

A close-up photograph of a Palmer amaranth plant, showing its characteristic green, deeply lobed leaves and a central inflorescence. The leaves have serrated edges and some show signs of being eaten, with small holes visible. The background is blurred, focusing attention on the plant.

Management of Palmer amaranth: Introducing the Zero Tolerance Threshold

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Dioecious *Amaranthus* Species in the Scientific Literature (mostly weed science)

Through 2000:

- **Waterhemp:**
 - 42 paper citations
- **Palmer amaranth:**
 - 9 paper citations

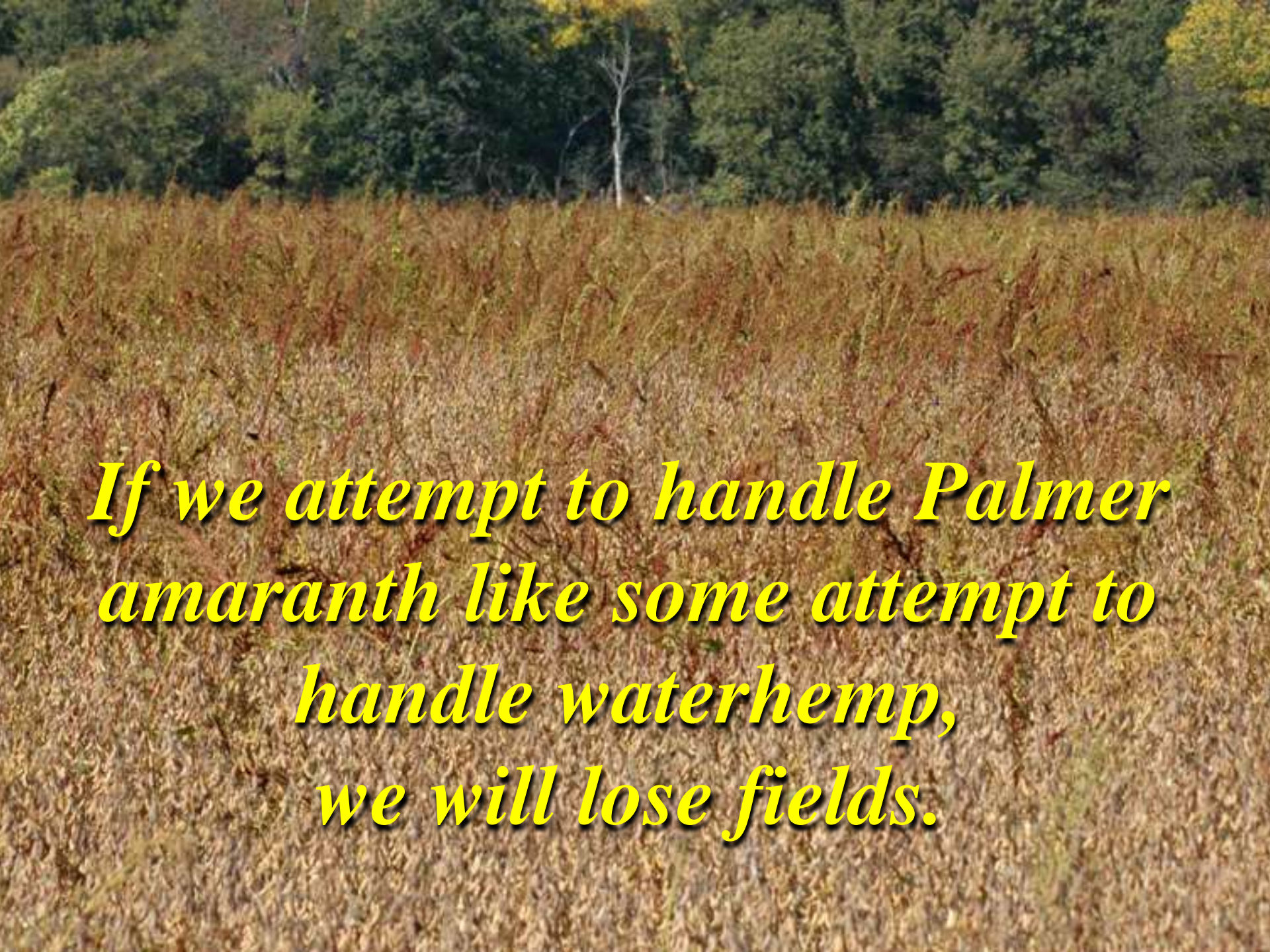
2001–2011:

- **Waterhemp:**
 - 175 paper citations
- **Palmer amaranth:**
 - 96 paper citations



Principles of Palmer amaranth Management

- Prevention is far better than eradication
 - any tactic that will prevent seed introduction or production
- Once established, herbicide costs generally double
 - often requires at least three to four applications
- Control should not be less than 100 percent
 - “zero tolerance threshold”



*If we attempt to handle Palmer
amaranth like some attempt to
handle waterhemp,
we will lose fields.*

Identification of Palmer amaranth

- Absolutely critical to identify Palmer amaranth before the plant exceeds 2”
 - **POST herbicide effectiveness rapidly declines**
- How to distinguish between Palmer amaranth and waterhemp?























Is it Palmer amaranth or Waterhemp?



Seedling leaves:
notched
broader, ovate
no waxy sheen



Seedling leaves:
notched
narrow, lanceolate
often with waxy sheen

Is it Palmer amaranth or Waterhemp?



Older leaves:
notched
broader, ovate
no waxy sheen



Older leaves:
notched
narrow, lanceolate
often with waxy sheen

Is it Palmer amaranth or Waterhemp?



Young plants:
no pubescence
petioles longer than leaf
may have watermark



Young plants:
no pubescence
petioles shorter than leaf
no watermark

Mucro





Palmer amaranth resources from the University of Illinois

UNIVERSITY OF ILLINOIS

WEED SCIENCE

DEPARTMENT OF CROP SCIENCES
weeds.cropsci.illinois.edu

8/15/2013

Guidelines for the Identification and Management of Palmer Amaranth in Illinois Agronomic Crops

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Palmer amaranth (*Amaranthus palmeri*) is a summer annual broadleaf weed species closely related to other pigweed species (waterhemp, smooth, redroot) common in Illinois agronomic cropping systems. Palmer amaranth is not native to Illinois; it evolved in deserts of the southwestern United States, including areas of the Sonoran Desert. Genotypic and phenotypic adaptability have allowed Palmer amaranth to expand its distribution beyond desert habitats, and colonize the vastly different agricultural landscapes across much of the eastern half of the United States, including Illinois.

Research has demonstrated that Palmer amaranth has a higher growth rate and is more competitive than other pigweed species. Growth rates approaching 3 inches per day and yield losses of 78% (soybean) and 91% (corn) attributed to Palmer amaranth interference have been reported in the scientific literature. Female Palmer amaranth plants typically produce a similar number of seeds as female waterhemp plants.

Early and accurate identification of Palmer amaranth plants, coupled with an integrated management program, are essential to reduce the potential for crop yield loss due to interference of Palmer amaranth.



Figure 1. Palmer amaranth (left) and waterhemp (right) seedling plants. Note the more rounded (ovate) true leaves of Palmer amaranth compared with the more tapered (lanceolate) leaves of waterhemp.



Figure 2. Leaves of Palmer amaranth sometimes have white or purple chevrons.

Identification

Immature plants

The cotyledon leaves of Palmer amaranth are relatively long compared with other *Amaranthus* species. Like all weedy *Amaranthus* species in Illinois, the true leaves (those produced after the cotyledon leaves) of Palmer amaranth have a small notch in the tip. The stems and leaves have no or few hairs and the stems feel smooth to the touch. Leaves are alternate on the stem and are generally ovate or egg-shaped (Figure 1) with prominent white veins on the underside. As plants become older, they often assume a poinsettia-like appearance and sometimes have a white or purple chevron on the leaves (Figure 2). Leaves are attached to the stem by petioles that are usually as long, or longer than, the leaf.

Mature plants

Palmer amaranth plants are either male or female: male plants produce only pollen while female plants produce only seed. The terminal inflorescence of male and female plants is generally unbranched and very long (Figure 3). Female Palmer amaranth plants have a long terminal inflorescence (10 to 24 inches) with flowers containing 5 spatulate-shaped tepals. The tepals are about twice the length of the seed, and the seed capsule (utricule) breaks into 2 regular sections when fractured. Grabbing the inflorescence of a mature female Palmer amaranth plant with your bare hand is not recommended as the bracts are very stiff and sharp. Palmer amaranth is an aggressively growing species which often reaches 6 to 8 feet tall (Figure 4). Figure 5 provides a pictorial comparison of Palmer amaranth and waterhemp.

Management Guidelines

Field scouting should occur throughout the growing season to identify Palmer amaranth plants.

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Guidelines for the Identification and Management of Palmer Amaranth in Illinois Agronomic Crops



Figure 3. Inflorescences of male (left) and female (right) Palmer amaranth plants.




Figure 4. Mature Palmer amaranth in soybean (photo courtesy of Robert Bellini).

- 1) If you discover a plant that you think may be Palmer amaranth, you can verify its identity by sending a leaf tissue sample to the University of Illinois (please find a sampling protocol at: <http://bulletin.ijm.illinois.edu/?p=923>) for identification using molecular biology techniques.
- 2) Plants confirmed or suspected of being Palmer amaranth should be physically removed from the field prior to flowering. Do not rely on herbicides for control. Physical removal can include hoeing or hand-pulling plants from the soil. If hoeing is used, be sure to sever the plant stem at or below the soil surface to reduce the potential for regrowth, and remove plants from the field as they will re-root from stem fragments.
- 3) If Palmer amaranth plants are not identified until after brown-to-black colored seeds are present on female plants, we suggest leaving the plants undisturbed in order to avoid inadvertently spreading seed.
- 4) Mark or flag areas where Palmer amaranth plants produced seed. These areas should be intensively scouted the following season and an aggressive Palmer amaranth management plan implemented to prevent future seed production.
- 5) Do not mechanically harvest mature Palmer amaranth plants. Physically remove the plants prior to harvest and either leave the plants in the field or place in a sturdy garden bag and remove the plants from the field. Bury or burn the bags in a burn barrel as soon as possible.
- 6) Fields in which Palmer amaranth seeds were produced should NOT be tilled during the fall or following spring. Leaving the seeds near the soil surface increases the opportunities for seed predation by various granivores.
- 7) Herbicides that control waterhemp also control Palmer amaranth. An integrated herbicide program should include soil-residual herbicides applied at full recommended use rates of within two weeks of planting and followed by postemergence herbicides applied before Palmer amaranth plants exceed 3 inches tall.

Palmer Amaranth	Chenopodium	Pitcher	Waterhemp	Waterhemp
Young leaves	Round	Star	Star	Star
Stems	Smooth	Smooth	Smooth	Smooth
Older leaves	Longer than wide	Longer than wide	Longer than wide	Longer than wide
Flowers	5	5	5	5
Inflorescence	Short	Short	Short	Short

Figure 5. Comparison of Palmer amaranth (left) and waterhemp (right).

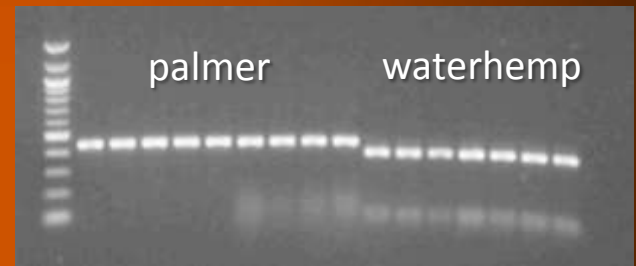
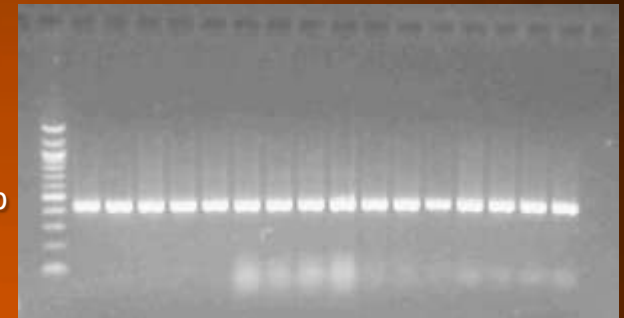
Palmer amaranth resources from the University of Illinois

 ILLINOIS <small>UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN</small>	
Palmer Amaranth Identification	
Mail samples and this completed form by next-day delivery to: Chance Riggins 320 ERML 1201 W. Gregory Drive Urbana, IL 61801	<div style="border: 1px solid black; padding: 5px;"><p style="text-align: center; margin: 0;">For Lab Use Only</p><p>Lab no. _____</p><p>Date received: _____</p><p style="text-align: center;">Condition on arrival</p><p><input type="checkbox"/> Excellent <input type="checkbox"/> Fair <input type="checkbox"/> Poor</p></div>
<small>Sample submission recommendations: Submit only healthy plant material. Samples should consist of at least the top 6 inches of each plant and include multiple leaves and flowers if available. Samples should be clean and with excess moisture removed (blot between paper towels) and placed in a sandwich-sized zipper bag. Sample five plants, and use a separate bag for each plant sampled. Ideally, samples should be sent the day of collection by overnight delivery to the address at the top of this form, however, they can be stored for a day or two in a refrigerator (do not freeze) until shipped.</small>	
Submitter information (please print): Date: _____ Submitted by: _____ Company: _____ Phone (specify office or cell): _____ Email: _____ <small>(Please provide an email address for receiving test results)</small>	
Location Information: State: _____ County: _____ Township: _____ GPS coordinates: _____ <small>(preferred but not required)</small>	
Plant & Site information: • Distribution of Palmer amaranth: <input type="checkbox"/> scattered <input type="checkbox"/> localized patch <input type="checkbox"/> heavy infestation • Occurrence of other pigweed species: <input type="checkbox"/> yes <input type="checkbox"/> no If yes, which species (if known): <input type="checkbox"/> waterhemp <input type="checkbox"/> smooth pigweed <input type="checkbox"/> redroot pigweed <input type="checkbox"/> spiny amaranth <input type="checkbox"/> Powell amaranth <input type="checkbox"/> tumble pigweed • Site Description (e.g., agricultural field, vacant lot, roadside, etc.): _____ _____	
Additional comments: _____ _____	

Molecular Markers for Species Identification

➤ ALS-EcoRV assay

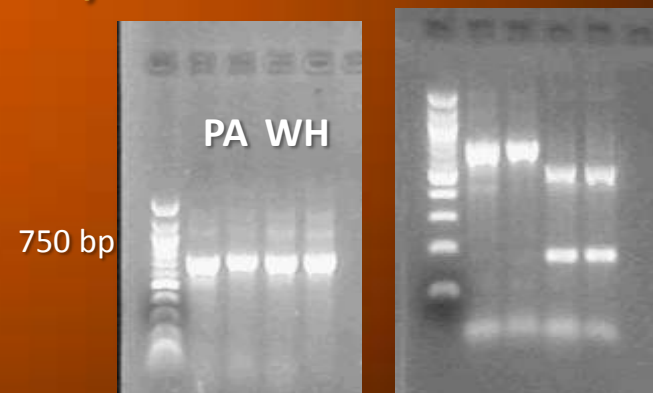
- Amplify region of ALS gene with EcoRV restriction site & digest
- Palmer & other weedy pigweeds lack site and do not cut



Tranel et al. (2002) TAG 105: 674-679.

➤ Nuclear ribosomal ITS-Ddel assay

- Amplify ITS region & digest
- Palmer lacks site and does not cut
- Alternative restriction sites can distinguish among other pigweeds

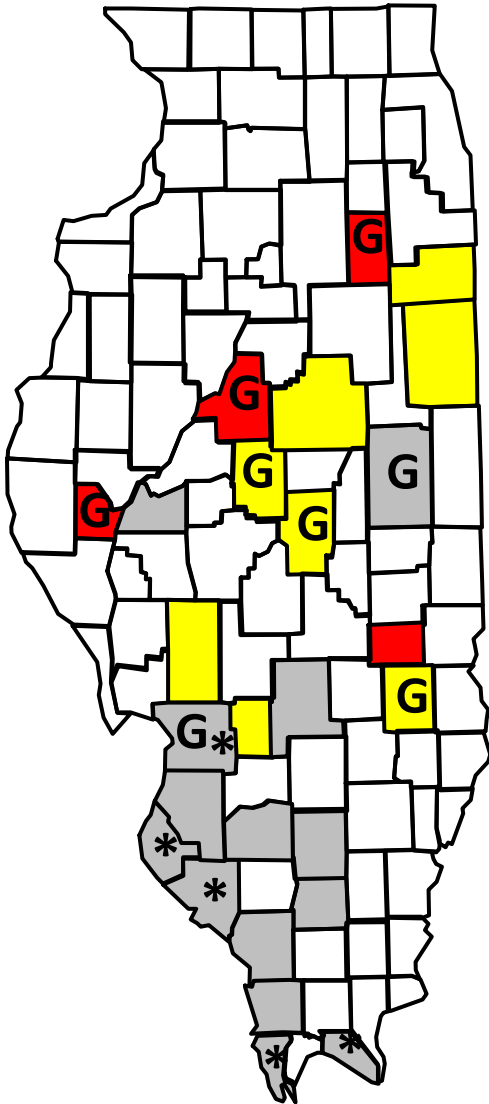


Wetzel et al. (1999) Weed Sci. 47: 518-523.

Management of Palmer amaranth

- **What we know:**
 - any population of Palmer amaranth was introduced from outside of Illinois
- **What we assume:**
 - seed likely came from areas where Palmer amaranth is well established
- **What we do not know with certainty:**
 - the sensitivity/resistance profile of the population

2013 Palmer amaranth survey in Illinois



- Palmer amaranth confirmed in 12 new counties (26 counties total)
- ALS-R populations found in 4 counties
- Gly-R populations found in 8 counties, 3 of which were multiple resistant (ALS + Gly)
- 6 samples ID'd as waterhemp

Chronology of Herbicide Resistance in Palmer amaranth

- **Palmer amaranth biotypes with resistance to:**
 - **Dinitroanilines (1989)**
 - **ALS inhibitors (1991)**
 - **Photosystem II inhibitors (1993)**
 - **Glyphosate (2005)**
 - **Multiple (glyphosate + ALS inhibitors) resistance (2008)**
 - **HPPD inhibitors (2009)**
 - **Multiple (glyphosate + ALS inhibitors + triazine) resistance (2010)**

Management of Palmer amaranth

- There is no single tactic that will keep Palmer amaranth from reducing crop yield
 - the more integrated the management approach the greater the likelihood of long-term success
- Management tactics must be tied with the biology and growth characteristics of Palmer amaranth
 - emergence periodicity/duration, growth rate, maturation and seed production

Palmer amaranth biology

- Emergence characteristics:
 - tends to display a prolonged emergence pattern
 - higher germination rates at shallow seed depths
- Previous research has demonstrated Palmer amaranth has a higher seed germination rate than other *Amaranthus* species (Steckel et al. 2004)
 - one of the first *Amaranthus* species to emerge
 - also germinates at higher temps than waterhemp
 - may provide for competitive advantages over waterhemp
 - emerges sooner and later

Palmer amaranth management

- Be sure to control all existing Palmer amaranth plants with tillage or burndown herbicides
 - **DO NOT plant into existing stands of Palmer**
- Apply a **full rate** (according to label guidelines) of an effective soil-residual herbicide not sooner than 7 days before planting or later than 3 days after planting
 - flumioxazin and sulfentrazone have performed well
 - pyroxasulfone, metribuzin, acetochlor, dimethenamid, metolachlor, etc. are other options

Palmer amaranth management

- Sulfentrazone should be applied at 0.25 lb ai/A

Product	Rate to provide 0.25 lb ai sulfentrazone	Maximum labeled rate
Authority Assist	10 fluid ounces	12 fluid ounces
Authority First	6.45 ounces	8 ounces
Authority Maxx	6.5 ounces	9.6 ounces
Authority XL	6.5 ounces	9.6 ounces

Palmer amaranth management

- **Flumioxazin should be applied between 0.063-0.095 lb ai/A**

Product	Rate to provide 0.063-0.095 lb ai	Maximum labeled rate
Valor	2-3 ounces	3 ounces
Valor XLT	3.4-5 ounces	5 ounces
Gangster	2-3 ounces (V)	3 ounces
Fierce	3-3.75 (0.0785)	3.75 ounces
Envive	3.5-5.25	5.3 ounces
Enlite	2.8 (0.063)	2.8 ounces

Palmer amaranth control as affected by residual herbicide rate 20, 40 and 60 days after application

	Palmer amaranth control (%)				
Residual Herbicide Rate	2006			2007	
	Oglethorpe	Mount Olive	Parkton	Oglethorpe	Mount Olive
	-----20 days after application-----				
1X	89	53	77	54	82
1.5X	93*	67*	87*	65*	86*
	-----40 days after application-----				
1X	69	10	62	59	30
1.5X	80*	8	77*	64*	35
	-----60 days after application-----				
1X	52	0	17	39	8
1.5X	64*	0	30*	49*	10

Data averaged over 13 herbicides. Means within an evaluation period followed by an asterisk are different at P=0.05.

Moisture and Soil-Residual Herbicides

- **For most soil-residual herbicides, the herbicide must be in the soil solution to be effective**
 - **applications to dry soil with no precipitation for >10 days can reduce effectiveness**
- **Timing of precipitation in relation to application**
 - **soil moisture at application**
- **Moisture also needed to facilitate herbicide degradation**
 - **reduce the potential for carryover**



Palmer amaranth biology

- Growth rate:
 - has a high photosynthetic rate, 3–4x that of soybean (Ehleringer 1983)
- Previous research has demonstrated Palmer amaranth has a higher growth rate than other *Amaranthus* species (Horak and Loughin 2000)
 - average height increase per GDD₅₀:
 - Palmer = 0.195 cm/GDD Waterhemp = 0.135 cm/GDD
 - 30-yr average GDD at Urbana for June 10–11 (42.5) and July 10–11 (50.5):
 - Palmer = 3.2–3.8"/24 hr Waterhemp = 2.2–2.6"/24 hr

Soybean planted into weed-free soil May 16



Photograph taken May 29

Photograph courtesy Dr. Larry Steckel

Palmer amaranth management

- **Begin scouting around 14-21 days after the crop emerges**
 - **post herbicides must be applied before Palmer amaranth plants are 4” tall**
- **POST herbicide options in corn and soybean are the same ones used for control of waterhemp**
 - **glyphosate or ALS inhibitors might/might not work**
- **Consider including a soil-residual herbicide**
 - **Zidua, Warrant, Dual Magnum, Outlook, etc.**

Controlling Palmer amaranth

- Integrated systems are essential
 - tillage: pre- and post-plant
 - soil-residual herbicides
- POST herbicides must be applied to small plants
 - grows inches per day!



Expected control of Palmer amaranth with POST herbicides
in relation to weed height (NC State Univ.)

	Palmer amaranth height (in) and expectation of complete control			
Herbicide	Always	Very often	Occasionally	Almost never
Glyphosate	20	40	60	>60
ALS inhibitors	4	8	12	20
Glufosinate	3	4	6	>10
PPO inhibitors	3	4	6	>6
Auxins	2	3	4–5	>6
HPPD inhibitors	3	8	10	>10

The Difference of 2 Days!

Flexstar on 6" Palmer

Flexstar on 3" Palmer



Photo courtesy
Dr. Larry Steckel

Palmer amaranth management

- Fields should be scouted within 7-10 days of the initial POST application
 - effectiveness of the POST herbicide, residual herbicide moved into solution, additional emergence
- Make a second application of POST herbicides if additional emergence occurs
 - only one fomesafen application every two years
- Physically remove remaining Palmer amaranth before pollination
 - sever below the soil surface and remove plants from field

Tillage, Cropping System, and Soil Depth Effects on Common Waterhemp (*Amaranthus rudis*) Seed-Bank Persistence

**Lawrence E. Steckel, Christy L. Sprague, Edward W. Stoller, Loyd M. Wax,
and F. William Simmons**

Weed Science 55(3):235-239. 2007

A field experiment was conducted in Urbana, IL, from 1997 to 2000 to evaluate the effect that crop tillage, and soil depth have on common waterhemp seed-bank persistence. A heavy field infestation of common waterhemp (approximately 410 plants m⁻²) was allowed to set seed in 1996 and was not allowed to go to seed after 1996. In 1997, 1998, 1999, and 2000, the percentage of the original common waterhemp seed bank that remained was 39, 28, 10, and 0.004%, respectively, averaged over tillage treatments. Initially, germination and emergence of common waterhemp was greater in no-till systems. Consequently, the number of remaining seeds was greater in the till treatments compared with no-till in the top 0 to 6 cm of the soil profile. This reduction was in part explained by the higher germination and emergence of common waterhemp in the no-tillage treatments. Tillage increased the seed-bank persistence of common waterhemp in the top 0 to 2 cm of the soil profile in 1997 and the top 0 to 6 cm in 1998. Crop had no effect on common waterhemp emergence or seed-bank persistence

Management Summary

- An integrated management approach is absolutely critical
 - PRE or POST only herbicide programs are unlikely to provide season-long control
- Soil-residual herbicides should be applied within two weeks of planting
 - rainfall or mechanical incorporation needed
- POST herbicides must be applied to small Palmer amaranth plants
 - small means 2–3” plants



*Best Wishes for a Safe
and Prosperous 2014*