Oats tolerance to trifluralin and other herbicides

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Key messages

WA oat varieties showed good tolerance to trifluralin at the permit rate (Permit Number 84040) and its mixture with terbuthylazine at label rate when incorporated by seeding with knife-points and press wheels seeding system.

Oats should be sown at a speed between 4.5km/h to 9km/h to avoid crop damage.

New oat varieties have shown sensitivities to the following herbicides at label rates and timings:

- Bannister to diuron+ MCPA amine and pyrasulfotole + MCPA ester (Precept®)
- Durack to chlorsulfuron (Glean®) and 2,4-D amine dual salt ((Amicide® Advance 700)
- Williams to chlorsulfuron, bromoxynil + MCPA ester + dicamba (Broadside®), picolinafen + bromoxynil + MCPA ester (Flight®) and 2,4-D amine dual salt.
- Carolup, an old variety used as a standard in the trials, showed sensitivity to chlorsulfuron.

Aims

The trials undertaken by the Department of Primary Industries and Regional Development (DPIRD) in the last 12 years identified the potential use of trifluralin as an incorporated-by-seeding herbicide to suppress/control certain annual grasses and broadleaf weeds in both oaten hay and grain oat crops. The Grain Industry Association of Western Australia (GIWA) Oat Council secured a permit (permit number 84040) through Australian Pesticide and Veterinary Medicines Authority (APVMA) allowing the use of trifluralin up to 960g/ha in oats. The aim of this research was to:

- Identify the tolerance of current oat varieties to trifluralin and other pre-emergent herbicides,
- Investigate the interaction of seeding speed with trifluralin and other pre-emergent herbicides in William, and
- Identify the tolerance of new oat varieties to post-emergent herbicides.

Method

A total of 11 trials were conducted under weed free conditions on loamy sand to sandy loam soils (pH-$Cacl_2$ 4.7 - 5.2 and OC 1.52 – 2.43%) using criss-cross design at DPIRD Katanning Research Facility from 2006 to 2017. Five trials (out of 11) during 2006 - 2008, 2015 and 2017 included trifluralin as treatments. During 2006 and 2007 the trials were sown using Chamberlain 753 combine fitted with superseder-points at 21cm row spacing and during 2008 and 2017 using Bourgault 8810 Airseeder fitted with knife-points (split boot) and press wheels at 25cm row spacing and these travelled at 7-9km/hr speed. The remainder of the trials were sown with a coneseeder fitted with knife-points and press wheels that travelled at 4–5km/h speed. The trials were sown in mid-June to early July each year to a depth of 3-4cm using around 75kg/ha seed. The herbicide treatments were applied to the variety plots in three replications using a spray rig fitted with air induction nozzles and shields on boom and the sprayer was calibrated to deliver 75-80L/ha water volume. Plot length varied from 9.5 to 10.5m with plot centre to centre 1.8–2.5m. 2006 was the driest season amongst all the trial seasons with 186mm rainfall from May to October at Katanning.

In 2017 a study to identify interaction of seeding speed with pre-emergent herbicides was undertaken using Williams oats (part of an oats herbicide tolerance trial). Williams was sown at two speeds of 4.5km/h and 9km/h on a loamy sand soil in 10m wide strips at right angles to the direction of herbicide application with 3 replications on 14 June. The remaining 4 varieties in the trial were sown at 9km/h speed only. Every 6th plot was kept as an untreated control to assess the spatial variability. Barley stubbles were raked from the site before trial seeding. At the time of pre-emergent herbicide treatments application and trial seeding, gravimetric soil moisture content at 0-10 and 10-20cm depth was 9.2 and 7.6%, respectively. Seeding furrow depth was measured from 10 randomly selected spots within each speeding speed and replication on 15 June and 14 July 2017. Oat plant establishment was determined by counting plants across all varieties from a 1m x 1m quadrat in 3 locations per plot on 14 July. Twenty plants were selected randomly from both the seeding speed treatments per replication (untreated control area) on 14 July to measure coleoptile length using a standard measurement method. Williams was assessed for hay yield across 2 speeds by cutting its plants from two 1m X 1m quadrats per plot at milky soft dough stage and oven drying at 60ºc for 72 hrs. After drying, the hay samples were used to determine the number of heads per metre square. The trial was harvested on 20 December 2017 and total rainfall from May to October was 263mm.

Table1: The results presented in the following tables were summarised using following criteria:

– not tested or insufficient data
✓ no significant yield reductions at the label recommended rates in (Z) trials.
N (w/z) narrow crop safety margin, significant yield reductions at higher than the label recommended rate, but not at the label recommended rate. Significant event occurring in w trials out of Z trials conducted. Eg (2/5) = tested in 5 trials, 2 trials returning with a significant yield reduction.
x% yield reduction (1/z), significant yield reduction at recommended rate in 1 trial only out of z trials conducted (warning).
x - y% yield reductions (w/z), significant yield reductions at recommended rate in w trials out of z trials conducted (warning), w = 2 or more trials.

Crop safety margins: Higher than label rates of some the herbicides were included in the trials to determine the crop safety margin of the herbicides at the maximum label rates. **Good crop safety margin** means that a herbicide at its maximum label rate and at the higher rate(s) was tolerated well by a crop variety. **Narrow crop safety margin** for a herbicide indicates that the variety tolerated the maximum label rate well, but at higher than the label rate(s) there was significant yield loss. A narrow crop safety margin implies that when spraying under less than optimal conditions, herbicide damage and yield loss may occur even at the label rate. For example, when overlapping herbicide; spraying under wet conditions (for soil active and residual herbicides) and /or there are stressed plants due to abiotic/biotic factors.

Results and Conclusions

Tolerance of oat varities to trifluralin and other pre-emergent herbicides (Table 2)

Trifluralin at 960g/ha (the permit rate) alone and in mixture with terbuthylazine at 1050g/ha, terbuthylazine alone and diuron + s-metolachlor at 500g + 480g/ha applied before seeding were tolerated well with good crop safety margin by all the oat varieties tested. However, diuron + metolachlor at label rate caused statistically significant grain yield loss in Carolup and Williams during 2012 and in Durack during 2014.

Trifluralin alone and in mixture with terbuthylazine at permit/label rate resulted in lower crop establishment in Bannister, Durack, Kowari and Williams (all the varieties in the trial) sown at 9km/h speed during 2017, except trifluralin alone x Williams interaction was not statistically significant. Similarly, diuron + s-metolachlor at higher than label rate also resulted in significantly (statistically) lower plant density in Bannister and Kowari, and terbuthylazine at higher rate in Bannister (data not shown). However, this negative effect on plant population appeared to be compensated with higher number of effective tillers and biomass, and ultimately there was no statistically significant negative effect on grain yield of these varieties.

Trifluralin, terbuthylazine and their mixture, and diuron + s-metolachlor at the permit/label rates also had no statistically significant negative effect on hay yield of Bannister, Carolup, Kojonup, Durack and Williams during 2015, while Kojonup registered narrow crop safety margin for triflurlain + terbuthylazine at 960g + 1050g/ha rate. Similarly, Wandering sprayed with pre-emergent trifluralin at the permit and higher rate produced hay yield statistically equal to the untreated control plots during 2007. Hay yield was only recorded across all the 5 varieties tested during 2015.

Interaction of seeding speed with trifluralin and other pre-emergent herbicides in Williams (Table 3)

An increase in seeding speed from 4.5 to 9km/h where trifluralin, and other pre-emergent herbicides at permit/label rate were applied did not result in statistically significant negative effect on crop establishment, number of heads per metre square (data not shown), hay yield and grain yield of Williams.

Seeding at the faster speed (9km/h) in combination with

- A three way mix of diuron + s-metolachlor + terbuthylazine at label rate reduced crop establishment but had no statistically significant negative effect on hay and grain yield,
- A higher rate of trifluralin reduced crop establishment and hay yield,

- A higher rate of trifluralin + terbuthylazine reduced grain yield significantly (statistically) compared to seeding at slower speed (4.5km/h), indicating narrow crop safety margin for these treatments.

This effect could be due to overthrow of herbicide concentrated treated soil in the adjacent furrows. The seeding furrow depth was around 1cm shallower under 9km/h speed as compared to 4.5km/h speed. Total rainfall within first month of trial seeding was 40mm with a single heaviest rainfall event of 11mm on 2 July 2017. This didn't appear to cause any furrow filling as the there was no difference in the depth of seeding furrows measured a month apart starting from one day after trial seeding (15 June). The average coleoptile length of Williams in the normal furrows (intact and not under wheel tracks) under both the speeds was very similar (3.6cm in 4.5km/h and 3.3cm in 9km/h speed).

The results indicate that trifluralin alone or in mixture with terbuthylazine at permit/label rate could be applied safely on a loamy sand soil by seeding oats with knife-points and press wheels at a speed between 4.5 to 9km/h. Further research work is required to validate these results as trifluralin selectivity in oats is largely due to placement of the seed away from treated soil and factors like soil type, soil moisture, point types, row spacing, crop residue, seeding speed etc determine the soil throw into the adjacent rows.

Tolerance of new oat varieties to post-emergent herbicides (Table 4)

The majority of the herbicides tested are registered for broadleaf weed control in oats. Chlorsulfuron is the only herbicide registered for early post-emergent ryegrass (Group B susceptible) control in oats.

The following herbicides at the label rate and timing have caused a statistically significant grain yield loss in the new varieties in at least two trials. Oat growers should be cautious when using those herbicides with new varieties.

- Chlorsulfuron (eg Glean®) in Carolup, Durack and Williams.
- Bromoxynil + MCPA ester + dicamba (eg Broadside®) and picolinafen + bromoxynil + MCPA ester (Flight®) in Williams
- Diuron+ MCPA amine and pyrasulfotole + MCPA ester (Precept®) in Bannister
- 2,4-D amine dual salt (Amicide® Advance 700) in Durack and Williams. Note that oat tolerance to 2,4-D is generally considered to be lower than for barley or wheat, and if a phenoxy herbicide needs to be used in oats then MCPA amine is the preferred option.

Williams has shown sensitivity to a higher number of herbicides than the other varieties.

Carolup, Durack and Williams's sensitivity to chlosulfuron suggests that oat growers should plan to manage ryegrass effectively in these varieties in seasons before growing oats or plan to use registered pre-emergent herbicides.

The research results presented in Table 4 allow oat growers and agronomists to select safer herbicides for specific new oat varieties, or select the more tolerant variety for their preferred herbicides/mixtures for specific weed control situations.

Note: Always follow label recommendations. The Department Primary Industries and Regional Development, does not endorse the use of herbicides above the registered rate or off-label use of herbicides or off-label tank mixes. Crop tolerance and yield responses to herbicides are strongly influenced by seasonal conditions.

Key words

Herbicides, trifluralin, oats, seeding speed

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Table 2: Oat varieties' response to trifluralin and other herbicides applied before seeding as measured by grain yield from 2006 to 2017 at Katanning.

Herbicides	Rate a.i./ha	Year of testing	Bannister	Carolup	Durack	Kojonup	Kowari	Mitika	Possum	Wandering	Williams	Wintaroo
			2011-13, 2015, 17	2008, 2010-12, 15	2014-15, 2017	2006-07, 2015	2017	2006-07	2006	2006-08	2012-2017	2008
Trifluralin	720g	2008	-	√ (1)	-	-	-	-	-	√ (1)	-	√ (1)
Trifluralin	960g	2006-07 2015,17	√ (2)	√ (1)	√ (2)	√ (3)	√ (1)	√ (2)	√ (1)	√ (2)	√ (2)	-
Trifluralin + terbuthylazine	960g + 1050g	2015, 17	√ (2)	√ (1)	√ (2)	√ (1)	√ (1)	-	-	-	√ (2)	-
Terbuthylazine	1050g	2015-17	√ (2)	√ (1)	√ (2)	√ (1)	√ (1)	-	-	-	√ (3)	-
Diuron + metolachlor	500g + 360g	2010-14	√ (3)	**16 (1/3)**	**9 (1/1)**	-	-	-	-	-	**9 (1/3)**	-
Diuron + s-metolachlor	500g + 480g	2015,17	√ (2)	√ (1)	√ (2)	√ (1)	√ (1)	-	-	-	√ (2)	-
Diuron + s-metolachlor + terbuthylazine	500g + 480g + 1050g	2017	√ (1)	-	√ (1)	-	√ (1)	-	-	-	√ (1)	-

See Table 1 for explanation of shading and marking. a.i = active ingredient. The products and rates used in the trials were TriflurX® 480 at 1.5L/ha (trifluralin 720g/ha), TriflurX® 480 at 2L/ha (trifluralin 960g/ha), Terbyne® Xtreme® at 1.2kg/ha (terbuthylazine 1050g/ha), Dual® at 0.5L/ha (metolachlor 360g/ha) and Dual Gold® at 0.5L/ha (s-metolachlor 480g/ha).

Treatments were compared with untreated controls within each variety.

Table 3: The effect of pre-emergent herbicides and seeding speed on number of plants, hay yield and grain yield of Williams (% of 4.5km/h seeding speed) at Katanning during 2017. All the herbicides were applied before crop seeding.

		Number of Plants		Hay yield		Grain yield	
Herbicides	**Rate a.i./ha**	**4.5km/h**	**9km/h**	**4.5km/h**	**9km/h**	**4.5km/h**	**9km/h**
Untreated Control		100 (174 m^{-2})	100	100 (6.9t/ha)	95	100 (3.5t/ha)	93
Trifluralin	960g	102	94	105	107	100	93
Trifluralin	Higher rate	103	**89**	126	109	101	89
Trifluralin + Terbuthylazine	960g + 1050g	94	**88**	112	98	103	98
Trifluralin + Terbuthylazine	Higher rate	98	**91**	103	87*	106	**87**
Terbuthylazine	1050g	100	107	105	101	**86**	94
Terbuthylazine	Higher rate	100	101	108	110	96	105
Diuron + s-metolachlor	500g + 480g	96	106	99	106	96	97
Diuron + s-metolachlor	Higher rate	98	101	95	107	90	92
Diuron + s-metolachlor + terbuthylazine	500g + 480g + 1050g	101	**92**	109	97	95	**87**
Lsd (0.05) Control vs herbicides within each speed or across speeds (1-tail)		7		14		12	
Lsd (0.05) herbicides vs herbicides within each speed or compare speeds at same level of herbicide (1-tail)		9		17		16	
CV (%)		7		13		12	

a.i = active ingredient. The products and rates used in the trials were TriflurX® 480 at 2L/ha (trifluralin 960g/ha), Terbyne® Xtreme® at 1.2kg/ha (terbuthylazine 1050g/ha), Diuron 900 at 556g/ha (diuron 500g/ha) and Dual Gold® at 0.5L/ha (s-metolachlor 480g/ha).
Figures in **Red** are significantly lower than untreated control plots sown at 4.5km/h speed. Figures in **Red** and/or Yellow are significantly lower than the plots sown at 4.5km/hr speed under same herbicide treatment. * this value is significant at 90% level of confidence.

Table 4: New oat varieties' response to post-emergent herbicides for grain yield from 2011 to 2017 at Katanning, WA.

Herbicides	Rate a.i./ha	Timing	Year of testing	Bannister	Carolup	Durack	Kowari	Williams
				2011-13, 2015, 17	2011-12, 2015	2014-15, 2017	2015, 2017	2012-17
Chlorsulfuron + BS1000 (*Glean®*)	15g + 0.1%	Z12-Z13	2011-2015, 17	√ (5)	**10-23 (2/3)**	**9-15 (2/3)**	**19 (1/2)**	**8 - 20 (2/5)**
Bromoxynil + MCPA ester + dicamba (*Broadside®*)	140g + 280g + 40g	Z13-Z14	2011-14, 17	√ (4)	√ (2)	**7 (1/2)**	√ (1)	**8 - 9 (2/4)**
Carfentrazone + MCPA amine (*Affinity Force® + MCPA amine*)	24g + 250g	Z13-Z14	2011-2014	√ (3)	√ (2)	√ (1)	-	√ (3)
Carfentrazone + metribuzin + MCPA amine (*Affinity Force® + Lexone® + MCPA amine*)	24g + 75g + 250g	Z13-Z14	2011	√ (1)	√ (1)	-	-	-
Carfentrazone + metribuzin + MCPA amine (*Aptitude® + MCPA amine*)	18g + 75g + 250g	Z13-Z14	2015-17	√ (2)	√ (1)	√ (2)	√ (2)	√ (3)
Diuron+ MCPA amine	180g + 200g	Z13-Z14	2014	-	-	√ (1)	-	√ (1)
Diuron+ MCPA amine	250g + 200g	Z13-Z14	2013	**5 (1/1)**	-	-	-	N (1/1)
Diuron+ MCPA amine	250g + 250g	Z13-Z14	2011-12	**11-15 (1/2)**	√ (2)	-	-	**17 (1/1)**
Diflufenican + MCPA (*Tigrex®*)	25g + 250g	Z13-Z14	2011-14, 18	**10 (1/4)**	√ (2)	**14 (1/2)**	√ (1)	√ (4)
Florasulam + MCPA ester + Uptake™ (*Conclude®*)	4.9g + 250g + 0.5%	Z13-Z14	2011-14	√ (3)	**15 (1/2)**	**7 (1/1)**	-	**7 (1/3)**
Halauxifen + florasulam + MCPA LVE + clopyralid (*Paradigm™ + MCPA LVE + Lontrel™ Advance*)	5g + 80g + 240g + 45g	Z13-Z14	2015	√ (1)	√ (1)	√ (1)	√ (1)	√ (1)
Picolinafen + bromoxynil + MCPA ester (*Flight®*)	25g + 150g + 250g	Z13-Z14	2011-14, 17	**16 (1/4)**	**11 (1/2)**	√ (2)	√ (1)	**11 - 12 (2/4)**
Pyrasulfotole + MCPA ester + Hasten (*Precept®*)	50g + 250g + 1%	Z13-Z14	2011-14, 17	**6-12 (2/4)**	√ (2)	**7 (1/2)**	√ (1)	**9 (1/4)**
Terbutryn + MCPA amine (*Igran® + MCPA amine*)	425g + 300g	Z13-Z14	2014	-	-	√ (1)	-	**6 (1/1)**
2,4-D amine dual salt (*Amicide® Advance 700*)	805g	Z15-Z16, Z31	2011-12,14-15,17	N (1/4)	N (1/3)	**23- 35 (2/3)**	**17 (1/2)**	**9 - 10 (2/4)**
2,4-D amine (*Amicide® 625*)	812.5g	Z15-Z16	2011-13	**5 (1/3)**	**13 (1/2)**	-	-	**13 (1/2)**

a.i. = active ingredient. Parentheses have names of the herbicide products used in the trials. Herbicide treatments within each variety were compared with untreated control plots (of the respective variety). For information on other oat varieties, please visit https://www.nvtonline.com.au/herbicide-tolerance/