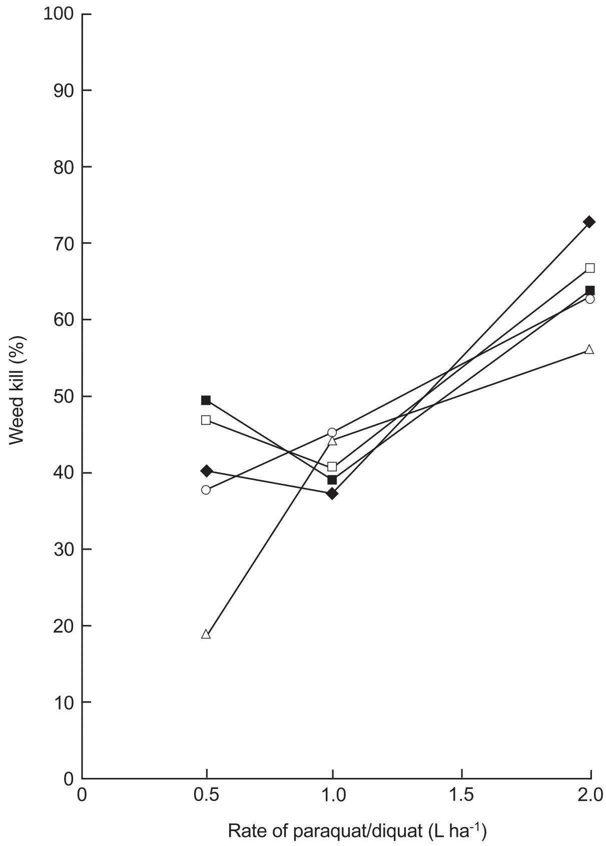

Figure 2. Comparison of a bluff plate and conventional boom sprayers: for total weed control before seeding wheat with the herbicide mixture paraquat/diquat (Sprayseed®). Treatment notation as for Figure 1.

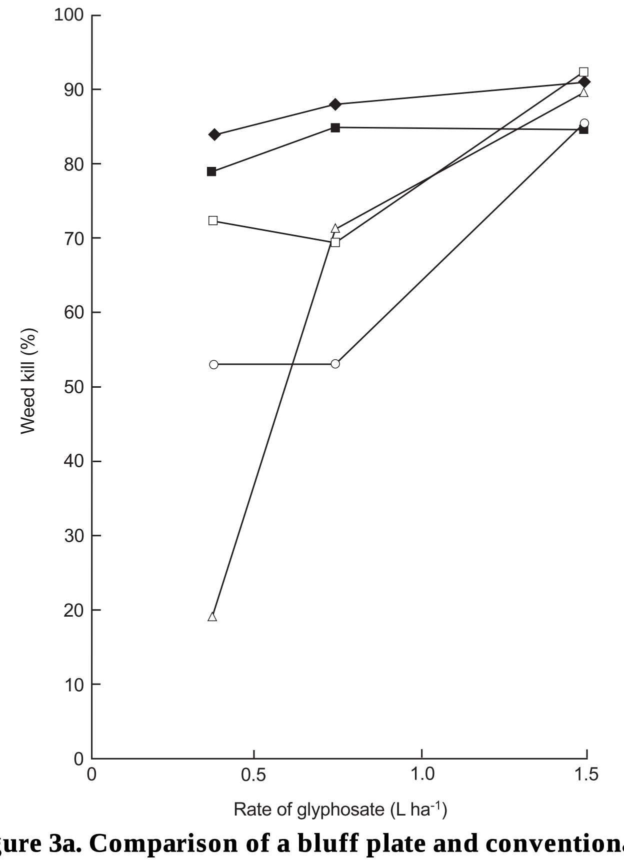

Figure 3a. Comparison of a bluff plate and conventional boom sprayers: with the herbicide glyphosate applied to newly emerged ryegrass pasture: first assessment. Treatment notation as for Figure 1.

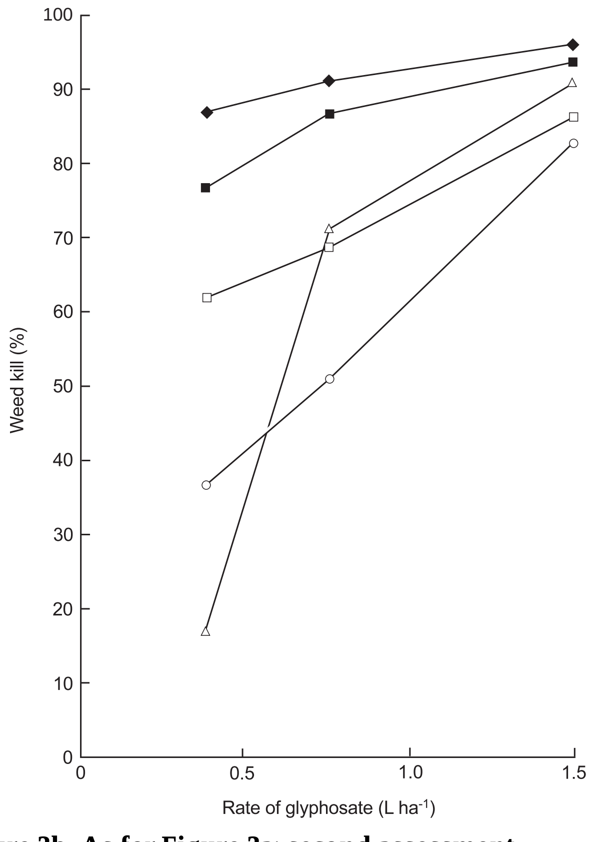

Figure 3b. As for Figure 3a: second assessment.

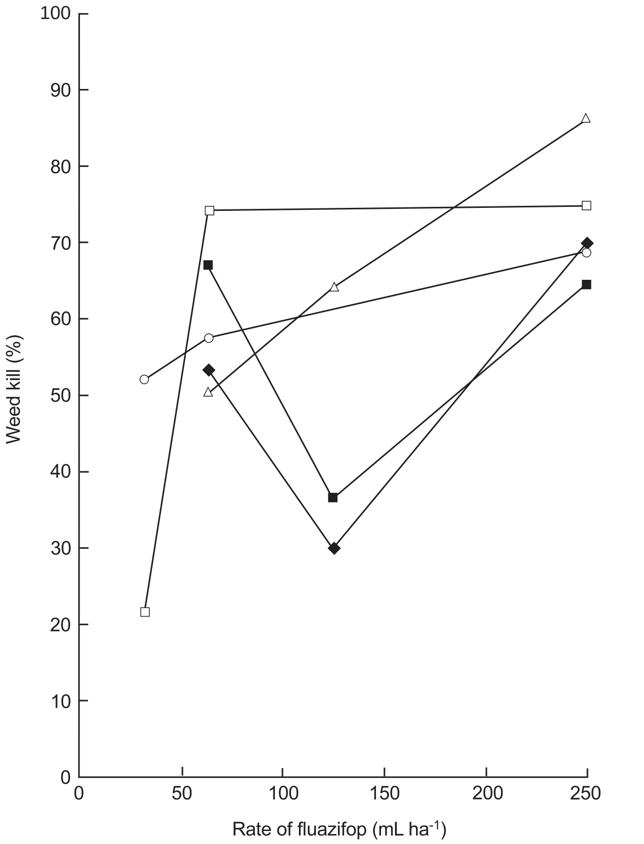

Figure 4. Comparison of a bluff plate and conventional boom sprayers: for the control of grassy weeds in lupins with the herbicide fluazifop. Treatment notation as for Figure 1.

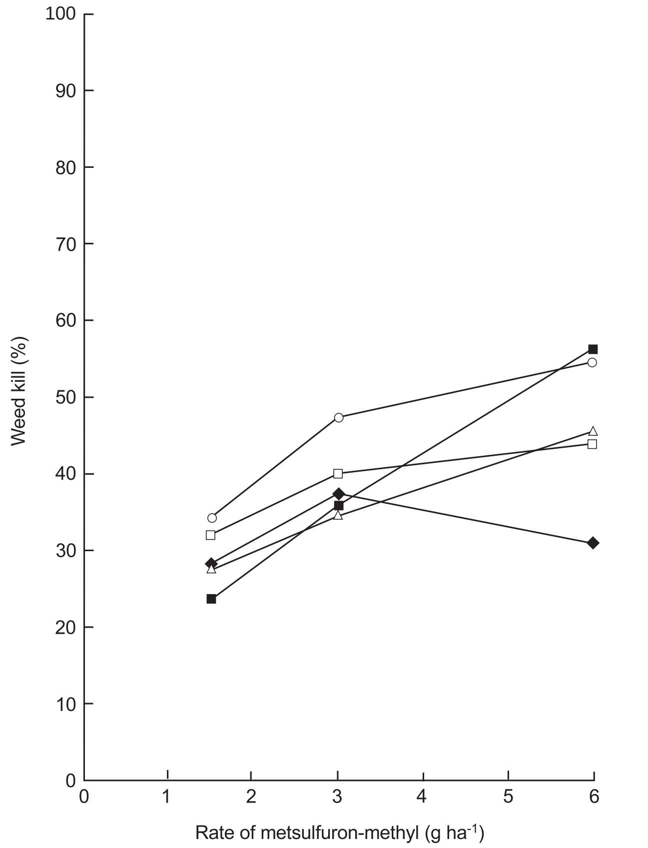

Figure 5. Comparison of a bluff plate and conventional boom sprayers: for vetch control in wheat post emergent with the herbicides metsulfuron-methyl and MCPA. Treatment notation as for Figure 1.

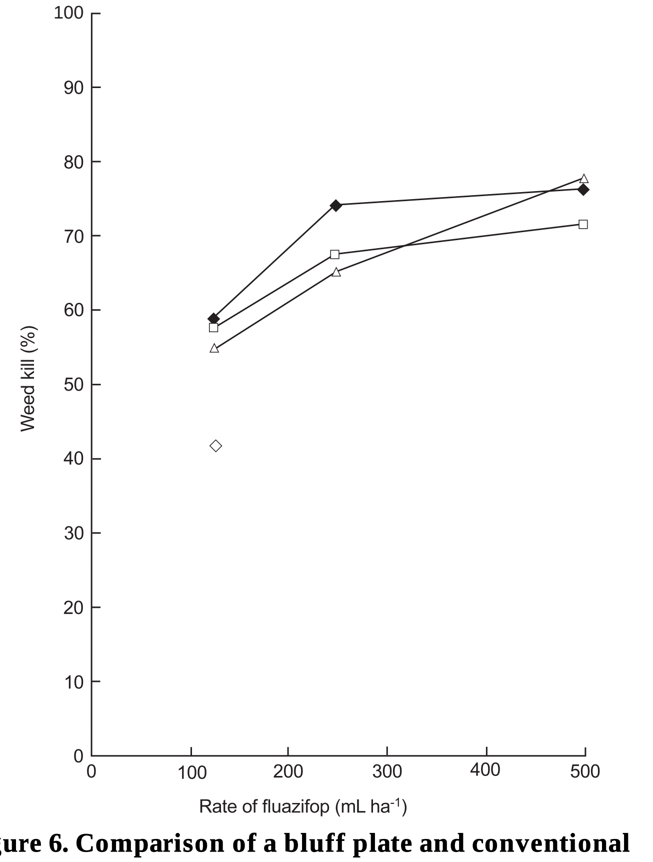

Figure 6. Comparison of a bluff plate and conventional boom sprayers: for barley grass seed set control in clover pasture with the herbicide fluazifop: visual rating. Fan 60 (◆); Fan + BP (☐); Cone + BP (△); SRSA+BP/Oil (◇).

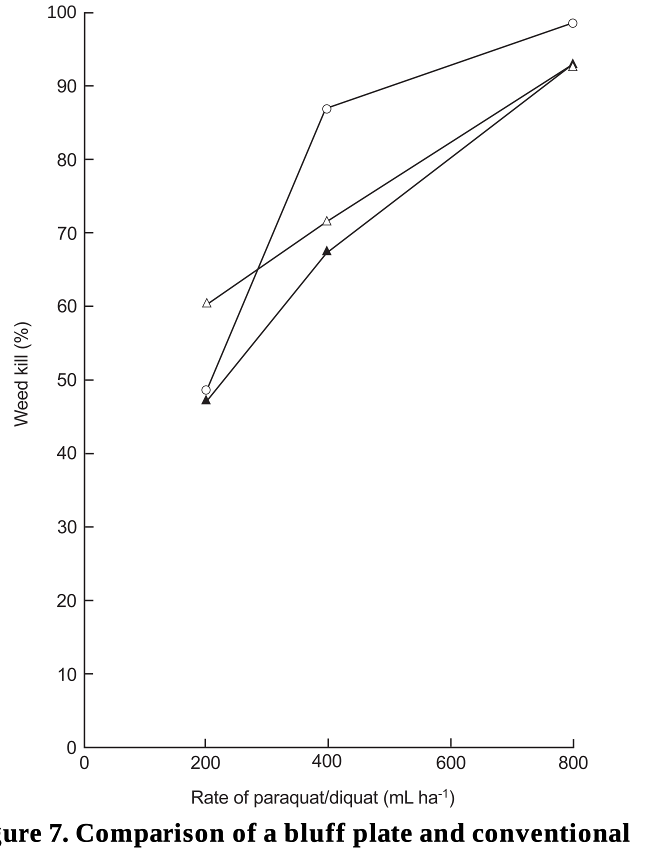

Figure 7. Comparison of a bluff plate and conventional boom sprayers: for controlling ryegrass seed set in pasture with the herbicide mixture paraquat/diquat (Sprayseed®). Fan 15 (▲); Cone + BP (△); SRSA+BP (○).

spray weeds closer to the optimum time, giving improved yields due to earlier removal of weed competition. Spraying weeds earlier may also reduce the amount of herbicide required, because lower rates are often used for controlling younger and smaller weeds. Earlier spraying generally increases the chance of spraying when weeds are actively growing and not suffering from water stress, which generally also increases the efficacy of many herbicides.

Again, at Livingston Farm the bluff plate sprayer has virtually eliminated herbicide failures , and the ability to spray in windy conditions (up to 20 km h^{-1}), combined with high travel speeds (20–30 km h^{-1}) and low spray volume (20–30 L ha^{-1}) has resulted in a 2–5 fold increase in work rate. Conventional spray booms (non air-assisted) in southern Australia typically apply 50–100 L ha^{-1} at operating speeds of 10–20 km h^{-1}. Other practical advantages of the bluff plate sprayer include less blockages with cone jets and the lower capital cost of the equipment when compared on the basis of work rate. A bluff plate, air assisted sprayer thus enables spraying in a wider range of wind conditions and enables equivalent weed control to be achieved with a higher work rate, that is by using lower spray volumes and higher travel speeds.

If the amount of turbulence in the air behind the bluff plate could be increased, better spray penetration and more even spray coverage (Furness and Pinczewski 1985) is likely. Further work is warranted to see if this improves efficacy. Efficacy studies with insecticides, fungicides and foliar applied nutrients could also be made.

Commercialization

The first commercial bluff plate boom sprayer was built for the University of Sydney, Livingston Farm, Moree, New South Wales. It was an 18 m unit (Figure 8) which sprayed in excess of 100 000 ha from 1990–93. A second 18 m unit was built in 1994 and had sprayed over 10 000 ha by the end of March 1995. A number of others were also operating from 1992–94 in several states. Joint work with Vogt Engineers, Tarlee South Australia, led to the commercial release of the bluff plate sprayer in late 1995 (Figure 8a,b,c).

Conclusions

The wedge shaped bluff plate reduces spray drift, and produces similar herbicide efficacy at higher speeds, lower spray volumes and with finer droplets than with a conventional (non air-assisted) spray boom. Consistent results are achieved in winds too strong for efficient operation of standard boom sprayers. These advantages mean that spray timing can be improved, especially on larger farms, such that weeds are sprayed closer to the optimum time while still newly emerged and actively growing. Earlier spraying gives improved efficacy with lower herbicide rates, and early removal of weed competition improves the yield and quality of the grain. Spraying costs (labour) are also reduced. While bluff plate sprayers of a given width are a little more expensive that a standard boomspray, they are cheaper when compared on the basis of work rate.

Ultra-low-volume application of herbicides formulated in petroleum spraying oil and applied without water using the bluff plate sprayer fitted with new atomizer technology is worthy of further study. Rates of 2 and 4 L ha^{-1} total spray volume cannot be readily achieved with conventional hydraulic nozzles but were readily achieved with the slotted rotary sleeve atomizer. Ideally, further work would also require input from formulation chemists to develop petroleum based formulations suited to application at these volumes.

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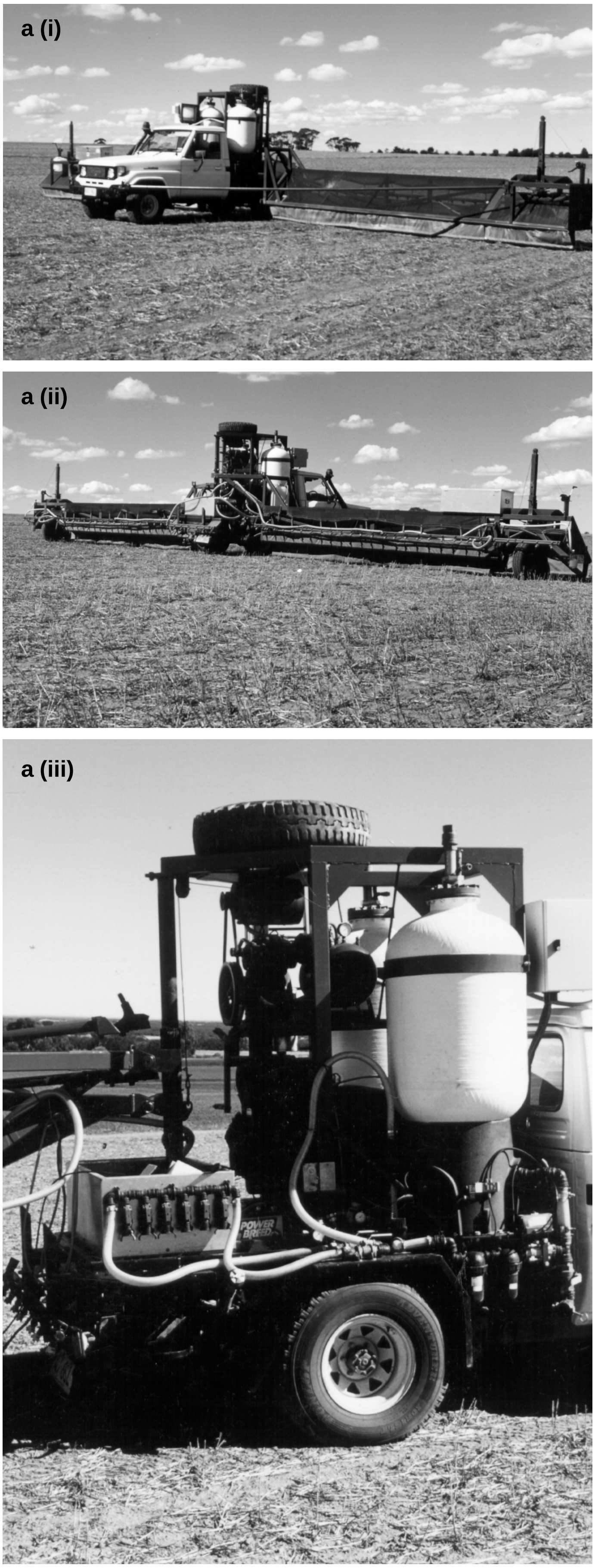

Figure 8a. Bluff plate sprayer – 12 m prototype commercial sprayer: (i) front view in spraying position, (ii) rear view in spraying position, (iii) side view of bluff plate hitch pole and liquid distribution system based on compressed air, mounted on the spray vehicle.

assisting with the construction of the experimental sprayers. Vogt Engineers have also worked with us to design, develop and market commercial bluff plate sprayers. Dr. T.J. Wicks and Dr. P.T. Bailey, SARDI, Plant Research Centre, Waite Precinct, Urrbrae, South Australia, reviewed the manuscript. Thanks are also extended to the farmers on whose properties the work was carried out and to several chemical companies who provided herbicides at no cost.

Figure 8b. Bluff plate sprayer – 18 m bluff plate sprayer at Livingston Farm, Moree, New South Wales – sprayer in operation at 25 km h^{-1}.

Figure 8c. Bluff plate sprayer – 25 m bluff plate sprayer: commercial model (i) folded position, (ii) towing and hitching layout.

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Appendix 1.

1. **Herbicide:** chlorsulfuron (Glean® (DuPont)) at 0, 3, 6 and 12 g ha^{-1}
Crop / weed: wheat (Machette), pre-seeding and pre-emergent / annual ryegrass (*Lolium rigidum* Gaudin)
Spraying date: 8 June 1986, Assessed: 14 August 1989, mid September 1989
Location/farmer: Loxton / A. May
Conditions: Fine, sunny, 15ºC, wind 8–15 km h^{-1} E
Replicates/plot number and plot size: 3 / 1, 8 × 25 m, Travel: N–S
Treatments: Table 2: all five

2. **Herbicide:** paraquat / diquat mixture (Sprayseed® (ICI)) at 0, 0.5, 1 and 2 L ha^{-1}
Crop/weed: wheat (*Triticum aestivum* L.), pre-seeding / wild oats (*Avena fatua* L.), onion weed (*Asphodelus fistulosis* L.), wild turnip (*Brassica tournefortii* Gouan), lucerne (*Medicago sativa*), *Salvia* sp. at or near flowering
Spraying date: 19 May 1989, Assessed: 30 May 1989
Location/farmer: Loxton / R. Reimann
Conditions: Overcast, fine, 25ºC, wind 2–4 km h^{-1} S
Replicates/plot number and plot size: 3 / 1, 8 × 25 m, Travel: E–W
Treatments: all five.

3. **Herbicide:** glyphosate (Roundup® (Monsanto)) at 0, 0.375, 0.75 and 1.5 L ha^{-1}
Crop/weed: Pasture, Mostly very small annual ryegrass less that 2 cm tall. Note: just germinated and shaded by numerous large bare soil clods up to 10 cm high – atypical.
Spraying date: 22 June 1989, Assessed: mid July 1989, 7 August 1989
Location/farmer: Bordertown / K Beare
Conditions: Partly overcast, fine, temp. db 13ºC, wb 9.5ºC, wind 5–10 km h^{-1} SW
Replicates/plot number and plot size: 3 / 1, 8 × 25 m, Treatments: N–S.
Treatments: all five

4. **Herbicide:** fluazifop (Fusilade® (ICI)) at 0, 62.5, 125, 250 mL ha^{-1}
Crop/weed: Lupins (Danja) (*Lupinus angustifolins* L.) / various grasses
Spraying date: 13 May 1989, Assessment date: 3 August 1989
Location/farmer: Kapunda / D. Shannon
Conditions: Overcast, fine, 15ºC, wind 0–5 km h^{-1} S–SE
Replicate/plot number and plot size: 3 / 1, 8 × 25 m
Treatments: all five

5. **Herbicide:** metsulfuron-methyl + MCPA mixture (Ally® (DuPont) + MCPA) at 0, 1.5, 3 and 6 g ha^{-1} Ally, and 600, 300 and 150 mL ha^{-1} MCPA
Crop/weed: wheat (growth Zadock scale: 14.5 / 22.0 to 15.2 / 23.5) / Vetch (Longuedok) (*Vicia sativa* L.) self sown (growth stage: 3 leaf / 1 branch to 8 leaf / 4.5 branches, 5–10 cm tall)
Spraying date: 14 July 1989, Assessed: mid August 1989
Location/farmer: Pinnaroo / N. Angel
Conditions: Fine, sunny, temp. db 14.5ºC, wb 12.5ºC, wind 7–10 km h^{-1} N
Replicate/plot number and plot size: 3 / 1, 8 × 25 m, Travel: E–W.
Treatments: all five

6. **Herbicide:** fluazifop (Fusilade (ICI)) at 0, 125, 250 and 500 mL ha^{-1}
Crop/weed: Clover pasture / Barley grass (*Hordeum leporinum* Link) flower heads (pasture topping) (Growth, Zadok scale: 1.7 / 2.1 to 1.4 / 2.4)
Spraying date: 5 September 1989, Assessed: 11 October 1989
Location/farmer: Primary Industries SA, Turretfield Research Centre
Conditions: Fine, sunny, temp 14ºC, wind 7–15 km h^{-1} N
Replicate/plot number and plot size: 4 / 1, 8 × 30 m
Treatments: Fan60, Fan + BP, Cone + BP, bluff plate and SRSA with mineral oil (C-23 NR (Furness *et al.* 1987)) only (no water) as the sole herbicide carrier, 2 L ha^{-1} spray volume, spraying speed 30 km h^{-1}: (SRSA + BP / O)

7. **Herbicide:** metsulfuron-methyl (Ally (DuPont)) at 0, 1.5, 3 and 6 g ha^{-1}
Crop/weed: wheat (growth Zadock scale: 17-24) / broad leafed weeds: wild turnip (*Brassica tournefortii* Gouan) (8 leaf, 20), Three cornered jack (*Emex australis* Steinh) (31, or mid sized), clover (61, or mid sized)
Spraying date: 11 August 1989, Assessed: late August 1989
Location/farmer: Wanbi / Primary Industries SA, Wanbi Agricultural Centre
Conditions: Fine, sunny, temp. db 16ºC, wb 13ºC, wind 5–10 km h^{-1} S–SE
Replicate/plot number and plot size: 4 / 1, 8 × 30 m, Travel: N–S
Treatments: Fan60, Fan + BP and Cone + BP

8. **Herbicide:** paraquat / diquat mixture (Sprayseed® (ICI)) at 0, 0.5, 1 and 2 L ha^{-1})
Crop/weed: Herbicide demonstration to desiccate both crop and weeds. Irrigated Triticale, boot stage (flowering) about 0.75 m tall with some broad leafed weeds, half grown as understory.
Spraying date: 22 June 1990, Assessed: 29 June 1990
Location/farmer: Loxton / R. Haby
Conditions: Fine, sunny, temp 14ºC, wind 2–5 km h^{-1} SW
Replicate / plot number and plot size: 5 / 2, 8 × 10 m, Travel: N–S
Treatments: Fan60 (65 L ha^{-1}, 15 km h^{-1}), Cone + BP (17.5 L ha^{-1}, 30 km h^{-1}), Cone + BP / 2 (as before but with 2 passes in opposite directions, 35 L ha^{-1}, 30 km h^{-1})

9. **Herbicide:** paraquat / diquat mixture + MCPA (Sprayseed (ICI) + MCPA (NuFarm)) at 0, 0.375, 0.75 and 1.5 L ha^{-1} (for both Sprayseed and MCPA)
Crop/weed: wheat before sowing / various broad leafed weeds about half grown
Spraying date: 19 June 1990, Assessed: late June, mid July 1990
Location/farmer: Keith / G. and I. Manser
Conditions: Overcast, fine, temp 13ºC
Replicate/plot number and plot size: 5 / 2, 8 × 10 m
Treatments: Fan60 (65 L ha^{-1}, 15 km h^{-1}), Cone + BP (26.5 L ha^{-1}, 20 km h^{-1}), Cone + BP / 2 (2 passes in opposite directions, 26.5 L ha^{-1}, 40 km h^{-1})

10. **Herbicide:** bromacil (Incitec) at 0, 0.35, 0.7 and 1.4 L ha^{-1}
Crop/weed: Barley (*Hordeum vulgare* L.) (tillering stage) / wild turnip, saffron thistle (*Carthamus lanatus* L.), iceplant (*Mesembryanthemum crystallinum* L.) (all at 4 leaf stage)
Spraying date: 9,10 July 1990, Assessed: 17 July, 4 August 1990
Location/farmer: Taplan (Noora basin), Fisher Bros.
Conditions: Fine, sunny, temp 14ºC, wind 2–5 km h^{-1} W
Replicate/plot number and plot size: 5 / 2, 8 × 10 m, Travel: N–S
Treatments: as for trial 9.

11. **Herbicide:** tralkoxydim (Grasp® (ICI)) at 0, 0.425, 0.85 and 1.7 L ha^{-1} with 150 mL ha^{-1} oil (C-23 NR) added to each treatment
Crop/weed: Barley (Galleon) / Wild oats (crop and weed both at tillering stage)
Spraying date: 31 July 1990, Assessed: 28 August, 27 September, 2 November 1990
Location/farmer: Sevenhill (Clare) / R. Jaeske
Conditions: Overcast, fine, temp 11ºC
Replicate/plot number and plot size: 2 / 5, 6 × 30 m, Travel: E–W
Treatments: Fan60 (50 L ha^{-1}, 15 km h^{-1}), Cone + BP (35 L ha^{-1}, 15 km h^{-1}), Cone + BP / 2 (2 passes in opposite directions, 70 L ha^{-1}, 15 km h^{-1}), SRSA + BP / O (bluff plate with SRSA and oil only as the sole pesticide carrier (no water), 2 L ha^{-1}, 30 km h^{-1})

12. **Herbicide:** paraquat / diquat mixture (Sprayseed (ICI)) at 0, 200, 400 and 800 mL ha^{-1}
Crop/weed: Annual ryegrass pasture, seed set control (pasture topping), ryegrass at early seed set
Spraying date: 26 October 1990, Assessed: 20 November 1990
Location/farmer: Spalding / E. Sommerville
Conditions: Fine, sunny, temp 36ºC, wind 7–10 km h^{-1} N
Replicate/plot number and plot size: 2 / 5, 6 × 30 m, Travel: E–W
Treatments: Fan60 (40 L ha^{-1}, 15 km h^{-1}), Cone + BP (16.7 L ha^{-1}, 30 km h^{-1}), SRSA + BP / O (2 L ha^{-1})

13. **Herbicide:** glyphosate (Roundup (Monsanto)) at 0, 200, 400 and 800 mL ha^{-1}
Crop/weed: Perennial ryegrass (*Lolium perenne* L.) pasture / Perennial ryegrass and silvergrass (*Vulpia* spp.) seed set control
(pasture topping). Pasture about 200 mm tall, flowering.
Spraying date: 30 October 1990, Assessed: 20 Nov 1990, Treatments: E–W
Location/farmer: Waitpinga (Parsons Beach) / R. Sedunary
Conditions: Overcast, fine, temp 30 $^{-1}$ C, wind 5–7 km h^{-1} N
Replicate/plot number and plot size: 2 / 5, 7 × 30 m, Travel: E–W
Treatments: Fan60 (40 L ha^{-1}, 15 km h^{-1}), Cone + BP (16.7 L ha^{-1}, 30 km h^{-1}), SRSA + BP (16.7 L ha^{-1}, 30 km h^{-1})

Wetting agents as and where recommended by the label were added to the tank mixes used.