Figure 1. Distorted grapevine leaf tissue from 2,4-D herbicide spray drift. Image courtesy Anna Baum, Clare Valley Wine & Grape Association.

The impact of 2,4-D herbicides on grapevines

In addressing several Helpdesk inquiries concerning spray drift in vineyards throughout Australia, AWRI Viticulturist, Dr Rochelle Schlank, explores some of the key questions surrounding the impact of 2,4-D on grapevines, particularly those relating to yield and vegetative responses.

What is 2,4-D and its mode of action?

2,4-D, or 2,4-dichlorophenoxyacetic acid, is a phenoxy herbicide widely used in agriculture. A popular choice for chemical weed control by broadacre farmers, 2,4-D is selective for broad leaf plants. The agrochemical functions as a synthetic auxin, mimicking naturally occurring plant hormones that regulate growth. At high concentrations, typical for herbicides, 2,4-D induces abnormal and uncontrolled cell proliferation,

2,4-D exposure can influence both the current season's crop and future years' production.

Image courtesy of Anna Baum, Clare Valley Wine & Grape Association.

eventually leading to growth inhibition and the formation of necrotic tissue in targeted plants. 2,4-D primarily achieves these effects through disruption of hormone signalling pathways, including those involving ethylene and abscisic acid (ABA), and by stimulating the production of reactive oxygen species.

How does 2,4-D exposure impact grapevine growth and vegetative health?

In grapevines, 2,4-D is readily absorbed by leaf tissue. Visual indicators of 2,4-D exposure in grapevines can include an array of vegetative symptoms, though the severity of symptoms depends on the dose, timing and frequency of exposure. Low rates of 2,4-D can cause mild tissue damage, such as tendril necrosis and leaf crinkling. Repeated or higher exposures can lead to severe symptoms like shoot epinasty (downward bending), pronounced leaf curling, and stunted growth. Upwards leaf curling, shoots exhibiting a zig-zag growth pattern with short internodes and developing leaves (towards the tip of the shoot) showing a distinct small, fan-shaped appearance are common symptoms that may develop in the weeks following 2,4-D exposure (Rossouw et al. 2018) (Figure 1). Younger vines and newly developing leaves are particularly vulnerable, showing greater damage compared to mature vines and leaves. In some cases, young vines exposed to high doses of 2,4-D may die. Research has showed that 2,4-D causes structural damage to leaf tissues, including the mesophyll layer and stomatal guard cells (Bondada 2011). This suggests that leaves showing symptoms of 2,4-D exposure are likely to have diminished photosynthetic capabilities, partly due to compromised stomatal functioning (which is important for facilitating intake of carbon dioxide, a critical resource for photosynthesis), as well as reduced chloroplast functioning (the cell structures responsible for photosynthesis) and ultimately compromising overall vine health.

What are the effects of 2,4-D exposure on grape yield?

2,4-D exposure can influence both the current season's crop and future years' production. Yield reductions are closely

tied to the timing, dose, and frequency of exposure. Research has shown that earlier exposures (around flowering) are more likely to lead to greater yield losses within the exposed season, compared to exposures which occur later in the season. Yield losses have been associated with the formation of live green ovaries (LGOs), which are small, undeveloped, seedless 'berries' that fail to ripen, and this can lead to fewer berries per bunch and lower bunch weights and yield. In some cases, 2,4-D exposure can also lead to increased incidence of primary bud necrosis (PBN) (Rossouw *et al.* 2018), potentially leading to fewer fruitful shoots and lower yields in the following season and further reducing yield. At a high rate of 2,4-D exposure, necrosis of part or whole bunches has been reported, which can also contribute to reductions in yield within the exposed season (Rossouw *et al.* 2018). Multi-year exposures to 2,4-D can lead to significant, though not always cumulative, yield reductions over time.

What is the persistence of 2,4-D in grapevines, and how does it affect recovery?

Research suggests that 2,4-D can persist in grapevines for several months. Foliar symptoms from early season exposure can persist in developing and older leaves at harvest and in subsequent years. However, it is also possible for vines to recover from 2,4-D exposure within the affected season. This is supported by research that showed vines with visible injuries from multiple simulated spray drift events over three years recovered the year after simulated drift events ceased (Ogg *et al.* 1991). Recovery depends on factors including vine age, timing and rate of exposure. Lower rates of 2,4-D allow for better recovery, while higher rates can cause severe damage or even death, particularly in young vines. Though recovery is possible, repeated exposure may have cumulative effects, particularly on photosynthesis and carbohydrate stores, potentially impairing long-term recovery, though this has not been scientifically tested.

What factors contribute to the severity of symptoms caused by 2,4-D exposure in grapevines?

Several factors influence the severity of symptoms from 2,4-D exposure, including:

Visual indicators of 2,4-D exposure in grapevines can include an array of vegetative symptoms, though the severity of symptoms depends on the dose, timing and frequency of exposure.

- **Amount of exposure:** Higher doses and repeated exposures can increase the severity of symptoms.
- **Vine age:** Younger vines are generally more vulnerable, while mature vines tend to be more resilient.
- **Growth stage at exposure:** The timing of exposure during the growing season significantly affects symptom severity, with earlier exposure around flowering being associated with more severe yield impacts.
- **Tissue age:** Younger leaves and shoots are more sensitive to 2,4-D compared to older, fully expanded leaves.

What should I do if I suspect my grapevines have been exposed to 2,4-D?

If you suspect your vineyard has been exposed to 2,4-D, it is important to report the damage and undertake testing to verify the cause and the potential level of impact to your crop.

Recommended reporting lines include:

- Rapid reporting to your state or territory government – as the responsible party for investigating spray drift incidents;
- Your winery/grape purchaser – to assist with assessment of damage, potential impacts on grape quality, and advice on vine recovery; and
- Your regional wine industry association – to assist in ascertaining whether your damage was related to an isolated incident or whether spray drift is a broader issue that requires a regional solution.

Residue testing for 2,4-D can be completed on foliage, grapes and wine. Contact Affinity Labs on (08) 8313 0444 or via email at customerservice@affinitylabs.com.au to discuss sample submission and testing.

AWRI helpdesk

The AWRI helpdesk provides a free-of-charge technical advice service to Australia's grapegrowers and winemakers. For further information about 2,4-D exposure or any other technical matter, contact the helpdesk on (08) 8313 6600 or helpdesk@awri.com.au

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