Tedera tolerance of herbicides and small crumbweed control

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Summary Tedera (*Bituminaria bituminosa* C.H. Stirton) is a new perennial leguminous pasture being developed for broadacre agriculture in Western Australia. Weed control around planting is required for reliable establishment especially in areas where small crumbweed (*Dysphania pumilio* (R.Br.) Mosyakin & Clemants) occurs. Small crumbweed is an allelopathic, Western Australian native plant that is spreading across Australia as a weed of crops and pastures. Young tedera showed useful tolerance to diflufenican, flumetsulam, glyphosate, imazamox, terbutryn, a bromoxynil plus diflufenican mix, a bromoxynil plus MCPA mix and an amitrole plus paraquat mix as spring applications in a Mediterranean environment in South Western Australia. These herbicides all provide around 90% control of small crumbweed with less than 10% damage to the tedera. No product tested provided complete control of small crumbweed without damage to the tedera.

Imazethapyr was also well tolerated by tedera but did not provide small crumbweed control. Atrazine, cyanazine and metribuzin were also tested but were generally too damaging to the tedera at normal label rates.

As there are no herbicides specifically registered for use in tedera pastures, this work provides an indication of which products could be targets for the production of registration packages. This paper reports the results of an experiment where 12 herbicides were applied with a logarithmic sprayer to determine the dose response of young tedera and small crumbweed.

Keywords Amitrole, atrazine, *Bituminaria bituminosa*, bromoxynil, control, crumbweed, cyanazine, flumetsulam, diflufenican, *Dysphania pumilio*, glyphosate, herbicide, MCPA, metribuzin, imazamox, imazethapyr, paraquat, tedera, terbutryn, weed.

INTRODUCTION

Tedera (*Bituminaria bituminosa* C.H.Stirton var. *albomarginata* and var. *crassiuscula*) is a perennial pasture legume introduced from the Mediterranean, Canary Islands and Macaronesia. It is being developed as a pasture species for Mediterranean climate areas with broadacre agriculture in Western Australia.

Currently there are less than 100 ha under cultivation for seed production and research in Western Australia. Winter weeds have hampered establishment of tedera planted in autumn to early winter and summer weeds like small crumbweed (*Dysphania pumilio* (R.Br.) Mosyakin & Clemants) and pigweed (*Portulaca oleracea* L.) hamper establishment when the tedera is planted in spring.

There are no herbicides registered specifically for tedera but a number of products are registered for use in legume based pastures or other closely related crops from the Fabaceae family (Moore and Moore 2014).

Imazethapyr (Spinnaker®) and imazamox (Raptor®) are imidazolinone (group B) herbicides. Within this group the tolerance of legumes varies widely. Spinnaker has a range of registrations in other legumes for both pre and post emergence applications, however it would need a new use registered before it could be commercially used on tedera. Raptor is registered for use in 'legume based pastures' and with a minor label change could include tedera.

Flumetsulam (Broadstrike®) is a sulfonamide herbicide and also from group B. It is registered on a wide range of leguminous pastures and crops.

Atrazine (Atradex®), cyanazine (Bladex®) and terbutryn (Igran®) are triazine herbicides and metribuzin (Metribuzin 750®) is from the closely related triazinone group. Atradex is registered for post emergence control of 'mintweed' in established lucerne. It is efficacious on small crumbweed which is often referred to as mintweed due to its minty odour. Bladex is registered for post emergence use in field peas and can damage some other legume species. It is not registered for pastures. Igran is registered for use on pastures containing Balansa (*Trifolium balansae* Boiss.), white (*Trifolium repens* L.) and subterranean (*Trifolium subterranean* L.) clovers. A minor label change could suffice if it is useful in tedera. Metribuzin is registered in various legume crops for post emergence weed control but not on pastures.

Alliance is a mixture of amitrole (group Q) and paraquat (group L) and is not registered for post emergence use on pastures, however its poor efficacy on legumes may allow acceptable control of susceptible weeds at low rates.

Diflufenican (Brodal®) is a nicotinanilide (group F) herbicide that is registered for use on clover pastures and some grain legume crops.

Jaguar® and Buctril® MA are mixtures of bromoxynil with diflufenican or MCPA respectively. Bromoxynil is a nitrile (group C) herbicide, closely related to the triazines and MCPA is a phenoxy (group I) or hormone herbicide. Bromoxynil plus diflufenican (Jaguar®) is registered for use in lucerne and clover pastures. Bromoxynil plus MCPA (Buctril MA®) is not registered for use on legume pastures but has been used on cereals undersown with clover.

Glyphosate is a glycine (group M) herbicide that has poor efficacy on many legumes at low rates. It is registered for pasture topping and pasture manipulation with no withholding period being required.

A search of CAB abstracts found no work on the efficacy of herbicides on tedera. However, some work has been done as agricultural projects and trials within the Department of Agriculture of Western Australia (Kelly 2008, Moore and Snowball 2010, Snowball and Moore 2010 and Gray 2011).

Small crumbweed (*Dysphania pumilio* formerly *Chenopodium pumilio* R.Br.) is a summer growing annual herb to 30 cm tall with a minty odour. It is sometimes erect but often sprawling or ground-hugging. It usually germinates after spring or summer rains and has dense clusters of tiny flowers in autumn and dies off with the onset of cold weather in winter. It is a Western Australia native species which is widespread throughout Australia and has become a weed of pastures, gardens and agriculture. It is often incorrectly called mintweed or goosefoot. It is allelopathic and reduces the germination and growth of crop and pasture plants.

This experiment tested the tolerance of seedling tedera and small crumbweed to various rates of broad leaf controlling herbicides in order to determine which were the most selective.

MATERIALS AND METHODS

The site for this experiment was on a 12 week old stand of tedera that was heavily infested with small crumbweed near Kojonup, Western Australia (37.9° S, 117.3° E). The tedera was planted on 28 August 2013 and was 10–15 cm tall with 10–25 leaves on the day of spraying (20 November 2013). The temperature was 20°C with 20% RH. The soil was dry at the surface, moist at 10 cm deep and a few tedera plants had a slight wilt. The small crumbweed was 2–25 cm wide/tall and plants ranged from seedlings with just cotyledons to plants with up to six branches and with many leaves. The herbicides were applied with a logarithmic sprayer over the range of rates shown in Table 1. These rates went from above normal use rates to well below normal use rates. All products were applied in 170 L ha^{-1} water with 0.25% organosilicone adjuvant (Pulse®) using 110-02 flat fan nozzles at 30.5 cm spacing on a boom travelling at 4.8 km h^{-1}.

Table 1. The products, active ingredients and rates used in the experiment.

Product	Active ingredients	Product applied
Alliance	Amitrole 250 g L^{-1} + paraquat 125 g L^{-1}	200–2000 mL ha^{-1}
Atragranz	Atrazine 900 g kg^{-1}	100–1000 g ha^{-1}
Bladex	Cyanazine 900 g kg^{-1}	200–2000 g ha^{-1}
Broadstrike	Flumetsulam 800 g kg^{-1}	20–200 g ha^{-1}
Brodal	Diflufenican 500 g L^{-1}	50–500 mL ha^{-1}
Buctril MA	Bromoxynil 200 g L^{-1} + MCPA 200 g L^{-1}	200–2000 mL ha^{-1}
Igran	Terbutryn 500 g L^{-1}	100–1000 mL ha^{-1}
Jaguar	Bromoxynil 250 g L^{-1} + diflufenican 25 g L^{-1}	200–2000 mL ha^{-1}
Metribuzin	Metribuzin 750 g kg^{-1}	100–1000 g ha^{-1}
Raptor	Imazamox 700 g kg^{-1}	20–200 g ha^{-1}
Roundup CT	Glyphosate 450 g L^{-1}	200–2000 mL ha^{-1}
Spinnaker	Imazethapyr 700 g kg^{-1}	50–500 mL ha^{-1}

The plots were 1.5 m wide by 20 m long, allowing two rows of tedera to be sprayed with one row unsprayed between plots. This helps when assessing the plots visually for damage ratings. The distance along each plot where there was 0, 10, 50 90 and 100% reduction in growth was visually assessed for the tedera and small crumbweed four weeks after spraying on 18 December, eight weeks after spraying on 15 January and 12 weeks after spraying on 18 February. These distances were then converted to the corresponding herbicide dose.

To determine relative selectivity the dose required to provide 90% control of small crumbweed was divided by the dose that caused 10% damage to the tedera. The absolute doses that provided varying degrees of damage to tedera were also calculated.

Data were analysed using the analysis of variance procedures in the DRC package in R.

RESULTS

Tedera tolerance Broadstrike, Raptor and Spinnaker all tolerated the maximum rate applied with less than 10% visual damage to the tedera (Table 2). Brodal, Buctril MA and Jaguar were also well tolerated with the maximum rate applied causing less than 50% damage to the tedera. Alliance, Atragranz, Bladex, Igran, Metribuzin750 and Roundup CT produced a

good range of responses by tedera over the range of rates tested and dose response curves were fitted using the DRC package in R. These are shown in Figure 1.

The estimated dose that caused less than 10% damage to the tedera is shown in Table 2.

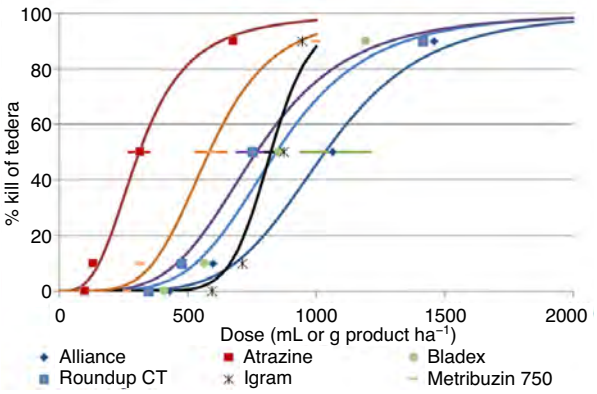

Figure 1. The response of tedera to various doses of six herbicides. (Solid lines are the fitted curves. Horizontal bars at the 50% kill level are the ED50 ± SE).

Table 2. The selectivity of products for control of small crumbweed in tedera.

Herbicide	Tedera tolerance ED10[1]	Weed kill ED90[2]	Selectivity
Alliance	682^{ef}	674^{e}	1.01^{c}
Atragranz	154^{a}	968^{f}	0.16^{d}
Bladex	529^{d}	>2000^{h}	<0.26^{d}
Broadstrike	>200^{a}	100^{a}	>2.00^{a}
Brodal	283^{b}	321^{c}	0.88^{c}
Buctril MA	1357^{g}	1480^{g}	0.92^{c}
Igran	664^{f}	650^{e}	1.02^{c}
Jaguar	1589^{g}	1659^{g}	0.96^{c}
Metribuzin	363^{c}	848^{f}	0.43^{d}
Raptor	>200	141^{b}	>1.42^{b}
Roundup CT	457^{d}	450^{d}	1.02^{c}
Spinnaker	>500	>500	?
LSD			0.30

Treatments with the same letter in each column are not significantly different (P <0.05). For shading: Green (■) = good, Yellow (■) = marginal and Red (■) = poor selectivity.

[1] Effective dose in g or mL (product) ha^{-1} for 10% reduction in growth.

[2] Effective dose in g or mL (product) ha^{-1} for 90% control.

Small crumbweed control None of the products tested provided 100% control of small crumbweed with no visual effect on the tedera. However 10 products gave 90% control within the rates tested. Of these, six had marginal selectivity and two (Broadstrike and Raptor) had good selectivity. The rates required for 90% control are greater than the maximum label rates in Australia, so permits would be required for application. Only suppression of small crumbweed would be expected at maximum label rates of Broadstrike or Raptor.

Products with higher selectivity numbers are safer or more selective than those with lower numbers. Broadstrike and Raptor had good selectivity. Alliance, Brodal, Buctril MA, Igran, Jaguar, Igran and Roundup CT all gave about 90% control of small crumbweed with less than 10% damage to the tedera. Imazethapyr was also well tolerated by tedera but did not provide small crumbweed control. Atragranz, Bladex and Metribuzin750 were generally too damaging to the tedera at normal label rates to warrant further investigation.

Ratings taken four and eight weeks after treatment were similar to those presented here, which were taken 12 weeks after treatment.

DISCUSSION

Good control of small crumbweed in spring planted tedera was achieved with eight of the products tested. After the four week rating the rest of the field was treated with 40 g ha^{-1} Broadstrike + 1% Uptake spray oil and this provided commercially acceptable control with little damage to the tedera. The choice of herbicide will be affected by many factors however these results indicate that several herbicides can provide adequate levels of control. Products containing diflufenican may be chosen where residual control is desired. Other products may be chosen depending on other weeds that may be present together with small crumbweed at other sites. For instance low rates of glyphosate may be chosen because it will suppress a large number of weeds and is cheap if the grower is willing to accept some growth reduction in the tedera.

Kelly (2008) also had Broadstrike and Brodal in her experiments and reported no significant differences between the treated plants and the controls which is consistent with this work. Similarly Snowball and Moore (2010) had good tolerance to Jaguar, Raptor and Spinnaker on young autumn sown tedera.

The low tolerance of tedera to Atragranz, Bladex and Metribuzin750 means that these products are not likely to be useful in most situations. However, none of

the products tested provided complete control of tedera for situations where control of tedera may be required. The highest rates tested of Alliance, Atragranz, Bladex or Roundup CT provided 90% control of this seedling stand, however control of established stands would need further testing.

ACKNOWLEDGMENTS

The assistance of Chris Oldham, Daniel Real and Eric Dobbe, use of the property of David and Lyn Mathwin and funding from the Department of Agriculture and Food Western Australia and Meat and Livestock Australia is gratefully acknowledged.

- Alliance is a trademark of Nufarm Australia Limited.
- Atragranz is a trademark of Nufarm Technologies USA Pty Ltd.
- Bladex is a trademark of AgNova Technologies Pty Ltd.
- Broadstrike is a trademark of Dow AgroSciences.
- Brodal, Buctril and Jaguar are trademarks of Bayer.
- Igran is a trademark of Syngenta Participations AG.
- Raptor and Spinnaker are trademarks of BASF
- Roundup is a trademark of Monsanto Technology LLC.

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