EFFECTS OF GLYPHOSATE ON OXALIS LATIFOLIA

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Summary

The foliage from bulbs of *oxalis latifolia* (*Oxalis latifolia*) planted in October 1974 was sprayed with glyphosate 1.5 kg/ha at different times between mid-December 1974 and mid-March 1975. All spray applications controlled foliar growth almost completely for the remainder of the season. The early treatments produced the least bulbils but even in the earliest there was a 17-fold increase in numbers. Glyphosate treatments were repeated for two further seasons and a final assessment made at the end of the fourth season when bulbil numbers had increased 185-fold on the most effective treatment compared with 1280-fold with no treatment.

INTRODUCTION

Some *Oxalis* species form bulbs — a characteristic almost unique in dicotyledonous plants. This ability accounts for the success of *oxalis latifolia* as a troublesome and usually uncontrolled weed in intensive horticulture. The plant has a versatile vegetative reproductive system including a contractile tuberous root connected to the parent bulb which facilitates the dispersal of the numerous bulbils formed each season. The growth pattern in New Zealand was first described in detail by Jackson (1960) and more recent studies in Kenya by Chawdry (1974) confirm its cosmopolitan nature.

With the exception of complete soil sterilization, chemical or other control measures meet with only moderate success because a natural infestation contains a mixture of 'ecological individuals' (Sagar and Mortimer 1976) consisting of bulbs and bulbils of various ages, many of which will be dormant at the time of treatment.

Initial tests at Levin Horticultural Research Centre showed that glyphosate actively controlled foliar growth. This paper describes the effectiveness of applications at various stages in the first season of growth of the parent bulb and follow-up treatments in succeeding years.

EXPERIMENTAL METHODS

First season (1974-75)

In late October 1974 plots 1 m x 1 m in size were marked out in a six-replicate randomised block layout on an area which had been previously sterilized with methyl bromide to provide weed free conditions for the trial. To facilitate subsequent retrieval of plants the soil in each plot was removed to a depth of 15 cm and a piece of woven polypropylene sacking was placed across the bottom and up the sides of the excavation. The soil was then replaced, made firm and level and planted with medium sized, graded bulbs of 13-17 mm diameter and 1.66 g average weight. Each plot contained 16 regularly spaced bulbs at 5 cm depth.

Glyphosate 1.5 kg/ha in 700 litres/ha was applied, using a modified

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Cambrian pressure sprayer (Cox 1974) at four different times, as follows:

- Treatment 1, sprayed 13 December 1974
- Treatment 2, sprayed 13 January 1975
- Treatment 3, sprayed 13 February 1975
- Treatment 4, sprayed 13 March 1975
- Treatment 5, unsprayed

As an indication of growth, petiole and peduncle counts were taken at intervals. At the end of the season, in June when the plants were dormant, half plots in one replicate were excavated and the below-ground parts extracted. These were washed, dried and separated into the following categories. Bulbil size grades were chosen arbitrarily.

1. Contractile tuberous roots. These would be expected to have served their purpose of supplying water and nutrients for new bulbils by this time and their remains were probably not all retrieved.
2. Parent bulbs. Usually these were fibrous remains, without fleshy scales, attached to the base of large new bulbils.
3. Large bulbils. Greater than 11 mm diameter.
 - (a) Loose bulbils, scales opening at centre top when squeezed. These had probably already produced leaves during the season.
 - (b) Firm bulbils, tightly closed. It is unlikely that these had produced leaves so far.
4. Small bulbils. As in 3(a) and (b) but smaller than 11 mm diameter.

Second and third seasons (1975-76 and 1976-77)

Treatments 1 to 4 were completely resprayed on four further occasions:

- 5 December 1975
- 10 February 1976
- 8 December 1976
- 14 February 1977

Leaf emergence was assessed at each time of spraying.

Fourth season (1977-78)

No further application of glyphosate was made and no assessments were made until the end of the growing season. In April 1978 a sample half plot of treatment 2 was dug. The tubers, bulbs and bulbils present were sorted and compared with material from a similar sized untreated area.

RESULTS

First season (1974-75)

Leaves began to emerge during the second half of November. The seasonal growth pattern to which treatment dates can be related is shown in Fig. 1. In early December bulbs had produced several leaves and were just beginning to flower. Treatment 1 was applied at the beginning of a rapid growth period for both leaves and flowers in mid-December. A week after application, treated leaves had become chlorotic and were withering. Usually the peduncles collapsed more rapidly than the leaf petioles. After a further week negligible live foliage or flowers were present. Although the rate of development of symptoms varied by a few days following different times of application, the development of effects on above ground parts of the plant was similar.

A month after applying treatment 1 negligible regrowth was to be seen. In this period of maximum flowering, mid-January, treatment 2 was applied. After a further month, in mid-February when flowering had almost finished, it was noted that there was hardly any growth on either treatment 1 or 2. Treatment 3 was applied. The same sequence of chlorosis

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FIG 1: Seasonal growth pattern of oxalis latifolia in first season.

and collapse of foliage resulted and by mid-March no growth was to be seen on any of the treated plots. Without treatment, leaf production continued to increase until this time.

Treatment 4 was applied in mid-March as the period of natural die-back began. After a further 3 weeks all treated leaves were dead. Only the earliest treatment showed any regrowth (six leaves per plant). By the middle of May senescence on all plots was almost complete.

An analysis in June of underground organs produced during the season is summarised in Table 1. Treatment 1 gave the smallest increase, 140 new bulbils originating from eight parent bulbs. Succeeding treatments resulted in increasing numbers with a maximum of 1911 from the unsprayed treatment. By far the greatest increase in all treatments was of small, firm bulbils. Increasingly more of the eight parent bulbs remained at the end of the season the later treatments were applied, with all eight bulbs being retrieved from the unsprayed treatment.

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TABLE 1: Separation of underground organs of oxalis latifolia present at end of first season. Numbers originating from eight planted bulbs per treatment. (See text for definition of categories.)

Glyphosate, 1.5 kg/ha applied :-	Tubers	Parent bulb remains	Large new bulbils		Small new bulbils		Total new bulbils
			Loose	Firm	Loose	Firm	
13 Dec 1974	0	2	2	5	6	127	140
13 Jan 1975	0	3	1	3	11	273	288
13 Feb 1975	0	6	7	7	9	356	379
13 Mar 1975	0	7	15	25	28	779	854
Untreated	4	8	12	69	11	1819	1911

Second and third seasons (1975-76 and 1976-77)

With the exception of treatment 4 in February 1976 all sprayed treatments produced substantially less foliage than untreated (Table 2). By the time of the final glyphosate application on 14 February 1977 leaf counts on treatments 1 and 2 were very low compared with treatments 3 and 4.

TABLE 2: Foliage growth of oxalis latifolia at time of glyphosate applications in second and third seasons. Petiole numbers as means per original bulb and, in brackets, expressed as % of untreated.

Initial Treatment	Second season applications		Third season applications	
	5 Dec 75	10 Feb 76	8 Dec 76	14 Feb 77
13 Dec 1974	19 (25)	31 (23)	9 (8)	9 (8)
13 Jan 1975	3 (4)	18 (13)	2 (2)	3 (2)
13 Feb 1975	8 (11)	45 (34)	12 (10)	39 (33)
13 Mar 1975	20 (27)	85 (64)	26 (22)	41 (35)
Untreated	75 (100)	133 (100)	117 (100)	118 (100)

Fourth season (1977-78)

Judging by foliage growth, treatments 1 and 2 appeared to be having the greatest effect so a final comparison was made of the underground organs of treatment 2 and untreated (Table 3). In treatment 2 the number of tubers, parent bulbs and new bulbils originating from eight bulbs planted 3½ years previously was 41, 18 and 1480 respectively. Without treatment, the comparable figures were 491, 997 and 10268. In the untreated plot, relatively more parent bulbs were found. In both plots small, firm bulbils accounted for over 90% of the total number of new bulbils.

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TABLE 3: Separation of underground organs of *oxalis latifolia* present at end of fourth season. Numbers originating from eight planted bulbs per treatment. (See text for definition of categories.)

Glyphosate Treatment	Tubers	Parent bulb remains	Large new bulbils		Small new bulbils		Total new bulbils
			Loose	Firm	Loose	Firm	
Treatment 2 followed by two applications in second and two in third season.	41	18	13	20	58	1389	1480
Untreated	491	997	24	16	894	9334	10268

DISCUSSION

The results of this work can be considered in two main parts. Firstly the effects were determined of applying glyphosate to the foliage of a known population of *oxalis latifolia* plants at different growth phases. At the end of the growing season it was shown that the herbicide applied early, i.e. up to the time of full flowering, had the greatest effect on bulbil production in that year. Leaf production was still increasing rapidly at the end of the flowering period but the application made when the plants were in full foliage had much less effect on the number of bulbils formed. Although there was apparently little regrowth during the season from any of the applications, the most effective early glyphosate treatment still resulted in a 17 to 18-fold increase in number of new bulbils. This can be compared with an increase almost 240-fold with no glyphosate.

The investigations from the start of the second season concerned the effect of glyphosate treatments applied to the foliage of mixed populations. It is not known to what extent underground bulbs and bulbils of different size and age germinated at different times.

In the second and third seasons glyphosate was applied once early (as suggested by the previous year's results) and again in February when some regrowth had appeared from the heterogeneous population. At the time, this programme was considered to be as severe as could be administered in practice. The final assessment was made in the fourth season by comparing the 'best' treatment so far (as judged by foliage growth in the second and third season) with no treatment. These now contained bulb numbers which had multiplied 185 and 1280 times, respectively, since planting. In retrospect, it seems unfortunate that no glyphosate was applied during the fourth season during which the weaker infestation would have recovered to some extent after the spray programme of the previous three years.

Glyphosate is probably the most active foliar herbicide available against *oxalis latifolia* but this work has demonstrated the difficulty of containing bulb production even when leaf growth was greatly reduced. When glyphosate was applied to the foliage following first introduction of the plant vegetative multiplication was reduced but not prevented. After the plant has become established and new bulbs are formed it is most unlikely that all will be in leaf at any one time. Thus, the timing of foliar sprays for best effect becomes increasingly difficult. The control finally

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obtained was incomplete and it remains to be determined whether a programme of repeat spraying can be devised to suppress an established infestation of the weed adequately.

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