Florasulam + clopyralid for broad spectrum broadleaf weed control in winter cereals in southern Australia

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Summary In 2007 Dow AgroSciences registered florasulam + clopyralid as Torpedo™ herbicide (50 g florasulam + 300 g clopyralid L^{-1}) for broadleaf weed control in winter cereals. This combination of active ingredients provides good control of many key weeds including wild radish (*Raphanus raphanistrum* L.), Indian hedge mustard (*Sisymbrium orientale* L.), turnip weed (*Rapistrum rugosum* (L.) All.), spiny emex (*Emex australis* Steinh.), capeweed (*Arctotheca calendula* (L.) Levyns), bedstraw (*Galium tricornutum* Dandy) and volunteer legumes, with excellent cereal selectivity and flexibility for rotational crops.

This paper summarises research trials to confirm cereal selectivity, weed control efficacy and crop rotation flexibility of this product.

Keywords Florasulam, clopyralid, efficacy, broadleaf weeds, control, selectivity, cereals, plantback.

INTRODUCTION

In 1993 the triazolopyrimidinyl sulfonanilide herbicides were first released in Australia (Downard and Webb 1993, Phimister and Downard 1993) and metosulam and flumetsulam were commercially released the year after. Florasulam was subsequently developed by Dow AgroSciences and is now registered in more than 30 countries.

Florasulam has both soil and foliar activity, but use is generally limited to post-emergence application due to an extremely short soil half life. Florasulam is highly selective to cereals and has activity on weeds in the plant families Asteraceae, Polygonaceae, Fabaceae and Brassicaceae.

Florasulam displays herbicidal activity at very low doses, resulting in low environmental impact. Initial registered Australian rates are 3.75–5 g a.i. ha^{-1}.

Florasulam has been combined with a low dose of clopyralid to complement the control of key southern broadleaved weeds, without compromising the crop rotation flexibility from potential residue carryover. Together they provide excellent control of the important broadleaved weeds of southern Australian cereals.

The two active ingredients formulated together as Torpedo™ herbicide have a wide window of application (Zadoks 13–31). Torpedo Herbicide is also compatible with commonly used broadleaf herbicides such as metsulfuron, bromoxynil or MCPA, which help broaden the spectrum of weed control.

MATERIALS AND METHODS

Research trials were conducted in all mainland states of Australia to determine cereal selectivity, weed efficacy and crop rotation safety.

Formulations and adjuvants Initial trials used a tank mix of florasulam as either a suspension concentrate (SC), or water dispersible granule (WDG) and clopyralid as a soluble liquid (SL). In 2004 florasulam + clopyralid was formulated as an SC, with concentrations of 50 g a.i. + 300 g a.e. L^{-1}. Treatments were applied with non-ionic surfactant (either Agral 60 at 0.1% v v^{-1} or BS-1000 at 0.1–0.2% v v^{-1}) or emulsifiable crop oil (Uptake™ spraying oil at 0.5% v v^{-1}).

Selectivity trials Cereal selectivity trials were conducted on research farms, with treatments applied to preplanted cereal crops. Varieties chosen were those that were commonly grown in each state. Treatments were applied at the three leaf cereal stage. Applications were made with either hand held small plot sprayers with 3 m booms and six flat fan spray tips at 50 cm spacings, or with tractor powered sprayers, to plots that were 3 to 6 m × 10–50 m or similar. Three or four replicates of each treatment were used in each trial. Total spray volume was 60–100 L ha^{-1}. Torpedo herbicide was applied at 100 and 200 mL ha^{-1} alone or with MCPA, bromoxynil/MCPA or metsulfuron.

Crop injury was taken by subjective visual assessment at about 7, 14 and 28 days after application (DAA) with 100% representing complete crop loss. Grain yield was taken at normal harvest and converted to percent of untreated control.

Crop rotation trials Crop rotation trials were conducted on either commercial farms or Dow AgroSciences research farms. Treatments were applied to cereal crops in the season prior to planting susceptible rotational crops and timed to ensure either a six month planting interval for northern Australia or nine months for southern Australia.

Susceptible crops planted in northern Australia were canola (*Brassica napus* var. *napus* L.), chickpea (*Cicer arietinum* L.), cotton (*Gossypium hirsutum* L.), sunflower (*Helianthus annuus* L.), lucerne (*Medicago sativa* ssp. *sativa* L.) and sorghum (*Sorghum bicolor* (L.) Moench). Crops planted in southern Australian trials were canola, chickpea, lentil (*Lens culinaris* Medik.), lupin (*Lupinus angustifolius* L.), serradella (*Ornithopus compressus* L.), field pea, subclover (*Trifolium subterraneum* L.), faba bean and vetch (*Vicia sativa* L.)

Applications were made with hand held small plot sprayers with 3 m boom and six flat fan spray tips at 50 cm spacings, to plots that were 3 to 6 m × 10–50 m or similar. Four replicates of each treatment were used in each trial. Total spray volume was generally 100 L ha^{-1}. Torpedo herbicide was applied at 100 and 200 mL ha^{-1}.

Crop injury was taken by subjective visual assessment at about 7, 14 and 28 days after application (DAA) and 100% represented complete crop loss. Grain yield was taken at normal harvest and converted to percent of untreated control. Stubble was left standing after harvest and then cultivated just prior to planting. Fallow weeds were treated with glyphosate based sprays. Susceptible rotational crops were then planted perpendicular to the original plots after the initial planting rain and assessment of crop emergence and injury was done for the full season.

Efficacy trials Weed control efficacy trials were conducted on commercial farms, with treatments applied to natural weed infestations. Sites were chosen for weed species and growth stage, with treatments generally applied at the early rosette stage. Treatments were applied with hand held small plot sprayers with 3 m booms and six flat fan spray tips at 50 cm spacings, to plots that were 3 × 10 m or similar. Four replicates of each treatment were used in each trial. Total spray volume was generally 80–150 L ha^{-1}.

Crop injury was taken by subjective visual assessment at about 7, 14 and 28 days after application (DAA) and 100% represented complete crop loss. Weed control ratings were done at about 14, 28, 56 DAA and just prior to grain harvest, to assess final control.

RESULTS

Crop selectivity trials Thirty seven wheat and 24 barley varieties were tested in weed free varietal herbicide tolerance trials to determine the selectivity of Torpedo herbicide alone or when tank mixed. Table 1 shows that wheat and barley injury by Torpedo herbicide alone or tank mixed was less than or similar to an accepted commercial standard and grain yield was similar to weed free untreated.

Crop rotation trials Seven trials were conducted to determine the safe plantback interval in both northern and southern Australia. Data summarised in Table 2 shows that the plantback period for all sensitive crops at the recommended label rate was six months in northern Australia and nine months in the south. At 2x the label rate, some sensitive crops in some trials were significantly affected by the treatment.

Efficacy trials Results for control of wild radish, capeweed and volunteer legumes are shown in Table 3. Torpedo herbicide alone or tankmixed gave similar or better control on key weeds such as wild radish, capeweed and volunteer legumes when compared to existing commercial standards. Robust control of capeweed required addition of MCPA or bromoxynil/MCPA.

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Table 1. Cereal injury (average % visual) and yield (average % of untreated) after treatment with Torpedo herbicide alone or tank mixed.

Product	Product rate (ha^{-1})	Wheat		Barley	
		Average % injury	Yield (% UTC)	Average % injury	Yield (% UTC)
Torpedo	100 mL	**3** (V=37, N=226)	**98** (V=18, N=112)	**5** (V=24, N=134)	**101** (V=24, N=84)
	200 mL	**6** (V=37, N=226)	**98** (V=18, N=112)	**6** (V=24, N=134)	**102** (V=24, N=84)
Torpedo + MCPA LVE	100 + 500 mL	**5** (V=21, N=121)	**97** (V=15, N=75)	**3** (V=21, N=107)	**101** (V=16, N=45)
	200 + 1000 mL	**5** (V=21, N=121)	**103** (V=15, N=75)	**4** (V=21, N=107)	**100** (V=16, N=45)
Torpedo + Bromoxynil/MCPA	100 + 500 mL	**2** (V=14, N=72)	**104** (V=14, N=66)	**1** (V=14, N=55)	**101** (V=11, N=27)
	200 + 1000 mL	**3** (V=14, N=72)	**95** (V=14, N=66)	**2** (V=14, N=55)	**95** (V=6, N=27)
Eclipse + Lontrel 750SG™ + MCPA LVE	7 g + 40 g + 500 mL	**15** (V=20, N=110)	**96** (V=15, N=66)	**8** (V=12, N=68)	**99** (V=12, N=40)
	14 g + 80 g + 1000 mL	**12** (V=20, N=110)	**99** (V=15, N=66)	**7** (V=12, N=68)	**102** (V=12, N=40)

V=no. varieties tested, N=total no. data points across varieties. Bold=average across data points.

Table 2. Safe plantback intervals for susceptible crops after cereal treatment with 100 or 200 mL ha^{-1} Torpedo herbicide in the previous season.

Trial location	Soil type	Rain (mm)	Plant-back (days)	Crops **safely** planted after 100 mL ha^{-1}	Crops **safely** planted after 200 mL ha^{-1}	Crops **damaged** when planted after 200 mL ha^{-1}
Northam, WA	Gravel sand	613	280	Canola, field pea, lupin, serradella, subclover	Canola, field pea, lupin, serradella, subclover	–
Halbury, SA	Sandy loam	340	331	Canola, chickpea, faba bean, field pea, lentil, lupin, vetch	Chickpea, faba bean, field pea, lupin	Canola, lentil, vetch
Donald, Vic	Clay loam	340	311	Canola, chickpea, faba bean, field pea, lentil, snail medic	Canola, chickpea, faba bean, field pea, lentil, snail medic	Field pea
Toodyay, WA	Gravel sand	360	288	Canola, field pea, lupin	Canola, field pea, lupin	–
Halbury, SA	Sandy loam	369	263	Canola, faba bean, field pea, lupin, lentil	Canola, faba bean, lupin, lentil	Field pea
St Arnaud, Vic	Clay loam	277	278	Canola, field pea	Canola, field pea	–
Dalby, Qld	Clay loam	406	208	Canola, cotton, chickpea, lucerne, sunflower, sorghum	Canola, cotton, chickpea, lucerne, sunflower, sorghum	–

Table 3. Average control (% visual) of capeweed, volunteer legumes and wild radish and frequency (F) of results higher than 90% after treatment with Torpedo herbicide alone or tankmixed.

Product	Product rate (ha^{-1})	Capeweed		Legumes		Wild radish	
		% control	F	% control	F	% control	F
Torpedo	75 mL			**95** *(64)*	91	**92** *(11)*	73
	100 mL	**81** *(54)*	28	**98** *(100)*	95	**94** *(50)*	86
Torpedo + MCPA LVE	100 mL + 500 mL	**93** *(34)*	82			**96** *(29)*	86
Torpedo + Bromoxynil/MCPA	100 mL + 500 mL	**96** *(26)*	92				
Tigrex + Lontrel 750SG	750 mL + 40 g	**91** *(40)*	73	**93** *(72)*	86	**98** *(24)*	100
Metsulfuron + MCPA LVE + Lontrel 750SG	5 g + 350 mL + 40 g	**82** *(26)*	42	**99** *(68)*	100		

( ) = No. of data points, F=frequency of data points > or = 90% control. Bold = average across data points.