

Herbicide Resistance Weeds found in California Almond Production Systems

It is presumed that all weed populations have individual plants, known as biotypes, which possess the necessary biological traits for resistances to take place. The selection pressure exerted by the repeated use of herbicides with the same mode of action, gradually increases the number of resistant individuals in a population, as shown in the diagram below (figure 1). Herbicides themselves do not cause resistance; instead, they select for naturally occurring resistant traits in a population. This results in the loss of adequate weed control by applications of that herbicide.

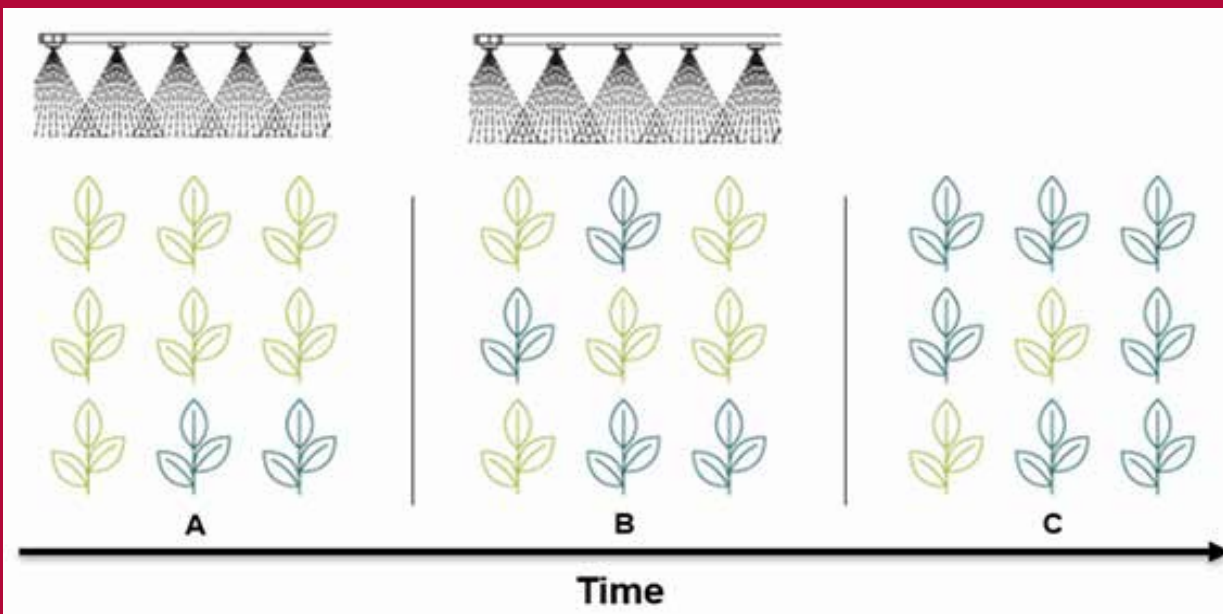


Figure 1. Figure 1 Illustrates how the selection pressure of using the same herbicide increases frequency of herbicide resistance in a population over time. A) Selection of resistant biotype which then goes to seed. B) Repeated use of the same herbicide allows for the population to keep growing. C) Establishment of resistant population.

Key definitions as described by the Herbicide Resistant Action Committee (HRAC):

Resistant: Weeds that were originally susceptible to an herbicide; over time control is lost through the selection of resistant individuals.

Tolerant: The inherent ability of a species to survive following an herbicide treatment – was never susceptible. Mode of Action (MOA): Describes the biochemical processes by which the herbicide effects the weed.

Cross Resistance: Resistance to 2 or more herbicides that share the same mode of action.

Multiple Resistance: Resistance to 2 or more herbicide with different modes of action.

How to identify herbicide resistance

Herbicide treatment failures may be mistaken for resistance developing in an orchard. For example, unfavorable weather at the time of application or spraying weeds that were too large may lead to what looks like the development of herbicide resistance. The key here is to not suspect herbicide resistance unless herbicide failure fits the following:

- The same herbicide was used year after year.
 - If you suspect resistance, check to see how often you've used the same MOA over the past couple of years.
- If you find a weed species, which normally should be controlled, and is not controlled even though all other weeds were.
 - In other words, "I used to be able to kill this plant with this herbicide, but now I cannot."

- Healthy weeds are mixed with uncontrolled weeds of the same species.
 - Scouting twice a year will help you identify the onset of a resistant population.
- A patch of an uncontrolled weed is spreading.

As of 2021, there are 30 confirmed occurrences of herbicide resistance in California. Below are 13 of the weed species that are commonly found in almond orchards throughout the California Central Valley. Each of these weeds have had confirmed cases of herbicide resistant biotypes in California. The table includes what MOA the species developed resistance to, whether there was cross or multiple resistance, and alternative control options.

| Species | Mode of Action * | A.I. Alternatives |
|----------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <i>Amaranthus palmeri</i> | EPSP synthase inhibitors (9) | POST: dicamba, 2,4-D, glufosinate, paraquat, oxyfluorfen, and carfentrazone PRE: flumioxazin, simazine, oryzalin, trifluralin |
| <i>Avena fatua</i> | Cell elongation inhibitors (8) | POST: glufosinate, glyphosate, paraquat, and rimsulfuron PRE: flumioxazin, indaziflam oryzalin, simazine, clethodim, fluazifop, and sethoxydim |
| <i>Conyza bonariensis</i> ^m | EPSP synthase inhibitors (9) PSI Electron Diverter (22) | POST: glufosinate, rimsulfuron, and 2,4-D PRE: flumioxazin, isoxaben, indaziflam, simazine, and rimsulfuron |
| <i>Conyza canadensis</i> ^m | EPSP synthase inhibitors (9) PSI Electron Diverter (22) | POST: glufosinate, rimsulfuron, and 2,4-D PRE: flumioxazin, isoxaben, indaziflam, simazine, and rimsulfuron |
| <i>Cyperus difformis</i> | ALS inhibitors (2), PSII inhibitor (Ureas and amides) (7) | POST: glufosinate, glyphosate, rimsulfuron, and 2,4-D PRE: rimsulfuron |
| <i>Digitaria ischaemum</i> | Synthetic Auxins (4) | POST: glufosinate, glyphosate, paraquat, rimsulfuron, clethodim, fluazifop, and sethoxydim PRE: oryzalin, pendimethalin, indaziflam, rimsulfuron, and trifluralin |
| <i>Echinochloa colona</i> | EPSP synthase inhibitors (9) | POST: sethoxydim, clethodim, fluazifop PRE: isoxaben, oryzalin, pendimethalin, trifluralin |
| <i>Echinochloa crus-galli</i> var. <i>crus-galli</i> ^m | ACCase inhibitors (1) Lipid Inhibitors (8) | POST: glyphosate, glufosinate, rimsulfuron, sethoxydim PRE: oryzalin, pendimethalin, rimsulfuron, trifluralin |
| <i>Lolium perenne</i> ssp. <i>Multiflorum</i> ^m | ACCase inhibitors (1), ALS inhibitors (2), EPSP synthase inhibitors (9), Glutamine synthase inhibitors (10), PSI Electron Diverter (22) | POST: paraquat, rimsulfuron PRE: oryzalin, pendimethalin, rimsulfuron, simazine, trifluralin |
| <i>Lolium rigidum</i> | EPSP synthase inhibitors (9) | POST: glufosinate, rimsulfuron, sethoxydim, clethodim, fluazifop PRE: oryzalin, pendimethalin, rimsulfuron, trifluralin |
| <i>Poa annua</i> | EPSP synthase inhibitors (9) | POST: glufosinate, paraquat, rimsulfuron PRE: oryzalin, pendimethalin, rimsulfuron, simazine, trifluralin |
| <i>Salsola tragus</i> | ALS inhibitors (B/2) | POST: glyphosate, glufosinate, paraquat PRE: isoxaben, simazine |
| <i>Senecio vulgaris</i> | Photosystem II inhibitors (C1/5) | POST: glyphosate, glufosinate, oxyfluorfen, paraquat, rimsulfuron, 2, 4-D PRE: flumioxazin, isoxaben, oxyfluorfen, rimsulfuron, simazine |