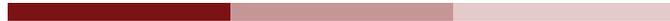


*Herbicide
Resistance
A Growing
Issue
in Arkansas*



Herbicide Resistance A Growing Issue in Weed Science

Herbicide resistance is used to describe weeds that have developed the ability to survive repeated normal rates of a herbicide that previously controlled them. Herbicide resistance is most often caused by a genetic mutation in the resistant plant and is passed on to future generations. A weed that has become resistant due to a genetic shift is known as a **resistant biotype**. The resistant biotypes are most often visually indistinguishable from their susceptible counterparts.

Documented Herbicide Resistant Weeds In Arkansas

Weed	Herbicide Group	Herbicide Example
Goosegrass	DNA	Treflan
Cocklebur	Organoarsenicals	MSMA
Barnyardgrass	Ureas and amides	Propanil
Palmer amaranth	ALS inhibitors	Staple Pursuit
Redroot pigweed	ALS inhibitors	Classic Scepter
Perennial ryegrass	ACCcase inhibitors	Select Poast
Perennial ryegrass	ALS inhibitors	Glean Hoelon
Cocklebur	ALS inhibitors	Scepter
Barnyardgrass	Synthetic Auxins	Facet
Red rice	ALS inhibitors	Newpath
Horseweed	Glycines	Roundup
Common ragweed	Glycines	Touchdown
Annual ryegrass	ACCcase inhibitors ALS inhibitors	Osprey Hoelon

Although it was once thought that weeds could not become resistant to herbicides, this theory has been proven very inaccurate. Currently, there are 304 weed biotypes in 182 species that have been identified as resistant to a particular herbicide or class of herbicides. **Thirteen** different weed biotypes have been documented resistant to **seven** different herbicide classes in **Arkansas**. When a weed becomes resistant to a herbicide, it most often is **cross-resistant** to all other herbicides with the same site of action. Some weeds develop resistance to herbicides with different sites of action and are known as **multiple resistant**.

Although the first herbicide resistant weed documented in Arkansas in 1989 caused concern, the level of concern warranted then was much less than today. In that era, new herbicides were coming into the market at a rapid rate and alternative control measures were readily available to control any weed that became resistant to a herbicide or class of herbicides. **If this attitude prevails today**, it will be as faulty as the earlier theory that weeds cannot develop resistance to herbicides. There are fewer herbicide companies and considerably fewer new herbicides being developed. There are **no new “silver bullets”** being developed to replace current herbicides.

Shifts In Arkansas Agriculture

Since 1997, the average size of cropland farm in Arkansas has decreased in every category below 2000 acres. However, there has been a tremendous increase in the number of acres in farms with greater than 2000 acres.

This shift has come as a result of genetically engineered crops allowing farmers to farm more acres with less equipment and labor. The number of acres devoted to conservation tillage has increased to near 60% of all cotton, soybean and corn acres since the introduction of glyphosate resistant crops. Control of herbicide resistant weeds may require incorporation of tillage back into farming operations; thus, severely threaten advances made in conservation tillage over the past few years.

How Weeds Become Resistant

The establishment of resistant weeds within a field can be caused by tow factors that may be closely related: genetic mutations and intense selection pressure. Genetic shifts or “mutations” continually occur in nature. Most of these go unnoticed or make the plant less adaptable to its environment and simply die out of the populations. When a genetic shift occurs that makes the plant more adaptable, it competes better and produces more seed than its less adaptable counterparts. If a population of plants is resistant to a specific herbicide, widespread resistance can occur. There are also cases where one or a few plants that are resistant to a specific herbicide are already present in a population. When those weeds are exposed to the same herbicide or class of herbicides over time, the high selection pressure allows the resistant weeds to thrive in that environment and produce viable seed. These offspring survive the same herbicide applications and produce a herbicide resistant population. Seldom is the first herbicide

resistant parent recognized or identified in a field situation. It simply goes unnoticed or is thought to be an “escape” due to inadequate herbicide coverage. It is well known that every weed that escapes a herbicide application is not resistant to that herbicide. Weed size, environmental conditions such as temperature, moisture and humidity, herbicide rate, application technique, sprayer calibration, canopy cover and other factors often allow a single or few weeds to escape. **An escaped weed may not be reason for alarm, but should be reason for concern. Clean Fields Do Not Produce Resistant Weeds!**

Management and Control of Resistant Weeds

Traditional resistance management techniques include crop and herbicide rotations, herbicide combinations, rotation of herbicide mode of action, and tillage. In Arkansas, greater than 90% of the soybeans and cotton and greater than 50% of the corn acreage are planted to Roundup Ready[®] varieties and greater than 25% of the rice acreage is planted to Clearfield[®] varieties. This puts tremendous selection pressure on weeds to become resistant to glyphosate and Newpath herbicides. Palmer pigweed is a weed species that has been determined to be resistant to glyphosate in several locations in the southern U.S. Because of the widespread distribution of this pest throughout Arkansas and its potential to cause significant economic losses, practices that can prevent or slow the development of glyphosate resistant Palmer in Arkansas are emphasized throughout this management guide. Red rice is the target weed of most Clearfield[®] rice programs and has shown the ability to outcross with conventional

rice that carries the imazethapyr resistant gene. Imazethapyr or Newpath resistant red rice will destroy the value of this technology.

1. Crop Rotation is a valid resistant management technique because it exposes weeds to different cultural environments as well as different herbicide programs. Rotation from one glyphosate resistant crop to another glyphosate resistant crop without changing herbicide and tillage programs is of little value in the fight against herbicide resistant weeds because it does not significantly change the environment to which the weeds are exposed. Rotation from glyphosate resistant cotton to conventional corn is an example that forces weeds into different cultural and herbicide programs and greatly reduces the possibility of developing a resistant population.
2. Rotation of Herbicide Chemistry and Mixing Herbicides help to reduce the chances of survival of the one weed that develops resistance to a single herbicide. Using herbicides other than just glyphosate in glyphosate tolerant crops and tank-mixing herbicides with different modes of action with glyphosate will reduce the possibility of developing resistance to glyphosate as well as the other herbicides used in the program. The herbicide mixed with glyphosate must be added at a rate that will control the targeted weed alone in absence of glyphosate. A glyphosate resistant weed treated with a sublethal dose of a second herbicide will continue to live and produce seed.

3. Tillage has long been used as a tool to combat herbicide resistant weeds. Timely cultivation effectively removes most annual weeds and can be used in combination with herbicide programs to combat resistance.

Glyphosate Resistance Management In Soybean

Currently there are over 3 million acres of soybeans in Arkansas. Of those, over 95% are Roundup Ready[®] and receive on average 1.75 applications of in-crop glyphosate per year. In addition, the number of different herbicides used in soybeans has been in decline since 1999. Couple this with the fact that many of these fields receive a burn-down application of glyphosate and are rotated with other Roundup Ready[®] crops; it is obvious that tremendous selection pressure is being placed on these weed populations. It should come as no surprise that several confirmed resistant and suspected resistant weeds are starting to surface around the state. The following are some suggestions to help prevent the development of resistance to glyphosate.

Recommendations/Suggestions

- Introduce at least one herbicide with an alternative herbicide mode of action (MOA) into the RR system. (You must apply the alternative MOA at a high enough rate to control weeds without glyphosate)
- Utilize effective soil applied herbicide program. (Soil herbicides must be applied properly and activated by irrigation or rainfall to have a significant impact on weed populations)

Herbicides might include: **Pre-plant incorporated** application of Dual Magnum or Prowl or Treflan + Sencor or Scepter* or **Pre-emergence** applications of Dual Magnum combined with Scepter, Sencor, or Canopy, or **Pre-emergence** applications of Valor combined with Scepter, Prowl or FirstRate.

- Utilize effective and properly timed POST herbicides, including glyphosate.
(POST herbicides should be used at a high enough rate to control weeds, also rotate tank-mix partners from year to year, in addition, herbicides including glyphosate should be applied at early timings for effective control of weeds)

Herbicides might include: **Burndown** applications of paraquat or glyphosate + 2,4-D or dicamba (Clarity) followed by **POST (in-crop)** applications of glyphosate + Flexstar (1.25pts) or Blazer (1.5pts) (must apply Blazer and Flexstar at full rates to <2" pigweed for effective control or resistance management).

- Rotate RR soybeans with corn, rice or cotton and use herbicides other than glyphosate in those programs
- Introduce tillage as a weed control option for burndown, rotate no or reduced tillage systems.
- Consider rotating cleaner fields to conventional soybeans for one year.

Resistance Management Plan for Cotton

The fact that a combination of herbicides has been required to provide adequate season long weed control has helped to prevent herbicide resistance weeds from becoming a problem in cotton. Although horseweed is a problem in all conservation tillage areas and does impact cotton farmers, other confirmed and suspected resistant weeds are more common in soybeans, wheat and rice where single herbicides have been used to control a particular species over several years. Hopefully, the lessons learned from Roundup Ready[®] soybeans will help prevent resistance from becoming a problem after the introduction of Roundup Ready Flex[®] cotton.

- I. To help prevent herbicide resistance from developing in cotton
 - A. Crop rotation with non-Roundup Ready crops
 1. Liberty Link Cotton
 2. Grain Sorghum
 3. Conventional Corn
 - B. Utilize more than one herbicide mode of action that is effective on weeds present
 1. Burndown program containing a residual herbicide
 - a. Meturon
 - b. Direx
 - c. Prowl
 - d. Caparol
 2. Preemergence herbicide at planting
 - C. Metolachlor in first application of glyphosate or Ignite

A residual herbicide will reduce the number of weeds germinating and thus reduce the chance that a single mutant biotype will become established in the field. However, residual herbicides are effective management tools only as long as the residual properties last. Using a residual herbicide becomes a “numbers game”. The fewer weeds that germinate, the smaller the chance that a resistant biotype will become established.

D. Directed spray with different mode of action

1. Suprend
2. Aim
3. MSMA

E. Use residual at layby

1. Valor
2. Direx + MSMA
3. Caparol + MSMA

Keep fields clean and scout for escapes

There are no perfect weed control programs under varying environmental and management conditions. Paying particular attention to escaped weeds can be instrumental in preventing major problems with herbicide resistant weeds. If the “escapes” are thought to have survived a herbicide application with good coverage and adequate rates, they should be treated as suspects and not allowed to produce seed. Early detection is important because many weed seed have the ability to germinate after laying dormant in the soil for several years.

Resistance Management in Rice and Clear-field Rice

Currently in Arkansas, propanil-resistant barnyardgrass, Facet-resistant barnyardgrass, and Newpath-tolerant red rice are of key concern to growers. Barnyardgrass has demonstrated the ability to develop resistance to several herbicides throughout the world and is of concern in Arkansas due to its competitive nature with rice.

Barnyardgrass in Rice

Fortunately over the past 4-5 years several new developments in rice herbicides have resulted in several options for the control of Facet and propanil-resistant barnyardgrass. These include rotation of a propanil or Facet based weed control program with one that includes Command herbicide applied PRE followed by POST applications of Clincher or RiceStar. Where the weed spectrum fits, Regiment and Grasp can also be used as resistance management tools for barnyardgrass.

These herbicide options should be used in combination with crop rotation. In Arkansas, this rotation is often with soybeans. In soybeans a herbicide program involving Dual Magnum applied either PPI or PRE followed by an application of glyphosate or one of the graminicides (Select, Assure II, Poast Plus, etc) provides excellent resistance management for barnyardgrass.

Clearfield Rice

Resistant barnyardgrass and other weeds

Numerous weeds have developed resistance to the ALS herbicide family. Newpath for use in Clearfield® rice is a member of this family. Newpath provides a wide spectrum of weeds controlled in rice production. The addition of another mode of action to the Clearfield® system is critical to aid in prevention of ALS resistant weed problems in Clearfield® rice. Newpath does not control hemp sesbania or northern jointvetch. Often, the addition of a tank-mix partner for the control of these weeds, such as Facet, propanil or Aim, will provide an alternative mode of action (MOA) for several weeds. Rotating tank-mix partners is a good resistance management strategy for Clearfield® rice. Also, the addition of Command applied PRE to a Clearfield® program will provide an alternative MOA for grass weeds if no broadleaves are of a concern.

Out-Crossing

In addition to the conventional buildup of resistant weeds common to any herbicide program, the Clearfield® rice program presents another resistance management challenge in the form of out-crossing. Because rice and red rice are the same genus and species, it is possible for a Clearfield® rice plant to pollinate a weedy rice biotype and vice-versa. If these cross pollinated plants produce seed, the resulting F1 hybrid will be a red rice plant with the Clearfield® trait for herbicide tolerance. This phenomenon was first documented in

a grower's field in Arkansas in 2003 and is now suspected to have occurred in numerous fields across the state. Luckily, these F1 hybrid plants have thus far been very easy to identify because of their late maturity, size (2X taller than CL 161) and tolerance to Newpath. They mature so late that harvest and subsequent tillage measures can eliminate seed production. However, there are no alternative in-crop control measures for red rice. Therefore, great care should be taken to steward the Clearfield® technology. **It should be mentioned that F2 generations or out-crossed plants from hybrid rice will not be as easy to identify nor will they be later maturing plants than conventional rice.**

Below are several suggestions to help limit the buildup of resistance both from out-crossing and normal resistant weeds in a Clearfield® rice system. Implementing any one suggestion into a production program will help and may delay development of resistance, but incorporating all four will provide the most protection against resistance and out-crossing.

Crop rotation. Currently, the University of Arkansas Cooperative Extension Service recommends a one-year rotational interval with Clearfield® rice. In Arkansas, this rotation is often with soybeans.

POST-Harvest. Any surviving red rice plants should be destroyed immediately POST harvest prior to the production of viable seeds (F1 hybrids if out-crossing has already occurred). Also, take measures to insure winter mortality, such as flooding the field to attract ducks and allow for premature emergence, etc.

Obtain Complete Control of Red Rice. Allowing any red rice plants to survive two Newpath applications will create the potential for out-crossing. Beyond herbicide, which is the same MOA as Newpath, is labeled under a 24C state label for late-applications to Clearfield® rice for the specific purpose of preventing late emerging or missed populations of red rice from out-crossing with Clearfield® varieties. Removal of small patches of red rice by roguing escapes may also be effective.

Do not save seed. Saving Clearfield® rice seed is currently restricted by US patent law. However, saving seed also creates a vessel by which out-crossed red rice seeds can travel and spread from field to field. Seed production fields are checked and certified by the Arkansas State Plant Board as red rice free, this adds an extra level of protection against the spread of resistant red rice.

Some Common Concerns About Resistant Management Programs:

Resistance costs as much to prevent as it does to manage.

While this statement is somewhat true for year one, in future years, once resistance is here, you lose the option of glyphosate alone. Additional benefits include: improved control of balloonvine, morningglory, hemp sesbania, nutsedge, smartweed sp. and other weeds.

Prevention is the same as the cure from a herbicide standpoint.

“Same as above. Also, who says the weed or weeds that become resistant will not need a second or third herbicide for control.”

I already pay a tech fee.

“While there are a few weeds that are resistant to glyphosate, it still controls a wide spectrum of weedy pests. Resistance management programs that help protect the viability of the herbicide and its associated technology are worth putting in place because alternative programs without the benefits of glyphosate may end up being more expensive.”

Arkansas Herbicide Resistance Committee



Ken Smith
Extension Weed Scientist
UACES
Committee Chair



David Black
Research & Dev, Scientist
Syngenta Crop Protection



Don Plunkett
CEA Agriculture
UACES



Randy Chlapecka
CEA Staff Chair
UACES



Bob Scott
Extension Weed Scientist
UACES



Chuck Farr
Consultant
Mid-South Ag Consultants



Zach Shappley
Technology Dev. Representative
Monsanto Co.



George Hackman
Technical Field Representative
Sipcam Agro



Keith Vodrazka
Sr, Technical Service Representative
Bayer CropScience

Herbicide resistance is real and poses a real threat to our Arkansas farming economy.

The Arkansas Herbicide Resistance Committee is committed to helping Arkansas farmers effectively and economically develop farming systems that will prevent or slow the development of herbicide resistant weeds.

Farming culture as we know it today will be severely negatively impacted by the development of resistant weeds such as glyphosate resistant pigweed.


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