Seedbank management of *Orobanche ramosa* in South Australia

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Summary Branched broomrape, *Orobanche ramosa* is a parasitic weed in Australia and has been the subject of an extensive quarantine effort in South Australia. A program to evaluate control options relevant to eradication has been underway since 2002. Studies on the seed bank decline in Australian conditions show that seed viability is slowly declining after four years. The soil drench Bio-Seed Eradicator® appears to reduce germination in broomrape seed and Basamid® also causes loss of viability by stimulating lethal germination. Many herbicides and adjuvants have been tested with complete suppression of emergence from some products. Herbicide tolerant canola and a herbicide tolerant annual medic have great potential as better herbicide options are available.

Keywords *Orobanche ramosa*, branched broomrape, seedbank, soil fumigation, Bio-Seed Eradicator®.

INTRODUCTION

Orobanche ramosa L. (branched broomrape) is a parasitic weed confined to the south eastern Murray Mallee region of South Australia. It has a wide range of hosts from various genera within the families Asteraceae, Brassicaceae and Fabaceae (Jupp *et al*. 2002). Many weedy species from these families infest the crop land and the eucalyptus scrubland in the area of infestation.

The persistence of *O. ramosa* populations is due to high levels of seed production from individual plants and the longevity of seeds in the soil. Field studies were initiated to monitor the decline of the seed bank with frequent retrieval of packaged seed samples.

The use of herbicides to prevent germination or emergence can be effective if the range of herbicides is appropriate to the local land use and management objectives. Herbicides that inhibit the synthesis of nucleic acids or their precursors are the most effective. A number of trials were also undertaken to evaluate herbicide effectiveness.

MATERIALS AND METHODS

Seed bank decline Mature seed from *O. ramosa* was collected from mature capsules and packaged in stainless steel 100 μ mesh envelopes. A number of seeds were packaged with 5 g of sieved seed-free soil and buried at one site, 2 cm and 5 cm deep (site 1) and at 5 cm and 10 cm at another site (site 2). Sixty packets were buried in three replicate areas at each depth in a typical soil environment. Potential host plants were controlled by weeding or contact herbicide. Samples were retrieved twice annually from the sites, air dried, sieved and counted. Sub-samples were counted and tested for germination with GR24, a known germination stimulant.

Herbicide trials Herbicides were applied to twice replicated plots with an ATV mounted sprayer with water carrier. Plots of cereals, canola, legume crops, legume pasture were established and volunteer pasture with a natural infestation of *O. ramosa* were treated with herbicides.

RESULTS

Seed bank studies Seed was retrieved at times shown in Table 1. Germination of a sub-sample and visually assessed numbers of intact seeds in each packet are shown in Tables 1 and 2.

Herbicide trials Herbicides that gave 100% suppression of emergence are shown in Table 3. Herbicides listed have given consistent results for each of five seasons except where indicated.

'Angel' medic is an annual medic developed by the CRC for Australian Weed Research and the South Australian Research and Development Institute, it is a registered variety now marketed by 'Seed-Mark' South Australia. It was developed to exhibit tolerance to herbicides that inhibit the synthesis of acetolactate synthase. These herbicides are effective for the suppression of germination and development of broomrape species because of the potent inhibition of the developing tubercule and haustorium. Identifying effective herbicides for the suppression of broomrape in conventional medic based or volunteer pastures is problematic and the tolerance of Angel medic to effective rates of the listed herbicides has been adequate to sustain useful levels of dry matter

Table 1. Viability of seed from buried packets 2003–2006.

Sampling times	Mean germination (%) ± SD			
	Site 1 2 cm	Site 1 5 cm	Site 2 5 cm	Site 2 10 cm
Pre burial	78.7 ± 4.8	78.7 ±4.8	78.7 ± 4.8	78.7 ± 4.8
Mar-03	69.0 ± 4.9	73.6 ± 10.5	n/a	n/a
Oct-03	*43.0 ± 22.5	*32.3 ± 28.4	*22.3 ± 12.0	*30.33 ± 27.5
Mar-04	*59.0 ± 12.4	*50.0 ± 8.6	*35.3 ± 29.9	*68.7 ± 23.29
Oct-04	73.3 ± 14.4	86.0 ± 1.7	74.7 ± 7.2	n/a
Mar-05	78.7 ± 14.7	76.7 ± 18.9	53.0 ± 21.0	61.3 ± 18.18
Nov-05	75.0 ± 7.9	79.8 ± 2.6	61.9 ± 7.7	56.1 ± 13.51
Nov-06	75.63 ± 4.6	83.23 ± 7.7	45.13 ± 23	13.87 ± 7.95
Mar-07	79.47 ± 12	79.43 ± 15	69.4 ± 4.1	52.53 ± 29.9

*Assessment of seed viability was affected by infestations of soil fungi which proliferated during the germination process.

Table 2. Number of viable seeds retrieved from buried seed packets, 2003–2006.

Sampling times	Mean seed number ± SD			
	Site 1 2 cm	Site 1 5 cm	Site 2 5 cm	Site 2 10 cm
Pre burial	1200	1200	2800	2800
March 04	959 ± 300.1	882.7 ± 303.5	2209.0 ± 156.0	2301.3 ± 84.3
October 04	1144.33 ± 415.1	1010.3 ± 211.6	2674.3 ± 464.8	2492.7 ± 70.6
March 05	1126.33 ± 296.4	1131.3 ± 169.9	2074.0 ± 970	2684.6 ± 96.0
Nov. 05	1241.3 ± 38.07	822.3 ± 398.5	2736.0 ± 333.9	2221.33 ± 752.4
Nov-06	1293.67 ± 212.5	1223.33 ± 369.05	2453.33 ± 750.85	2543.00 ± 772.46
Mar-07	1170 ± 298	1398 ± 470	2542 ± 197	2517 ± 264

production, seed production for regeneration, and ground cover.

Aerial application of herbicides Aerial application and ground application of herbicides has recently been undertaken by the Broomrape Eradication Task Force of the SA Department of Water, Land and Biodiversity Conservation to reduce the emergence of broomrape in areas not managed or otherwise not amenable to owner operator management. The area treated in 2007 is shown in Table 4. The area comprises about 7000 ha of Crown or public land. Herbicides are usually applied in July and August as conditions permit and the success rate is displayed in Table 4. 22.89% of unsprayed paddocks had broomrape emerge in 2007. Failure to suppress emergence is usually related to inadequate coverage on sprayed area edges or persistence of broomrape hosts.

Table 5 lists the herbicides applied to paddocks in the quarantine area and the usefulness at suppressing broomrape emergence.

Table 3. Herbicides that consistently gave 100% suppression of broomrape emergence.

Crop	Herbicides
Cereals	chlorsulfuron
	metsulfuron methyl
	triasulfuron
	iodosulfuron
	sulfosulfuron
	metosulam
Clearfield canola	imazapic + imazapyr
	imazamox + imazapyr
Lupin	metosulam
Vetch	pyrithiobac sodium[A]
Field peas	imazethapyr
Legume pastures	
Medicago sp. 'Angel'	imazapic + imazapyr
	imazamox + imazapyr
	triasulfuron
Lucerne	imazethapyr
All crops and pastures	glyphosate

[A] Pyrithiobac sodium has been trialled for two seasons only.

Table 4. Details of aerial and ground herbicide application in the quarantine area.

	Area (ha)	Paddocks (#)	Broomrape emerged	Emerged %
Aerial	5830	143	18	12.6
Ground	4237	94	10	10.6
Hand	11	10	1	10.00
Total	10,078	233	29	12.40

Table 5. Effectiveness of and herbicides applied in the quarantine area.

Herbicides used Aerial application	Paddocks (#)	Broomrape emerged	Emerged %
Ally 3 g ha^{-1}	65	8	13.80
Ally 5 g ha^{-1}	41	4	9.70
Broadstrike 30 g ha^{-1}	28	6	21.40
Broadside ground application	1	0	0.00
Ally 5 g ha^{-1}	23	2	8.70
Ally mixtures	2	0	0
Broadstrike 30 g ha^{-1}	26	4	15.30
Glyphosate (various)	22	2	9.10
Other	43	5	12

DISCUSSION

Eradication of *O. ramosa* depends upon stopping plant emergence or stopping seed set, in association with either active or passive reduction of the number of seeds in the soil. The longevity of seeds in the soil is an important consideration when planning eradication and canvassing support for the eradication effort. Methods to stop seed production need to be compatible with the favoured land-use during the period of eradication and with maintenance of sufficient ground cover on the fragile soils to minimise erosion. Longevity of *Orobanche* sp. has been reported to be from 12–20 years (Linke and Saxena 1991). Our trials (Tables 1 and 2) indicate that loss of seed viability is not rapid and therefore a sustained effort is required to reduce the number of seeds in the soil. Work on reducing the viability of seed in the soil with Basamid and BioSeed Eradicator is continuing. The previously reported trials with these products (Matthews *et al*. 2006) are continuing and improved application methods and analysis of efficacy is being undertaken.

The use of selective herbicides has been most effective in reducing the numbers of and the seed production from *O. ramosa*. The herbicides listed have given complete control of emergence in at least five seasons. The application rates of the herbicides fall within the range of product recommendations when used as in crop selective herbicides. In some cases the herbicides are used as a part of a mixture to reduce weed numbers for adequate crop yield response but otherwise as an application targeted against broomrape emergence. Care needs to be exercised with herbicide carryover effects on subsequent crop or pasture performance. Herbicide application to public or Crown land has been effective in suppressing emergence and seed return to mostly inaccessible or poorly managed areas. To eradicate branched broomrape from the area every effort must be made to prevent seed production for as long as the viable seed remains in the earth.

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