The tolerance of grapevines to herbicides

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Summary Eleven herbicides and one oil (2,2-DPA, 2,4-D amine, amitrole, bromoxynil plus diflufenican, carfentrazone, diquat plus paraquat, diuron, glufosinate, glyphosate, norflurazon, oxyfluorfen and spray oil) were applied to nine varieties of grapevines as an overall spray either before bud burst in mid September or after bud burst in late October. Fruit yields and symptoms were recorded on the sprayed and adjacent rows to determine tolerance and effects of drift. Applications of herbicides before bud burst generally caused less yield loss than applications after bud burst apart from diuron. Glyphosate, amitrole and glufosinate caused no significant yield loss with pre bud burst applications. Drift from post bud burst (October) applied diquat + paraquat and 2,4-D caused about 50% yield loss on the adjacent row and no significant loss 6.5 m from the edge of spraying. All other products had no significant effect on the adjacent row.

Keywords Herbicides, tolerance, grapevines, *Vitis vinifera*.

INTRODUCTION

The wine grape industry in southern Western Australia has grown three fold in the past decade and is scattered amongst existing broad acre grazing and cropping farms. Herbicide damage from drift or overspray in vineyards has long been a concern. Applicators are required to obtain a permit to use hormone herbicides. However there is a little information on the likely effects of the numerous other herbicides on vines.

An old research vineyard comprised of rows of various varieties was due for pulling out. This presented an opportunity to study the effects of herbicides on vine health and yield and to document the symptoms caused by various products.

An experiment was conducted to determine the effects of spraying various herbicides either before or after bud burst on various varieties of various ages and to assess the effects of drift on adjacent vines.

MATERIALS AND METHODS

Eleven herbicides and a spray oil simulating a non volatile carrier, at rates shown in Table 1, were applied as an overall spray either just before bud burst on September 13–14 (early spray) or after bud burst from October 22 to November 1, 2004 (late spray) at Mt Barker Research Station. The times of application of herbicide were assigned to varieties to balance the treatments across expected times of bud burst. The early spray was applied to 30 year old Cabernet Sauvignon, Chardonnay, Malbec, Merlot, Meunier, Pinot, Riesling, Shiraz and Verdelho, and five year old Cabernet Sauvignon. The late spray was applied to Cabernet Franc, Cabernet Sauvignon, Chardonnay, Muller Thurgau, Riesling and Sauvignon Blanc, and five year old Cabernet Sauvignon and Chardonnay. Each variety had 60 vines in a single row apart from the Cabernet Sauvignon where the vines were split over two rows. The treatments were applied to panels of five vines and fresh fruit weights taken from the central three vines in March, 2005.

Herbicide treatments were applied in 250 L ha^{-1} water sprayed over the tops of the vines using Spraying Systems® 110-02 nozzles at 200 kPa on a three nozzle, 1 m wide, hand held mini boom. Spray oil was applied

Table 1. The herbicides used, formulation and quantity applied per hectare.

Herbicide	Application rate g a.i. ha^{-1}
2,2-DPA 700 g kg^{-1} as Propon® at 20 kg ha^{-1}	14000
2,4-D amine 500 g L^{-1} as 2,4-D amine 500® at 1 L ha^{-1}	500
amitrole 250 g L^{-1} as Amitrole T® at 5 L ha^{-1}	1250
bromoxynil 250 g L^{-1} plus diflufenican 25 g L^{-1} as Jaguar® at 1 L ha^{-1}	250 + 25
carfentrazone 240 g L^{-1} as Hammer® at 100 mL ha^{-1}	24
diquat 115 g L^{-1} plus paraquat 135 g L^{-1} as Spray.Seed® at 5 L ha^{-1}	575 + 675
diuron 900 g kg^{-1} as Diuron 900® at 4 kg ha^{-1}	3600
glufosinate 200 g L^{-1} as Basta® at 5 Lha^{-1}	1000
glyphosate 450 g L^{-1} as Roundup® CT at 4 L ha^{-1}	1800
norflurazon 800 g kg^{-1} as Zoliar® at 5 kg ha^{-1}	4000
oxyfluorfen 240 g L^{-1} as Goal® at 3 L ha^{-1}	720
mineral spray oil 855 g L^{-1} as Ulvapron® at 100 L ha^{-1}	85500

neat at 100 L ha^{-1} with the same equipment. A 3 m wide strip was sprayed leaving a 1 m unsprayed buffer between rows. Conditions were fine with temperatures between 14 and 18°C and a 1–5 km h^{-1} south east wind at all times of spraying. Fungicides were applied for powdery mildew control.

In Table 2 treatments were compared with the two treatments with the greatest yields for each variety. In Table 4, two rows of 30-year-old and 1 row of 5-year-old Chardonnay were unsprayed and used to assess drift from the adjacent row as there were insufficient vines of other varieties.

RESULTS

Analysis of variance was used to assess treatment effects and interactions. There was a three way interaction between herbicide, time of application and variety when all data were combined and there were large differences in the average yield between varieties.

The young Cabernet and old Cabernet, Chardonnay and Riesling were the only vines that had treatment combinations represented in equal numbers. Data from these vines were used to evaluate the effects of herbicide, time of application and variety. For ease of comparison yields are presented as percentages of the two least damaging treatments for each variety/age with the actual yield of these treatments in the bottom row of Table 2.

There was a significant 3-way interaction between herbicide, variety and time of application.

The most notable of these were:

1) 2,4-D was damaging to all varieties at both times of spraying. 2,2-DPA, carfentrazone, diquat + paraquat, glufosinate and glyphosate were equally damaging at the late time of spraying but variable in their effects at the early time of spraying.
2) Glyphosate was one of the safest herbicides applied before bud burst and one of the most damaging herbicide when applied after bud burst.
3) Chardonnay and young Cabernet suffered more yield loss from early spraying of glufosinate and oil than old Cabernet or Riesling.
4) Riesling was more tolerant of early sprays of diquat + paraquat than other varieties.
5) Young Cabernet suffered more yield loss from late spraying of bromoxynil + diflufenican than other varieties.
6) Compared to other varieties Riesling was more sensitive to late applications of diuron whereas Chardonnay was more sensitive to early sprays.
7) Riesling and old Cabernet were more sensitive to early sprays of oxyfluorfen than other varieties but Riesling was the most tolerant to late sprays.

All varieties were included in the analysis of the effects of individual herbicides within each time of spraying (Table 3). 2,2-DPA, 2,4-D amine and possibly oxyfluorfen and diquat + paraquat reduced fruit yield at the early spray. 2,2-DPA, 2,4-D amine, carfentrazone, and glyphosate caused more than 95% loss of yield compared to the best treatment. Diquat + paraquat, glufosinate, oxyfluorfen and even oil caused a significant 38–85% reduction in yields at this time.

2,4-D amine drift was determined by inspecting adjacent unsprayed vines for symptoms. No symptoms were found on vines on the windward side of spraying. On the leeward side, symptoms were observed on vines in the adjacent row (2.5 m from the sprayed edge) and

Table 2. Percentage fruit yield for various herbicides applied before or after bud burst on various varieties.

Time of application	Early	Early	Early	Early	Late	Late	Late	Late
Herbicide Variety:	CabernetY	Cabernet	Chardonnay	Riesling	CabernetY	Cabernet	Chardonnay	Riesling
2,2-DPA	11	16	2	82	0	1	0	22
2,4-D	14	18	13	19	0	6	0	0
amitrole	81	49	83	81	47	57	65	110
bromoxynil + difluf.	62	84	41	68	23	89	69	62
carfentrazone	33	79	30	57	26	1	1	4
diquat + paraquat	33	54	49	96	16	5	9	8
diuron	108	76	48	80	120	111	130	56
glufosinate	17	76	78	92	0	12	10	21
glyphosate	78	98	64	104	0	1	3	0
norflurazon	92	64	58	91	22	32	42	57
oxyfluorfen	78	40	81	32	11	25	40	90
spray oil	49	102	117	90	80	51	59	64
Weight g vine^{-1}*	2515	5165	4619	9793	992	4565	2352	5375

LSD ($P < 0.05$) = 34 for percentages. * fruit wt from the best two treatments. CabernetY = young Cabernet.

none were observed in the next row, 6.5 metres from the edge of spraying.

There were three rows of Chardonnay that had herbicide applied to them after bud burst (late spray) that had unsprayed Chardonnay on the leeward side of spraying. These were used to determine the effects of drift on fruit yield in Table 4. Chardonnay was generally more sensitive to 2,4-D amine than other varieties. Drift from diquat + paraquat and 2,4-D amine significantly reduced yields below the least damaging treatments but was not significantly more damaging than eight of the other herbicides tested. There was only a moderate correlation (r = 0.41) between the damage caused by the overall late spray and drift from that spray.

On the leeward side of the spray oil treatment, occasional spotting of leaves was observed up to 40 metres from the sprayed area that was caused by the non volatile oil droplets landing on the leaves but this had no effect on yield.

Table 3. Fruit yields (g vine^{-1}) over all varieties.

Herbicide	Time of application*	
	Early	Late
2,2-DPA	1466	183
2,4-D	1832	101
amitrole	4148	2438
bromoxynil + diflufenican	3749	2043
carfentrazone	4327	137
diquat + paraquat	3253	454
diuron	3981	3074
glufosinate	3672	530
glyphosate	4344	64
norflurazon	3444	2037
oxyfluorfen	3211	1239
spray oil	4480	1899
LSD (P <0.05)	1034	1157

Comparison between times of application is not appropriate as there are different sets of varieties.

Table 4. The effect of herbicide, time of application and drift from the late spray on the adjacent row on Chardonnay fruit yield (g vine^{-1}).

Herbicide	Early spray	Late spray	Drift from late spray
2,4-D	583	0	1061 c*
diquat + paraquat	2253	124	1123 c
glufosinate	3620	163	1442 bc
norflurazon	2703	1021	1582 bc
2,2-DPA	73	0	1634 bc
carfentarzone	1407	37	1659 bc
glyphosate	2950	78	1792 bc
diuron	2220	1697	1851 bc
amitrole	3813	827	1993 bc
bromoxynil + diflufenican	1873	893	2070 bc
oxyfluorfen	3767	473	2224 ab
spray oil	5425	761	3227 a
LSD (P <0.05)	1807	1475	1044

* Yields in the drift column with the same letter are not significantly different (P <0.05).

DISCUSSION

In most analyses there was a significant 3-way interaction between herbicide, time of application and variety, so it is difficult to make generalisations about time of spraying, variety or herbicide. For example diquat + paraquat applied before bud burst had little effect on Riesling whereas Riesling was the most sensitive to late applications of diuron.

Pre bud burst 2,4-D and 2,2-DPA generally reduced yields though Riesling was more tolerant to 2,2-DPA. Post bud burst 2,2-DPA, carfentrazone, diquat + paraquat, glufosinate and glyphosate were very damaging and similar to 2,4-D. These results indicate that specific controls placed on 2,4-D amine use are largely a result of political pressures resulting from the large scale use of 2,4-D in close proximity to vines and the characteristic symptoms. Five of the 11 other herbicides tested are just as damaging when applied as an overall spray after bud burst and nine caused similar levels of damage due to drift on Chardonnay.

This trial showed signs of significant movement of spray oil from the area of application but no evidence of damaging quantities of herbicides in water moving more than 6.5 m with winds around 5 km hour^{-1}. Visible spray drift could be seen impacting on the row adjacent to sprayed area but not on the next row. Heavy yield losses occurred where several herbicides were applied at label rates over the top of vines, but yield losses from low levels of these herbicides that occurred in spray drift appeared to be minimal at distances greater than a few metres from the edge of spraying under good conditions.

ACKNOWLEDGMENTS

Technical support by Rob Hetherington and Sheena Lyons and funding by DAFWA is acknowledged.