Control of the recently-introduced weed butterprint (*Abutilon theophrasti*) in maize

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Abstract Butterprint (velvetleaf in many countries) is one of the worst broadleaf weeds in maize (*Zea mays*) and soya bean (*Glycine max*) crops in USA. It has been accidentally introduced into New Zealand on several occasions. Recently it has been found in three maize fields in Waikato and has become well established at one 20 ha site. Twelve different post-emergence herbicides were evaluated for control of butterprint in glasshouse pot trials and in a field trial. In the glasshouse bromoxynil, dicamba, mesotrione, aminopyralid and topramezone all gave 100% control. In the field trial, dicamba showed the most activity but overall efficacy was less than in the glasshouse. Dicamba controlled most of the plants that were present at spraying, but germination over the next month resulted in a final population of 88% of the original. This population of butterprint also shows a very high tolerance to atrazine when treated post-emergence.

Keywords butterprint, velvetleaf, *Abutilon theophrasti*, maize, herbicides, chemical control.

INTRODUCTION

Butterprint or velvetleaf (*Abutilon theophrasti*), originally from China and India, is now a problem weed in many countries in North America, Europe, Asia and Africa (Warwick & Black 1988; Sattin et al. 1992). It was introduced to North America in the 18th century from China and has now become the foremost broadleaf weed in maize and soya bean crops there. The first recorded incidence of it in New Zealand was when MAF imported it as a species for fibre production in 1948 (Herbarium voucher, Allan Herbarium, Lincoln, New Zealand), but since then it has been accidentally imported with soya bean seed and as a contaminant of other grains, although none of these introductions are known to have established. Currently, there are four confirmed infestations: at Waihou, Morrinsville

and Mangatawhiri in Waikato, and at Helensville, north of Auckland.

Butterprint is a member of the mallow family (Malvaceae) and is easily distinguished by its tall, erect habit and large, alternate, heart-shaped leaves, which are soft and velvety to the touch and have a musky odour. It has small yellow to yellow-orange flowers that only open for a few hours during the hottest part of the day. It has distinctive black seed pods containing about 40 large, hard black seeds (Warwick & Black 1988).

Butterprint is a summer-growing annual plant that has the ability to germinate throughout the warmer months. Growing to 3 m tall, its biological and ecological characteristics make it particularly competitive and persistent in cultivated fields. It has been reported to cause severe crop losses

particularly in fields of maize, sorghum, soya bean and cotton (Spencer 1984). Examples include up to 37% and 72% loss in soya bean yields at butterprint densities of 3 and 12 plants/m² respectively, and 51% to 91% inhibition in growth of maize plants by a butterprint plant 5 cm away (Sterling & Putnam 1987). It also has allelopathic effects on seed germination and seedling root elongation of other plants (Bhowmik & Doll 1982; Sterling et al. 1987).

Because butterprint germinates throughout the season, it is very difficult to eradicate by herbicides, and once established it will almost always produce seed (Warwick & Black 1988; Sattin et al. 1992). Successful post-emergence control depends on herbicide application to the weed at the two to four leaf stage. To complicate matters there are now atrazine-resistant biotypes of this weed (Ritter 1986), with atrazine being one of the main herbicides used by maize growers in New Zealand. This work was undertaken to evaluate several post-emergence herbicides in pot trials and in a field trial for control of butterprint.

MATERIALS AND METHODS

Glasshouse trials

Trials 1 and 3 were carried out in a glasshouse at Ruakura Research Centre. Plants were grown in 150 mm diameter plastic pots and Dalton's standard potting mix. Six seeds, collected from the Waihou site, were planted per pot but emergence was irregular resulting in uneven plant sizes at treatment and between two and four plants per pot. Trial 1 was planted on 25 November 2011 and treated on 23 December when the butterprint plants were between 60 and 170 mm tall with two to eight leaves. Trial 3 was planted on 23 January 2012 and treated on 14 February when the butterprint plants were between 150 and 300 mm tall with six to 10 leaves. All treatments (Tables 1 and 3) were applied to five replicate pots with a CO₂ powered, moving belt sprayer fitted with a single TeeJet 8003 nozzle to apply 200 litres/ha. After treatment the pots were laid out on glasshouse benches in a randomised block layout. Visual assessments of percent damage, averaged over all the plants in a pot, were made by two observers until the

plants had either recovered or died. Seedlings that emerged after the treatments were applied were ignored in the assessments.

Field trial

Trial 2 was carried out on the property of Mark Holms, Lyons Road, Mangatawhiri, Waikato, in a maize crop where the roadside headland was severely infested with butterprint. Individual plots were 10 × 3 m with 12 treatments and four replicates laid out in a randomised block design. All herbicides (Table 2) were applied on 21 December 2011 with a CO₂ powered backpack sprayer and a 3 m boom fitted with four TeeJet AIC11003 air induction nozzles at 75 cm spacing centred to cover the crop inter-row area applying 200 litres/ha. Most of the butterprint plants had six to eight leaves and were 150–250 mm tall, although a few were larger and there were also some smaller plants that ranged down to only recently emerged. Whole plot counts of butterprint were made prior to treatment application and are presented in Table 2. At the time the treatments were applied, the air temperature was 23.1°C, soil temperature 24.5°C, 50% cloud cover, slight wind of 0–2 m/s and the soil surface was moist from recent rain. The maize plants had 10–11 leaves and were mostly between 500 and 600 mm high. A visual assessment of damage to the butterprint was made on 10 January, being an agreed percent damage to the weeds combining deformation, discolouration and necrosis, by four observers. On 25 January 2012 all surviving butterprint plants were counted, removed and destroyed prior to setting seed.

All data were analysed using analysis of variance (ANOVA). The arithmetic means and least significant difference (LSD) are presented to separate the means for all data in the tables.

RESULTS

The emergence of butterprint in the glasshouse was slow and irregular leading to plants varying in size in each pot. After treatment the smaller plants generally died back faster than the larger plants. By the final assessment 6 weeks after application several of the treatments had killed all the plants growing in pots (Table 1). The fastest acting was bromoxynil, which had killed

all the plants within 3 weeks while dicamba, mesotrione, aminopyralid and topramezone all took around 6 weeks to kill all plants. None of the plants treated with either atrazine, clopyralid or the Latro formulation of nicosulfuron died. In the remaining treatments some of the smaller plants died while the larger plants grew on and eventually showed signs of recovery.

When compared to the results from the pot trial, results from the field trial (Table 2) were

disappointing. In the field most of the larger plants survived the herbicide treatment and many new plants emerged and grew in most of the plots as well. Thus for treatments with lower efficacy such as clopyralid there were more than double the number of butterprint plants in the plots on completion of the trial compared to the beginning (Table 2). Only two treatments, dicamba and flumetsulam, had fewer plants present at the end of the trial although this was

Table 1 Mean percent damage at various intervals after treatment of butterprint from post-emergence treatments applied in the glasshouse on 13 December 2011 (Trial 1).

Herbicide	Rate (g/ha)	Adjuvant	Rate (%)	Percent damage			
				29.12.11	9.1.12	16.1.12	25.1.12
Aminopyralid	60			73	89	88	100
Atrazine	1500			0	9	20	20
Bromoxynil	200			95	100	100	100
Clopyralid	300			7	20	40	40
Dicamba	400			82	93	96	100
Flumetsulam	52	Bonza	0.5	64	83	78	76
Mesotrione	96	Synoil	1	83	96	98	100
Nicosulfuron ¹	83	Bonza	0.5	20	41	30	40
Nicosulfuron ²	80	Benefit	0.5	80	90	86	74
Nicosulfuron ³	78			79	89	87	73
Terbuthylazine	1530	Bonza	0.5	81	64	54	30
Topramezone	101	Hasten	0.5	81	90	94	100
LSD (P<0.05)				5.3	4.0	5.9	7.1

¹Latro formulation; ²Astound formulation; ³Neeko Oleo formulation.

Table 2 Means of pre- and post-treatment plant counts and percent damage at 2 weeks post-treatment of butterprint from post-emergence treatments applied in the field on 21 December 2011 (Trial 2).

Herbicide	Rate (g/ha)	Adjuvant	Rate (%)	Count	Count	% of	Damage
				Pre-treat	25.1.12	pre ⁴	10.1.12
Aminopyralid	60			22	24	112	48
Atrazine	1500			17	19	110	13
Bromoxynil	200			21	24	114	57
Clopyralid	300			30	64	212	27
Dicamba	400			27	24	88	84
Flumetsulam	52	Bonza	0.5	23	21	92	71
Mesotrione	96	Synoil	1	32	49	152	80
Nicosulfuron ¹	83	Bonza	0.5	37	52	141	40
Nicosulfuron ²	80	Benefit	0.5	11	17	153	50
Nicosulfuron ³	78			27	43	159	50
Terbuthylazine	1530	Bonza	0.5	28	34	124	27
Topramezone	101	Hasten	0.5	43	79	186	70
LSD (P<0.05)				42.7	78.0	77.6	19.4

¹Latro formulation; ²Astound formulation; ³Neeko Oleo formulation.

⁴Count on 25.1.12 expressed as a percentage of the pre-treatment count.

not significant. Two other herbicides, mesotrione and topramezone, also showed good activity on butterprint, but lacked sufficient residual activity to suppress further germination.

As a result of the lack of efficacy in the field trial, a second trial was carried out in the glasshouse evaluating higher rates of several herbicides and herbicide combination treatments (Table 3). Results from this trial showed that up to four times the recommended rate of atrazine was required to kill butterprint. Also, none of the nicosulfuron formulations killed the test plants even when applied at three times the normal field rate. The Latro formulation appeared to perform much better when the adjuvant was changed from Bonza to Benefit. When used in combination with dicamba, various formulations of nicosulfuron killed all the plants, but so did dicamba alone. Mesotrione with and without dicamba also killed all the butterprint plants.

DISCUSSION

It is clear from these results and from overseas reports (Warwick & Black 1988; Sattin et al.1992)

that butterprint is much more susceptible to herbicides when very small (two to four leaves) and that for effective control plants should be sprayed at this growth stage. However, as few post-emergence herbicides have sufficient residual activity to further suppress emergence, and as seedling butterprint plants continue to germinate through the season, this early post-emergence application is not likely to result in adequate control of this weed. The use of dicamba or flumetsulam in combination with other herbicides could offer longer residual control but this was not specifically measured in these trials. As butterprint is presently being considered by the Waikato Regional Council as a containment weed under the terms of their Regional Pest Management Strategy, its control could become obligatory. For this several post-emergence applications could be required in infested maize fields and specialised equipment might be required for late applications when the maize plants are large.

Based on several trials with nicosulfuron over 2 years, Dobbels & Kapusta (1993) found

Table 3 Percent damage at various intervals after treatment of butterprint from post-emergence herbicide treatments applied in the glasshouse on 14 December 2012 (Trial 3).

Treatment	Rate (g/ha)	Adjuvant	Rate (%)	Percent damage			
				20.2.12	27.2.12	19.3.12	2.4.12
Atrazine	1500			19	20	44	30
Atrazine	3000			68	77	80	54
Atrazine	6000			87	99	100	100
Bromoxynil	200			96	100	100	100
Bromoxynil	400			97	100	100	100
Nicosulfuron ¹	83	Benefit	0.5	44	48	80	58
Nicosulfuron ¹	248	Benefit	0.5	60	66	72	54
Nicosulfuron ²	80	Benefit	0.5	62	66	64	58
Nicosulfuron ²	240	Benefit	0.5	84	93	82	81
Nicosulfuron ³	78			60	67	70	67
Nicosulfuron ³	234			87	94	93	98
Nico ¹ +dicamba	83+400			40	50	86	90
Nico ² +dicamba	80+400			30	40	86	96
Nico ³ +dicamba	78+400			36	45	91	100
Mesotrione	96	Synoil	1.0	60	75	97	100
Meso+dicamba	96+400			58	75	99	100
Dicamba	400			50	56	98	100
Untreated	-	-	-	0	0	0	0
LSD (P<0.05)				5.1	4.0	5.8	9.3

¹Latro formulation; ²Astound formulation; ³Neeko Oleo formulation.

butterprint control ranging from 0-100% and concluded that both application rate and plant size were critical factors. This supports the present findings and shows that nicosulfuron alone should not be used to control butterprint unless the plants are very small. Results from the glasshouse trials also show that choice of adjuvant is very important when using nicosulfuron as the use of Bonza with the Latro formulation in Trials 1 and 2 gave inferior results to its combination with Benefit in Trial 3. The exception is the Neeko Oleo formulation, which contains a propriety blend of adjuvants and performed as well as the tank mixes with Benefit in the trials reported here.

When used pre-emergence, Schmenk & Kells (1998) found that atrazine applied at 1.1 kg/ha did not completely control butterprint. However, Gray et al. (1995) found that when used post-emergence, susceptible butterprint plants were killed by 0.22 kg/ha but that resistant plants required up to 16 kg/ha of atrazine to achieve the same result. In the present trial up to 6 kg ai/ha of atrazine was required to kill the butterprint plants, so it would appear that the plants in at least two of the sites (Waihou and Mangatawhiri) are possibly a biotype resistant to atrazine. If this is the case it would indicate that these introductions occurred after 1986 when atrazine resistance was first reported (Ritter 1986).

All four infested sites are currently being managed by their regional councils with the aim of eliminating further spread of this very troublesome weed and if possible eradicating it, although it is realised this will take many years to achieve.

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APPENDIX

Active ingredient and formulation of products used in the trials

aminopyralid: Tordon™ Max; atrazine: Gesaprim® 500 FW; bromoxynil: Emblem® Flo; clopyralid: Archer™; dicamba: Banvel®; flumetsulam: Preside™; mesotrione: Callisto®; nicosulfuron: Astound® Flo, Latro® 750WG and Neeko™ Oleo; terbutylazine: Nu-terb 900WDG; topramezone: BAS670 01H.