PNW 758

A PACIFIC NORTHWEST EXTENSION PUBLICATION
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Pigweeds: Current and Emerging Weed Threats in the Pacific Northwest

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Background

THERE ARE AT LEAST TWENTY-TWO weed species in the genus *Amaranthus*. These species are commonly called pigweeds. Pigweeds are widespread in the United States and most prevalent in disturbed areas such as agricultural lands. They can also be found along roadsides and fencelines but rarely in pastures or rangelands. Pigweeds can be challenging to differentiate at seedling and very early growth stages. However, their overall appearance, reproduction, and aggressiveness differ greatly. Competition by some pigweeds in agricultural systems can be great enough to reduce crop yields. In the Pacific Northwest (PNW) region of the United States, redroot pigweed (*Amaranthus retroflexus*), Powell's amaranth (*Amaranthus powellii*), prostrate pigweed (*Amaranthus blitoides*), and tumble pigweed (*Amaranthus albus*) are common and widespread. Of these, redroot pigweed is probably the most common and troublesome to control. Populations of redroot pigweed resistant to metribuzin, a widely used herbicide, can be found in the United States, including the PNW.

Palmer amaranth (*Amaranthus palmeri*), known as careless weed in some regions, and waterhemp (*Amaranthus tuberculatus*) remain two of the most aggressive pigweeds in the United States. Although waterhemp is native to most states, including Idaho and Washington, it currently is not a major weed problem in the PNW. Palmer amaranth, however, is not native to the PNW and is a new threat to PNW agriculture. Populations of both weeds have developed resistance to several herbicides making control difficult. It is critical, therefore, to prevent or curtail the spread of these weeds in the PNW, especially in our agricultural lands.

Current Distribution in the United States

Palmer amaranth is native to the southwestern United States. It has been around for more than a century but has only become an economically important agronomic weed over the last two decades. Ward et al. (2013) notes that "in little over 20 years, Palmer amaranth has risen from relative obscurity to its current status as one of the most widespread, troublesome, and economically damaging agronomic weeds in the southeastern US."

Potential for Introduction in the PNW

Although Palmer amaranth has not yet been confirmed as present in the PNW to the date of this publication, it is more than likely already here due to the fact that it has been found in surrounding states, including California, Nevada, Utah, and Wyoming (Figure 1). Limiting the spread of this weed in the PNW, therefore, is critical. To do so, potential sources of introduction must be found and methods to prevent movement across the PNW must be developed and implemented. Methods of spread include the following:

- *Livestock feed*. The seeds of Palmer amaranth are very small and difficult to detect or remove from other crop seeds (Figure 2). They can be introduced to the PNW through contaminated hay or cottonseed meal purchased and transported from infested states.
- *Manure*. Palmer amaranth has a hard seed coat and thus can pass undamaged through the cattle's digestive tract and deposit on the soil via their manure. It is believed that Palmer amaranth was introduced to South Dakota via manure contaminated in this manner. Before purchasing manure to use as fertilizer, note its source. If you do not know or suspect that the manure might be contaminated with Palmer amaranth seed, it is good practice to spread a small amount of the manure at the edge of your field or other areas where it will be used to see if any Palmer amaranth or other weeds not common to that location emerge from the manure. If you detect Palmer amaranth, do not spread the manure. Call your county Extension office for advice on how to proceed.
- *Rights-of-way*. Highway rights-of-way provide corridors along which Palmer amaranth and other exotic weeds spread by blowing out of uncovered trucks or other vehicles that carry material contaminated with weed seeds. If your farm or property abuts a main highway or interstate, scout the area periodically for any signs of Palmer amaranth.
- *Farm equipment*. Palmer amaranth seeds in debris or soil or that lie on the surface can be easily picked up by tires and other farm equipment parts. When transporting farm equipment to your field or moving equipment from field to field or purchasing used equipment, inspect it to ensure that it is thoroughly clean and free of soil, debris, and weed seeds.
- *Seed (cover crop, bird feed, and restoration)*. One common source of Palmer amaranth seed introduction to new areas is through contaminated seed mixes used as cover crops, restoration seed, or pollination habit improvement. Birdfeed can also be a source, so frequently check in and around the area where feed has been placed.

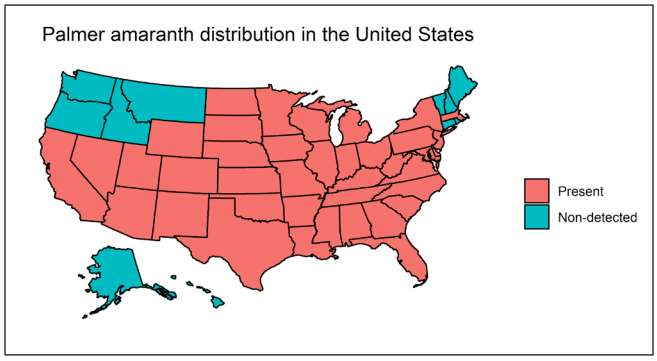

Figure 1. Current distribution of Palmer amaranth in the United States.

Figure 2. Palmer amaranth (left) and redroot pigweed (right) seed. 1 mm scale interval. Courtesy of Andrew Kniss.

Biology and Ecology

Palmer amaranth is a fast-growing, aggressive, agronomic weed able to adapt to many soils and environmental conditions. It has an erect growth habit that can reach a height of 6–8 feet. It can grow 2–3 inches a day under ideal growing conditions. A single female plant can produce up to 500,000 seeds when there is no competition from other plants. As mentioned previously, the seeds are very small (Figure 2) and easily transported with farm equipment, seed, feed, manure, etc. Buried seeds usually remain viable in the field for 3–5 years. Palmer amaranth can germinate and emerge from late spring to late summer, making management very difficult.

Identification

Although the different pigweeds are more easily distinguishable as they mature (Figure 3), they can be incredibly similar during their seedling and vegetative growth stages (Figure 4). However, for proactive management, these species must be identified at either the seedling or early vegetative growth stage.

Fortunately, there are some key features such as leaf shape, size, length, and the presence or absence of watermarks that may help differentiate young Palmer amaranth from other pigweeds. While some of the features shown below are unique to Palmer amaranth and the other pigweeds, it must be noted that the appearance of any given weed tends to vary based on the growing conditions and location. Therefore, it is advisable to rely on multiple features or characteristics for correct identification.

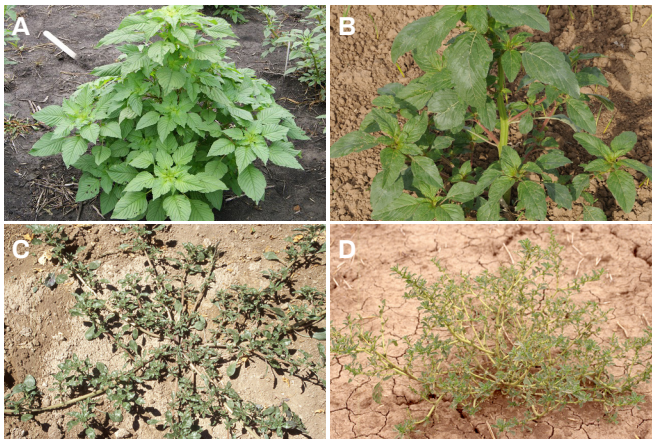

Figure 3. Mature plants of Palmer amaranth (A) and common pigweeds (redroot pigweed (B), prostrate pigweed (C), and tumble pigweed (D) in the PNW. Courtesy of Lynn Sosnoskie.

Leaf

Leaf shape. Palmer amaranth has a diamond or lance-shaped leaf (Figure 5). Redroot pigweed has broad ovate leaves with wavy margins; prostrate pigweed leaves are ovate to spatulate (spoon-shaped), smooth, and pale green with a notch on the tip; and tumble pigweed has small, light green leaves with wavy margins.

Leaf petiole length. The length of Palmer amaranth petioles (the stemlike structure that connects the leaf blade to the main stem) can be more than three inches long, which is longer than the leaf blade (Figure 5). This is not the case with other pigweeds (Figure 6).

Leaf-tip hair. While most pigweeds have a leaf tip notch, Palmer amaranth often has one hair in the leaf-tip notch (Figure 6), a feature that is lacking in most other pigweeds. This hair is typically found on the first 2–3 leaves. As mentioned, this is one of the features that can be quite variable even within the same Palmer amaranth population and must be used in addition to other features to successfully identify this weed.

*Presence of watermar*k. The leaves of Palmer amaranth tend to have a V-shaped watermark, often referred to as a chevron (Figure 7A), although this is not always the case (Figure 3A). Some redroot pigweeds have leaves with a white, blotchy watermark with or without red (Figure 7B).

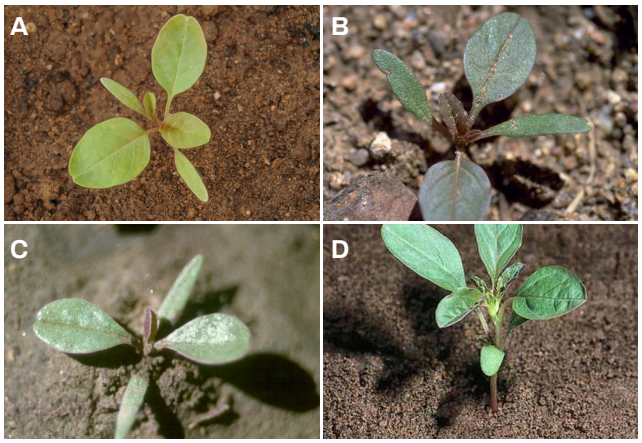

Figure 4. Seedlings of Palmer amaranth (A), redroot pigweed (B), prostrate pigweed (C), and tumble pigweed (D). Courtesy of Lynn Sosnoskie and Joseph M. DiTomaso. Figure 4B courtesy of Phil Westra, Colorado State University, Bugwood.org.

Stems

Palmer amaranth has smooth stems that often lack hairs. Redroot pigweed has hairs on the upper stems (Figure 8B), one of the key features that distinguish redroot pigweed from other pigweeds such as Palmer amaranth (Figure 8A, C, and D).

The use of a combination of all the features described above can make it easier to identify pigweed at the young and seedling vegetative growth stage and facilitate proactive, rather than reactive, control measures. As mentioned and shown in Figures 3 and 9, identification can be easier at the mature stages.

Figure 5. Diamond/lance-shaped leaf of Palmer amaranth with a long petiole (A). The leaf with petiole folded (B) demonstrates that the petiole is longer than the leaf blade. Courtesy of Travis Legleiter and William G. Johnson (2013).

Figure 6. The first few leaves of some Palmer amaranth plants have a single hair in the leaf tip notch. Courtesy of Lynn Sosnoskie.

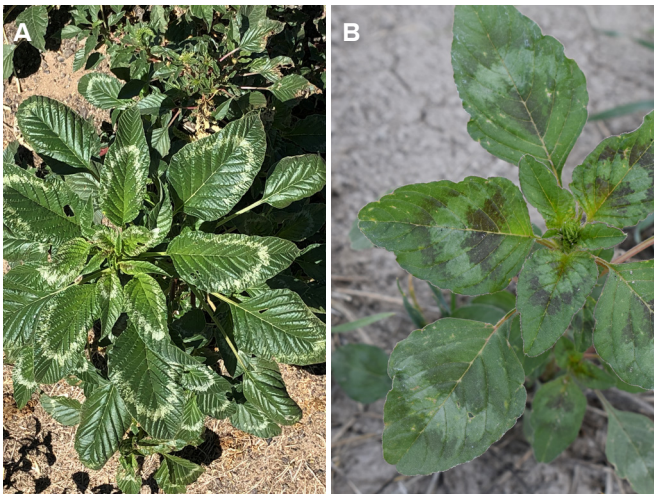

Figure 7. Some Palmer amaranth leaves have white chevron or V-shaped watermarks (A) while some redroot pigweed tends to have a white, blotchy watermark (B). Courtesy of Lynn Sosnoskie.

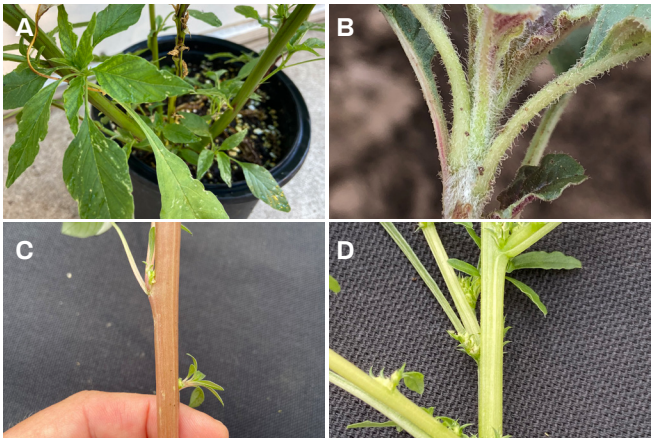

Figure 8. Redroot pigweed stems (B) are hairy compared to Palmer amaranth (A), prostrate pigweed (C), and tumble pigweed (D). Courtesy of Lynn Sosnoskie.

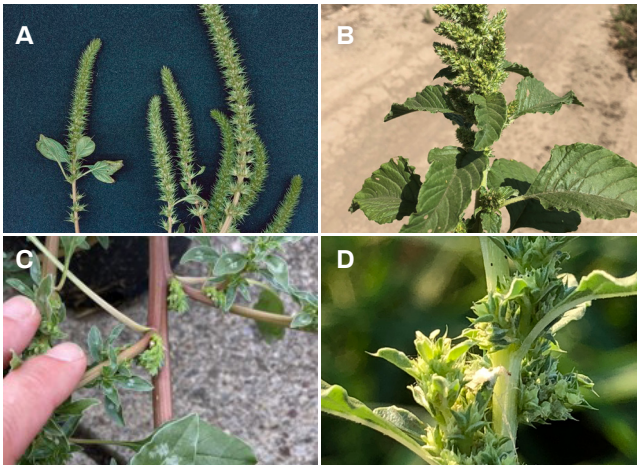

Figure 9. Palmer amaranth (A) and redroot pigweed (B) flowers are produced on terminal flower spikes while prostrate (C) and tumble (D) pigweed flowers are produced in clusters in leaf axils. Courtesy of Lynn Sosnoskie.

Reproduction and Flowering Structures

Pigweed flowers are small and green, not "showy." Redroot, prostrate, and tumble pigweed have male and female flowers that develop on the same plant (monoecious). In Palmer amaranth, however, male and female flowers develop on different plants (dioecious). Both Palmer amaranth and redroot pigweed flowers are produced in groups of flowers at the ends of upper branches and the flowers attach directly to the stem. Redroot pigweed flowers are short and more compressed compared to Palmer amaranth (Figure 9). In contrast, prostrate and tumble pigweed flowers are produced in spiny clusters at the base of leaves.

Impacts

Palmer amaranth is an aggressive competitor and can cause significant yield loss in crops, especially when it emerges with or before the crop. For instance, just one amaranth plant growing per foot of corn row reduces corn yield by 40%–80%. In short-statured crops such as sugar beet, just one plant per 6.6 feet of row emerging at the same time as the crop can cause up to 89% yield reduction. Palmer amaranth can also contaminate forage and seeds, thereby reducing their value. Aside from its high seed production, ability to adapt to different environments, and competitiveness, its ability to evolve resistance to multiple herbicide modes of action is by far the most important impact on cropping systems. This increases the time, effort, and cost of control.

Control or Management Options

Once Palmer amaranth has been successfully identified, every effort must be made to remove all plants and not allow them to produce seed even if the population has not developed resistance. Integrated weed management (IWM) strategies should be adopted to prevent the weed from becoming established in new areas and preventing seed production. Several management practices are available, but the most important key is to rely on a strategic mix aimed at keeping the weed off-balance and preventing it from becoming herbicide-resistant or adapted to any given, single management practice.

Sanitation

As mentioned previously, Palmer amaranth produces a lot of seeds. Eliminating seed sources and preventing Palmer amaranth from getting established in clean fields are thus often the most economical control method. However, this strategy requires sustained effort over time. Apply a combination of the following methods that fit your situation best:

- Plant crops using clean, certified seeds.
- Clean the machinery, including combines, before entering a field. Harvest heavily infested fields last.
- Identify and destroy Palmer amaranth seedlings and plants in cultivated fields and field borders before they produce seed.
- Control small patches or areas of infestations before they spread.

Mechanical

Tillage. Where applicable, deep tillage can be an effective management tool as part of IWM strategies. Because of the small seed size, deep tillage buries seeds below its preferred emergence depth and reduces the number of seeds that emerge from the topsoil. Palmer amaranth seedling emergence can be reduced with deep tillage by up to 50% in heavily infested fields. Palmer amaranth seeds can remain viable in the soil for up to five years and thus, continuous tillage brings up buried seeds to the soil surface in subsequent years. It is advisable to deep till only once.

Hand weeding. In heavily infested fields and where Palmer amaranth escapes other control practices, hand weeding can be used to remove Palmer amaranth plants before seed production. This is especially important when herbicide-resistant populations are suspected in the field. Palmer amaranth can reroot if pulled and left on the soil surface. Thus, pulled or hand-weeded Palmer amaranth must be removed from the field and burned, composted (if pulled before seed production), or laid on a hard surface to dry.

Cultural

Crop diversity and competition. Crop rotation is one of the most effective control measures for Palmer amaranth because it enables the use of multiple herbicide sites of action and management practices. In addition, crops differ in competitiveness against Palmer amaranth. Herbicides are more effective in a competitive crop than in a poorly competitive one. Good crop stands leave few open spaces for Palmer amaranth to invade. Small grains, especially ones seeded in the fall, can be competitive because establishment usually occurs before Palmer amaranth emergence.

Small grains are also often harvested before Palmer amaranth produces seed, thereby reducing weed seed production. Perennial forage crops that are harvested multiple times, such as alfalfa, can also set Palmer amaranth back and reduce seed production. Aside from the choice of crops in a rotation, other factors can increase competitiveness. For instance, prepare a firm seedbed, use the appropriate variety, and seed at recommended rates. Also, apply fertilizer to promote early crop growth. Deep banding instead of broadcasting can help achieve this goal.

Cover crops. As mentioned, fall-planted crops such as winter wheat and barley as well as well-managed cover crops can help outcompete Palmer amaranth. Also, cover crop biomass left on the soil can reduce Palmer amaranth seedling emergence, which ultimately reduces the time, effort, and costs to control this weed.

Herbicides

Herbicides remain the most common practice for large-scale weed control. However, Palmer amaranth has developed resistance to several herbicide modes of action that are currently used in the PNW (Table 1). According to Heap (2021) about twenty redroot pigweed populations have developed herbicide resistance; however, there have been more than sixty cases of herbicide-resistant Palmer amaranth populations reported in several states across the United States (Figure 10).

Palmer amaranth seeds introduced to the PNW would likely come from populations in other states with resistance to at least two herbicide modes of action (most likely, *glyphosate* [group 9] and acetolactate synthase–inhibition [group 2] herbicides). In this case, chemical control of this weed depends on

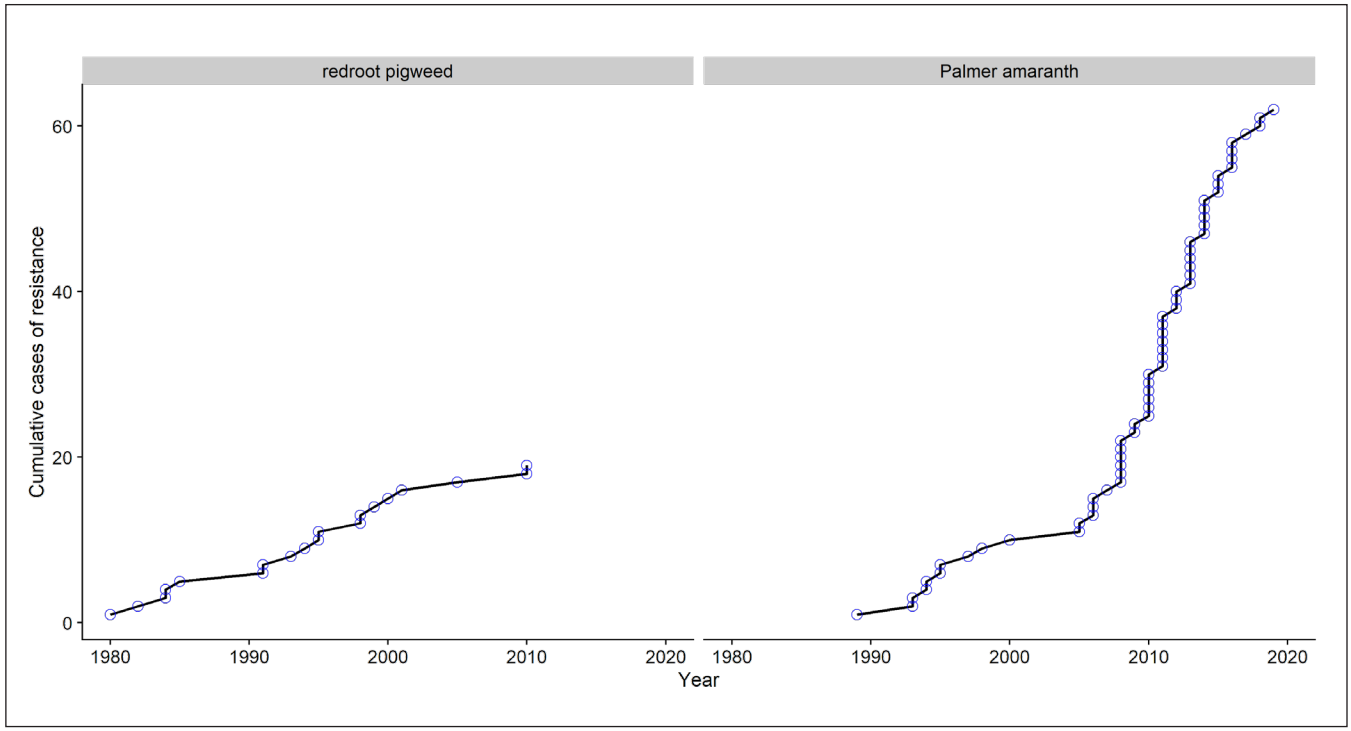

Figure 10. Cumulative cases of herbicide-resistant redroot pigweed and Palmer amaranth in the United States (Heap 2021).

Table 1. Herbicide resistance in redroot pigweed and Palmer amaranth in the United States. ALS, acetolactate synthase; PPO, protoporphyrinogen oxidase

Active Ingredient (Trade Name)*	Mode of Action (group #)	Redroot Pigweed	Palmer Amaranth
mesosulfuron-methyl (Osprey) *imazamox* (Raptor) *rimsulfuron* (Matrix FNV)	ALS inhibitor (2)	Yes	Yes
pendimethalin (Prowl H2O) *ethalfluralin* (Sonalan HFP) *trifluralin* (Treflan HFP)	Microtubule inhibitor (3)	No	Yes
2,4-D (various) *dicamba* (Clarity)	Auxin mimics (4)	No	Yes
glyphosate (Roundup PowerMax)	EPSPS inhibitor (9)	No	Yes
glyphosate-ammonium (Liberty 280 SL)	Glutamine synthetase inhibitor (10)	No	Yes
carfentrazone-ethyl (Aim EC) *saflufenacil* (Sharpen) *sulfentrazone* (Spartan 4F)	Glutamine synthetase inhibitor (10)	No	Yes
s-metolachlor (Dual II Magnum) *dimethenamid-P* (Outlook) *pyroxasulfone* (Zidua)	Very long-chain fatty acid inhibitor (15)	No	Yes
tembotrione (Laudis) *mesotrione* (Callisto) *topramezone* (Impact)	HPPD inhibitor (27)	No	Yes

*These examples are for general informational purposes only. Individuals using such products assume responsibility for their use in accordance with the current label or directions of the manufacturer.

understanding which herbicides the weed is resistant to in order to select herbicides that kill Palmer amaranth. Registration for use in the planted crop is a factor. Palmer amaranth populations have the ability to quickly develop resistance to any single herbicide, so delaying the onset of resistance and effective control of already resistant populations is often achieved by tank mixing at least two herbicide modes (as allowed by the product label) or by sequentially applying the appropriate soil-applied residual and postemergence herbicides. *Glyphosate* (Roundup PowerMax) plus group 4 herbicides (auxin mimics) such as *dicamba* (Clarity) and/or 2,4-D can be effective. Very long-chain fatty-acid inhibitors (group 15) such as *pyroxasulfone* (Zidua), *s-metolachlor* (Dual II Magnum), and *dimethenamid-P* (Outlook) can also provide preemergence and residual control. Herbicides like *glufosinate-ammonium* (Liberty 280 SL, group 10), *saflufenacil* (Sharpen; group 14), *paraquat* (Gramoxone SL 2.0; group 22), and *metribuzin* (Tricor 4F, Dimetric Liquid, group 5) can also provide effective control of small susceptible Palmer amaranth.

Further Reading

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