New Herbicide Uses for California Tree and Vine Crops

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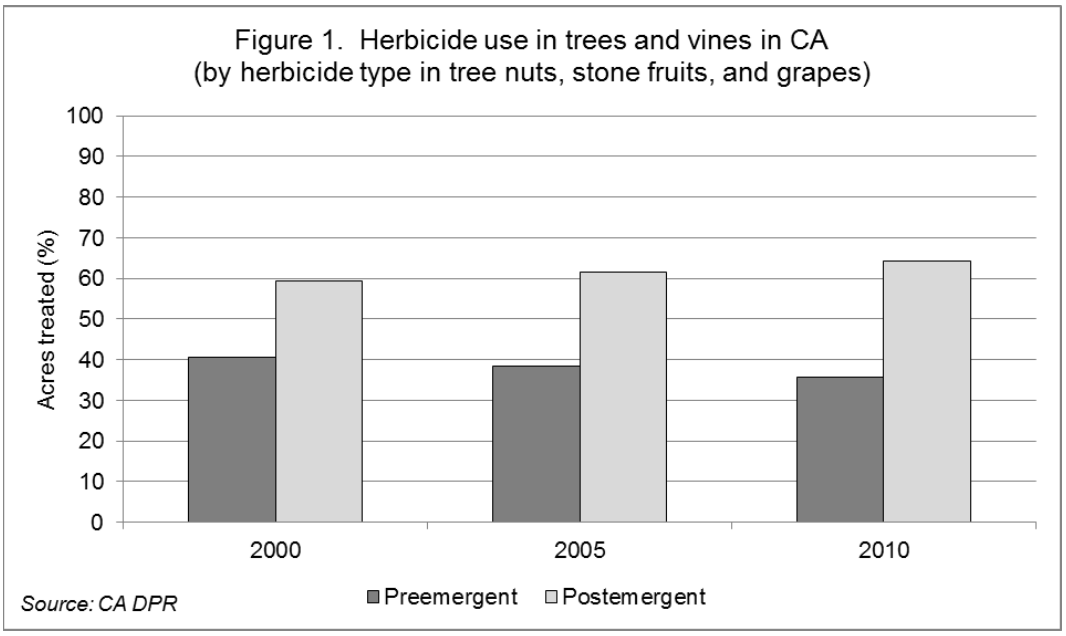
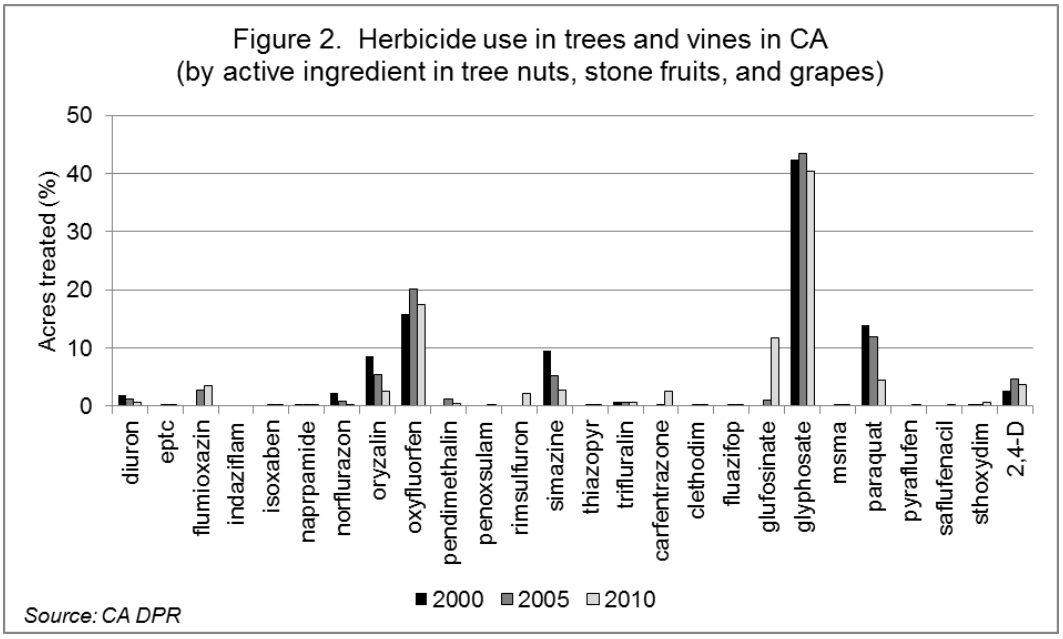
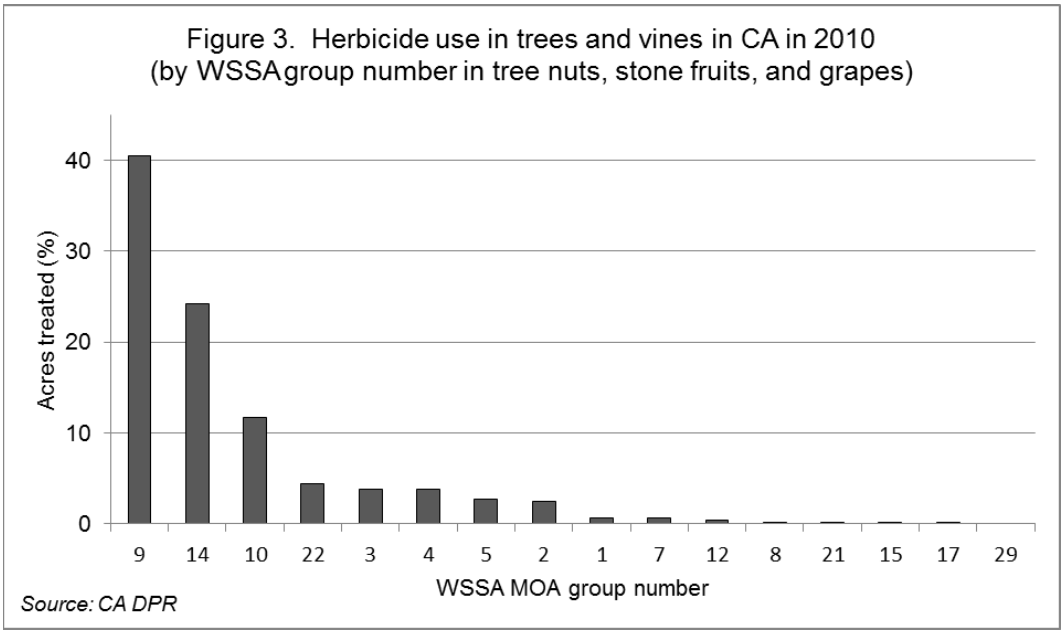
For decades, herbicides have been used for weed management in perennial tree and vine crops in California. When used under the right conditions, herbicides provide effective control of a large variety of weeds and aid crop growth and productivity. While both pre- and postemergent herbicides are widely used, there has been a trend towards greater reliance on postemergent materials in recent years, particularly glyphosate (Figure 1). Between 2000 and 2005, growers relied mostly on five herbicide active ingredients (glyphosate, oxyfluorfen, paraquat, oryzalin, and simazine) for weed control in tree nuts, stone fruits, and grapes (Figure 2). In 2010, more than 80% of the acreage in the state was treated with three herbicide mode of actions (MOA), with over 40% attributed to a single MOA; the EPSP synthase inhibitor, glyphosate (Figure 3).

Widespread reliance on glyphosate in postemergent-only programs has contributed to glyphosate-resistant horseweed, hairy fleabane, rigid ryegrass, and junglerice in the state. Also, the implementation of regulated groundwater protection areas (GWPA) in 2004 contributed to this increase in glyphosate use as growers replaced using preemergent herbicides, like simazine, bromacil, and norflurazon (sensitive to runoff and leaching in GWPA), with safer alternatives, including glyphosate.







Currently, there are about 30 herbicide active ingredients with 16 different MOAs (by WSSA group number) registered for use in the various perennial tree and vine crops in California (see table). Since 2004, eight new herbicide active ingredients with three new MOAs were registered for use. These materials were developed, in-part, in response to a need to find safer alternatives that could be used on farms located in GWPAs and offer control of a wide-array of weeds,

including those resistant to glyphosate. While these newer herbicide have only been available a few years, they are already having a positive impact on the ability of growers to manage glyphosate-resistant weeds and others. These herbicides are not available for use in all tree and vine crops grown in the state, but each has its own fit in a particular set of crops. With the addition of these new herbicides, growers have been more diligent in rotating or tank-mixing herbicides with different MOAs to help maintain weed control and combat weed resistance.

Herbicides currently registered in perennial tree and vine crops in California

WSSA	HRAC	Herbicide mode of action	Herbicide active ingredient	Activity
1	A	Acetyl CoA carboxylase inhibitor	clethodim, fluazifop-p-butyl, sethoxydim	POST
2	B	Acetolactate synthase inhibitor	rimsulfuron*, penoxsulam*	PRE
3	K1	Microtubule assembly inhibitor	oryzalin, pendimethalin, thiazopyr, trifluralin	PRE
4	O	Synthetic auxin	2,4-D	POST
5	C1	Photosystem II inhibitor	bromacil, simazine	PRE
7	C2	Photosystem II inhibitor	diuron	PRE
8	N	Lipid synthesis inhibitor	EPTC	PRE
9	G	EPSP synthaseinhibitor	glyphosate	POST
10	H	Glutamine synthase inhibitor	glufosinate*	POST
12	F1	Carotenoid biosynthesis inhibitor	norflurazon	PRE
14	E	Protoporphyrinogen oxidase inhibitor	flumioxazin*, oxyfluorfen carfentrazone*, flumioxazin*, oxyfluorfen, pyraflufen*, saflufenacil*	PRE POST
15	K3	Cell division inhibitor	napropamide	PRE
17	Z	Unknown (Organoarsenicals)	MSMA	POST
21	L	Cellulose biosynthesis inhibitor	isoxaben	PRE
22	D	Photosystem-I-electron diversion	paraquat	POST
29	L	Cellulose biosynthesis inhibitor	indaziflam*	PRE
*Registered for use in California since 2004				

In California, preemergent materials are mainly applied during the winter dormant period to take advantage of winter rainfall for incorporation and activation and to improve crop safety. Here, newer materials like flumioxazin, rimsulfuron, penoxsulam, and indaziflam are providing good residual weed control. Postemergent herbicides, like glyphosate, glufosinate, and 2,4-D are added to the spray tank to control weeds that are emerged at time of treatment. Combinations of preemergent products (i.e. flumioxazin plus pendimethalin, indaziflam plus rimsulfuron, etc.) with different MOAs are often used to provide long-term control of a wide-array of weeds like hairy fleabane, horseweed, and ryegrass. In many cases, residual control with the newer materials last six months or more. Efficacy is usually improved where leaves and other trash are mechanically blown from the soil surface before the herbicides are applied. As the newer preemergents become more widely used, growers should see improved overall weed control and a need to rely less on postemergent materials for control.

Since about 2005, glufosinate has been an important herbicide for the control of established horseweed, hairy fleabane, grasses and other weeds not readily controlled with glyphosate. Glufosinate is often combined with glyphosate to control a large number of weeds, including nutsedge. To date, no weeds have shown resistance to glufosinate. However, lack of glufosinate

availability in California since 2011 has caused growers to turn to other alternatives for burn-down control efforts, like using saflufenacil in tree nut crops. Since saflufenacil does not control grassy weeds, it too is usually combined with glyphosate to help control grassy species. A selective grass herbicide, like sethoxydim, is sometimes used to control glyphosate-resistant junglerice if glufosinate is unavailable. Paraquat continues to be an important player in postemergent weed control efforts. However, since it is a Restricted Use Pesticide, it requires a permit to purchase and use, a closed system for delivery, and special protective clothing during mixing, loading, and application, which sometimes discourages its use.

Tree and vine growers in California are fortunate to have a fairly large number of herbicide active ingredients and MOAs to select from to help manage weeds. Selecting and using these herbicides in a manner that considers weed species present, weed resistance, crop safety, and the environment is essential for their long-term viability. While no one herbicide can be expected to control all the weeds in any particular field, each one can play an important role when used appropriately.