The Herbicide 2,4-D

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The herbicide 2,4-D (2,4-dichlorophenoxyacetic acid) is classified, along with several closely related compounds, in the phenoxy family of herbicides. This paper will specifically discuss 2,4-D, recognizing that all phenoxy herbicides have similar activity and implications for sensitive crops such as grapes.

Herbicides containing 2,4-D are generally inexpensive and among the most commonly used herbicides on the market. It is a selective herbicide that kills dicots (broadleaf plants), but not monocots (grass species). Although the exact mode of action of 2,4-D is not fully understood, it is considered to have activity similar to the natural plant growth hormone auxin. On susceptible plants, effective concentrations cause uncontrolled and disorganized plant growth resulting in death. 2,4-D is believed to acidify plant cell walls, causing cells to elongate in an uncontrolled manner. (Tu et al., 2001). It is also reported that low concentrations can stimulate plant RNA, DNA, and protein synthesis leading to uncontrolled cell division and elongation, ultimately destroying vascular tissue. In contrast, high concentrations of 2,4-D inhibit cell division and growth; plant death may occur within 3-5 weeks of treatment (Tu et al., 2001).

As a dicot, grapevines are highly sensitive to 2,4-D, displaying minor injury symptoms when exposed to as little as 0.1 ppm 2,4-D (Kasimatis, et al., 1968). All grape varieties are sensitive to 2,4-D, although expression of visual symptoms (leaf distortion and shoot stunting) varies among varieties (Weaver, et al., 1958; Hellman, 1987). Severity of injury increases with the dosage of exposure to 2,4-D. Damage to grapevines is visually expressed in growing shoots and young leaves because of 2,4-D's effect on cell division and cell growth. Developing flower clusters and young fruit are also effected by 2,4-D, resulting in poor fruit set and reduced crop yields (Weaver, et al., 1958; Kasimatis, et al., 1968). Fruit quality may also be affected; experimental application of 2,4-D delayed sugar accumulation in grape berries (Matsui, et al., 1990).

Long-term effects of 2,4-D exposure have also been documented; carbohydrate storage was significantly reduced in grapevines damaged by 2,4-D drift in a commercial vineyard in California (Weaver, et al., 1958). The quantity of stored carbohydrates has long-term consequences since it directly influences grapevine cold hardiness, vine vigor and crop yields. Kasimatis, et al (1968) also demonstrated that 2,4-D can be stored in the vine over winter and translocated to growing shoot tips in the following season, causing damage to leaves and shoot tips.

Symptoms of 2,4-D damage to grapevines is distinctive and most easily recognized on young leaves and shoot tips. Expansion of growing leaf blades is inhibited resulting in irregular, small, fan-shaped, pale-green leaves with enlarged main veins and an irregular dense network of lateral veins (Pratt, 1974). Leaves are often puckered and leaf margins are highly serrated. Palisade parenchyma cells are malformed and stomatal morphology and position are altered (Bondada, 2009). During active shoot growth in spring and early summer, 2,4-D is translocated to the shoot tip, damaging newly developing leaves and sometimes killing the shoot tip (Kasimatis, et al., 1968).

Grapevines are typically exposed to 2,4-D inadvertently through off-target drift of herbicide sprays applied to non-sensitive crops, pastures, rights-of way, or lawns. All formulations of 2,4-D are volatile and increasing temperature increases the potential for vaporization (Tu, et al., 2001). Widespread damage to sensitive plants resulting from clouds of volatilized 2,4-D have occurred in the past (WHO, 1984), but currently, localized damage from immediate drift is of greatest concern.

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