Extension Service
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Managing Herbicide-Resistant Weeds

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Understanding herbicide resistance

What is herbicide resistance? After using a herbicide continuously to control a weed over time, it may no longer be effective in controlling that weed. In other words, the weed species becomes resistant to the herbicide and is not longer controlled by it. However, the entire population of the weed species may not necessarily behave in the same manner; some members of the same species may still be controlled by the herbicide. To better understand herbicide resistance and to minimize the occurrence of resistance development, it is necessary to have a good idea of the processes that govern resistance.

How does herbicide resistance develop? Two basic processes are involved. Most of the time, it develops as a result of selection pressure. In this case, a very small fraction of the population of a particular weed species may possess a slightly different genetic makeup from the rest of the population -- referred to as a biotype -- that makes it tolerate herbicide “X” the first time it is used. The individuals that survived will complete their life cycle and come to seed. Subsequently, if the same herbicide “X” is used to manage weeds, the resistant biotype becomes more and more widespread, resulting in a significant population. Typically, it takes about 10 to15 years for a given weed to develop resistance to a new herbicide but resistance has been documented in as few as five years. Another process by which resistance develops, although less common, is through mutations. In this case, one or more members of a weed species undergoes a change in genetic makeup due to frequent exposure to the herbicide. The modifications usually occur at the site where the herbicide binds at the target site in order for it to be effective. Eventually, the herbicide is no longer effective in controlling this weed biotype. In either case, only the modified biotype is resistant to the herbicide. The original wild type would still be susceptible to the herbicide.

If a weed becomes resistant to one herbicide, will it develop resistance to other types of herbicides too? Herbicides are grouped into families, with different members in the same family behaving similarly. Members belonging to different groups or families have different modes of action. The mode of action is the mechanism by which a given herbicide travels to a target site within a plant where it exerts activity by inhibiting a growth process vital to the plant. Certain families of herbicides may inhibit the process of photosynthesis. Others may inhibit the synthesis of chlorophyll or amino acids vital to plant’s growth, still other groups may cause leaks to plant cells resulting in plant kill. If a weed species develops resistance to two or more herbicides belonging to the same family, the phenomenon is called Cross Resistance. If it develops resistance to two or more herbicides belonging to different families, it is called Multiple Resistance. Differential behavior within plants is caused by changes in the site where the herbicide binds to become active. Other changes may include the ability of the plant to break down the herbicide into nonlethal fragments or decreased transport to the site of action.

What factors affect the speed of resistance development? Biology and life cycle of the weeds play an important role. The shorter the life cycle, the faster the development of resistance. Weeds like pigweed and common lambsquarters which are capable of seeding and germinating multiple times a year, develop resistance faster than perennials like johnsongrass that produce seeds only once a year. Frequency of resistance within a population, diversity of herbicides used, and the number of sprays carried out are other factors governing development of resistance.

Because herbicide resistance is a significant problem, it is imperative to establish logical steps to prevent resistance buildup. The primary cause of herbicide resistance is selection pressure or repeated use of the same herbicide or other herbicides with the same mode of action. Therefore, the most effective step is to use all possible methods of weed control rather than depending upon a single tactic. This helps avoid the use of the same or similar herbicide repeatedly. An Integrated Pest Management (IPM) method that encompasses cultural, mechanical, chemical, and biological control methods, rotating with different families of herbicides, tank-mixing herbicides having different modes of action, and occasionally using a non selective herbicide to control all weeds are

practical methods to reduce resistance buildup. Do not apply herbicide above or below a recommended rate. Monitor fields for escapes and kill them mechanically. Crop rotation is a good cultural practice that reduces selection pressure by encouraging the use of different families of herbicides.

ALS-Resistant Johnsongrass in West Virginia

Johnsongrass (*Sorghum halepense* L.) is a troublesome weed in row crops. This was introduced into the United States by the early European settlers for its forage value, but it later became a weed. Being a perennial weed, it reproduces both sexually through seed and through underground vegetative organs called rhizomes that can persist in the soil from year to year. Its close relative, shattercane (*Sorghum bicolor* L.), is an annual. However, hybrids with short rhizomes exist in parts of West Virginia and Virginia.

Cost-effective options for controlling johnsongrass prior to emergence are limited. There are no pre-emergence (PRE) or soil-applied herbicides to control rhizome johnsongrass on the market today. Therefore, we are limited to the use of post-emergence (POST) herbicides for controlling this weed in row crops. Commonly used selective herbicides for effective control of johnsongrass are a group called ALS inhibitors that include:

Trade Name	Active ingredient/s
Accent	nicosulfuron
Beacon	primisulfuron
Basis Gold	atrazine + rimsulfuron + Accent
Celebrity Plus	dicamba + diflufenzopyr + Accent
Exceed	prosulfuron + Beacon
Northstar	dicamba + Beacon
Steadfast	rimsulfuron + Accent
Option	foramsulfuron + isoxadifen

The herbicides listed above inhibit an enzyme called Acetolactate synthase (ALS) and mostly belong to a family of sulfonylureas (SUs). Apart from the herbicides listed, there are certain other ALS inhibitors that belong to the family called imidazolinones (IMIs). These include Lightning, Pursuit, and Scepter. Conventional corn would be injured by these compounds; however, genetically modified IMI-tolerant corn would tolerate these herbicides.

Due to a reported failure of johnsongrass control after two applications of Accent at a farm in Moorefield, West Virginia, in 2003, field and greenhouse studies were conducted to determine if it was due to a biotype of johnsongrass that developed resistance to Accent and other ALS inhibitors. In field studies, Accent, Lightning, Northstar, Pursuit, and Roundup were applied at recommended use rates in the problem area when the johnsongrass plants were chest high on average. Ratings taken three weeks later indicated no control of johnsongrass except in the plots that received Roundup. Further testing was carried out in the greenhouse at Morgantown by transplanting johnsongrass plants ranging from 15" to 36". Johnsongrass plants collected from Morgantown area (susceptible to ALS inhibitors) were also treated with the different herbicides for comparison. Herbicide treatments consisted of Accent applied at 0.66 oz/A, 1.22 oz/A, and 2.44 oz/A. An untreated control was also included. Ratings taken four weeks after application indicated that the johnsongrass collected from Morgantown were controlled 90% to 100% by the different Accent treatments. Those collected from the Moorefield location exhibited active growth, with several plants setting seed-heads at this time. These studies conclusively indicate that there is now a biotype of johnsongrass in the Moorefield area that is resistant to ALS inhibitors. Seeds collected from the area germinated in the greenhouse, which indicates that a reservoir of viable seeds exists now.

Management ALS resistant johnsongrass

Since ALS herbicides have been the primary tool used to manage johnsongrass in corn in the past 10 to12 years, adjustments in the spray program may have to be made to reduce the risk of ALS-resistant johnsongrass in your fields. How would you do this? Rotating to a crop like soybean and using post-emergence grass herbicides like Assure, Fusilade, Poast, Select, or Typhoon would be one option. Prowl and Treflan provide good pre-emergence control of seedling johnsongrass but unacceptable control of rhizome johnsongrass. Rotating to Roundup Ready soybean or Roundup Ready corn and using a glyphosate product registered for use in such crops would be the other option. A minimum of two- to three-year sequence of an alternative spray program may be needed to reduce the levels of the resistant biotype. While complete suppression of this biotype is unlikely, several years of management efforts may result in low enough levels. If a field is left fallow, treating with a systemic herbicide to control johnsongrass would be recommended to reduce spread of this biotype.