



Managing Herbicide-Resistant Weeds in Peanuts in the United States

Some members of a weed species can survive and reproduce after exposure to a rate of herbicide that normally kills other weeds of the same species. Such plants are said to be herbicide resistant. Herbicide resistance is the inherited ability of a weed species to survive and reproduce following exposure to a rate of herbicide that was previously effective in controlling this species. Application of herbicide may reveal biotypes within the population that can survive exposure to the herbicide. Applying herbicides with the same mechanism of action repeatedly and successively allows these resistant plants to continue to survive and reproduce. Increasingly, peanut growers must consider the mechanism behind development of herbicide-resistant weeds and approaches to delay, curtail, and prevent development of resistant weed populations. Prevention is the most effective way to manage herbicide resistance.

The probability that a weed will develop resistance to a herbicide (and to related herbicides with the same mechanism of action) depends upon three factors:

- specificity of the mechanism of action (Table 1),
- degree of selection pressure exerted on the population, and
- ability of the species to reproduce.

The grower can only control the amount or degree of selection pressure exerted on the weed population. To prevent development of herbicide resistance, it is most effective to reduce selection pressure on resistant biotypes. Do not apply herbicides with the same mechanism of action repeatedly and successively. Use a herbicide with a different mechanism of action to kill weeds that survive the previous herbicide application. Table 1 lists mechanisms of action for various herbicides and also groups herbicides by the likelihood of resistance development.

Poor weed control may be caused by a number of factors other than herbicide resistance. Be diligent in determining if a weed control failure is in fact due to herbicide resistance. Consider all factors when diagnosing weed control failures (Table 2). Several key indicators may be used to determine if herbicide resistance is the cause of poor weed control. If herbicide resistance is confirmed or highly suspected, approaches to managing herbicide resistance need to be incorporated into weed management strategies immediately for the species in question. The Web site that contains the most conclusive summary of documented cases of herbicide-resistant weeds is www.weedscience.org/in.asp.

Herbicide resistance is prevalent in peanut-growing regions (Table 3), and specific herbicide programs are suggested to help the grower manage herbicide-resistant weeds in peanut fields (Table 4). Growers lose effective herbicide options if populations of several weed species in a given field develop significant herbicide-resistant biotypes.

Distributed in furtherance of the acts of Congress of May 8 and June 30, 1914. North Carolina State University and North Carolina A&T State University commit themselves to positive action to secure equal opportunity regardless of race, color, creed, national origin, religion, sex, age, or disability. In addition, the two Universities welcome all persons without regard to sexual orientation. North Carolina State University, North Carolina A&T State University, U.S. Department of Agriculture, and local governments cooperating.

Table 1. Herbicide Families and Relative Propensity of Developing Resistance to Herbicides.

Trade Name	Active ingredient	Herbicide family	Mechanism of action
<i>Herbicides with high potential to select for herbicide resistance</i>			
Cadre, Impose	Imazapic	Imidazolinone	Inhibition of acetolactate synthase (ALS)
Pursuit	Imazethapyr	Imidazolinone	Inhibition of acetolactate synthase (ALS)
Strongarm	Diclosulam	Triazolopyrimidine sulfonamide	Inhibition of acetolactate synthase (ALS)
Classic	Chlorimuron	Sulfonylurea	Inhibition of acetolactae synthase (ALS)
<i>Herbicides with moderate to high potential to select for herbicide resistance</i>			
Arrow, Select, Select Max, Volunteer	Clethodim	Cyclohexanedione	Inhibition of acetyl CoA carboxylase
Poast, Poast Plus	Sethoxydim	Cyclohexanedione	Inhibition of acetyl CoA carboxylase
<i>Herbicides with moderate potential to select for herbicide resistance</i>			
Prowl, Pendimax	Pendimethalin	Dinitroaniline	Inhibition of microtubule assembly
Sonalan	Ethalfuralin	Dinitroaniline	Inhibition of microtubule assembly
Treflan	Trifluralin	Dinitroaniline	Inhibition of microtubule assembly
<i>Herbicides with low potential to select for herbicide resistance</i>			
Basagran	Bentazon	Benzothiadiazole	Inhibition of photosynthesis
Cobra	Lactofen	Diphenylether	Protox inhibitor (PPO)
Firestorm, Gramoxone INTEON, Parazone	Paraquat	Bipyridilium	Acceptor of electron transfer in Photosystem I
Dual Magnum, Parallel PCS, Stalwart	Metolachlor	Chloroacetamide	Inhibition of nucleic acid formation, other
Outlook	Dimethenamid	Chloroacetamide	Inhibition of nucleic acid formation, other
Storm	Acifluorfen + Bentazon	Diphenylether + Benzothiadiazole	Inhibition of photosynthesis and protox inhibitor (PPO)
Ultra Blazer	Acifluorfen	Diphenylether	Protox inhibitor (PPO)
Valor SX	Flumioxazin	N-phenylphthalimide derivative	Protox inhibitor (PPO)
Butyrac 200, Butoxone	2,4-DB	Phenoxy	Plant growth inhibition



Palmer amaranth biotype no longer controlled by Cadre or Pursuit in a peanut field in Georgia.

Table 2. Detection and Approaches to Management of Herbicide Resistance.

Possible reasons why herbicides do not control weeds that are not associated with herbicide resistance

- Improper herbicide choice or rate.
- Improper application of herbicide, including poor incorporation.
- Poor timing of herbicide application.
- Weather conditions were not favorable when herbicides were applied.
- Weeds emerged after application of postemergence herbicides that do not have residual activity, or weeds emerged prior to application of herbicides that do not have postemergence activity.

Indicators suggesting that weeds are resistant to herbicides

- Performance of the herbicide poor on the species in question while other weed species that are normally controlled are controlled well.
- Herbicide normally controls the weed in question.
- Poor control is confined to spots in the field.
- Some plants of the same species controlled well while other plants of the same species controlled poorly.
- Field history of a single herbicide or heavy use of herbicides with the same mechanism of action.

Steps to take to prevent or manage herbicide resistance

- Rotate to herbicides having different mechanisms of action.
- Use tank mixes or sequential applications of herbicides having different mechanisms of action.
- Be especially vigilant when using herbicides with a high potential for selecting for herbicide resistance.
- Integrate non-chemical controls, such as cultivation and hand-removal of weeds, when possible or spot sprays using non-selective herbicides.
- Do not allow weeds to produce seeds when herbicide resistance is suspected.

Table 3. Prevalence of Herbicide Resistance in Peanut in the United States. (click for accessible table)

Southeastern region (Alabama, Florida, Georgia)	Southwestern region (New Mexico, Oklahoma, Texas)	Virginia-Carolina region (North Carolina, South Carolina, Virginia)
Acetolactate synthase inhibiting (ALS) herbicides (Cadre, Classic, Impose, Pursuit, Strongarm)		
Palmer amaranth Pigweed species	Palmer amaranth Pigweed species	Common cocklebur Common ragweed Palmer amaranth Pigweed species
Dinitroaniline herbicides (Prowl, Sonalan, Treflan)		
Goosegrass		Goosegrass
Palmer amaranth		Palmer amaranth



Palmer amaranth suspected to be resistant to Cadre and Pursuit, herbicides that inhibit acetolactate synthase. Postemergence herbicides, such as Cobra and Ultra Blazer (PPO), which are Protax inhibiting herbicides that disrupt cell membrane integrity, will not control Palmer amaranth and other pigweed species at this growth stage.

Table 4. Specific Herbicide Programs to Manage Herbicide-Resistant Weeds in Peanut.

NOTE: Consult local recommendations and product labels for effectiveness and restrictions on uses of herbicides.
(click for accessible table)

Weeds suspected to be resistant	Herbicides that no longer control this weed due to resistance	Herbicides effective on these herbicide-resistant weeds		
		Preplant incorporated	Preemergence	Postemergence
Palmer amaranth, pigweed	Prowl Sonalan Treflan	Dual Magnum Outlook Parallel PCS Pursuit Stalwart Strongarm	Outlook Dual Magnum Parallel PCS Pursuit Stalwart Strongarm Valor SX	2,4-DB Cobra Cobra + 2,4-DB Cadre or Impose Cadre or Impose + Cobra Cadre or Impose + 2,4-DB Cadre or Impose + Ultra Blazer Classic Paraquat (Gramoxone INTEON, Firestorm, or Parazone) Paraquat + Dual Magnum or Parallel PCS or Stalwart Paraquat + Outlook Paraquat + Storm Pursuit Pursuit + 2,4-DB Pursuit + Ultra Blazer Roundup Weather MAX* Storm Storm + 2,4-DB Ultra Blazer Ultra Blazer + 2,4-DB
Goosegrass	Prowl Sonalan Treflan	Dual Magnum Outlook Parallel PCS Pursuit Stalwart	Outlook Dual Magnum Parallel PCS Pursuit Stalwart	Arrow, Poast, Poast Plus, Select, Select Max, or Volunteer Cadre or Impose Paraquat (Gramoxone INTEON, Firestorm, or Parazone) Paraquat + Dual Magnum or Parallel PCS or Stalwart Paraquat + Outlook
Palmer amaranth, pigweed	Cadre Classic Impose Pursuit Strongarm	Dual Magnum Outlook Parallel PCS Prowl Sonalan	Dual Magnum Outlook Parallel PCS Valor SX Stalwart	2-4DB Cobra Cobra + 2,4-DB Paraquat (Gramoxone INTEON, Firestorm, or Parazone) Paraquat + Dual Magnum or Parallel PCS or Stalwart Paraquat + Outlook Roundup Weather MAX* Storm Storm + 2,4-DB Ultra Blazer Ultra Blazer + 2,4-DB

*Apply Roundup Weather MAX with a rope-wick applicator in row middles with no contact with the peanut canopy. This treatment will not control glyphosate-resistant weeds.

Table 4. Specific Herbicide Programs to Manage Herbicide-Resistant Weeds in Peanut.

NOTE: Consult local recommendations and product labels for effectiveness and restrictions on uses of herbicides.
 (click for accessible table)

Weeds suspected to be resistant	Herbicides that no longer control this weed due to resistance	Herbicides effective on these herbicide-resistant weeds		
		Preplant incorporated	Preemergence	Postemergence
Common cocklebur	Cadre Classic Impose Pursuit Strongarm	None	None	Basagran Basagran + 2,4-DB Cobra Cobra + 2,4-DB Paraquat (Gramoxone INTEON, Firestorm, or Parazone) + Basagran Storm Storm + 2,4-DB Ultra Blazer Ultra Blazer + 2,4-DB 2,4-DB
Common ragweed	Strongarm	None	Valor SX	Cobra Paraquat (Gramoxone INTEON, Firestorm, or Parazone) Roundup Weather MAX* Storm Ultra Blazer
Goosegrass, Palmer amaranth, pigweed	Cadre Classic Impose Prowl Pursuit Sonalan Strongarm	Dual Magnum Outlook Parallel PCS Stalwart	Dual Magnum Outlook Valor SX	Cobra Cobra + 2,4-DB Paraquat (Gramoxone INTEON, Firestorm, or Parazone) Paraquat + Dual Magnum or Parallel PCS or Stalwart Paraquat + Outlook Paraquat + Storm Ultra Blazer Ultra Blazer + 2,4-DB

*Apply Roundup Weather MAX with a rope-wick applicator in row middles with no contact with the peanut canopy. This treatment will not control glyphosate-resistant weeds.

Prepared by

Dr. David Jordan, Professor, North Carolina State University
Dr. Eric Prostko, Associate Professor, University of Georgia
Dr. Peter Dotray, Professor, Texas Tech and Texas A&M Universities
Dr. John Wilcut, Former Professor, North Carolina State University
Dr. Todd Baughman, Associate Professor, Texas A&M University
Dr. Barry Brecke, Professor, University of Florida
Dr. Jay Chapin, Professor, Clemson University
Dr. Joel Faircloth, Assistant Professor, Virginia Tech
Dr. Wilson Faircloth, Research Agronomist, National Peanut Research Lab, USDA-ARS
Dr. Jason Ferrell, Assistant Professor, University of Florida
Dr. Timothy Grey, Assistant Professor, University of Georgia
Mr. James Grichar, Research Scientist, Texas A&M University
Dr. Greg MacDonald, Associate Professor, University of Florida
Dr. Case Medlin, Assistant Professor, Oklahoma State University

Review Committee

Dr. Nilda Burgos, Associate Professor, University of Arkansas
Dr. Stanley Culpepper, Associate Professor, University of Georgia
Dr. George Kennedy, William Neal Reynolds Distinguished Professor of Entomology, North Carolina State University
Dr. Jill Schroeder, Professor, New Mexico State University, President Weed Science Society of America
Dr. Turner Sutton, Professor of Plant Pathology, North Carolina State University
Dr. Alan York, William Neal Reynolds Distinguished Professor of Crop Science, North Carolina State University

This publication is dedicated to the memory of Dr. John Wilcut, Professor, North Carolina State University.
Dr. Wilcut was involved in many research projects associated with weed management in peanuts,
including helping develop strategies to manage herbicide-resistant weeds.

Preparation of this publication was supported with funds administered through the
North Carolina Peanut Growers Association and the
North Carolina State University Extension and Engagement Seed Grant Program.

3,000 copies were printed at a cost of 1,446, or \$0.42 per copy.

Published by

NORTH CAROLINA COOPERATIVE EXTENSION SERVICE

