

Eradication of three-horned bedstraw (*Galium tricornutum*) in Western Australia

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Summary There are five known locations of three-horned bedstraw in Western Australia. Economic analysis indicated a high benefit to cost ratio for an eradication program. This paper outlines the history and the development of the processes required to eradicate this weed from Western Australia. The eradication program is tailored to the individual situations in consultation with the land owner and industry. Control costs and loss of production caused by the infestation or control program are funded by government on behalf of the industry until new legislation takes effect. The various strategies used, their effectiveness and costs are discussed. The importance of early detection of infestations is emphasised and sampling of grain to assist early detection is proposed.

Keywords Three-horned bedstraw, *Galium tricornutum*, control, Western Australia, herbicides.

INTRODUCTION

Three-horned bedstraw (*Galium tricornutum* Dandy) is a declared plant in Western Australia and the focus of an eradication campaign. Plants have been found on eight properties in four shires. Three of these had active infestations in 2007. One occupies less than 1 ha, the second is scattered over several paddocks and along fencelines, and the last is widespread over several hundred hectares on one farm. A paddock on a fourth property is in quarantine, but no three-horned bedstraw has been found there for two years.

The cost of the eradication program has been approximately \$140,000 year⁻¹ in control and other costs, and the compensation paid for lost income has been similar.

HISTORY

1968 Boddington Three-horned bedstraw plants collected in 1968 were believed to have originated from contaminated pasture seed. There have been no further reports of plants from there since then.

2001 Mount Barker Twenty plants covering an area of less than 1 ha were found in November 2001 and the paddock was quarantined. Plants were removed by hand and the debris collected by vacuum cleaner. Three-horned bedstraw seeds were also found in screenings from peas harvested from a different part of

the infested paddock. In 2002 the paddock was sprayed in winter with Broadstrike® plus diuron and grazed. From 2003 to 2004 the paddock was grazed with no other control. In 2005 triazine tolerant canola was planted and 1 kg a.i. ha⁻¹ of atrazine was applied pre-plant and repeated post emergence. One three-horned bedstraw seed per tonne of canola grain was found in the screenings. In 2006, the paddock was planted to barley and sprayed with 300 g a.i. ha⁻¹ of bromoxynil plus 300 g a.i. ha⁻¹ of MCPA early post emergence and again at the late tillering stage of the crop. No three-horned bedstraw was found in the paddock or in the harvested grain. In 2007 the paddock was planted to imadazolinone tolerant canola and treated with 16.5 g a.i. ha⁻¹ imazamox, 7.5 g a.i. ha⁻¹ imazapyr plus 60 g a.i. ha⁻¹ clopyralid for three-horned bedstraw control, 17 days after planting.

2003 Cordering Seed was found in lupin samples from a Cordering farm in January 2003. Inspections in September revealed a widespread infestation covering approximately 340 ha on one farm. Plants were also found around silos on two other farms and in a paddock on a third farm where contaminated lupins had been fed to stock. These areas were quarantined and subsequently released after no more plants were found. Barley on the main property was sprayed with 280 g a.i. ha⁻¹ bromoxynil plus 280 g a.i. ha⁻¹ MCPA in October and all grain was sent for export overseas in 2003.

In 2004 and 2005, some infested paddocks were cropped to oats (for stock feed) and others were grazed. Infested paddocks generally received a single herbicide application, while some paddocks were also spray-topped late in the season. Three-horned bedstraw continued to be found and little progress was made in reducing the infestation.

In 2006 a group comprising the farmer, Department of Agriculture and Food, Western Australia (DAFWA) and industry representatives was formed to manage the eradication program at Cordering. The whole farm of 1000 ha was aerial sprayed with 32 g a.i. ha⁻¹ flumetsulam plus 90 g a.i. ha⁻¹ diuron plus 1% spray oil in July. Inspections in August revealed that a second germination had occurred and the infested paddocks were then sprayed with 200 g a.i. ha⁻¹ fluroxypyr

plus 625 g a.i. ha⁻¹ 2,4-D amine in October (a total of 340 ha). The rest of the farm, where no three-horned bedstraw had been found, was sprayed with 32 g a.i. ha⁻¹ flumetsulam plus 90 g a.i. ha⁻¹ diuron plus 1% spray oil as a precautionary measure. In October, a few plants were found that had set seed which did not germinate when tested in Petri dishes, but a tetrazolium test showed that some seeds were viable. Paddocks were monitored by satellite (Pasture Watch®) to determine the effects of three-horned bedstraw control on pasture production.

In 2007, the infested paddocks were shallowly cultivated to encourage germination of the three-horned bedstraw and grasses at the break of the season, and 100 kg ha⁻¹ of ammonium sulphate was applied to increase grass competition with the weed. These areas had little clover as a result of their cropping history and the application of fluroxypyr. The whole farm was again aerial sprayed with 32 g a.i. ha⁻¹ flumetsulam plus 90 g a.i. ha⁻¹ diuron plus 1% spray oil. Spraying was delayed until late June because the dry start caused plant stress. A trial area was treated in early July with 10 g a.i. ha⁻¹ aminopyralid plus 140 g a.i. ha⁻¹ fluroxypyr (Hotshot®) and 10 times these rates to test efficacy and effects on pasture. A follow up spray of Hotshot plus 0.5% spray oil was applied to the heavily infested areas in mid August. Inspections in October revealed no plants on the Hotshot treated areas, but many plants were found on the areas that had only received flumetsulam plus diuron. These areas were sprayed with 200 g a.i. ha⁻¹ of fluroxypyr plus 200 g a.i. ha⁻¹ bromoxynil plus 200 g a.i. ha⁻¹ MCPA plus 1% oil. Areas that had clover present and a history of three-horned bedstraw were sprayed with 300 g a.i. ha⁻¹ bromoxynil plus 300 g a.i. ha⁻¹ MCPA plus 1% oil, while areas with no history of the weed were sprayed with 16 g a.i. ha⁻¹ flumetsulam plus 90 g a.i. ha⁻¹ diuron plus 1% oil. Areas treated with Hotshot in August were resprayed with 300 g a.i. ha⁻¹ bromoxynil plus 300 g a.i. ha⁻¹ MCPA plus oil as an insurance spray, with a small area left for monitoring. Portions of the infested paddocks that did not receive the August spray and the most heavily infested areas were sprayed with 132 g a.i. ha⁻¹ fluroxypyr plus 300 g a.i. ha⁻¹ bromoxynil plus 300 g a.i. ha⁻¹ MCPA plus 1% oil. In October three-horned bedstraw was found scattered over 2 ha in one paddock and a few plants in the second, whereas plants were found in five of the six infested paddocks the previous October

2004 Hines Hill Three-horned bedstraw seeds were detected in barley grain samples in November 2004. The paddocks were quarantined and the grain delivered for export overseas. The infested area was centred on

a holding paddock where stock were often unloaded from trucks; this is the most likely means of introduction. The infested area covered about 25 ha, with a single outlying infestation of several plants about 600 m away in a neighbouring paddock where kangaroos passed through a fence line. Mouldboard ploughing was attempted the following winter, but the soil was too clayey for effective seed burial. Multiple spraying with glyphosate on the infested areas was used to create a chemical fallow. Surrounding paddocks were sprayed with bromoxynil plus MCPA.

Inspections in spring 2005 revealed plants on most of the infested area. Glyphosate was reapplied to these areas. Barley grain from adjacent paddocks was exported. In 2006, three-horned bedstraw plants were found over an area of 688 m² in a crop that had been sprayed with bromoxynil plus MCPA. Seed was collected and the area sprayed out with glyphosate. Less than 1% of the seed germinated, but a tetrazolium test showed that more seed was viable.

In 2007, infested areas and surrounding crops were sprayed with glyphosate or bromoxynil plus MCPA. Most of the infested area was green manured in October. No three-horned bedstraw plants were found in the infested areas or surrounding paddocks at the end of 2007 season.

2005 Cranbrook Three-horned bedstraw plants were found growing in an oat crop over an area of approximately 1 ha in August 2005. No plants were found on the rest of the farm. A 2 ha area was sprayed out with glyphosate. Oats from the rest of the paddock were exported overseas.

In 2006, the paddock was planted to imadazolinone tolerant canola and treated with 24.75 g a.i. ha⁻¹ imazamox plus 11.25 g a.i. ha⁻¹ imazapyr as Intervix® at the cotyledonary stage of the canola. A follow up spray was recommended, but was not applied by the farmer. In September, three-horned bedstraw plants were found in the infested area and 1350 g a.i. ha⁻¹ paraquat plus 1150 g a.i. ha⁻¹ diquat was applied to the infested 2 ha. Contour banks and areas under trees were sprayed with 500 g a.i. ha⁻¹ imazapyr. In October plants that had survived the paraquat plus diquat were hand-weeded. The surrounding canola grain was graded and no three-horned bedstraw seeds were found in the screenings, indicating that the rest of the paddock contained no three-horned bedstraw.

In 2007 the paddock was grazed. Half of the infested area was treated with 33 g a.i. ha⁻¹ imazamox plus 15 g a.i. ha⁻¹ imazapyr (Intervix), while the other half was treated with 10 g a.i. ha⁻¹ aminopyralid plus 140 g a.i. ha⁻¹ fluroxypyr (Hotshot) in early July. No three-horned bedstraw plants were found in 2007.

DISCUSSION

The three-horned bedstraw infestations are widely separated in WA and there appear to be no links between the main infestations. Trace backs of possible sources have not revealed any other infestations in WA, even though the Cordering and Hines Hill infestations were identified initially by the detection of seed in grain. Forward tracing from the Cordering infestation identified four other properties that had received contaminated feed grain, allowing effective eradication measures to be implemented. In Cordering, the infestation had probably been present for many years and has been spread between cropping paddocks, probably by harvesting machinery (Monjardino *et al.* 2004).

Spread from crop to pasture paddocks by vehicles or stock is very limited, with only one instance caused by kangaroos traversing a fence.

Infestations were discovered more easily and economically by sampling harvested grain than by undertaking exhaustive inspection of paddocks for plants. At Mount Barker in two instances three-horned bedstraw seeds were found in grain that had come from areas where no plants had been found by visual inspections. Planting a crop and sampling the grain is a cost effective way of monitoring.

Active intervention by an individual or by an organisation that has weed eradication as a primary goal has generally been required to achieve the very high levels of control needed for the eradication program. An area is deemed to be free of three-horned bedstraw if no plants or seeds are found for three consecutive years. Small infestations are likely to be eradicated within a five year program with active intervention, but far longer if left solely to the landholder. Medium infestations at Mount Barker and Hines Hill are likely to achieve eradication in 5–10 years. Larger or widespread infestations, such as at Cordering, will require a high level of active intervention if there is to be a reasonable chance of eradication within 10 years.

Monitoring of the program and flexibility in response are essential for high levels of control. Several germinations of three-horned bedstraw over the season have been observed at all active sites. Early germinating plants can set seed before late germinants emerge. At least two post emergent sprays or residual products are required.

The WA bedstraw eradication program includes aminopyralid and imadazolinones which are providing good residual control. Hand weeding is used at the end of the season to remove escapees. Farmer actions such as surveillance, green manuring and small scale spraying of any patches missed during contract spraying has also contributed to high levels of control

and the prevention of seed set. In some areas nitrogen application and early cultivation have been utilised to increase competition from grasses and encourage three-horned bedstraw germination. Broadstake plus diuron is applied by air on the 'clean' areas of the farm because it has little effect on pasture production, it reduces the risk of establishment of transported seed, and it covers all areas including bushland that cannot be sprayed by ground sprayers. APVMA permits are required for some circumstances. The importance of using a range of techniques and maintaining landholder involvement cannot be overemphasised.

The cost of the three-horned bedstraw control program has been around \$250,000 year⁻¹. Economic analysis (Edward and Kingwell 2003) estimated the cost of eradication to be several orders of magnitude less than a 'do nothing strategy'. With updated total costs of control over a 12 year period being around \$3m (including compensation paid) the benefit to cost ratio is still greater than 100.

The general trend in WA has been to find a new three-horned bedstraw infestation every one or two years and the rate of clearance of properties is similar. This means that WA is likely to have four to eight properties undergoing active eradication programs at any one time.

Increased surveillance and sampling of grain are cost effective ways of finding new infestations and determining if neighbouring properties are infested. Grain sampling provides some confidence that there are no large unknown infestations in the district that could affect the costs of the control program or noticeably reduce the benefit to cost ratios.

Payment for lost income is unusual in biosecurity programs, but was required in this case to maximise landholder support and voluntary reporting of new infestations. At present, the WA Government is paying compensation costs on behalf of the main agricultural industry organisations. WA's new Biosecurity and Agriculture Management legislation will enable industry to raise and disburse compensation funds in future.

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