Gorse control using ultra low volumes of herbicides and unmanned aerial vehicles

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Summary Unmanned aerial vehicles such as quadcopters or remote controlled helicopters offer the potential to control weeds in difficult-to-access or dangerous situations but are limited by small payloads. Ultra low volume application of concentrated herbicide applied with controlled droplet applicators provides a solution. The effectiveness of this technology was tested on gorse which is a declared plant under eradication in WA and occurs in difficult situations. Very concentrated solutions of glyphosate, metsulfuron, triclopyr or triclopyr plus picloram applied at ultra low volumes with a spinning disk controlled droplet applicator were just as effective as high volume applications. Adding an organosilicone adjuvant improved the efficacy of glyphosate and metsulfuron but had little effect on the hormone herbicides, triclopyr and triclopyr plus picloram mixes.

Keywords Control, CDA, controlled droplet applicator, glyphosate, gorse, helicopter, herbicide, metsulfuron, picloram, quadcopter, triclopyr, *Ulex europaeus*, ULV, ultra low volume, UAV, unmanned aerial vehicle.

INTRODUCTION

Gorse (*Ulex europaeus*) is a prickly shrub introduced from Europe in the 1800s and has become a Weed of National Significance (WoNS) in Australia due to its invasiveness, impacts, potential for spread and effects on socioeconomic and environmental values. It was originally planted for hedges, fodder and ornamental uses (Gouldthorpe *et al.* 2009).

It currently infests 23 million hectares in the temperate climates of southern Australia. In Western Australia and in some localities in other states, it is the focus of eradication campaigns under the National Gorse Taskforce strategy (Moore and Kennewell 2010). To achieve eradication, plants that occur in very difficult locations need to be treated and aerial application of herbicides is a cost effective solution.

In the latter stages of an eradication program finding the last few gorse plants and treating them is also greatly assisted by aerial operations because all the easy-to-access plants have generally been found and controlled. Small unmanned aerial vehicles can carry small quantities of herbicide and rotary winged craft can apply it accurately because they can hover over single bushes. Applying herbicide with very little or no carrier means that more area may be treated with a given payload. It also allows cameras and other equipment to be carried to monitor operations or find new infestations using image analysis (Moore and Moore 2010).

Glyphosate, metsulfuron, picloram and triclopyr are all registered for the control of gorse when applied as a spray with one hundred to several thousands of litres of water as a carrier. (Moore and Moore 2012). Garlon® is registered for use on blackberry using controlled droplet applicator (CDA) equipment with about 30 L ha^{-1} water as a carrier. A search of CAB abstracts found no literature on the efficacy of herbicides being applied with very little or no carrier on gorse.

MATERIALS AND METHODS

A small quadcopter was built and fitted with a Micron Herbi spinning disk controlled droplet applicator (CDA). This produces droplets in the 200 micron VMD range. Flow rates are determined by the viscosity of the liquid herbicide, the size of a restricting orifice and pressure (or head for gravity- fed systems). In this experiment, a fixed quantity of herbicide was prepared and spraying was continued over a 5 m by 2 m plot until it had all been used because the product and adjuvants under test had a wide range of viscosities (Table 1).

Four herbicides were applied at two rates with and without Pulse® (an organosilicone surfactant) using CDA equipment. These were compared with the same herbicides applied using conventional high volume spraying or unsprayed control plants as shown in Table 2. One additional treatment of Tordon DS® at the high rate with Pulse® using a CDA was also applied because this product is formulated with amine forms of triclopyr and picloram and can be used in restricted spraying areas. The herbicide rates were those recommended for gorse and ten times these rates.

All treatments were applied on March 10, 2011. There were 3 replicates of each treatment and 12 unsprayed control plots. The herbicides are listed by their product or trade name because the formulation

affects the viscosity which affects the performance of the controlled droplet applicator (CDA).

Liquid herbicides were applied without dilution or carrier. Brush-Off® was mixed in 17.5 mL water plus 2.5 mL Pulse® for the CDA plus Pulse® treatments or 5 mL water for the low rate or 10 mL water for the high rate treatments without adjuvant. High volume treatments were applied in 1000 L ha^{-1} of water plus 2.5 L ha^{-1} Pulse® using a hand held wand.

Treatments were scored using the European Weed Research Council (EWRC) 1 to 9 rating system where 1 = complete control, 3 = acceptable control and 9 = no control. Ratings were taken 7, 20 and 57 weeks after spraying.

Data were analysed using the analysis of variance procedures in Genstat.

Table 1. The herbicides and active ingredients used.

Product	Active ingredients
Garlon®	600 g L^{-1} of triclopyr as the butoxyethyl ester
Grazon Extra®	300 g L^{-1} triclopyr as the butoxyethyl ester
	100 g L^{-1} picloram as the hexyloxypropylamine salt.
	8 g L^{-1} aminopyralid preset as the hexyloxypropylamine salt
Brush-Off®	600 g kg^{-1} metsulfuron-methyl
PowerMAX®	540 g L^{-1} of glyphosate as the potassium salt
Tordon DS®	200 g L^{-1} triclopyr as the triethylamine salt
	100 g L^{-1} picloram as the triisopropanol-amine salt
Pulse®	Organosilicone surfactant

RESULTS

Ratings taken at 7 weeks after treatment did not reflect longer term levels of control. Ratings taken at 20 weeks after treatment showed the greatest levels of control. Significant regrowth and/or emergence of seedlings had occurred on some treatments by 57 weeks after treatment. As this gave a better indication of the long term level of control from a single spray these are the main results presented.

Grazon Extra® and Tordon DS® applied without carrier by CDA at high rates provided complete control 57 weeks after application. Garlon® applied by CDA at high rates also provided complete control of established plants when rated 20 weeks after treatment but by 57 weeks after treatment some seedlings were present. At normal rates with Pulse®, gorse control using the CDA was not significantly different to that achieved using the high volume sprayer. Grazon Extra® provided good levels of gorse control in all the treatments tested.

The organosilicone adjuvant, Pulse®, increased the efficacy of PowerMAX® and Brush-Off® but had no significant effect on the hormone herbicides, Garlon® or Grazon Extra®, when applied using a CDA. Generally, gorse control improved as the rate of herbicide increased though this was not significant for Grazon Extra®.

For high volume spraying, Grazon Extra® was the most effective product at recommended rates when assessed 57 weeks after treatment. However all high volume treatments received EWRC ratings of 3–3.3 when assessed 20 weeks after spraying.

DISCUSSION

Good control of gorse can be achieved by applying very concentrated herbicides with little or no carrier.

Table 2. The herbicides, methods of application, rates and adjuvant used in the experiment and European Weed Research Council (EWRC) ratings of control 57 weeks after application.

Treatment	Hi Vol, Normal rate + Pulse®	CDA, Normal rate	CDA, Normal rate + Pulse®	CDA, High rate	CDA, High rate + Pulse®
Garlon®	4.3de	6.2fgh	5.8efgh	1.2ab	2.0ab
Grazon Extra®	2.7bc	2.0ab	2.0ab	1.0a	1.0a
PowerMAX®	6.0fgh	6.3gh	5.7efg	5.3efg	3.7cd
Brush-Off®	4.7def	7.3hi	5.3efg	5.2defg	2.7bc
Tordon DS®					1.0a
Nil	7.9i	7.9i	7.9i	7.9i	7.9i

CDA = Controlled Droplet Applicator. Hi vol = High volume application.
Normal rate = 5 L product ha^{-1} for Garlon®, 10 L product ha^{-1} for PowerMAX® and Grazon Extra® and 100 g product ha^{-1} for Brush-Off®.
High rate = 50 L product ha^{-1} for Tordon DS® and ten times the normal rate for other products.
EWRC rating 1 = complete control, 9 = no control.
LSD = 1.59. Treatments followed by the same letter are not significantly different ($P < 0.05$).

This gives small UAVs the ability to control significant areas of gorse with payloads of a few kilograms. Grazon Extra® at rates of 10 L ha^{-1} or Garlon® at 50 L ha^{-1} applied without carrier or extra adjuvants are expected to provide high levels of control. 1 kg ha^{-1} of Brush-Off®, 100 L ha^{-1} PowerMAX® and 50 L ha^{-1} Tordon DS® also provided high levels of control when applied with Pulse® using CDA equipment. It is expected that Tordon DS® would not need the adjuvant and behave similarly to Grazon Extra® and Garlon® because they are closely related herbicides. This, together with lower rates, requires testing.

The choice of herbicide will be affected by many factors however these results indicate that several herbicides can provide high levels of control when applied in very concentrated forms. Products containing picloram such as Grazon Extra® or Tordon DS® may be chosen where residual control is desired. Metsulfuron may be chosen where large areas need treating at minimum cost and glyphosate products may be chosen for use in sensitive areas.

For application by small UAVs the weight of Grazon Extra® or Brush-Off® plus water plus Pulse® per hectare was similar in the treatments tested here. Research is required to determine if Brush-Off® can be applied in less water or applied as a powder and possibly with a powdered adjuvant. The rate response of the other products needs to be defined more accurately and at different times of the year as spring is generally considered to be the best time to spray rather than autumn as in this experiment.

These results could also be used for treating scattered bushes with hand held CDA equipment where water supplies are limited. It is probably not suitable for treating large infestations by hand held CDA equipment because of the need to fly over the infestation to achieve good levels of coverage.

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Garlon®, Grazon® and Tordon® are trademarks of DowAgrosciences.

Brush-Off® is a trademark of DuPont.

PowerMAX® is a trademark of Monsanto Australia Limited.

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