# Low volume applications of herbicides sprayed on to soil, crop or pasture with a bluff plate sprayer

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## Summary

**A herbicide sprayer with a bluff plate has the potential to spray herbicides effectively in low volumes at high speeds because it incorporates air assistance to aid droplet deposition and the use of 80–100 μm droplets. Field experiments measuring weed control and grain yield were conducted in order to compare the spray volumes of 10 and 20 l ha$^{-1}$ using the bluff plate with the spray volumes of 40 and 80 l ha$^{-1}$ using the hydraulic boom.**

**The bluff plate sprayer produced similar reductions in the seed set of brome grass (*Bromus rubens* L.) as those produced by the hydraulic boom when glyphosate and paraquat were sprayed on to panicles about 10–15 cm in height. However, the bluff plate was less effective at weed control than a hydraulic boom sprayer when trifluralin and chlorsulfuron were sprayed on to soil and when MCPA, MCPA/bromoxynil/dicamba and diclofop-methyl were sprayed on to weeds less than 4 cm in height. Some factors that may improve droplet deposition on short targets are discussed which would then increase the scope for the bluff plate to be used in weed management on farms.**

## Introduction

The efficiency of herbicide spraying could be improved with a spraying system incorporating the principles of controlled droplet application (CDA) atomizers and air assistance compared with spraying systems using large droplets from hydraulic nozzles. The larger droplets of sprays are considered to be inefficient in achieving most biological objectives due to the improved capture efficiency of smaller droplets (Spillman 1983). In addition, Matthews (1978) stated that an advantage of CDA is that a higher proportion of the spray reaches the target owing to the narrow range of droplet sizes limiting the bounce of larger droplets and drift of smaller droplets. Another advantage of CDA atomizers is the possibility of reduced spray volumes since a given volume of spray as smaller droplets would cover a larger surface area than larger droplets, assuming that all the spray reaches the target (Banks *et al.* 1983). The improved efficiency of herbicides being sprayed by CDA in low spray volumes may allow a reduction in the rate of active ingredient (Bals and Agr 1978).

The use of air to increase the impaction efficiency of droplets less than 100 μm has been recommended by Parkin (1983) and Matthews (1979) since small droplets can drift away from the target. The benefits of air assistance include improved penetration and coverage of crop canopies as shown by Furness and Pinczewski (1985). They used rotary drum CDA atomizers with low velocity turbulent air to give improved coverage of horticultural crops with lower volumes of spray per area than conventional air blast sprayers. Hislop (1983) quotes work where the use of rotary disc atomizers using ultra low volumes of spray from a mist blower successfully controlled orchard pests.

An experimental sprayer has been developed that incorporates the principles of CDA, low spray volumes and air assistance. A rectangular metal plate (bluff plate) was placed in front of rotary drum CDA atomizers and pulled along in a vertical position; the droplets were entrained by air blast and turbulence in order to aid deposition and reduce drift (Furness 1984). In the work of Furness (1984), fluorescent dye emitted at a height of 50 cm on wheat plants was increased four times by 5.6 l ha$^{-1}$ of solution from a bluff plate sprayer using 80 to 100 μm droplets from Beecomist atomizers, compared to 109 l ha$^{-1}$ of solution from a hydraulic sprayer (same amount of dye applied per ha). Drift beyond the spray swath, as measured by fluorescent dye, was also negligible when spraying was done in winds of up to 18 km h$^{-1}$ using the bluff plate system of Furness. Rotary drum CDA atomizers were used in the trials of Furness because they have high maximum flow rates of liquid in large volumes of air and are robust and reliable (Furness and Pinczewski 1985, Furness 1986).

These results indicate that a bluff plate CDA sprayer could be used for herbicide applications in lower volumes than the volumes of 30 to 80 l ha$^{-1}$ in South Australia and 20 to 30 l ha$^{-1}$ in Western Australia currently used with hydraulic sprayers. On the basis of the fluorescent dye work, field trials were established to ascertain whether there was any significant difference in weed control and crop phytotoxicity when herbicides were sprayed with the bluff plate or hydraulic boom, using various rates of solution and herbicides.

## Materials and methods

The bluff plate sprayer used in these experiments was a prototype built by G. Furness (S.A. Department of Agriculture) with a plate 6.0 m long by 1.5 m wide which had four Beecomist rotary atomizers placed at the top of the plate and pointing in the opposite direction to the direction of travel (as described by Furness 1984). A hydraulic sprayer with flat fan nozzles (Spraying Systems stainless steel 8001) and a 4.6-m boom was chosen as the standard for comparison to the bluff plate sprayer.

Each of the experiments (I–VII) had four replications of one or three main plots as rates of herbicide, each with five split plots of 10 and 20 l ha$^{-1}$ of solution from the bluff plate, 40 and 80 l ha$^{-1}$ of solution from the hydraulic boom and an unsprayed control. The split plot size was 20 × 6 m with a 1.5-m buffer.

The spraying and site details of the seven field experiments were as follows:

(I) trifluralin as 0.2, 0.4 and 0.8 kg ha$^{-1}$ sprayed preplanting and incorporated for the control of annual ryegrass (*Lolium rigidum* Gaudin) in a crop of wheat (cv. Millewa) grown on soil type Dr 5.83 (Northcote 1974);

(II) chlorsulfuron as 5.6, 11 and 23 g ha$^{-1}$ sprayed preplanting for the control of annual ryegrass in a crop of wheat (cv. Bindawarra) grown on soil type Ug 5.2;

(III) MCPA as 0.3, 0.5 and 1.0 kg ha$^{-1}$ sprayed at the second tiller stage of wheat (cv. Millewa) grown on soil type Dr 5.83 for the control of the broadleaf weeds prickly lettuce *Lactuca serriola* L., Indian hedge mustard *Sisymbrium orientale* L., capeweed *Arctotheca calendula* L. Levyns and wild turnip *Brassica tournefortii* Gouan;

(IV) MCPA/bromoxynil/dicamba as 0.1/0.5/0.01, 0.2/0.1/0.03 and 0.4/0.2/0.06 kg ha$^{-1}$ sprayed at the three-leaf stage of wheat (cv. Warrigal) grown on a soil type Gc 1.2 for the control of wild turnip;

(V) diclofop-methyl as 0.2, 0.4 and 0.8 kg ha$^{-1}$ with the addition of X77 surfactant at 25 ml per 100 l of solution sprayed on to pasture for the control of annual ryegrass at the two-leaf stage;

(VI) glyphosate as 0.1, 0.2 and 0.4 g ha$^{-1}$ with the addition of X77 surfactant at 150 ml per 100 l of solution, if the dilution of glyphosate was greater than 1 in 100 l of solution (J. Hall pers. comm., Monsanto) sprayed at panicle emergence for the control of seed set of brome grass (pasture topping) on soil type Uc 5.11; and

(VII) paraquat as 0.2 kg ha$^{-1}$ sprayed at the same site and for the same purpose as for glyphosate except with 150 ml of X77 surfactant per 100 l of the solution (according to label recommendations).

Weeds were counted within 10 quadrats (each 900 cm$^2$) per split plot, as five quadrats on each side of the split plot in order to detect any effect of wind on herbicide efficacy. An area of 20 × 2 m was harvested from each split plot for the wheat yields.

## Results

The 10 and 20 l ha$^{-1}$ spray volumes from the bluff plate produced significantly less control of annual ryegrass than the 40 and 80 l ha$^{-1}$ spray volumes from the hydraulic boom with all herbicide rates of chlorsulfuron and diclofop-methyl and the 0.4 and 0.8 kg ha$^{-1}$ rates of trifluralin (Figure 1). In addition, the two spray volumes from the bluff plate produced significantly less control of the broadleaf weeds than the two spray volumes from the hydraulic boom with the herbicide rates of 0.3 and 0.5 kg ha$^{-1}$ of MCPA and all herbicide rates of MCPA/bromoxynil/dicamba (Figure 1).

The control of annual ryegrass was significantly lower with some rates of trifluralin and diclofop-methyl sprayed in the volume of 10 l ha$^{-1}$ compared to 20 l ha$^{-1}$ (Figure 1). Only with trifluralin was the weed density in the unsprayed plots not significantly different from the weed density in plots sprayed with the volume of 10 l ha$^{-1}$.

Wheat yields were significantly lower from plots sprayed with trifluralin, chlorsulfuron and MCPA/bromoxynil/dicamba by the bluff plate compared to those sprayed by the hydraulic boom (Table 1), which is the same trend as that found in the weed control. In the trifluralin experiment only, the wheat yields after the spray volumes of 10 and 20 l ha$^{-1}$ from the bluff plate were not significantly different from the yields of unsprayed wheat. Wheat yield was not increased by spraying any rate of MCPA by either sprayer due to the low density of weeds.

In the paraquat experiment, the highest reduction in the seed set of brome grass was achieved with the 20 l ha$^{-1}$ spray volume from the bluff plate as well as the 40 and 80 l ha$^{-1}$ from the hydraulic boom (Table 2). The spray volume of 10 l ha$^{-1}$ resulted in significantly less weed control with paraquat as also occurred with trifluralin and diclofop-methyl.

When the response to glyphosate was averaged over the three herbicide rates, the reduction in seed set of brome grass was not significantly different among the spray volumes from either the bluff plate or the hydraulic boom (Table 2). With the 0.1 kg ha$^{-1}$ rate of glyphosate, however, the spray volumes of 10, 20 and 40 l ha$^{-1}$ produced greater than 90% efficacy, while 80 l ha$^{-1}$ produced an efficacy significantly less than 10 and 20 l ha$^{-1}$ of spray volume (Table 2).

During the spraying of MCPA/bromoxynil/dicamba and diclofop-methyl by the bluff plate the wind was at 70–90 degrees from the direction of travel, and the weed kill was significantly greater on the upwind side of the swath in 67% and 13% of the plots respectively. The wind speed was consistent at 7 km h$^{-1}$ when the MCPA bromoxynil/dicamba was being applied but was gusting from 4 to 13 km h$^{-1}$ when the diclofop-methyl was being sprayed. In the other experiments the wind direction was either 0 or 23 degrees from the direction of travel of the bluff

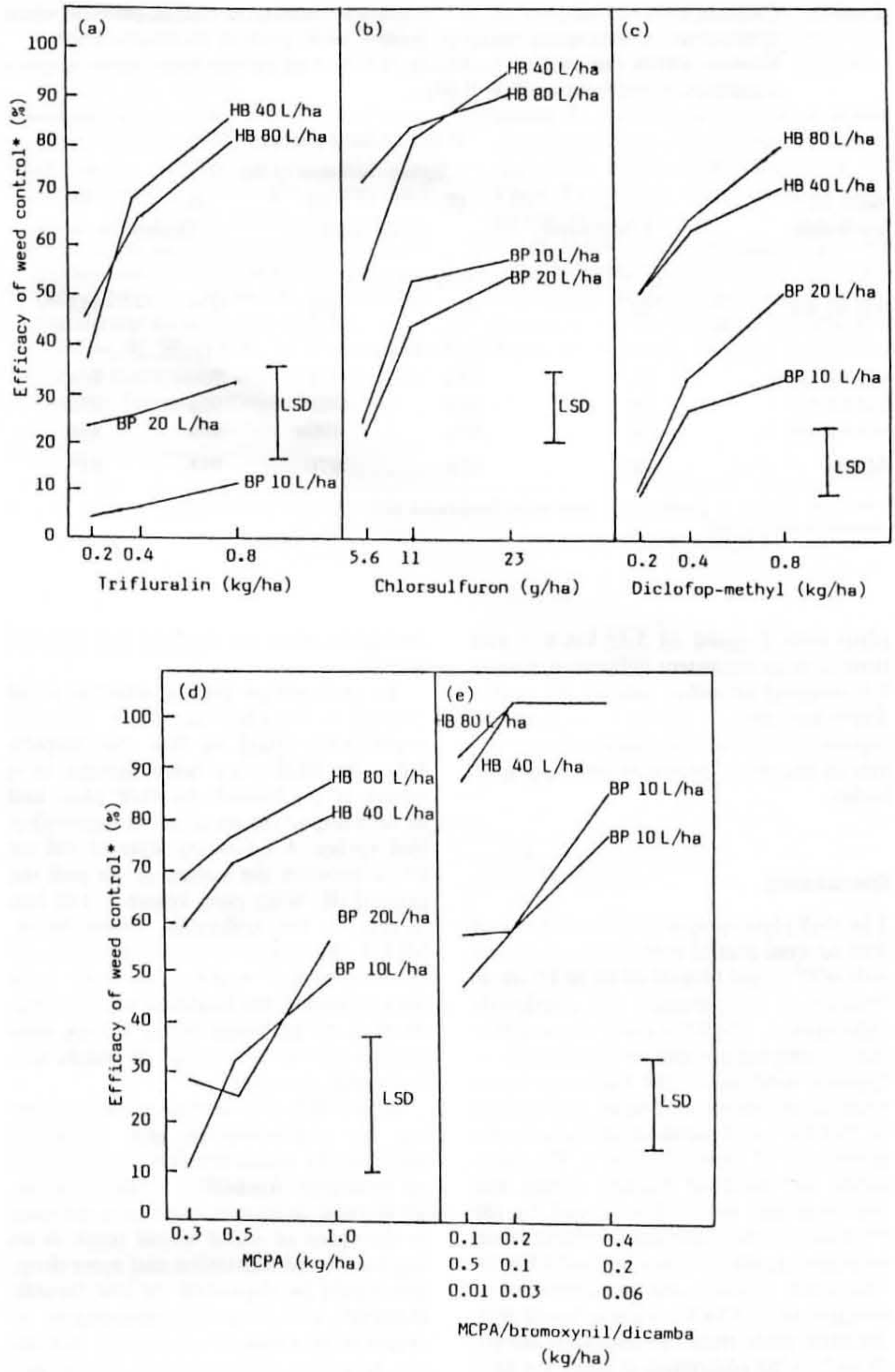


**Figure 1** The weed control produced by rates of (a) trifluralin, (b) chlorsulfuron, (c) diclofop-methyl, (d) MCPA and (e) MCPA/bromoxynil/dicamba sprayed in volumes of solution from a bluff plate (BP) or hydraulic boom (HB). (The LSD's are at $P$ = 0.05.)

*Efficacy (%) = [Weed density (unsprayed plot — sprayed plot)/weed density unsprayed plot]*100

**Table 1** Wheat yields (t ha$^{-1}$) when four herbicides (mean of three rates) were sprayed at various spray volumes by the bluff plate or hydraulic boom (Means followed by the same letter are not significantly different at $P$ = 0.05)

| | | Spray volumes (l ha$^{-1}$) | | | |
|---|---|---|---|---|---|
| | | 10 | 20 | 40 | 80 |
| **Herbicide** | **Unsprayed** | **Bluff plate** | | **Hydraulic boom** | |
| Trifluralin | 0.64a,b | 0.59a | 0.73b | 0.86c | 0.91c |
| Chlorsulfuron | 1.09a | 1.94b | 1.97b | 2.28c | 2.50c |
| MCPA | 1.00b | 0.85a,b | 0.80b | 0.83b | 0.87a,b |
| MCPA/bromoxynil/ dicamba | 0.27a | 0.42b | 0.42b | 0.53c | 0.53c |

**Table 2** Reduction in the seed set of brome grass by paraquat and glyphosate when sprayed at various spray volumes from a bluff plate or hydraulic boom (Values within one rate of herbicide, if followed by the same letter, are not significantly different at $P = 0.05$)

| Rate of herbicide | Unsprayed | Weed control efficacy (%)[A] Spray volumes ($l\ ha^{-1}$) 10 | 20 | 40 | 80 |
|---|---|---|---|---|---|
| | | Bluff plate | | Hydraulic boom | |
| | | *Paraquat* | | | |
| 0.2 kg $ha^{-1}$ | 0a | 85b | 94c | 92c | 93c |
| | | *Glyphosate* | | | |
| 0.1 kg $ha^{-1}$ | 0a | 95b | 93b | 90ab | 86a |
| 0.2 kg $ha^{-1}$ | 0a | 96a | 98a | 95a | 97a |
| 0.4 kg $ha^{-1}$ | 0a | 99a | 100a | 99a | 99a |
| Mean | 0a | 97b | 97b | 95b | 94b |

[A] Per cent efficacy = [incidence of filled grain (unsprayed plot − sprayed plot)/incidence of filled grain in unsprayed plot] × 100.

plate with a speed of 5-15 km $h^{-1}$ and there were no consistent differences in weed kill detected on either side of the swath. There was also no difference in the weed control between the upwind and downwind side of any plots sprayed by the hydraulic boom.

## Discussion

The bluff plate sprayer produced the same level of weed control as the hydraulic boom only with target heights of 10 to 15 cm as occurred in the paraquat and glyphosate experiments. The bluff plate was as effective in reducing the seed set of brome grass (pasture topping) as the hydraulic boom when glyphosate was sprayed in a volume of 10 l $ha^{-1}$ and paraquat and glyphosate in volumes of 10 and 20 l $ha^{-1}$. The fluorescent dye work of Furness (1984) had indicated that herbicides applied by the bluff plate to the upper part of plants would be at least as effective as a hydraulic boom. This work, however, did not show that the effective rate of herbicide was lower with the bluff plate than the hydraulic boom. Therefore the advantages of using the bluff plate for pasture topping would involve reduced water cartage and labour requirements.

Davies and Taylor (1980) found that the activity of glyphosate and paraquat was increased with lower spray volumes presumably due to the higher concentration of surfactant. Therefore the concentration of surfactant may have been a contributing factor to the high level of weed control when the bluff plate sprayed glyphosate and paraquat in low spray volumes.

Inferior weed control to that of the hydraulic boom sprayer occurred with all targets that were less than 4 cm in height, e.g. prostrate weeds and low grass found in the trifluralin, chlorsulfuron, MCPA, MCPA/bromoxynil/dicamba and diclofop-methyl experiments. This could indicate that weed control from the bluff plate was dependent on the height of the target, although a constraint to this argument is that the same herbicides were not used on low and tall targets.

An explanation for the effective weed control in the glyphosate and paraquat experiments could be that the droplets from the bluff plate were moving in a vortex of air behind the bluff plate and as such impacting on to tall targets within that vortex. A boundary layer of still air exists between the vortex of air and the ground (B. Wills pers. comm.). The low targets in the trifluralin, clorsulfuron, MCPA, MCPA/bromoxynil/dicamba and diclofop-methyl experiments may have been located in this boundary layer, so that droplets of herbicide in the vortex were passing above the ground or weeds in a horizontal direction.

Wills (1985) discussed an equation relating the sedimentation and impaction processes by which droplets are deposited on to targets. According to the equation, an increase in droplet mass or a decrease in the speed of travel would result in an increase in sedimentation and more droplets would be deposited on low targets. However, with air-assisted spraying an increase in the speed of travel could increase the impaction of droplets on low targets. Therefore altering the droplet and speed parameters of the bluff plate, in addition to relocating the atomizers, may produce effective weed control with low targets.

May and Ayres (1978) showed that herbicides sprayed on to soils with CDA atomizers and low volumes of solution can be effective provided the droplets reach the ground. In their work, the herbicides linuron, chlorpropham and simazine produced the same weed control when sprayed on to soil with the 20 l $ha^{-1}$ of spray volume (CDA 250 $\mu$m droplets) as with 80–640 l $ha^{-1}$ of spray volume (hydraulic nozzles droplets up to 500 $\mu$m). These results were attributed to an increased coverage of the soil by small droplets.

There were instances where the weed kill from the spray volume of 10 l $ha^{-1}$ was inferior to that from 20 l $ha^{-1}$, such as in the trifluralin, diclofop-methyl and paraquat experiments. The reason for the inferior results may have been poor coverage of the target by the herbicide, evaporation or drift.

The significant increase in spray deposited on the upwind side within the swath, when the wind was at 70 or 90 degrees from the direction of travel, was probably caused by horizontal turbulence inside the swath of the bluff plate (B. Wills pers. comm.). Therefore the use of the bluff plate for pasture topping would have to be restricted to travel in the direction or 180 degrees to the direction of the wind.

## Conclusions

The commercial use of the bluff plate spraying system with 80–100 $\mu$m droplets is limited to pasture topping with a 20 l $ha^{-1}$ spray volume of glyphosate or paraquat, but a 10 l $ha^{-1}$ spray volume only with glyphosate. The limitations to commercial use are due to: (i) lack of weed control with targets less than 4 cm in height; and (ii) uneven weed control within a swath with winds at 70 to 90 degrees from the direction of travel. An increase in the size of the droplet, a change in the travel speed of the bluff plate, or a relocation of the atomizers may give a greater vertical component to the droplet trajectory such that more herbicide would be deposited on to short targets below the boundary layer. If this can be shown to occur, the uses for the bluff plate sprayer may be extended to include types of herbicide spraying other than pasture topping.

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