MANAGEMENT OF *OXALIS LATIFOLIA* AND *CALYSTEGIA SEPIUM* IN MAIZE

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ABSTRACT

Fish-tail oxalis (*Oxalis latifolia*) and pink bindweed (*Calystegia sepium*) are problem perennial weeds in maize crops. Four field trials were conducted over two growing seasons to evaluate both cultural and chemical control methods. The post-emergence application of nicosulfuron provided good control of fish-tail oxalis, as did imazethapyr/imazapyr in imidazolinone-tolerant maize. Use of maize cultivars with strong early season growth or long "staygreen" attributes did not provide the expected reduction in oxalis bulb production. Two trials with pink bindweed showed that the post-emergence herbicides, nicosulfuron, dicamba and imazethapyr/imazapyr gave good control of this weed. Post-harvest crop management with stubble mulching, cultivation or glyphosate treatment had little effect on pink bindweed but use of glyphosate as close as possible to maize planting significantly reduced the bindweed population.

Keywords: Weed control, *Oxalis latifolia*, fish-tail oxalis, *Calystegia sepium*, pink bindweed.

INTRODUCTION

In New Zealand weed control in maize (*Zea mays*) is most commonly achieved with a combination of a triazine herbicide (commonly atrazine) and a grass herbicide (Rahman 1988). However, after many years of use of such combinations two types of weed problems have arisen. The first is where weeds have become physiologically resistant to triazine herbicides, the three confirmed instances being fathen (*Chenopodium album*), willow weed (*Polygonum persicaria*) (Rahman et al. 2001) and black nightshade (*Solanum nigrum*) (Harrington et al. 2001). The second type of problem is a predominance of weeds, usually perennial, that are less susceptible to these commonly used herbicides. Two such weeds are fish-tail oxalis (*Oxalis latifolia*) and pink bindweed (*Calystegia sepium*), both of which compete vigorously with maize plants and as such have been identified as major problem weeds by maize growers in recent years.

Fish-tail oxalis, the worst among the many species of oxalis growing in New Zealand, has large clover-like leaves, and attractive pink flowers in clusters of six to ten on long slender stalks. Plants are dormant in winter and usually flower in summer. Fish-tail oxalis has a versatile vegetative reproductive system including a contractile tuberous root connected to the parent bulb. This facilitates the dispersal of the numerous bulbils formed each season. The bulbils can remain alive in the soil for years and plants can grow from bulbils lying as deep as 250 mm (Esler 1962; Jackson 1960). While glyphosate and oxadiazon have shown good potential for control of this weed (Cox & Kerr 1981), no selective herbicides have been available to effectively control it in maize.

The two closely related species of bindweed that maize growers are confronted with are greater bindweed (*Calystegia sylvatica*), which has white flowers and pink bindweed (*Calystegia sepium*) which has pink flowers (Webb et al. 1988). Both species are perennials and regrow each spring from large fleshy underground roots. Their deep rhizomatous root systems are capable of generating new plants from small fragments broken up by cultivation. The sprawling climbing stems often cover the crop rows and entwine the young maize plants.

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This paper reports results of field trials conducted over two growing seasons to investigate different management strategies, including cultural and chemical methods for selective control of these problem perennial weeds in maize crops.

MATERIALS AND METHODS

Fish-tail oxalis: Trial 1

A field trial was conducted during the 1999/2000 season at Rukuhia near Hamilton on a Hamilton clay loam soil (16% sand, 45% clay, 2.8% organic carbon and a pH of 6.4). The maize crop (cv. Garst 8541 IT) was planted on 2.11.99 at 750 mm spacing between rows. A pre-emergence treatment of acetochlor (Roustabout) was applied on 9.11.99. This was followed by the post-emergence treatments of imazethapyr + imazapyr (Lightning), nicosulfuron (Amaze) or dicamba (Banvel 200) applied on 15.12.99 when oxalis was well-established with many completely formed leaves. The trial design was a randomised block with four replicates. Plots were 5 m x 3 m and consisted of four rows. On the day the post-emergence treatments were applied, the number of emerged oxalis leaves was counted in two 0.1 m² quadrats/plot. After treatment, visual assessments of weed control and crop damage were made at regular intervals. Oxalis dry matter was determined on 21.3.00 by harvesting the top growth at ground level from two 0.125 m² quadrats.

Fish-tail oxalis: Trial 2

Another field trial was conducted at the same location during the 2000/2001 season. This was a 4 x 3 factorial, fully randomised design with four maize cultivars and three herbicide regimes replicated four times (Table 1). Individual plots were 10 m x 3 m. The maize cultivars were selected for maximum contrast in two areas, viz. early season vigour (Pioneer 3730 vs 3751) and long "staygreen" attributes (Pioneer 33G26 vs 33R87). The herbicide treatments (no herbicide, acetochlor + atrazine pre-emergence, and atrazine pre-emergence followed by nicosulfuron + adjuvant (Amaze Activator) post-emergence) were selected to aim for nil, partial or good control of the fish-tail oxalis. The maize was planted on 23.10.00 at 750 mm row spacing; pre-emergence treatments were applied two days later and the post-emergence treatments on 13.12.00. On three occasions during the growing season (19.12.00, 17.1.01 and 19.2.01) maize leaf area and total plant dry weight were determined from two representative maize plants harvested 100 mm above ground from the two centre rows of each plot. Green leaf area was estimated using the equation, area = 0.73 x length x width (at the widest point), and summing all of the leaves present. Weed dry matter (for those weeds other than oxalis) was determined from two 0.1 m² quadrats from each plot in January. Dry matter of oxalis bulbs was determined by collecting 30 soil cores (75 mm diameter x 100 mm deep) from each plot on 17.4.01 and recording the dry weight of bulbs therein.

Pink bindweed: Trial 3

The first bindweed field trial was conducted during the 1999/2000 season at the Waikato Research Orchard near Hamilton on a Te Kowhai silt loam soil (44% sand, 34% clay, 3.0% organic C and a pH of 5.8). The maize crop (cv. Pioneer 33951R) was planted on 20.10.99 and the pre-emergence treatment of acetochlor was applied to all plots on 21.10.99. The post-emergence treatments (Table 2) were applied on 8.12.99 when the maize plants had 8-10 leaves and the bindweed had runners up to 500 mm long. The 10 m x 3 m plots were arranged in a randomised block design with four replicates. Three visual assessments of early damage to the bindweed were made within two weeks of the herbicide application. Bindweed regrowth was also evaluated at the third assessment. Thereafter, visual assessments of the overall control were made at monthly intervals and bindweed DM was determined in March by harvesting runners from two 0.125 m² quadrats from each plot. Maize grain yield was determined by harvesting 50 cobs from each plot on 9.5.00. These were shelled, dried, weighed and yields were adjusted to 14% moisture content.

Pink bindweed: Trial 4

A second bindweed trial in the 2000/2001 season was conducted at the same site and comprised three post-harvest management options (mulching, cultivation or glyphosate (Roundup Renew) at 2.2 kg/ha), each of which was followed by two pre-planting treatments (cultivation or glyphosate) on a random split-plot basis. The mulching treatment on 7.6.00 left a 20 – 50 mm thick layer of chopped up trash over the whole plot which partially rotted down over the winter. Cultivation consisted of rotary hoeing twice on 8.6.00 which chopped up bindweed roots that had grown through the summer. The glyphosate applied on 13.6.00 controlled plants that were still green and alive. The pre-planting glyphosate or cultivation treatment was applied on 20.10.00 when bindweed had emerged on most plots. The whole site was then rotary hoed again on 7.11.00 and the maize (cv. Pioneer 36H36) planted two days later. After planting, a pre-emergence treatment of acetochlor + atrazine (2.5 + 1.5 kg/ha) was applied on the same day over the whole site for control of annual weeds. Individual plots were 15 m x 3 m arranged in a randomised block design with four replicates. Visual assessments of weed control and crop damage were made at regular intervals. Pink bindweed DM was measured in October (before pre-planting treatments were applied) and February from two 0.1 m² quadrats in each plot. Grain yield was determined by harvesting cobs from 5 m lengths of each of the two centre rows on 9.5.01; final yields are adjusted to 14% moisture content.

In all four trials the herbicide treatments were applied with a CO₂ powered precision sprayer in 300 litres/ha water. For all pre-emergence applications the sprayer was set up with six 80° nozzles at 500 mm spacing and 210 kPa pressure. For the post-emergence applications the sprayer was set up with four 110° nozzles at 750 mm spacing and 330 kPa pressure and the treatments applied inter-row. The data collected from all trials were subjected to ANOVA to separate the means. The observational data and crop yield data were analysed unmodified but the weed dry matter data were transformed [$\log(x + 0.01)$] before analysis to reduce heterogeneity of variance, with back-transformed means presented in the tables.

RESULTS AND DISCUSSION**Fish-tail oxalis**

In Trial 1 the pre-emergence treatment of acetochlor (2.5 kg/ha) reduced the number of emerged oxalis leaves by around 50% compared to that in the untreated areas (counts on 15.12.99). The post-emergence herbicides resulted in 95-99% reduction in DM of oxalis, except for dicamba (300 g/ha) which reduced the growth only by 75% (data not presented). The efficacy of imazethapyr + imazapyr was independent of the rate (100 to 300 g/ha + 1.0% Hasten) and nicosulfuron (60 – 80 g/ha) proved equally effective with or without the recommended adjuvant, Amaze Activator (0.5%). Dicamba did not adequately control the emerged oxalis and did not prevent further plants from emerging.

For Trial 2 the data collected on maize leaf area, maize plant height, maize DM, weed DM and fish-tail oxalis were used to examine the two main interactions, viz. cultivar and herbicide treatment. Only the data collected at the end of growing season are presented in Table 1. To evaluate the effects of the different traits, the two pairs of cultivars should be considered separately. The accelerated early season growth of Pioneer 3730 (vs Pioneer 3751) was expected to result in greater shading and thus slow the establishment of oxalis. The consequence of slower establishment was expected to be lower production of oxalis DM and number of bulbs throughout the season. Similarly the long Staygreen trait of Pioneer 33G26 (vs Pioneer 33R87) was expected to provide extra shade and thus inhibit bulb production at the end of the season. Unfortunately these expected results were not apparent for fish-tail oxalis bulb production or bulb dry weight (Table 1). However, the principles did apply to other weeds present in the plots (mainly fathen) as the production of these weeds was lower in both the Pioneer 3730

and 33G26 treatments (Table 1). In fact this could have worked against our stated aim, with the reduced weed competition (from weeds other than oxalis) allowing for greater growth of the fish-tail oxalis.

TABLE 1: Main effects for maize cultivars and herbicide treatments on growth of maize plants, weeds and fish-tail oxalis in Trial 2.

Treatment	Maize plant on 19.2.01			Weed DM ¹ (kg/ha) on 24.1.01	Oxalis bulbs on 17.4.01	
	Height (m)	Leaf area (m ²)	DM (g)		DM (kg/ha)	No. (/m ²)
Maize cultivars						
Pioneer 3730	2.55	0.350	141.1	2069	239	813
Pioneer 3751	2.19	0.331	135.8	2778	239	680
Pioneer 33G26	2.47	0.385	126.5	1472	452	1101
Pioneer 33R87	2.43	0.322	121.1	2208	318	933
LSD (P<0.05)	0.29	0.058	41.1	320	145	427
Herbicide treatments						
None	2.08	0.260	88.6	6379	483	1332
Acetochlor + atrazine ²	2.70	0.423	170.6	12	298	729
Atrazine + nicosulfuron ³	2.40	0.344	134.2	4	80	359
LSD (P <0.05)	0.18	0.042	23.7	1409	176	319

¹Dry matter of all weeds other than fish-tail oxalis.

²Both herbicides applied pre-emergence.

³Atrazine applied pre-emergence and nicosulfuron post-emergence.

As would be expected, in the absence of any weed control, maize plants were smaller, lighter and had less leaf area than those in the plots treated with acetochlor + atrazine pre-emergence (Table 1). In the third herbicide treatment, the pre-emergence atrazine did not control atrazine-resistant fathen, resulting in some competition for maize plants, but the fathen was controlled by post-emergence nicosulfuron. The effects of this early season growth check on the crop lasted throughout the season (Table 1). By January there were very few weeds in these plots and they remained weed free for the rest of the season. By the end of season the acetochlor + atrazine treatment had reduced oxalis bulb numbers by about 45% and bulb dry matter by about 40%. The atrazine + nicosulfuron treatment reduced bulb numbers and dry matter by 73% and 83% respectively. The overall efficacy of herbicides on oxalis was similar to that recorded in Trial 1.

Pink bindweed

The best treatment for long-term control of pink bindweed in Trial 3 was imazethapyr + imazapyr (Table 2). The fastest acting treatment was the desiccant bromoxynil (Emblem) which showed dramatic burning of the bindweed within a few days of treatment. As a non-systemic herbicide it allowed significant regrowth, but by this time the maize crop was well advanced and the consequent shading appeared to limit the regrowth of bindweed. When used in combination with nicosulfuron, the long-term efficacy of bromoxynil was lower than when used in combination with atrazine. Nicosulfuron was also very effective at both rates when used in combination with the

recommended adjuvant, Amaze Activator. These treatments allowed some regrowth but final bindweed dry matter was less than 1% of that of untreated plots. Dicamba also effectively controlled the top growth of bindweed and provided residual activity to prevent regrowth. Clopyralid (Versatill) did not provide adequate control. None of the treatments caused any apparent damage to the maize crop and no maize yields were significantly different from untreated despite different levels of bindweed present. Normally bindweed will interfere with mechanical harvesting but as these plots were hand harvested, this interference did not occur.

TABLE 2: The effect of various herbicide treatments on pink bindweed and final maize yields in Trial 3.

Post-emergence treatment ¹	Rate (g ai/ha)	% bindweed control			Bindweed DM ² (kg/ha)	Grain yield (t/ha)
		23.12.99	17.1.00	29.2.00	1.3.00	9.5.00
Untreated	-	0	0	0	745.1 a	9.52
imaze/imaza ³	52.5/17.5	81	99	98	0.8 fgh	10.28
imaze/imaza ³	79.8/26.2	77	100	99	0.6 h	8.03
imaze/imaza ³	158/52.5	85	99	99	0.4 h	10.59
bromoxynil	400	86	74	88	13.9 cd	7.67
brom + atrazine	400 + 1500	93	75	90	9.7 de	10.09
brom + nicosulfuron	400 + 40	86	78	88	61.9 cd	9.48
dicamba	300	94	93	96	2.3 efg	10.46
clopyralid	300	15	60	66	218.6 ab	10.99
Nicosulfuron ⁴	60	88	81	92	6.7 de	10.92
Nicosulfuron ⁴	80	73	89	91	3.1 def	8.56
Nicosulfuron	80	51	76	70	167.8 abc	10.33
LSD (P<0.05)		12.2	10.2	9.0		2.14

¹All these treatments were additional to pre-emergence acetochlor at 2520 g ai/ha.

²Values followed by the same letter do not differ significantly (P<0.05).

³Imazethapyr + imazapyr + the adjuvant Hasten 1%.

⁴Plus Amaze Activator 0.5%.

In Trial 4 infestation by bindweed immediately before the pre-planting treatments was lower in plots that were mulched and covered with trash than in plots that were either left undisturbed but treated with glyphosate or were cultivated (Table 3). Later observations suggest that this was probably not due to partial control but rather that the bindweed was slower to emerge in the mulched plots due to the insulating layer of trash keeping soil temperatures lower. The combined effects of both the post-harvest and pre-planting treatments are presented in Table 3. Analysis of the main effects showed that the post-harvest treatments had no significant effect on the growth of bindweed the following season. Conversely, the pre-planting treatments did have a significant effect and there was a 60% reduction in the amount of bindweed on plots treated with glyphosate compared to those that were cultivated. The combination of post-harvest mulching followed by pre-planting glyphosate was the least effective because less bindweed emerged in these plots for treatment in spring.

TABLE 3: Pink bindweed control and dry matter production, and maize grain yields in Trial 4.

Post-harvest treatment	Pre-planting treatment	Bindweed DM ¹ (kg/ha) 17.10.00	Bindweed control ² 19.1.01	Bindweed DM (kg/ha) 26.2.01	Grain yield (t/ha) 9.5.01
Mulch	Cultivate	219	1	1755	10.4
Mulch	Glyphosate	273	2	1274	10.4
Cultivate	Cultivate	699	1	2339	12.6
Cultivate	Glyphosate	664	3	755	11.8
Glyphosate	Cultivate	584	1	2231	11.2
Glyphosate	Glyphosate	552	4	531	11.4
LSD (P< 0.05)		309	-	1534	1.8

¹Amount of bindweed present when the pre-planting treatments were applied.

²Bindweed control on a 1-5 scale where 1 = no control.

This study showed that selective control of both pink bindweed and fish-tail oxalis is possible through the use of certain herbicides, although this could require more than one growing season. The post-emergence herbicides provided much better efficacy on both weeds. Of these, the commercial mixture of imazethapyr + imazapyr can only be used in imidazolinone tolerant (IT) maize cultivars. Furthermore, this herbicide mixture as well as nicosulfuron must be used with the recommended adjuvant for best results. The cultural control options evaluated (viz. cultivar selection for oxalis and mulching/cultivation for bindweed) did not prove effective in these trials.

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