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Comparison of controlled droplet and conventional application of postemergence herbicides

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Summary

Eleven field experiments were conducted at Kingaroy in south-eastern Queensland to compare the effectiveness of controlled droplet application (CDA) with a conventional hydraulic application system. The postemergence herbicides evaluated for broadleaf weed control in summer leguminous and cereal crops were acifluorfen, atrazine, bentazone, dicamba and dinoseb.

Herbicides applied by CDA with rotary nozzles in 40 L/ha gave weed control equivalent to that achieved by conventional application with hydraulic flat fan nozzles in 200 L/ha. However, in certain situations herbicide efficacy was marginally reduced when applied by CDA in spray volume of 20 L/ha to the more herbicide resistant weeds. Effect of reducing the herbicide rate from 100% to 50% was similar for the different application techniques.

INTRODUCTION

Controlled droplet application (CDA) of pesticides was defined by Linke (1978) as the application of low spray volumes having a defined and restricted droplet size range required to give acceptable biological results. Droplet size can be controlled, within fairly narrow limits, by using centrifugal-energy nozzles and droplet size can be adjusted by varying their rotational speed and flow rate (Matthews 1979).

With CDA it should be possible to choose a droplet size which gives the most efficient collection on the intended target (Bals 1978), and to minimize spray volume (Matthews 1977). Reduction in spray volume permits more rapid spraying and thus a greater opportunity to spray in periods of more favourable meteorological conditions (Matthews 1977). As well, with the reduction in spray volume good quality water, often unavailable in large quantities, can be used which has been shown to improve pesticide efficacy (Buhler and Burnside 1983). Bals (1978) also suggested that more efficient pest control may be achieved by CDA thus permitting reduced amounts of pesticide used.

Since commencement of this research, some similar research has been conducted overseas comparing controlled droplet and conventional application of herbicides in crops, as well as determining the optimum droplet size and spray volume for CDA. Phillips *et al.* (1980) and Bailey *et al.* (1982) found that better weed control was achieved with CDA by using a water volume of 40 L/ha rather than 20 L/ha. As well Phillips *et al.* (1980) found that weed control with CDA can be improved by using a droplet size around 170µm as opposed to 250µm, whereas Bailey *et al.* (1982) concluded that weed control was not affected by changing droplet size from 125 to 250µm. Scoresby and Nalewaja (1981) applied acifluorfen, bentazone and dinoseb plus naptalam by flat fan nozzles (80 L/ha) and by CDA with 240µm droplets (45 L/ha) and 75µm droplets (9 L/ha), all of which gave similar weed control regardless of application method.

Eleven field experiments were conducted to compare the effectiveness of rotary and hydraulic nozzles when applying postemergence herbicides onto broadleaf weeds in summer leguminous and cereal crops under local conditions. The effect of varying spray volume and rotational speed on the efficacy of herbicides applied by rotary nozzles was also measured.

MATERIALS AND METHODS

Experiments were conducted at four sites in 1980–81 and at seven sites in 1981–82 near Kingaroy in south-eastern Queensland. The spray application treatments applied to Sites 1 to 4 are given in Table 1, for Sites 5 to 7 in Table 2, and for Sites 8 to 11 in Table 3.

Table 1. Effect of nozzle type, spray volume and herbicide rate on weed densities at Sites 1 to 4, together with herbicide used, weed species and weed growth stage for each site

Spray application treatment			Weed density (number/m²)				
			Site 1 bentazone		Site 2 bentazone	Site 3 dinoseb	Site 4 aciflourfen
Nozzle type	Spray volume (L/ha)	Herbicide rate (%)	*D. ferox*† (2 leaf)	*A. cristata* (2 leaf)	*C. benghalensis* (4 leaf)	*C. benghalensis* (2 leaf)	*D. ferax* (6 leaf)
Untreated		0	112	139 (11.8)‡	38 (6.2)	26 (5.2)	43 (6.6)
Hydraulic nozzle . .	200	100	0	4 (2.2)	1 (1.1)	1 (1.0)	0 (0.9)
Rotary nozzle§	40	100	0	11 (3.4)	0 (1.0)	2 (1.5)	2 (1.4)
Rotary nozzle	20	100	0	3 (1.8)	1 (1.1)	6 (2.6)	0 (0.9)
Hydraulic nozzle . .	200	75	0	10 (3.2)	0 (0.8)	3 (1.8)	1 (1.0)
Rotary nozzle	40	75	0	7 (2.7)	0 (0.8)	5 (2.4)	2 (1.5)
Rotary nozzle	20	75	0	6 (2.5)	0 (0.9)	2 (1.7)	0 (0.9)
Hydraulic nozzle . .	200	50	0	21 (4.6)	0 (0.9)	5 (2.4)	2 (1.5)
Rotary nozzle	40	50	0	32 (5.7)	1 (1.4)	8 (2.9)	5 (2.4)
Rotary nozzle	20	50	1	58 (7.6)	0 (0.9)	10 (3.2)	4 (2.2)
l.s.d. P=0.05				(2.6)	(1.2)	(1.4)	(1.4)
Source of variation:	nozzle type/spray volume			n.s.	n.s.	n.s.	n.s.
(for analysis without untreated data)	herbicide rate			*	n.s.	*	*
Nozzle/volume treatment × herbicide rate				n.s.	n.s.	n.s.	n.s.

* significant difference at P=0.05 level.

† data not analysed.

‡ square root (x+0.5) transformation.

§ speed was 2000 rpm for all treatments with rotary nozzles.

n.s. not significant.

Herbicides were applied through either a conventional boom sprayer with hydraulic nozzles (flat fan, 80%, Allman No.00) at 35 cm spacing and 40 cm above the target, or a boom with two rotary nozzles (Micromax, Micron Sprayers Limited) at 1.8 m spacing and top of nozzle at 60 cm above the target. The hydraulic nozzles applied a spray volume of 200 L/ha at 210 kPa pressure and operating speed was 1.5 m/s. The rotary atomisers were fitted with two speed pulley which operated at 2000 and 3000 rpm. Spray volume was either 20 L/ha with a flow rate of 250 mL/min or 40 L/ha with a flow rate of 500 mL/min, and operating speed was 1 m/s. Frost and Green (1978) measured the droplet size spectra from a Micromax rotary nozzle and found that the volume median diameter of the spray produced from a flow rate of 500 mL/min was 230μm at 2000 rpm and 190μm at 3000 rpm.

The full dose of the herbicides tested, in grams of active ingredient per hectare, were: acifluorfen 450, atrazine 2250, bentazone 980, dicamba 280, and dinoseb 1100.

Experiments were located either in peanuts (Sites 2, 3 and 8), soybeans (Sites 10 and 11), navy beans (Site 9), or in fallow situations (Sites 1, 4, 5, 6 and 7). All crops were

Table 2. Effect of nozzle type, rotary nozzle speed and herbicide rate on weed densities at Sites 5 to 7, together with herbicide used, weed species and weed growth stage for each site

Spray application treatment			Weed density (number/m²)				
Nozzle type	Rotary nozzle speed (rpm)	Herbicide rate (%)	Site 5 bentazone		Site 6 atrazine		Site 7 dicamba
			D. ferox† (2 leaf)	*A. cristata* (2 leaf)	*D. ferox* (4 leaf)	*A. cristata* (3 leaf)	*D. ferox* (4 leaf)
Untreated		0	20	73 (8.6)‡	70	47 (6.9)	99 (10.0)
Hydraulic nozzle§ . .		100	0	13 (3.6)	0	1 (1.1)	13 (3.7)
Rotary nozzle	2000	100	0	30 (5.5)	0	1 (1.4)	14 (3.8)
Rotary nozzle	3000	100	0	35 (5.9)	0	1 (1.1)	11 (3.3)
Hydraulic nozzle . .		75	0	22 (4.7)	0	2 (1.6)	44 (6.6)
Rotary nozzle	2000	75	1	20 (4.5)	0	2 (1.6)	23 (4.8)
Rotary nozzle	3000	75	0	28 (5.4)	0	5 (2.5)	29 (5.5)
Hydraulic nozzle . .		50	0	31 (5.6)	0	12 (3.5)	67 (8.2)
Rotary nozzle	2000	50	1	38 (6.2)	0	8 (2.9)	55 (7.4)
Rotary nozzle	3000	50	0	64 (8.0)	1	12 (3.5)	56 (7.5)
l.s.d. P=0.05				(2.1)		(2.1)	(2.7)
Source of variation:	nozzle type/rotary nozzle speed			*		n.s.	n.s.
(for analysis without untreated data)	herbicide rate			*		*	*
Nozzle type/nozzle speed treatment × herbicide rate				*		n.s.	n.s.

* significant difference at P=0.05 level.

† data not analysed.

‡ square root (x+0.5) transformation.

§ spray volume of treatments with hydraulic nozzle was 200 L/ha and rotary nozzle was 20 L/ha.

n.s. not significant.

Table 3. Effect of nozzle type, rotary nozzle speed and spray volume on weed densities at Sites 8 to 11, together with herbicide used, weed species and weed growth stage for each site

Spray application treatment			Weed density (number/m²)					
Nozzle type	Rotary nozzle speed (rpm)	Spray volume (L/ha)	Site 8 dinoseb		Site 9 bentazone		Site 10 bentazone	Site 11 acifluorfen
			I. plebeia (2 leaf)	*C. benghalensis* (2 leaf)	*A. cristata* (3 leaf)	*I. plebeia* (3 leaf)	*X. pungens* (6 leaf)	*X. pungens* (6 leaf)
Untreated			9 (3.0)†	16 (4.0)	1 (1.2)	2 (1.5)	14 (3.8)	10 (3.3)
Hydraulic nozzle‡ . .		200	3 (1.9)	1 (1.1)	0 (0.8)	0 (0.8)	6 (2.5)	6 (2.6)
Rotary nozzle	2000	40	3 (1.9)	2 (1.5)	0 (0.8)	0 (0.8)	4 (2.2)	4 (2.2)
Rotary nozzle	3000	40	3 (1.8)	2 (1.6)	0 (0.9)	0 (0.8)	5 (2.4)	10 (3.2)
Rotary nozzle	2000	20	4 (2.2)	3 (1.8)	0 (0.9)	0 (0.8)	6 (2.5)	12 (3.6)
Rotary nozzle	3000	20	3 (1.8)	1 (1.4)	0 (0.8)	0 (0.8)	6 (2.4)	8 (3.0)
l.s.d. P=0.05			(0.8)	(0.6)	(n.s.)	(0.2)	(0.7)	(0.8)

† square root (x+0.5) transformation.

‡ all treatments with hydraulic and rotary nozzles applied at 100% of herbicide rate.

n.s. not significant.

small and did not restrict spray coverage of the weed. At each site there was a natural infestation of one or two of the following weeds; *Anoda cristata, Commelina benghalensis, Datura ferox, Ipomoea plebeia,* and *Xanthium pungens* (Tables 1, 2 and 3). Weeds were young (Tables 1, 2 and 3) and actively growing at time of spraying. Sprays were applied early to midmorning under similar climatic conditions with maximum temperatures of spraying days ranging from 25 to 33°C.

Seven to fourteen days after herbicide application weeds were counted in either three or four 0.25 m^2 quadrats in each plot. The experiments were designed as randomised blocks with three replications for Sites 1 to 7 and with four replications for Sites 8 to 11. Analyses of variance of *Datura ferox* density data at Sites 1, 5 and 6 were not conducted as the treatment differences were obvious (Tables 1 and 2). Prior to analyses data were subjected to a square root (x+0.5) transformation. Data were first analysed as a randomised block design and data from Sites 1 to 7 were reanalysed as a 3×3 factorial design (3 nozzle type–spray volume or nozzle type–rotary nozzle speed treatments×3 herbicide rates) without the untreated data.

RESULTS AND DISCUSSION

Herbicide effectiveness varied among the 11 sites depending upon susceptibility of the weed species to the applied herbicides.

At Sites 1 to 7 rotary nozzles were as effective as hydraulic nozzles in controlling 9 of 10 weed infestations (Table 1 and 2). At Site 5 control of *A. cristata* by rotary nozzles at 3000 rpm and in 20 L/ha was less effective than hydraulic nozzles at 50 and 100% of herbicide rate, whereas control by rotary nozzles at 2000 rpm and in 20 L/ha was similar to hydraulic nozzles.

At Sites 8 to 11, in which weed populations were low, weed control was similar for both nozzle types except at Sites 8 and 11, where control of *C. benghalensis* and *X. pungens* was slightly less by rotary nozzles at 2000 rpm and in 20 L/ha than by hydraulic nozzles.

Effect of reducing the herbicide rate was similar for the different application techniques. Control of most weeds was reduced with lower herbicide rates except for *D.ferox* at Sites 1, 5 and 6 and *C. benghalensis* at Site 2 which were effectively controlled at 50% of herbicide rate.

Herbicide efficacy was maintained when applied by CDA in spray volume of 40 L/ha compared with conventional spraying in 200 L/ha. However, in certain situations herbicide efficacy was marginally reduced when applied by CDA in spray volume of 20 L/ha to the more herbicide resistant weeds *A. cristata, C. benghalensis* and *X. pungens.* Reducing the droplet size with the lower spray volume did not consistently improve control of these weeds. These results indicate that CDA can be an effective method of applying postemergence herbicides in greatly reduced spray volumes.

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