University of Kentucky
College of Agriculture, Food and Environment
Cooperative Extension Service

Palmer Amaranth and Waterhemp Control in Corn and Soybean

Travis Legleiter, Plant and Soil Sciences

Biology

Understanding the biology of a weed is the first step in implementing an effective weed control program. This is especially true with Palmer amaranth (*Amaranthus palmeri*) and waterhemp (*Amaranthus tuberculatus*), as understanding their emergence patterns, competitiveness, adaptability, and seed production all need to be considered when developing a control program.

Emergence Pattern

Unlike most summer annual weeds that have a primary emergence period of a couple of weeks to a month, Palmer amaranth and waterhemp emergence can occur from late April through the fall months. While the majority of Palmer amaranth and waterhemp emerges during May and June in Kentucky there is still some emergence that occurs in July, August, and September if crop canopy is limited. This extended emergence pattern makes season-long control difficult to accomplish.

Seed Production and Spread

Palmer amaranth and waterhemp can produce nearly a million seeds per plant when in an uncompetitive environment. The production of 100,000 to 500,000 seeds per plant is more typical when these weeds exist in corn and soybean fields, though this is still considered prolific seed production. The seeds of Palmer amaranth and waterhemp are also very small, about the size of coarsely cracked pepper, and are easily transported. Any piece of equipment that is used in a field infested with waterhemp or Palmer has the potential to spread seed, including with soil attached to equipment (Figure 1).

Competitiveness and Rapid Growth

Palmer amaranth and waterhemp are as competitive as any other weed that is encountered in corn and soybean. Waterhemp allowed to compete with soybean season-long can reduce yields by up to 44 percent when present at high populations; whereas, the more competitive Palmer amaranth can reduce yields up to 79 percent.

Table 1. Confirmed herbicide resistance events in waterhemp and Palmer amaranth in Kentucky and prevalence of resistance within the state.

Site of action	Site of action group #	Example active ingredient	Prevalence of resistance in KY	
			Waterhemp	Palmer amaranth
ALS-inhibitor	2	Chlorimuron, Imazethapyr	Widespread	Widespread
EPSPS-inhibitor	9	Glyphosate	Widespread	Widespread
PPO-inhibitor	14	Fomesafen	Moderate and rapidly spreading	Isolated and spreading
PSII-inhibitor	5	Atrazine	No confirmed populations	Isolated with limited spread

Palmer amaranth and waterhemp can grow rapidly under ideal growing conditions. During peak summer temperatures both species can grow 1 to 2 inches per day. This rapid growth can make timely post-emergence herbicide application difficult.

Adaptability

A key characteristic of all weed species is the ability to adapt to a multitude of environments, this is a characteristic that is especially pronounced in waterhemp and Palmer amaranth. Palmer amaranth is native to the arid southwestern United States but has adapted and spread across a wide geography from Florida to North Dakota.

The most obvious adaptation is the rapid selection of herbicide resistance that has occurred in both waterhemp and Palmer amaranth. Both species are dioecious, meaning that an individual plant has only male or female flowers. This reproductive mechanism increases genetic diversity amongst a population and thus selection of resistance events occurs quickly and can be spread rapidly. This rapid resistance development and spread of resistance has been on display within in Kentucky for the last ten to fifteen years. Resistance events that have occurred in each species in the state of Kentucky are listed in Table 1. Most of the herbicide resistant populations that exist now in Kentucky likely originated from introduction and spread of seed from populations that had already developed resistance within other geographies of the United States.

Management

Cultural Practices

Cover Crops

Cover crops have become popular due to their contributions to soil quality and protection against erosion, especially in Kentucky where no-tillage is a predominate practice. Weed suppression is also a benefit that some cover crops can provide, although it should be known not all cover crops provide equal suppressive abilities. Cereal rye is the only cover crop that has consistently shown suppression of early season waterhemp and Palmer amaranth emergence and should be used as a supplement for *Amaranthus* management and not as a replacement for residual herbicides.

Crop Rotation

Rotation of crops allows for alternate or additional weed control tactics and herbicides to be applied in order to help mitigate herbicide resistance. Rotation of fields that have been in continuous soybean to corn allows for additional herbicide sites of action to be applied that are still effective in controlling waterhemp and Palmer amaranth.

Eliminate all Seed Production and Spread

Eliminating seed production and controlling seed spread may be one of most overlooked management practices for weed control. Although with Palmer amaranth and waterhemp it is essential and is the single most important practice to assure complete control in future growing seasons.

Equipment Hygiene

The small seed exist even in the small amounts of soil that can remain on planter coulters, press wheels, tillage equipment, and equipment tires (Figure 1). When moving any piece of equipment from an infested field to a non-infested field it is essential to clean the equipment of all excessive soil picked up during field operations.

A primary contributor to seed spread is combines that harvest fields with mature infestations of waterhemp and Palmer. Combines not only spread the mature seed through the chaff within the field, but are also contain small amounts of seed within the threshing mechanisms

Figure 1. Soil and waterhemp seedling on a tractor tire after use in a field infested with waterhemp.

that will likely be spread to future harvested fields. The best policy is to not allow any mature pigweed to pass through a combine, but if it does occur, the interior and exterior of the machine should be cleaned to the best of your abilities.

Hand Rouging

Pulling waterhemp and Palmer plants from heavily infested fields with failed herbicide applications can be costly, but in some cases may be warranted. Hand rouging isn't just limited to this situation. In most cases a few plants may escape a herbicide program or emerge in areas of uncompetitive crops. Allowing just a couple of plants to escape in a single field can lead to disastrous implications in the future given the seed production capacities of these weeds. Hand rouging of a few plants at the end of the season prior to harvest and seed rain can pay significant dividends in future growing seasons.

Control Peripheral Plants

Plants or weeds that exist along field edges often are overlooked as they do not compete directly with crops in the field. In most cases these plants pose little threat to the crop and often stay contained within that area. However, in the case of Palmer amaranth and waterhemp they do pose a threat as seed and pollen produced by those peripheral plants contribute to the spread of seed and herbicide resistance.

Control Plants Emerging after Corn

The extended emergence pattern of waterhemp and Palmer amaranth allows for plants to emerge at the end of a corn crop as the crop canopy opens at maturity and corn is cleared off fields in August and September. These plants are not competitive with the corn crop and certainly seem to pose little threat as they are eventually killed off by frost events in October and November. Although in that short window of time these plants, regardless of size, are still capable of producing viable seed. Control of these plants, either through chemical or mechanical methods will further reduce seed production.

Chemical Control

Herbicides are the preferred method of weed control for most Kentucky corn and soybean producers, although overreliance on herbicides has led to herbicide resistance especially in waterhemp and Palmer amaranth. In order to mitigate current and future resistance farmers should use a diverse herbicide program with multiple sites of action (SOA) and should incorporate as many cultural practices as possible to complement their herbicide program.

Burndown Options

Starting clean is essential for all weed control programs but is especially paramount for fields that are infested with waterhemp and Palmer amaranth. If waterhemp and Palmer are emerged at the time of the burndown application then one of the following herbicides needs to be included to achieve complete control of Amaranthus species: paraquat [Group 22], glufosinate [Group 10], 2,4-D [Group 4], or dicamba [Group 4].

Effective Residual Herbicides

Effective residual herbicides are required for complete control of waterhemp and Palmer amaranth. The lack of an effective residual herbicide in a waterhemp or Palmer amaranth management program will assure failed control, end of season escapes, and selection of future resistance events.

Residual herbicides should contain at least two, if not three different effective herbicide site of action groups. Effective residual sites of action and active ingredients for both corn and soybean are listed in Table 2. A complete list of Trade

Table 2. Pre-emergence residual herbicide active ingredients that are effective for waterhemp and Palmer amaranth control in corn and soybean.

Active ingredient	Site of action	Site of action group #	Crop
Atrazine	PSII-inhibitor	5	Corn
Metribuzin	PSII-inhibitor	5	Soybean
Isoxaflutole	HPPD-inhibitor	27	Corn and LLGT27 Soybean
S-metolachlor	Long-chain fatty acid-inhibitor	15	Corn and soybean
Pyroxasulfone	Long-chain fatty acid-inhibitor	15	Corn and soybean
Dimethenamid-P	Long-chain fatty acid-inhibitor	15	Corn and soybean
Acetochlor	Long-chain fatty acid-inhibitor	15	Corn and soybean
Flumioxazin	PPO-inhibitor	14	Corn and soybean
Fomesafen	PPO-inhibitor	14	Soybean
Sulfentrazone	PPO-inhibitor	14	Soybean
Pendimethalin	Microtubule inhibitor	3	Corn and soybean

Table 3. Post-emergence herbicide active ingredients that are effective for waterhemp and Palmer amaranth control in corn and soybean.

Active ingredient	Site of action	Site of action group #	Crop
Mesotrione	HPPD-inhibitor	27	Corn
Topramezone	HPPD-inhibitor	27	Corn
Tembotrione	HPPD-inhibitor	27	Corn
2,4-D	Synthetic auxin	4	Corn and Enlist E3 Soybean
Dicamba	Synthetic auxin	4	Corn and RR2Xtend and RR2XtendFlex Soybean
Glufosinate	Glutamine synthetase-inhibitor	10	LibertyLink Corn and LibertyLink, Enlist E3 and RR2XtendFlex Soybean
Lactofen[a]	PPO-inhibitor	14	Soybean
Fomesafen[a]	PPO-inhibitor	14	Soybean
Acifluorfen	PPO-inhibitor	14	Soybean

[a] PPO sensitive biotypes only.

name products that contain combinations of these actives is too extensive for this publication and can be found in UK Extension bulletin AGR-6: *Weed Control Recommendations for Kentucky Grain Crops.*

Multiple effective site of action residuals are especially important in soybean. A complete list of soybean residual herbicides with multiple effective sites of action can be found in AGR 259: *Multi-SOA Pre-emergence Herbicides for Palmer Amaranth and Waterhemp Control.*

Post-emergence Herbicides

Post-emergence herbicide applications should be made as a compliment to control waterhemp and Palmer amaranth plants that have escaped the residual herbicide. Growers should strive to use sites of action in their post-emergence application that differ from those used in the burndown and residual applications. Effective herbicide active ingredients and sites of action are listed in Table 3.

Regardless of the herbicide used, the size of waterhemp and Palmer amaranth at the time of application is critical. Plants should be 2 to 4 inches in height at time of post-emergence application (Figure 2). Plants taller than 6 inches in height are likely to only be partially controlled or completely uncontrolled by post-emergence herbicide applications.

Figure 2. Two- to 4-inch tall waterhemp plants that are the ideal height for post-emergence herbicide applications.

Layover Residual Herbicides

The use of residual herbicide in crop can be very beneficial in reducing waterhemp and Palmer amaranth escapes at the end of the season. This is especially true in soybean. Active ingredients that can be applied post-emergence in soybean that provide residual control of waterhemp and Palmer amaranth include: pyroxasulfone [group 15], S-metolachlor [Group 15], dimethenamid-P [Group 15], and acetochlor [Group 15].

Multiple Sites of Action

Regardless of crop the key to an effective herbicide program that provides not only control in the short term but reduces risk in the future should include as many herbicide site of action groups as possible. Depending on the crop and herbicide resistance events in both the crop and weed species there are up to six different herbicide site of action groups that can be used in a single cropping season. Producers should strive to maximize the number of sites of action every cropping season when managing waterhemp and Palmer amaranth.

Issued 12-2020