RESEARCH REPORTS

Factors affecting the crop tolerance and weed control of metribuzin in barley and wheat

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Summary

Tolerance of metribuzin by two barley and four wheat varieties was evaluated in glasshouse trial using two soils. Barley was more tolerant to metribuzin than wheat, while plants grown in krasnozem were more tolerant than those grown in sandy loam. Varietal differences in tolerance were found between all barley and wheat varieties, especially in the sandy loam. Metribuzin at 0.6 kg ha^{-1} was more phytotoxic than at 0.3 kg ha^{-1} in the sandy loam. The addition of wetter increased initial plant damage on both soils.

In field trials metribuzin was applied to three growth stages of wheat and barley at three rates. Initial crop tolerance increased with increased development of the crop and decreased with increased rate of metribuzin and the addition of wetter. Metribuzin controlled most annual weeds but not sorrel. Control of wireweed and plantain was variable.

Introduction

Both broadleaf and grass weeds infest cereal crops grown in the southern and midlands areas of Tasmania. Broadleaf weeds are controlled with MCPA, 2,4-D, bromoxinil or dicamba, but grasses are not susceptible to these herbicides.

Metribuzin was evaluated in barley and wheat in Tasmania in 1976–77 and 1977–78 and showed promise for the control of both broadleaf and grass weeds (R. S. Smith, 1977, and I. D. Black, 1978, unpublished). Since both barley and wheat have been shown to exhibit varying degrees of varietal tolerance to metribuzin (Callihan *et al.*, 1977), a study of its effects on the main varieties grown in Tasmania was considered necessary. This paper reports the effects of two rates of metribuzin with and without additional wetting agent on two barley and four wheat varieties grown on two soil types in the glasshouse and at three rates on three soil types to one barley and one wheat variety in the field.

Methods and materials

Glasshouse experiment

Plastic pots each containing one plant were arranged in seven replicates of 72 treatments in randomized complete blocks. Half the pots were filled with a krasnozem (16.3% organic matter, 62.0% clay, 17.8% silt, 5.6% sand) and half with a sandy loam (2.6% o.m., 6.3% cl., 7.8% si., 82.5% sa.). The pots were kept moist and fertilized and were re-randomized three times during the trial. The herbicide treatments consisted of two rates of metribuzin (0.3 and 0.6 kg ha^{-1}) (as Sencor 70) with and without wetter (Agral 60) and a standard herbicide (dicamba at 0.14 kg ha^{-1} as Banex plus MCPA at 1.6 kg ha^{-1} as Methoxone), applied 39 days after planting when the plants averaged four leaves, in a spray cabinet with an output of 310 L ha^{-1} at 207 kPa through a Tee Jet 8015 nozzle.

Plant height was measured at spray application and then at intervals as shown in Figure 1. The plants were harvested at maturity and grain weight recorded (Table 1).

Field experiments

One experiment with Shannon barley was conducted at Cressy Research Station on a Brumby soil (Nicolls, 1957) (5.1% o.m., 42.6% cl., 26.9% si., 25.8% sa.) and the other at Elliot Research Station on a krasnozem (19.7% o.m., 59.6% cl., 16.5% si., 8.9% sa.). The Egret wheat experiment was conducted at Cressy Research Station on a Brickendon soil (5.9% o.m., 34.5% cl., 37.7% si., 22.4% sa.). All were in foundation seeds crops grown under normal recommended cultural practices.

Table 1 Yield of barley and wheat in the glasshouse experiment (grams of grain per plant)

Crop	Proctor barley	Shannon barley	Egret wheat	Condor wheat	Isis wheat	Mersey wheat	mean[1]
Krasnozem							
unsprayed	10.3	10.0	11.2	8.4	10.2	9.5	9.9
dicamba + MCPA	9.6	8.7	10.5	8.6	8.9	9.8	9.4
metribuzin rate (kg ha^{-1})							
0.3 – wetter	10.2	10.7	12.2	11.0	9.2	9.8	10.5
0.3 + wetter	10.8	11.0	11.5	10.1	9.5	9.7	10.5
0.6 – wetter	10.0	9.5	11.6	10.5	8.3	7.7	9.7
0.6 + wetter	10.8	9.1	10.0	9.4	7.1	7.4	8.8
Sandy loam							
unsprayed	5.7	4.6	6.0	5.3	6.4	5.7	5.6
dicamba + MCPA	6.2	5.7	4.6	4.3	5.0	5.5	5.2
metribuzin rate (kg ha^{-1})							
0.3 – wetter	6.9	5.7	2.6	3.7	0	1.5	3.4
0.3 + wetter	3.0	5.8	2.2	3.3	0	0.6	2.5
0.6 – wetter	3.5	2.6	0.3	0	0	0	1.1
0.6 + wetter	0.8	1.7	0	0	0	0	0.4
LSD (P = 0.05) : 1.7							

[1]LSD (P = 0.05) for treatments meaned over cultivars : 0.7

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The barley was sown on 23 August 1978 at Cressy and 3 September 1978 at Elliott and the wheat at Cressy on 18 May 1978. The barley at Elliott and the wheat were harvested on 12 February and 16 January 1979 respectively and the barley at Cressy on 23 February 1979.

Each experiment consisted of three rates of metribuzin (0.2, 0.3 and 0.6 kg ha^{-1}) with and without additional wetter, an untreated control and the standard herbicide treatment of dicamba plus MCPA, with four replicates in randomized blocks. Each plot was 20 m x 2 m with a 1 m strip between plots. The herbicides were applied with a self-propelled offset-boom plot sprayer with an output of 310 L ha^{-1} at 210 kPa through Tee Jet 8003 nozzles. Application was made on various dates between 28 June and 10 October 1978 at the crop stages shown in Table 2.

Weed control was assessed by weed counts on three fixed quadrats of 0.25 m^2 per plot at the time of spraying and again three to four weeks later. Assessment of the fully tillered spray application on the Egret wheat at Cressy was omitted as the crop was too far advanced. Effects on the crop were assessed by measuring the length to the end of the longest leaf of 20 plants in each plot (four sequences of five adjacent plants, chosen at random) at the intervals shown in Figure 2, and yield per plot was recorded at harvest.

Results

Glasshouse experiment

Symptoms of metribuzin damage observed were general foliar chlorosis with leaf tip necrosis increasing to full leaf necrosis depending on the level of damage, followed by plant death in the most severe cases. There was also retardation of tiller development. On the krasnozem one Mersey wheat plant died in each of the 0.6 kg ha^{-1} treatments. All plants in the other krasnozem treatments appeared to recover completely, as indicated by the mean plant heights in Figure 1. The barley plants had recovered 37 days after metribuzin application and the surviving wheat plants after 58 days. The addition of wetter increased the initial rate of metribuzin damage and the maximum growth depression, but metribuzin at 0.6 kg ha^{-1} did not consistently further depress growth compared to metribuzin 0.3 kg ha^{-1}.

There were markedly different responses to the metribuzin treatments on the sandy loam and many plants died. The addition of wetter increased the

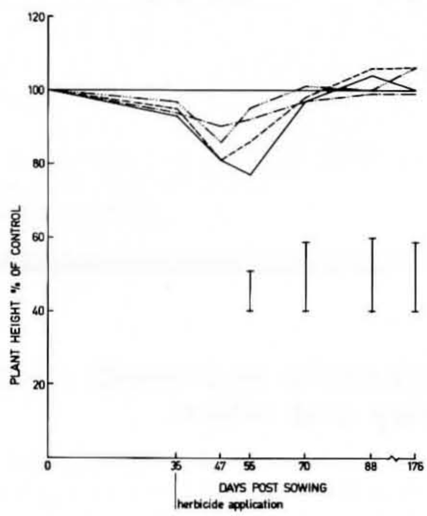

Figure 1a Proctor — krasnozem

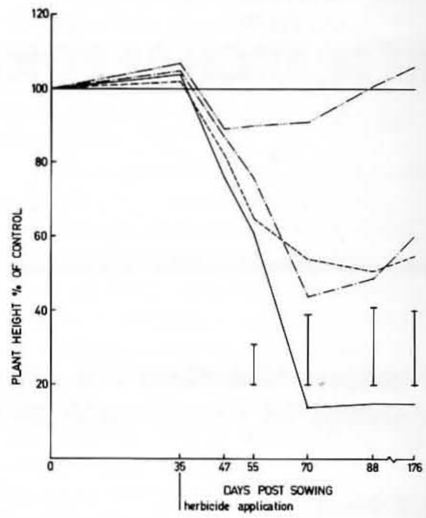

Figure 1b Proctor — sandy loam

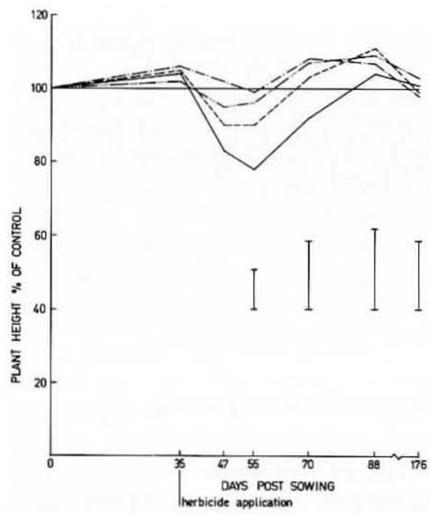

Figure 1c Shannon — krasnozem

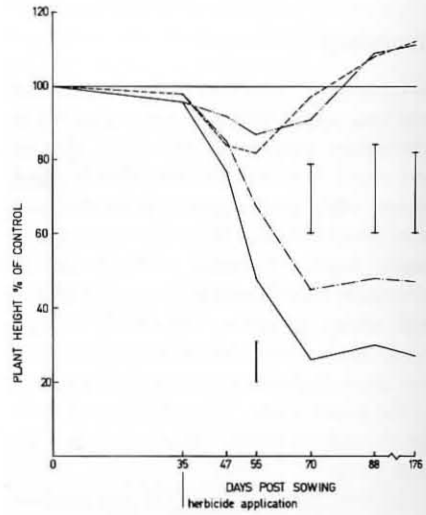

Figure 1d Shannon — sandy loam

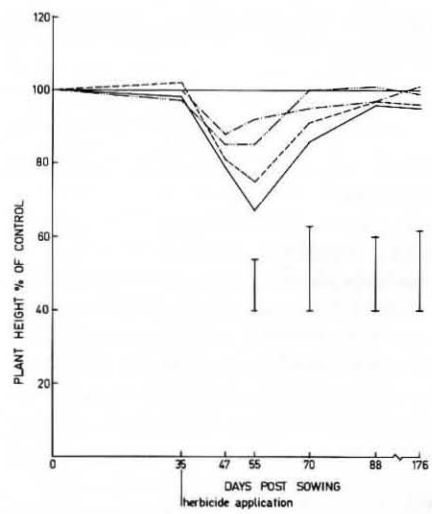

Figure 1e Egret — krasnozem

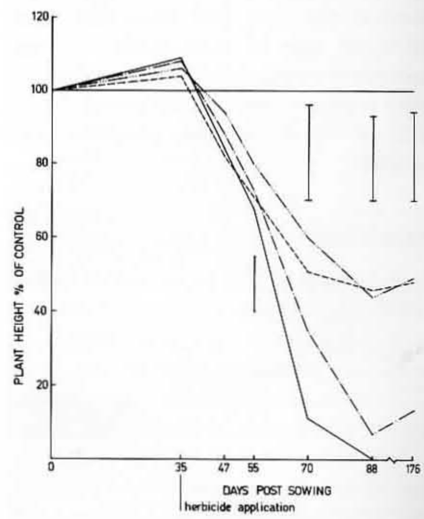

Figure 1f Egret — sandy loam

—···—···— metribuzin 0.3 kg a.c. ha^{-1}
— — — — metribuzin 0.3 kg a.c. ha^{-1} plus wetter
—·—·—·— metribuzin 0.6 kg a.c. ha^{-1}
———— metribuzin 0.6 kg a.c. ha^{-1} plus wetter

The bars represent L.S.D. (P = 0.05)
Due to the way the information is presented, no direct statistical comparison between graphs is possible

Figure 1 Mean plant height of metribuzin treated plants in the glasshouse (percentage of untreated controls)

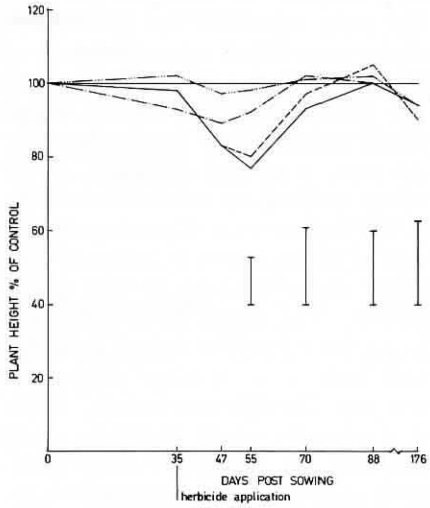

Figure 1g Condor — krasnozem

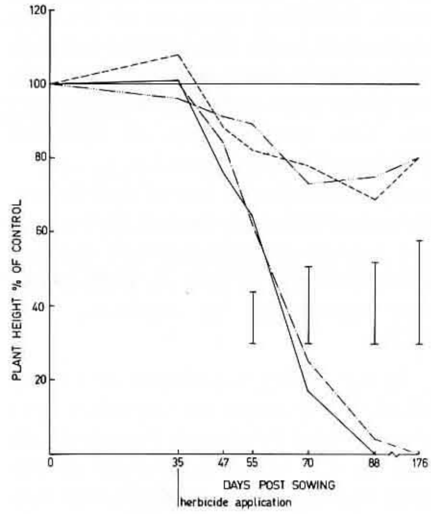

Figure 1h Condor — sandy loam

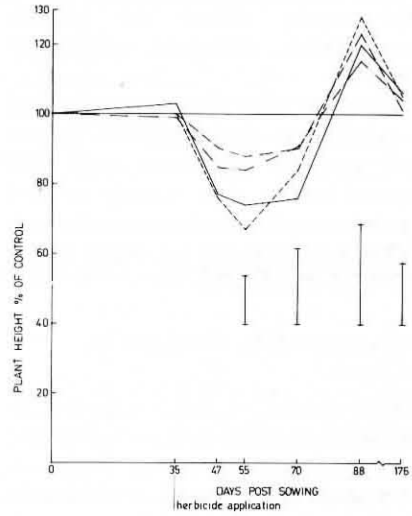

Figure 1i Isis — krasnozem

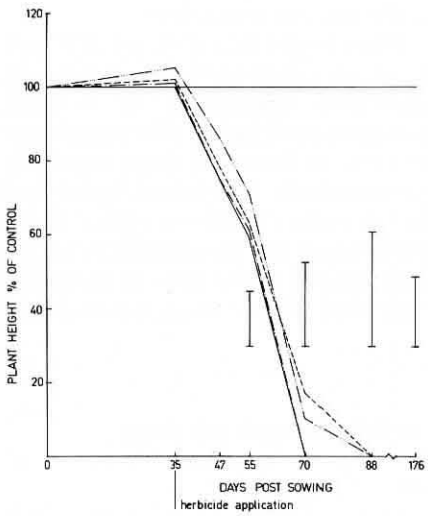

Figure 1j Isis — sandy loam

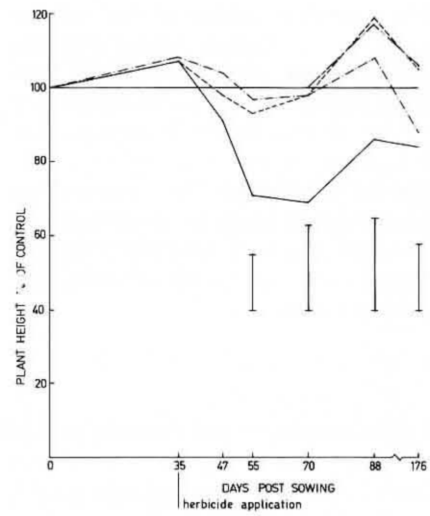

Figure 1k Mersey — krasnozem

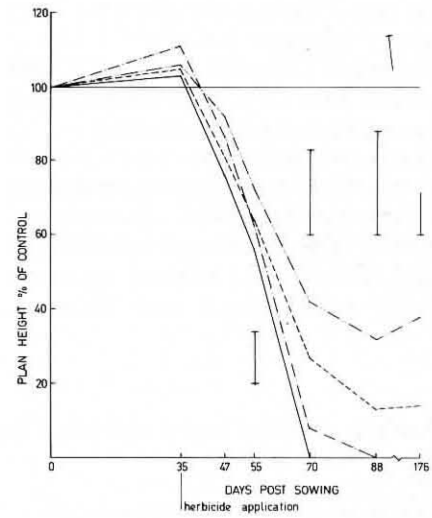

Figure 1l Mersey — sandy loam

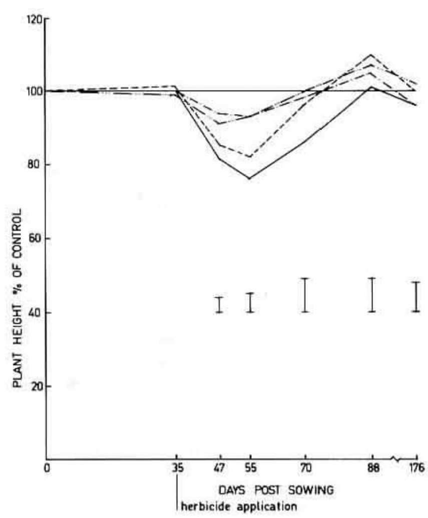

Figure 1m Means — krasnozem

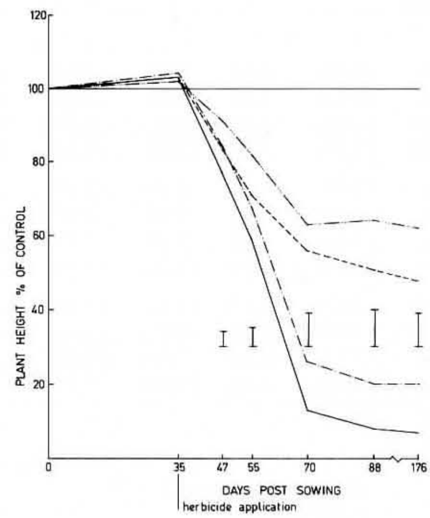

Figure 1n Means — sandy loam

—··—··— metribuzin 0.3 kg a.c. ha^{-1}
— — — — metribuzin 0.3 kg a.c. ha^{-1} plus wetter
—·—·—·— metribuzin 0.6 kg a.c. ha^{-1}
——————— metribuzin 0.6 kg a.c. ha^{-1} plus wetter

The bars represent L.S.D. (P = 0.05)
Due to the way the information is presented, no direct statistical comparison between graphs is possible

Figure 1 Mean plant height of metribuzin treated plants in the glasshouse (percentage of untreated controls) *continued*

initial metribuzin damage although the effect was not as marked as on the krasnozem. Plants of Proctor barley were killed by metribuzin at 0.3 kg ha^{-1} plus wetter but not plants of Shannon barley. Barley was less tolerant of metribuzin at 0.6 than at 0.3 kg ha^{-1}, and the addition of wetter to the high rate further increased damage (Figure 1). Metribuzin at 0.6 kg ha^{-1} was not tolerated by any wheat variety either with or without wetter and the tolerance to metribuzin at 0.3 kg ha^{-1} with or without wetter decreased in the order Condor, Egret, Mersey and Isis. No metribuzin treatment was satisfactorily tolerated by the wheat varieties on the sandy loam.

The yield results on the krasnozem generally reflected the growth of the cultivars except that the high rate of metribuzin reduced yield in Isis as well as Mersey (P = 0.05), in contrast to the mean plant height data. This result is probably due to a reduced number of seed heads in both varieties compared to the control. On the sandy loam the yield results reflect the growth measurements discussed previously (Table 1).

When the dead plants were ignored in calculating the treatment means there were no significant yield differences within each variety or soil type between the survivors, confirming observations that the surviving plants recovered completely.

Field experiments — effects on the weeds

Several species of weeds occurred in significant numbers in moist soil at one or more of the experiments, including winter grass (*Poa annua* L.), chickweed (*Stellaria media* (L.) Vill.), mouse-ear chickweed (*Cerastium glomeratum* Thuill.), montia (*Montia fontana* L.), fat hen (*Chenopodium album* L.), corn spurry (*Spergula arvensis* L.), scarlet pimpernel (*Anagallis arvensis* L.), and parsley piert (*Aphanes arvensis* L.). All were satisfactorily controlled by all metribuzin treatments, which gave 90 to 100% kill and caused severe damage to the survivors. The vegetative regrowth of sorrel (*Rumex acetosella* L.) at Elliott was not affected by metribuzin in the longer term. Development was retarded for about three weeks following spraying at the first application stage. Retardation was less at the second stage, especially with the two lower rates and those without wetter. The susceptibility of common plantain (*Plantago lanceolata* L.) at Elliott increased with rate of metribuzin, decreased with later time of application and tended to increase with the addition of wetter (Table 3). Both weeds were controlled by dicamba plus MCPA.

In the barley experiment at Cressy wireweed (*Polygonum aviculare* L.) showed more resistance to metribuzin than in the wheat experiment at the same station. The site difference was probably a function of differences in topsoil moisture status and soil temperature between seasons. The warm spring weather tended to dry out the topsoil in the barley, whilst with the autumn sown wheat the topsoil was moist throughout the normal period of activity of metribuzin. It appears that there must be adequate topsoil moisture for wireweed to be controlled in the cotyledon stage by metribuzin at 0.2 and 0.3 kg ha^{-1}, and that it rapidly becomes resistant to the chemical beyond this stage.

Field experiments — effects on the crop

The only treatment in which crop plants were killed was metribuzin at 0.6 kg ha^{-1} plus wetter applied at the two- to three-leaf stage to Egret wheat. Visual symptoms of metribuzin damage were a general chlorosis of the foliage and leaf tip necrosis increasing to full leaf necrosis depending on the level of damage, with reduction in crop height and retardation of tiller development. The visual symptoms were greatest at the earliest time of spraying, with little or no damage at the last spraying. Damage was initially worse in treatments which included wetter and with the highest level of metribuzin compared to the two lower levels. The symptoms disappeared within three weeks in the spring sown barley experiments but persisted much longer in the autumn sown wheat.

Plant height data is shown in Figure 2. In all experiments the metribuzin treatments significantly (P = 0.05) depressed plant height after spraying at the one- to three-leaf stage, especially for treatments with added wetter and for the high rate without wetter. In the Egret wheat the growth effects on the crop sprayed at the two- to three-leaf stage were delayed because growth had

Table 2 Yield of barley and wheat sprayed with metribuzin and dicamba plus MCPA at different rates and times

	Grain yield (t ha^{-1})											
Location and crop	Elliott – barley				Cressy – barley				Cressy – wheat			
Stage of crop growth	2–3 leaf	4–5 leaf	mid-tillering	(mean)	2 leaf	4–5 leaf	mid-tillering	(mean)	2–3 leaf	mid-tillering	fully tillering	(mean)
Metribuzin rate (kg ha^{-1})												
0.2 – wetter	3.75	3.69	3.63	(3.69)	4.13	3.80	3.96	(3.96)	7.81	7.00	7.08	(7.30)
0.3 – wetter	3.64	3.97	3.56	(3.72)	3.91	3.84	3.74	(3.83)	7.85	7.26	7.04	(7.38)
0.6 – wetter	4.11	3.98	3.68	(3.92)	3.94	3.81	3.94	(3.90)	6.88	8.21	7.66	(7.58)
(mean)	(3.83)	(3.88)	(3.62)	(3.78)	(3.99)	(3.82)	(3.88)	(3.90)	(7.51)	(7.49)	(7.26)	(7.42)
0.2 + wetter	3.58	3.86	4.41	(3.95)	4.14	4.13	3.95	(4.07)	7.24	6.64	6.65	(6.84)
0.3 + wetter	3.73	3.83	3.69	(3.75)	4.06	3.90	4.03	(3.99)	7.77	6.93	7.51	(7.40)
0.6 + wetter	3.58	3.81	3.46	(3.62)	3.78	3.79	3.83	(3.80)	5.09	7.56	6.68	(6.44)
(mean)	(3.63)	(3.84)	(3.85)	(3.78)	(3.99)	(3.94)	(3.94)	(3.95)	(6.70)	(7.04)	(6.95)	(6.90)
0.2 ± wetter (mean)	(3.66)	(3.78)	(4.02)	(3.82)	(4.13)	(3.97)	(3.96)	(4.02)	(7.52)	(6.82)	(6.87)	(7.07)
0.3 ± wetter (mean)	(3.69)	(3.90)	(3.62)	(3.74)	(3.98)	(3.87)	(3.88)	(3.91)	(7.81)	(7.09)	(7.27)	(7.39)
0.6 ± wetter (mean)	(3.85)	(3.90)	(3.57)	(3.77)	(3.86)	(3.80)	(3.89)	(3.85)	(5.99)	(7.88)	(7.17)	(7.01)
(mean)	(3.73)	(3.86)	(3.74)	(3.78)	(3.99)	(3.88)	(3.91)	(3.93)	(7.11)	(7.27)	(7.10)	(7.16)
unsprayed control				3.60				3.85				6.75
dicamba + MCPA			4.26				3.80				7.27	
	Significant F			SED	Significant F			SED	Significant F			SED
	Untreated, standard,			0.27[1]					wetter***			0.42[2]
	metribuzin mean*			0.19[2]	–			–				0.18[3]
	rate x wetter*			0.22[2]					rate x wetter*			0.45[2]
				0.15[3]								0.32[3]
									rate x stage***			0.48[2]
												0.39[3]

*P = 0.05 **P = 0.01 ***P = 0.001

[1]For use when comparing the untreated and standard treatments

[2]For use when comparing the untreated or standard treatments with the appropriate metribuzin entries

[3]For use when comparing the appropriate metribuzin entries

Table 3 Effect of metribuzin on control of common plantain and wireweed in barley and wheat three to four weeks after treatment

	Weed density (% reduction compared with unsprayed control)							
Weed	**Common plantain**			**Wireweed**				
Location and crop	**Elliott – barley**			**Cressy – barley**			**Cressy – wheat**	
Stage of plant growth								
Cereal	2–3 leaf	4–5 leaf	mid-tiller	2 leaf	4–5 leaf	mid-tiller	2–3 leaf	mid-tiller
Weeds	cotyledon	cot–2 leaf	cot–4 leaf	cotyledon	cot–4 leaf	2–3 leaf	cotyledon	cot–4 leaf
Metribuzin rate (kg ha^{-1})								
0.2 – wetter	82	5	4	62	11	14	98–100[1]	68
0.2 + wetter	81	2	0	63	54	37	98–100	81
0.3 – wetter	76	7	0	82	57	51	98–100	80
0.3 + wetter	97	0	0	84	57	32	98–100	87
0.6 – wetter	100	62	21	94	97	78	98–100	95
0.6 + wetter	93	80	17	94	94	77	98–100	94

[1]Estimate only. Weeds continued to germinate for over a month after herbicide application.

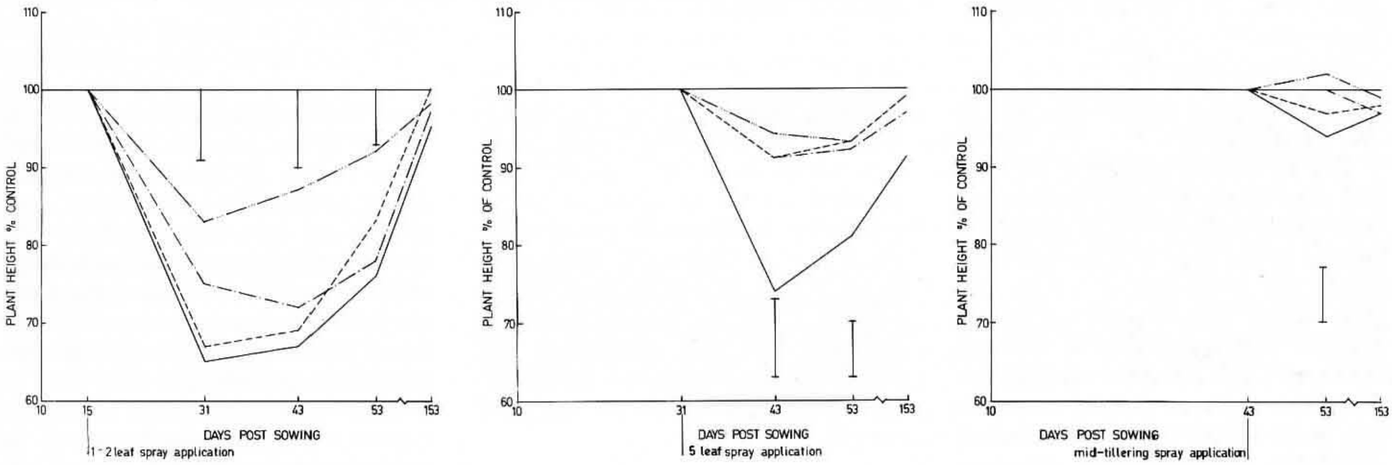

Figure 2a Shannon barley — Cressy Research Station

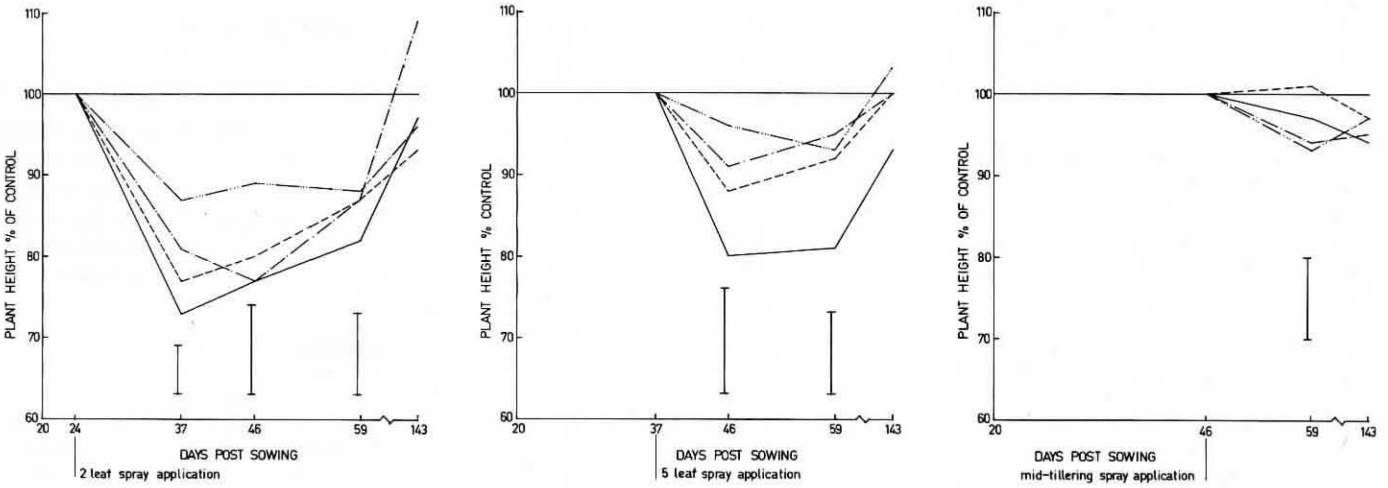

Figure 2b Shannon barley — Elliott Research Station

Figure 2 Mean plant height of the metribuzin treated plants in the field experiments (percentage of untreated control)

- metribuzin 0.2 and 0.3 kg a.c. ha^{-1} (mean)
- metribuzin 0.2 and 0.3 kg a.c. ha^{-1} plus wetter (mean)
- metribuzin 0.6 kg a.c. ha^{-1}
- metribuzin 0.6 kg a.c. ha^{-1} plus wetter

The bars represent L.S.D. ($P = 0.05$). Where these are absent there is no significant difference. There was no significant difference between metribuzin 0.2 and 0.3 kg a.c. ha^{-1} at any assessment.

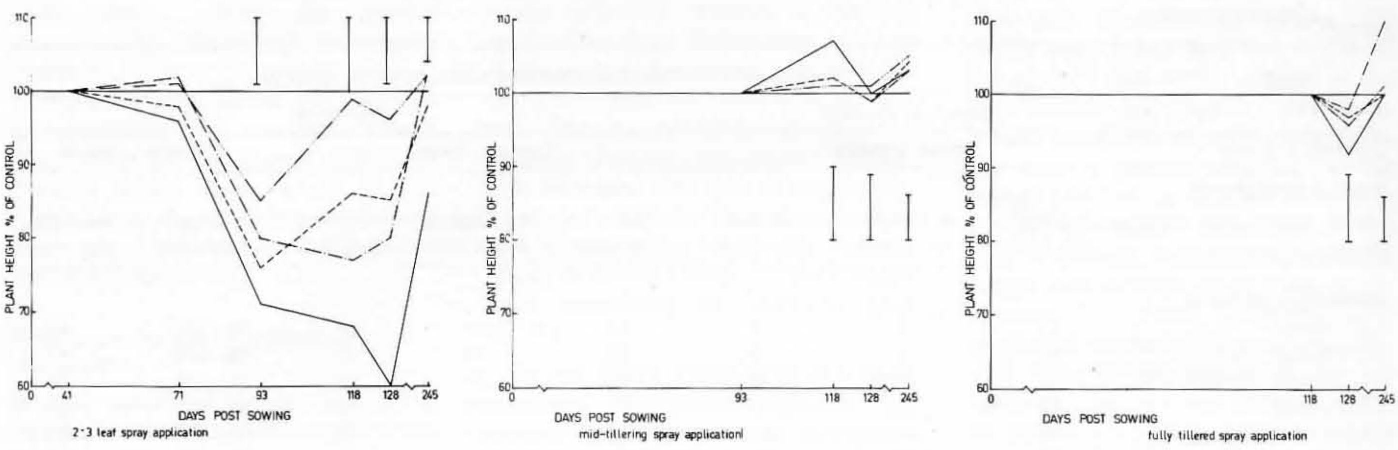

Figure 2c Egret wheat — Cressy Research Station

Figure 2 Mean plant height of the metribuzin treated plants in the field experiments (percentage of untreated control) *continued*

—…—… metribuzin 0.2 and 0.3 kg a.c. ha^{-1} (mean)
– – – – metribuzin 0.2 and 0.3 kg a.c. ha^{-1} plus wetter (mean)
—·—·— metribuzin 0.6 kg a.c. ha^{-1}
——— metribuzin 0.6 kg a.c. ha^{-1} plus wetter

The bars represent L.S.D. (P = 0.05). Where these are absent there is no significant difference. There was no significant difference between metribuzin 0.2 and 0.3 kg a.c. ha^{-1} at any assessment.

virtually stopped at that time due to low temperatures.

The treatments applied at the five-leaf stage in the two barley experiments were much better tolerated than those applied at the two- to three-leaf stage except for metribuzin at 0.6 kg ha^{-1} plus wetter. The height of plants sprayed with metribuzin at 0.2 and 0.3 kg ha^{-1} did not differ significantly from that of the unsprayed control at any time, though there was some yellowing but no leaf necrosis. The treatments applied at mid-tillering resulted in no significant height reduction and there were no visual symptoms of damage. The second time of application in the Egret wheat was delayed until mid-tillering due to wet soil. At this stage and at full tillering there was no significant height retardation as a result of the metribuzin treatments (Figure 2), although there was transient crop yellowing at the mid-tillering application.

With the exception of metribuzin at 0.6 kg ha^{-1} plus wetter applied at the two- to three-leaf stage to wheat, the statistical analyses showed that the yields from the metribuzin treatments were either equal to or significantly greater than the untreated control in all experiments. The significant differences shown in Table 2 can be explained by the effect of earlier weed control together with crop tolerance of the herbicide. Significant yield increases from the herbicide treatments were not expected in the barley experiment at Cressy because the within treatment variation (SED: 0.2 t ha^{-1}) is well in excess of the 0.06 t ha^{-1} yield reduction which could be expected from competition due to wireweed at the population encountered (49 m^{-2}) in wheat crops in Victoria (G. Wells, pers. comm.). The other main weed, scarlet pimpernel, quickly became weak and etiolated from crop competition and probably did not contribute significantly to yield reduction in the untreated control.

Discussion

The results of the glasshouse experiment confirm the findings of Callihan *et al.* (1977) that barley is more tolerant to metribuzin than wheat and that wheat has a wider range of varietal response than barley. In contrast, Nicholl (1978) found that the four wheat varieties Halberd, Olympic, Summit and Pinnacle did not differ in tolerance to metribuzin in field trials. The work reported here supports his finding that wheat crops grown on heavy soils were more tolerant to metribuzin than those grown on light soils.

It can be concluded from the results of the spring sown barley experiments that application of metribuzin should be delayed until the five-leaf stage to minimize initial crop damage. This is important in spring sown dryland crops because there is no guarantee of sufficient moisture in the spring to allow the crop to recover fully from an early check in growth.

The results of these experiments also show that metribuzin is better tolerated by the barley varieties Shannon and Proctor than by the wheat varieties Egret, Condor, Isis and Mersey. Although the experiments indicate that the commercial rates of metribuzin could be used safely on Egret and Condor wheat when grown on medium and heavy soils, the margin of crop tolerance was considerably less than in barley. Further evaluation should be carried out before metribuzin can be safely recommended for general application to wheat in Tasmania.

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