Assessment of flupropanate tank mixtures: compatibility with other herbicides

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Summary Serrated Tussock (ST) commonly occurs together with thistles and other broadleaf weeds in pastures. Herbicide labels for flupropanate do not state what herbicides it is compatible with. The mixtures of Flupropanate with broadleaf selective or knockdown herbicides which were tested, were physically compatible. The Flupropanate and broadleaf selective herbicide mixtures were also effective in controlling ST and broadleaf weeds, which indicated biological compatibility. Tank mixing for the control of Chilean needle grass (CNG) and broadleaf weeds is not conclusive at this stage.

The findings in this paper provide an outline of the use of chemicals in a manner that is not specified on the product label. Further work needs to be undertaken in conjunction with the Australian Pesticide and Veterinary Medicines and product registrants to obtain off-label permits or product registration.

Keywords Serrated tussock, Chilean needle grass, flupropanate, tank mixing, selective herbicides.

INTRODUCTION

Unpalatable grasses such as serrated tussock (ST) (*Nassella trichotoma* (Nees) Arech.) and Chilean needle grass (CNG) (*Nassella. neesiana* Trin. & Rupr.) are Weeds of National Significance due to their agricultural and environmental impacts (Thorp and Lynch 2000). These unpalatable grasses commonly grow in pastures that are also affected by broadleaf weeds. Once the density of both of these grass weeds are beyond the point of spot spraying, boom spraying is generally used. Although flupropanate is registered for the control of ST and CNG in pastures, it does not affect broadleaf weeds, necessitating a second application with a broadleaf herbicide. Tank mixing two or more herbicides is a useful practice that is extensively used in intensive agriculture aiming: to broaden the spectrum of weed control; to improve efficacy of the combined herbicides, to delay herbicide resistance development in weed populations; or to reduce herbicide rates and consequently to reduce the cost of weed control (Damalas 2004). The effects of tank mixing flupropanate and broadleaf selective herbicides are unknown, with regard to the physical compatibility of the mixtures, or the biological compatibility of the mixtures on their respective targets. Generally interactions between herbicides after mixing are more frequently antagonistic than synergistic (Zhang *et al.* 1995).

This paper outlines the herbicide mixing compatibility of flupropanate with knockdown or broadleaf herbicides and their efficacy against ST, CNG and a range of broadleaf species.

MATERIALS AND METHODS

Herbicide mixtures used in this trial were chosen after discussions with affected land managers, weed control contactors in the Sunbury area (Victoria) and from findings of a series of farmer-led workshops (Grech 2011).

Mixing of herbicides For the following tests, herbicides were mixed in the spray tank/vessel with agitation—they were not mixed in the measuring jug. Wettable granules were added to the mix first, whilst flupropanate was always the first of the liquid herbicides to be added. Adjuvants were added to the tank mix last.

Herbicide stability The physical compatibility of the herbicide mixtures was measured over a 24 h period in replicated laboratory experiments. Flupropanate (745 g ai L^{-1} as Taskforce®) was mixed at a rate equivalent to 2 L ha^{-1} in two dilutions to simulate both ground spraying (150 L ha^{-1} water) and aerial spraying (40 L ha^{-1} water). These mixtures were then mixed with a range of broadleaf selective chemicals and adjuvants, as well as with glyphosate (Table 1). Photos were taken periodically of each mixture and each water rate, to see whether the mixture was clear, cloudy or had separated over the 24 hour time.

Herbicide mixture biological compatibility glasshouse trials on live plants Both CNG and ST plants were grown in glasshouse conditions together with broadleaf weeds including saffron thistle (*Carthamus* *lanatus* L.), St Barnaby's thistle (*Centaurea solstitialis* L.), artichoke thistle (*Cynara cardunculus* L.) and variegated thistle (*Silybum marianum* L.). All plants were potted in separate pots and were sprayed with herbicide mixtures at 150 L ha^{-1} rates of water (Table 2).

Statistical analysis Plant damage caused by the herbicide mixture was measured on a scale of 0 (not affected) to 9 (dead). Each plant was classified as 'dead' if damage score was 9, or 'severely affected' if the damage score was 7, 8 or 9 at 202 days after application (DAA). These two classifications were analysed as logistic generalised linear models with Bernoulli errors and with terms for replicate: flupropanate added (yes or no), species (ST or CNG), flupropanate added within ST (yes or no), flupropanate added within CNG (yes or no), type of broadleaf herbicide within serrated tussock species (none vs Hammer® vs Brushoff® vs Terbutyrn) and type of broadleaf herbicide within CNG species (none vs Hammer® vs Brushoff® vs Terbutyrn).

Chi-square analysis of deviance tests are presented for the effects of type of broadleaf herbicide within ST and CNG species, after adjusting for other terms in the model. These tests have 3 degrees of freedom. It should be noted that the tests for broadleaf herbicide effects are only applicable for the situation where flupropanate was added.

RESULTS

Stability assessments showed that most flupropanate and broadleaf or knockdown herbicide mixtures were stable at either water rate tested (Table 1).

CNG spayed with Flupropanate alone was severely affected but did not completely die. Similarly,

Table 1. Flupropanate mixtures and results from physical compatibility laboratory analysis. Active 1 was flupropanate as Na salt (745 g L^{-1}) at 2 L ha^{-1}.

Treatment	Rate/ha (mL or g)	Compatibility 40 L ha^{-1}	Compatibility 150 L ha^{-1}
MCPA as dma (750g/L)	700 & 1300	S	S
MCPA as dma (750g/L) + Metsulfuron-methyl (600g/kg)	1300 + 15	CS	CS
2,4-D as dea/dma (625g/L)	1000 & 2000	PS	S
2,4-D as dea/dma (625g/L) + Metsulfuron-methyl (600g/kg)	2000 + 15	CS	CS
Metsulfuron-methyl (600g/kg)	8 & 15	S	S
Clopyralid as tipa (300g/L)	300 & 600	S	S
Clopyralid as tipa (300g/L) + MCPA as dma (750g/L)	300 + 1300	S	S
Clopyralid as tipa (300g/L) + 2,4-D as dea/dma (625g/L)	300 + 2000	S	S
2,4-D as tipa (300g/L) & Picloram as tipa (75g/L)	300 & 600	S	S
2,4-D as tipa (300g/L) & Picloram as tipa (75g/L) + MCPA as dma (750g/L)	300 +1300	PS	S
2,4-D as tipa (300g/L) & Picloram as tipa (75g/L) + 2,4-D as dea/dma (625g/L)	300 + 2000	PS	S
Carfentrazone-ethyl (400g/L)	20 & 45	CS	CS
Carfentrazone-ethyl (400g/L) + MCPA as dma (750g/L)	45 +1300	CS	CS
Carfentrazone-ethyl (400g/L) + 2,4-D as dea/dma (625g/L)	45 + 2000	CS	CS
Terbutryn (275g/L) & MCPA as K salt (160g/L)	1500 & 3000	PS	PS
Glyphosate as K salt (540g/L)	1000	S	S

Footnote – S = stable, CS = cloudy + scummy, PS = particles + sediments after 24 hours.

Table 2. Flupropanate mixtures used for the biological compatibility glasshouse analysis – all include flupropanate (745 g L^{-1}) at 2 L ha^{-1}.

Mixture	Active	Trade name used	Rate used
Mixture 1	Carfentrazone-ethyl (200g/L)	Hammer	75ml/ha
	MCPA as dma (750g/L)	Thistle killem 750	1.3l/ha
	Alcohol alkoxylate (1000g/L)	BS1000	0.1ml/l
Mixture 2	Metsulfuron-methyl (600g/kg)	BrushOff	5g/ha
	MCPA as dma (750g/L)	Thistle killem 750	1.3l/ha
	Alcohol alkoxylate (1000g/L)	BS1000	0.1ml/l
Mixture 3	Terbutryn (275g/L)+MCPA as K salt (160g/L)	Agtryne MA	1.5l/ha

CNG sprayed with the flupropanate plus broadleaf herbicides mixtures did not die (Table 3). Antagonism interactions with herbicide mixtures are more common with monocots than with dicots (Zhang *et al.* 1995). ST sprayed with flupropanate alone completely died and was severely affected by the flupropanate and broadleaf mixtures, except the Terbutryn mixture. Generally all thistles were affected by the mixtures.

Table 3. Flupropanate biological compatibility of tank mixtures with broadleaf herbicides on CNG, ST and thistles, measured by weed death or severely affected at 202 DAA.

Herbicides	Deaths	Severely affected
Chilean needle grass		
Flupropanate only	1/4	3/4
No herbicide	0/4	0/4
Flupropanate with:		
Hammer, Thistle Killem 750 & BS1000	0/3	0/3
Brushoff, Thistle Killem 750 & BS1000	0/3	0/3
Agtryne MA	2/3	2/3
Serrated tussock		
Flupropanate only	4/4	4/4
No herbicide	0/4	0/4
Flupropanate with:		
Hammer, Thistle Killem 750 & BS1000	2/3	2/3
Brushoff, Thistle Killem 750 & BS1000	2/3	3/3
Agtryne MA	1/3	2/3
Thistles		
Flupropanate with:		
Hammer, Thistle Killem 750 & BS1000	11/12	11/12
Brushoff, Thistle Killem 750 & BS1000	11/12	11/12
Agtryne MA	10/12	12/12

DISCUSSION

Flupropanate was compatible when tank mixed with the knockdown herbicides and compatible with most of the broadleaf selective chemical mixtures. Even those that produced sediments or separated out of the mixture (e.g. Agtryne MA) were easily resuspended and proved to be efficacious.

CNG was not effectively controlled by flupropanate mixtures with broadleaf chemicals or on its own at 2 L ha^{-1}. This is despite CNG being known to be susceptible to flupropanate at rates as low as 1.5 L ha^{-1} (Grech *et al.* 2008). Further investigation is needed.

CONCLUSION

This trial found that that flupropanate and broadleaf selective herbicide tank mixtures tested were stable and effective in controlling ST and the listed broadleaf weeds simultaneously. Tank mixing for the control of CNG and broadleaf weeds is not conclusive at this stage. Other factors that also require further investigation include the effect of tank mixing on grazing withholding periods and the use of different chemical rates to compensate for antagonistic effects of tank mixing.

The findings of this trial will be used to consult with the APVMA and investigate opportunities to obtain an off-label permit, and it is hopeful that product registration may also be arranged so that these chemicals can be used to control unpalatable grasses and broad leaf weeds together with time and money savings to farmers as a consequence.

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