

# How Herbicide Resistance Works

## The Basics

Herbicide resistance is the inherited ability of a plant to survive and reproduce following exposure to a dose of herbicide that would normally be lethal to the species. Resistance occurs naturally due to selection, as a result of random and infrequent genetic mutations, and is not caused by herbicide induced mutations. Herbicide resistant plants may occur naturally and infrequently in weed populations that are predominantly herbicide susceptible, and the use of herbicide provides the pressure that selects for herbicide resistant plants. Repeated use of the same herbicide, or one with the same "site of action", will rapidly (over just a few generations) lead to an herbicide resistant population. While this phenomenon is common in weeds in agricultural production systems, it is still rare with invasive plants in more natural settings. This is likely because the selection agent, herbicide, has not been as aggressively applied outside of production systems.

## A Bit More Depth

Most plants contain a tremendous amount of genetic variation which allows them to survive under a variety of environmental conditions. Herbicides are designed to affect a specific site of action within a plant. For example, herbicides may affect certain enzymes which contribute to the production of amino acids or lipids, or they may interrupt photosynthesis, any of which would be fatal to the plant. The site of action is typically controlled by only a single gene, and any mutation (natural genetic variation) of this gene that causes even minor changes in the way it is expressed, will cause resistance by modifying the site where the herbicide has the toxic effect. Essentially, after gene mutation, the herbicide no longer "fits" into the location where it causes toxicity and the plant is no longer susceptible to the herbicide.

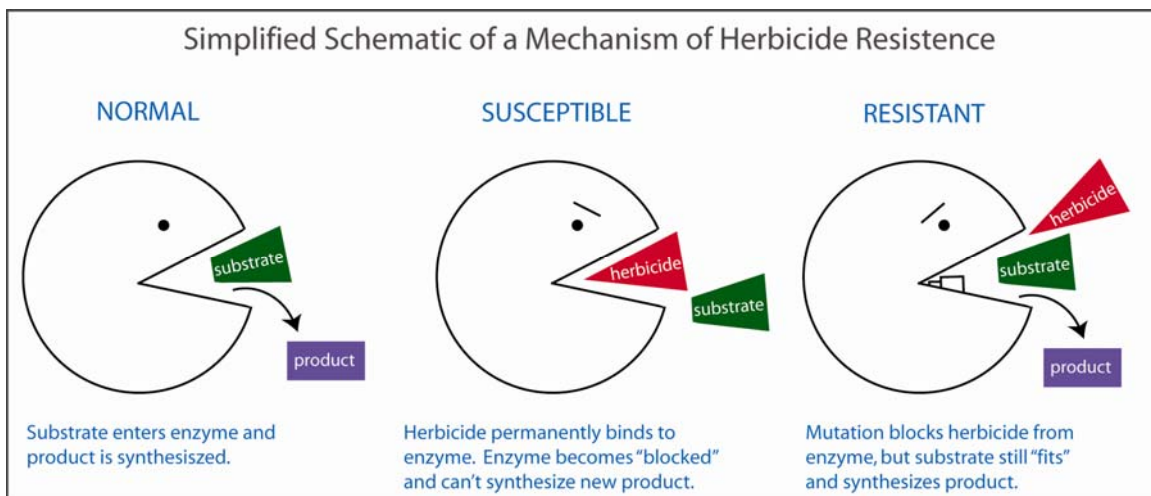


Diagram modified from B. Dyer, Montana State University

Plants that do not have the genetic mutation are still susceptible to the herbicide and are killed, leaving only resistant plants to survive and reproduce. Over time, the seed source of susceptible plants will be depleted and the entire population will consist of resistant plants. The diagram below illustrates this evolution of herbicide resistance (percent values are arbitrary).

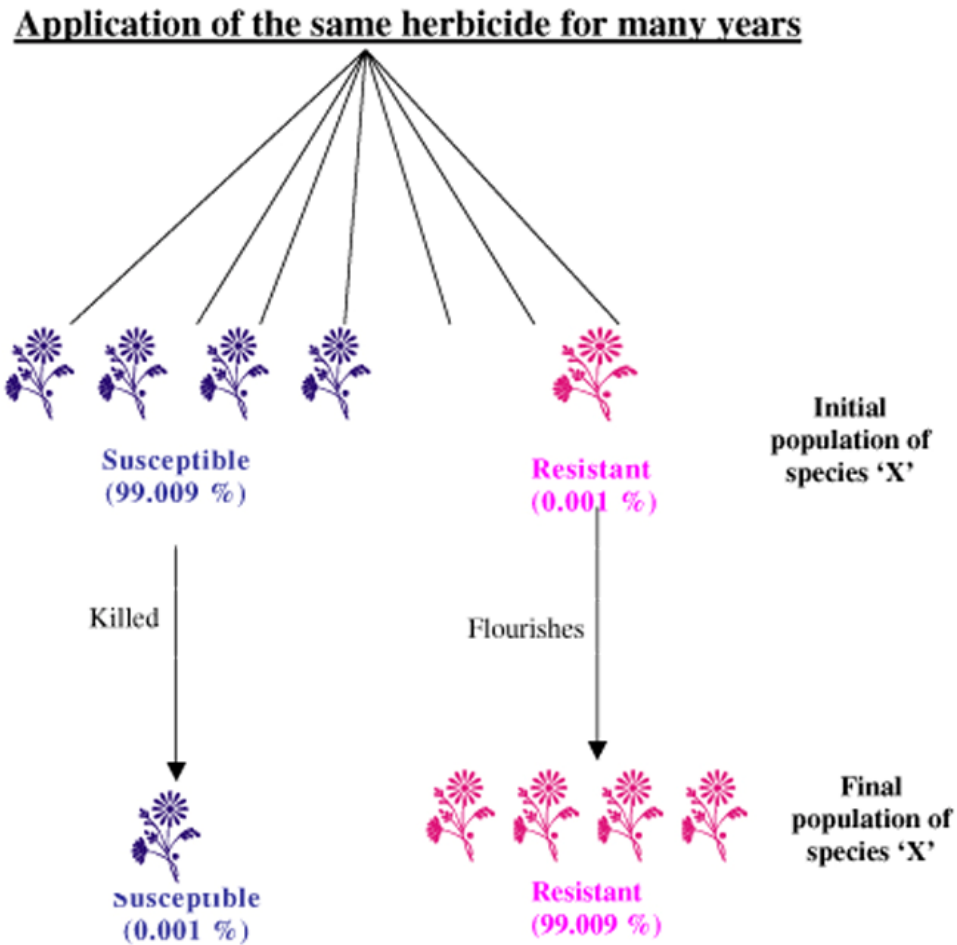


Diagram from Tharayil-Santhakumar, N. 2003. Mechanism of Herbicide Resistance in Weeds. University of Massachusetts, Amherst, MA.  
<http://www.weedscience.org/paper/Mechanism%20of%20Herbicide%20resistance.PDF>

## Some Statistics

There are currently 326 weed species with resistant biotypes, most of which have developed since the 1980s. Some of the invasive plants for which resistant biotypes have been discovered include Russian thistle (northwestern states), yellow starthistle (Washington), Canada thistle (Europe) and cheatgrass (Oregon and Europe). For more information on herbicide resistance by specific species visit:

<http://www.weedscience.org/summary/MOASummary.asp>

### World Wide Chronological Increase in the Number of Herbicide Resistant Weeds

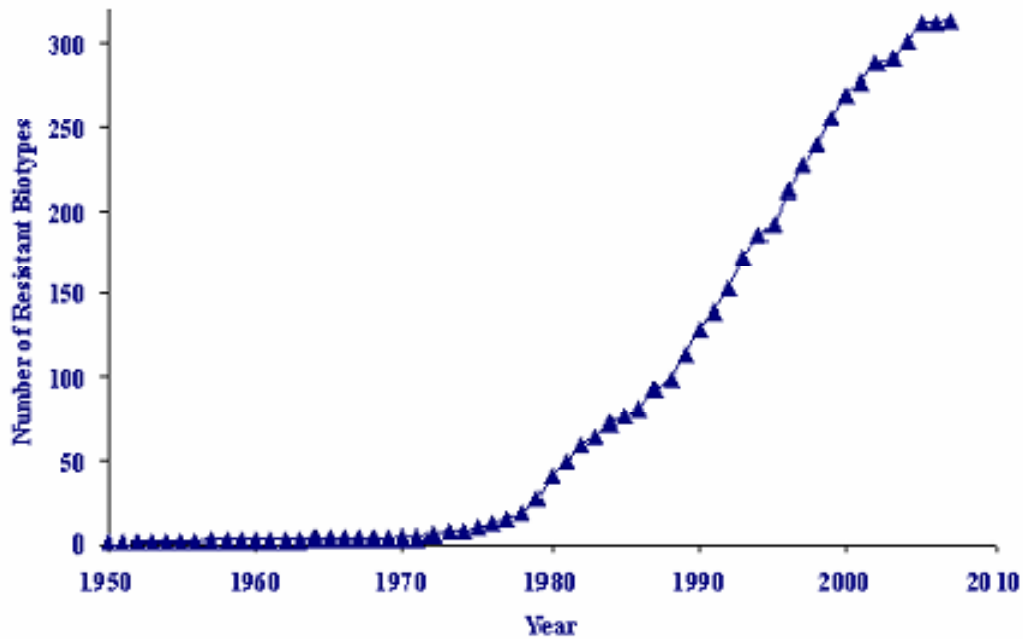


Diagram from Heap, I.M. 2007. Herbicide-Resistance and Weed-Resistance Management.  
[http://www.weedscience.org/paper/Book\\_Chapter\\_1.pdf](http://www.weedscience.org/paper/Book_Chapter_1.pdf)

## Prevention and Management

In cropping situations, the key to preventing resistance is to rotate herbicides so that ones with different sites of action are used. This will prevent the buildup of a population of weeds resistant to a certain type of herbicide. Also, non-chemical weed control techniques such as crop rotation, cultivation, mulching or hand weeding can be used to break the cycle of resistant biotypes surviving an herbicide application. While many of these techniques are not available in natural settings, the principal remains the same. Different herbicides should be used for repeat treatments, and other forms of weed control including hand pulling or biological control (where available) should be used. Finally, a monitoring program can be useful to detect weeds that were not killed by an herbicide treatment.

## Acknowledgements

Much of the information in this summary came from:

Prather, Timothy S., Joseph M. DiTomaso, Jodie S. Holt. 2000. Publication 8012. Herbicide Resistance: Definition and Management Strategies. University of California, Division of Agriculture and Natural Resources.

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