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Weed Control in Arkansas Watermelon Production

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Watermelon is a high value crop, and production practices that maximize yield and fruit quality should be implemented. Weeds are a common pest that, if left uncontrolled, can reduce watermelon yield and fruit quality and interfere with harvest (Adkins et al. 2010; Monks and Schultheis 1998).

There are many problematic weed species that commonly occur in watermelon fields, including annual grass and broadleaf species. Palmer amaranth (*Amaranthus palmeri*), redroot pigweed (*A. retroflexus*), yellow nutsedge (*Cyperus esculentus*) and purple nutsedge (*C. rotundus*) are among the most common and troublesome weeds in southern watermelon fields (Webster 2010; Van Wychen 2016). An effective weed management strategy should include knowledge of weed biology, the prevention of the introduction of new weeds, diligent monitoring of fields and implementation a diverse weed control strategy including mechanical and cultural control and the use of herbicides and/or fumigants.

Weed Biology

Palmer amaranth and redroot pigweed are small-seeded summer annual weeds of the Amaranthaceae family (Figure 1). Palmer amaranth is a tall, erect, branching summer annual that commonly reaches heights of 6 to 8 feet and occasionally 10 feet or more (Figure 2; Figure 3; Sellers et al. 2003; Norsworthy et al. 2008). Palmer amaranth is dioecious, meaning it exists as separate male and female plants. One female Palmer amaranth can produce from 200,000 to 600,000 seed (Figure 4; Keeley et al. 1987; Sellers et al. 2003). Redroot pigweed is monoecious: both male and female flowers are produced on the same plant. A single redroot pigweed can produce up to 290,000 seed (Sellers et al. 2003). Resistance to herbicides has been documented in both species. Globally, some populations of Palmer amaranth and redroot pigweed have been reported as resistant to 6 and 3 herbicide modes of action, respectively (Heap 2018). In Arkansas, Palmer amaranth has resistance to microtubule inhibitors, glyphosate, ALS inhibitors and PPO inhibitors. Across the United States,

Figure 1. Palmer amaranth has oval leaves with long petioles attaching them to the stem. Palmer amaranth can be distinguished from redroot pigweed by the absence of hairs along the stem. As the name suggests, redroot pigweed has a red-colored root, which is not observed in Palmer amaranth. Proper identification of these weeds is critical to select effective herbicides for weed control.

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Figure 2. Palmer amaranth growing alongside watermelon approximately 3 weeks after transplanting. Polyethylene mulch creates a physical barrier, preventing the emergence of many weeds. But it is possible for weeds to emerge from the planting hole in the plastic mulch where watermelon vines were transplanted.

there are documented cases of Palmer amaranth resistant to photosystem II inhibitors and HPPD inhibitors in addition to all other MOAs already listed (Heap 2018).

Yellow nutsedge and purple nutsedge are creeping perennial monocots of the Cyperaceae family. Nutsedge species have narrow, linear leaf blades and are superficially similar to grasses, but nutsedges can be distinguished by their triangular stems (Figure 5). Nutsedge reproduce and spread primarily via dispersal of tubers. Mature tubers can produce new shoots, allowing nutsedge to spread and infest new areas of a field in the process of tillage or cultivation. Tubers can also be inadvertently carried by farm machinery to other fields, thus starting new infestations over long distances.

After one year, a single purple nutsedge tuber can grow to cover an area of 238 square feet and produce 3,440 shoots (Webster 2005a). In one year, a yellow nutsedge tuber can grow to cover an area of 34 square feet and can produce from 1,700 to 6,900 new shoots (Ransom et al. 2009; Tumbleson and Kommedahl 1961).

Both purple and yellow nutsedge are capable of penetrating polyethylene mulch, suggesting that even plastic mulching is not sufficient to control nutsedge infestations (Figure 6; Webster 2005b). In fact, purple nutsedge growth is stimulated by the increased temperatures under black plastic mulch compared to a field with no mulch (Webster 2005a).

Nutsedges are not controlled by graminicides (ACCase inhibitors). There are few herbicide options for nutsedge control.

Monitor Fields and Maintain Records

The first step in weed management is to collect and review information about weeds in each field. To develop an effective weed management strategy, identify the weed species present in a field and where they are likely to occur. Proper identification of weed species will determine which weed control options will be effective. Seasonal records on weed species and distribution within a field will help decide where to implement additional weed control measures, or where to avoid measures that could exacerbate the problem. In addition, by monitoring weed species numbers each year, the weed management program can be adjusted to increase weed control effectiveness specific to the weeds present.

Implement a Diverse Weed Control Strategy

Due to the limited choices of herbicides for watermelon, weed control in watermelon requires a diverse weed control strategy including mechanical, cultural and chemical methods.

Mechanical Control

Mechanical control includes tillage, hoeing and hand weeding, all of which are methods that physically remove or destroy developing or germinating weedy plants. Depth of tillage is an important consideration. Tillage depth should be set as shallow as possible without reducing weed control. Shallow tillage will unearth fewer weed seeds than a deep tillage event. It is important to consider that with a perennial weed species (e.g., purple and yellow nutsedge), a single tillage event may only serve to spread the weed across the field, causing more problems than no tillage at all. Research suggests that biweekly tillage would disrupt growth of both purple and yellow nutsedge, but long-term control would require supplementary control practices (Bangarwa et al. 2012). After watermelon vines have extended into row middles, tillage is no longer an option.

Hoeing and hand weeding are alternative forms of mechanical

Figure 3. Comparison of a weed-free watermelon plot (left) vs. a plot with four Palmer amaranth per 25 ft^2 (right) at 6 weeks after transplant. Palmer amaranth grows upright and can shade out much of the watermelon plot, reducing watermelon yield and fruit counts.

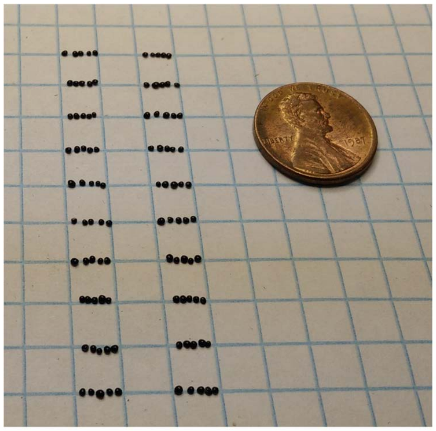

Figure 4. Seeds of Palmer amaranth are extremely small and are produced in large quantities. A single female Palmer amaranth can produce 200,000 to 600,000 seed. Left uncontrolled, small infestations of Palmer amaranth can overtake a field in a just a few growing seasons.

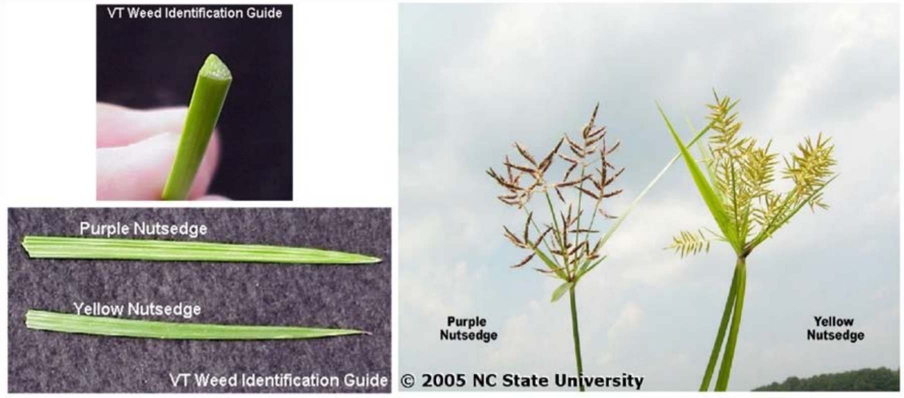

Figure 5. Nutsedge species are superficially similar to grasses but can be distinguished by their triangular stems. Emerging purple and yellow nutsedge can be identified by the leaf tips, which are blunted in purple nutsedge or tapering to a narrow point in yellow nutsedge. If flowering, the two species can be more easily distinguished by purple or yellow flowers

weed control in watermelon. These options require hand labor and will cost more on a per-acre basis than tillage. Manual weed control is best implemented in areas of the field where tillage is not possible, such as within rows or in row middles after watermelon vines have run together.

Hand weeding and hoeing are excellent options to remove late-season weeds that have escaped herbicide application. Late-season hand weeding can prevent weeds from depositing seeds to the soil, an important preventive measure for future growing seasons.

Growers are advised to maintain a zero-tolerance threshold for Palmer amaranth in fields, particularly when herbicide resistance is a concern (Norsworthy et al. 2014). The zero-tolerance threshold stops new deposits to the soil seedbank. This is particularly important in preventing the expansion of herbicide-resistant weed populations, which limit chemical control options and may limit yields in subsequent years. If Palmer amaranth seeds remain near the soil surface (~0.5 inch depth), the number of viable seed drops by 91 percent within three years, reducing the number of seeds present in future seasons (Sosnoskie et al. 2013). Diligent weed management is necessary to prevent future outbreaks, and limiting seed production can make weed control easier and more effective in subsequent growing seasons.

Cultural Control

Cultural control is a form of weed control that creates an environment favoring crop development and limiting growth and development of weeds. Cultural control practices include transplanting rather than direct seeding, proper fertilizer application, irrigation, use of cover crops to reduce weed populations and plastic mulching. Cultural control is generally beneficial, regardless of weed species present. However, some cultural practices are more effective than others, depending on the weed species.

Watermelon may be direct seeded or transplanted as three- to four-leaf-plug plants. Typically, triploid (seedless) watermelon are transplanted due to germination requirements and high seed cost. Transplanted watermelon develop more rapidly than direct-seeded watermelon. Early crop development shortens the time from transplanting until canopy closure, when emerging weeds no longer compete with the crop and reduce yield. Use of transplants, rather than direct-seeded watermelon, increases the early season competitiveness of the watermelon and may suppresses weed emergence, due to more rapid canopy development, particularly in rows.

Fertilizer applications may also affect weed populations, which compete for nutrients in the soil. Fertilizer can be broadcast over the field, applied in bands over watermelon rows or applied via drip irrigation. Broadcast applications of fertilizer deliver nutrients to the entire field, including row middles. Watermelon roots do not reach into row middles until late in the season; therefore, broadcasting fertilizer early in the season serves to fertilize mostly the weeds that are growing in the row middles. Banded applications place the fertilizer in close proximity to watermelon roots, giving advantage to the crop, although competition still occurs with weeds growing in the row. The best option is to apply fertilizer via drip irrigation, so the fertilizer is delivered directly to the root zone of the crop, reducing the amount of nutrients available to weeds.

Polyethylene mulch can be used to suppress weed seed germination in rows. Raised plastic beds with drip irrigation prevent emergence of weeds in rows and allow application of irrigation and fertilizer to the crop root zone. Black polyethylene mulch prevents light from reaching small seeds, and it prevents germinating seed from emerging in rows. Growers are cautioned that tears or small rips in plastic will allow weed emergence through the plastic. This includes emergence of weeds in the planting holes (Figure 2). In addition, plastic mulches can be penetrated by purple and yellow nutsedge as early as six days after plastic has been laid (Figure 6; Patterson 1998; Webster 2005b). In addition to plastic mulch, winter cover crops or straw in row middles can provide weed control between rows and reduce the ability of weeds to establish in the field (Webster et al. 2013; Wilhoit and Coolong 2013).

Figure 6. Purple and yellow nutsedge are capable of penetrating polyethylene mulch and competing with watermelon vines in-row. Use of polyethylene mulch will not provide adequate weed control if either nutsedge species is present in the field

The use of cover crops for weed control in specialty crops (vegetables, small fruits, fruit trees, etc.) has been studied over many decades, more in some crops than others. There are summer cover crops and winter cover crops. The latter can work well with watermelons.

The two main strategies for incorporating winter cover crops as a means for weed control in commercial watermelon production are strip-till and no-till cover crop management. In both systems winter annual grasses like cereal rye or winter wheat are planted in the fall to provide soil cover over the winter. These grasses produce large amounts of biomass that is then used as physical means to suppress weeds during the subsequent spring and early summer watermelon cropping season (Teasdale et al. 2007). Cereal rye and wheat also produce natural chemicals that are inhibitory to small-seeded weeds. The physical and chemical weed suppression from these cover crops can last for about one month, depending on the amount of biomass produced in a particular site.

In the strip-till system, the cover crop is mowed and tilled into the soil in strips or rows to allow for plasticulture raised beds to be laid using standard bedding equipment. In this system, the cover crop is left standing in the row middles to serve as a windbreak to protect young transplants from wind damage and desiccation during the early transplant stage. Later, the cover crop stubble can be rolled down in the row middles to provide a straw mat that reduces weed emergence and over which the watermelon vines can run.

In the no-till system, the entirety of the cover crop biomass is rolled down and left on the soil surface to physically suppress weeds. Typically, a roller, roller-crimper, herbicide or some combination of the three is used to kill the cover crop and create the smooth weed mat into which watermelons are transplanted directly (Ashford and Reeves 2003; Balkcom et al. 2007). The no-till system is also typically combined with an application of preemergence (PRE) or postemergence (POST) herbicides to fully suppress weeds until the vines achieve canopy closure (Hand et al. 2018). In organic production systems, cover crops are often an important component of weed management due to the lack of chemical control measures approved for organic production. The use of winter cover crops is also an important soil conservation strategy, particularly on the sandy soils commonly used for watermelon production. For more information on cover crops, see *Understanding Cover Crops,* FSA2156.

Some growers have elected to use grafted watermelon, though its adoption is still limited in the United States (Kubota et al. 2008). Grafting is a technique that combines the shoot of one plant (the scion) with the rootstock of another cultivar or species. The scion is a watermelon cultivar selected for high yield or high quality fruit, while the rootstock would be selected for disease resistance or tolerance to abiotic stresses, such as drought or cold (Keinath and Hassell 2013; Miguel et al. 2004; Yetisir et al. 2006).

Field trials in North Carolina determined that the same weed management practices for non-grafted watermelon will work for grafted watermelon (Bertucci et al. 2019). However, results also indicate that grafting will not provide yield benefits in the absence of disease pressure from soilborne pathogens (Bertucci et al. 2018). For more information regarding watermelon grafting, please contact the authors or visit http://www.vegetablegrafting.org.

Herbicides

Few herbicides are registered for watermelon. Restrictions for use include crop planting method, use of polyethylene mulch, timing of application and where applications are made within the field. Some preplant applications may be broadcast above polyethylene mulch (e.g., glyphosate, terbacil); but to avoid crop injury, a minimum 0.5 inch rainfall or irrigation must wash the herbicide from the plastic prior to planting.

Specific restrictions may apply to a transplanted or direct-seeded crop, as with DCPA (Dacthal®) which is not registered for application in transplanted watermelon. Additionally, herbicides may be registered for preplant, PRE or POST applications. Lastly, herbicides may be registered for use as a fumigant or for broadcast-, banded- or hooded-sprayer application. Due to crop sensitivity, only two herbicides are registered for POST broadcast applications in watermelon. Clethodim (Select®) and sethoxydim (Poast®) are registered for application over emerged watermelon for control of annual and perennial grass species. The remaining POST herbicide options must be applied as a post-directed application to row middles in order to avoid crop injury.

Most herbicides registered for use in watermelon are non-selective and may cause crop injury if applied improperly (Dittmar et al. 2008; Grey et al. 2000; Mitchem et al. 1997). Thus, proper calibration of sprayers is critical. Check the sprayer pressure, tractor speed and flow rate (gallons per minute) from each nozzle. The output from each nozzle must be uniform. Damaged nozzle tips must be replaced. All applications should be made at the recommended rate and according to label instructions. For additional advice for calibration and specific herbicide recommendations, please refer to MP44, *Recommended Chemicals for Weed and Brush Control*.

Grass Weeds

Common grass weeds in southern watermelon fields include large crabgrass (*Digitaria sanguinalis*) and goosegrass (*Eleusine indica*) (Webster 2010). Fortunately, several PRE and POST herbicides are available for control of these annual grass species (Table 1). Applicators should be aware that ACCase herbicides (clethodim and sethoxydim) can take several days to produce symptoms in treated weeds. The first symptom on a treated grass is a brown, mushy growing point. Of course, the growing point of a grass

Table 1. Herbicide options for use in Arkansas watermelon production, herbicide application timings and weeds controlled. Always read and follow label instructions.

		Timing and placement to the crop					Weed growth stage		Weeds controlled/ suppressed		
Common Name	Trade Name	Before seeding	After seeding before emergence	Before transplanting	Postemergence	Postemergence – row middles only	Preemergence	Postemergence	Annual grass	Broadleaves	Perennial sedges
Bensulide	Prefar®	X[1]		X			X		X	X	
Carfentrazone	Aim®			X		X		X		X	
Clethodim	Select Max®				X			X	X		
Clomazone	Command®		X	X			X		X	X	
Clomazone + Ethalfluralin	Strategy™		X	X		X	X		X	X	
DCPA	Dacthal®				X[2]		X		X	X	
Ethalfluralin	Curbit®		X	X		X	X		X	X	
Glyphosate	Roundup®	X		X		X		X	X	X	X
Halosulfuron	Sandea®		X	X		X	X	X	X	X	X
Imazosulfuron	League®					X	X	X	X	X	X
Paraquat	Gramoxone®	X		X				X	X	X	
Pyraflufen ethyl	ET®	X						X	X		
Sethoxydim	Poast®				X			X	X		
S-metolachlor[3]	Dual Magnum®			X	X		X		X	X	X
Terbacil	Sinbar®		X	X		X	X		X	X	
Trifluralin	Treflan®					X	X		X	X	

[1]PPI – Preplant incorporated
[2]Not labeled for transplanted crop
[3]*S*-metolachlor (Dual Magnum®) has a Section 24(c) registration. Label must be obtained from Arkansas State Plant Board's website: https://www.agriculture.arkansas.gov/registration

is hidden beneath the sheath, so you will have to pull on the youngest emerging leaf to see the affected area. Symptoms then progress to discolored purple leaves followed by plant death.

Because of the limited chemical options, control of broadleaf and sedge weed species is more challenging than control of grass species. Below are examples of weed control options for Palmer amaranth, redroot pigweed, purple nutsedge and yellow nutsedge.

Palmer Amaranth and Redroot Pigweed (and Most Other Pigweed Species)

1. Apply non-selective burndown herbicides such as glyphosate or paraquat (Gramoxone®), followed by tillage to prepare the planting beds. Alternatively, till the field, allow weeds to germinate and then burn down weed seedlings with non-selective herbicides. This sequence will reduce the in-season weed population significantly.
2. Form beds and apply halosulfuron-methyl (Sandea®, 0.5 to 0.75 ounce per acre), terbacil (Sinbar®, 2 to 4 ounces per acre) or metam sodium (Vapam®, rate varies) below polyethylene mulch. Vapam® carries a 14- to 21-day preplant interval (up to 30 days in some environments). Sandea® carries a 7-day preplant interval.
3. Black polyethylene mulch and the herbicides below the plastic should effectively control pigweeds in the beds.
4. The row middles can be tilled to control small pigweed seedlings. Trifluralin (Treflan®, 1 to 2 pints per acre) should be applied to row middles following the last tillage event. Trifluralin and *S*-metolachlor (Dual Magnum®, 0.67 to 1.27 pints per acre) both have a 60-day preharvest interval, so they should be applied within 10 to 12 days after transplanting.
5. POST options for row middles include glyphosate in a hooded sprayer, shielded sprayer or applied with a wick bar. Additionally, carfentrazone-ethyl (Aim®) can be applied at 1 to 2 ounces per acre with a hooded sprayer.

Note: If pigweeds are present following herbicide applications and there is concern they will cause reduction in watermelon fruit yield and quality, they should be hand weeded. Any female pigweeds that escape this herbicide regime should be hand weeded and removed from the field to eliminate seed deposition and to prevent development of herbicide resistant populations.

Purple and Yellow Nutsedge

1. The best option is a preplant application of metam sodium (Vapam®) at 75 GPA to control the nutsedge. Rates range from 15.7 to 31.5 pounds per acre depending on soil conditions. Fourteen to 21 days must pass before transplanting watermelons (up to 30 days, depending on environmental conditions).
2. Halosulfuron-methyl (Sandea®) should be applied after bed formation, but before laying plastic, at a rate of 0.5 to 0.75 ounces per acre. Seven days must pass before planting. Glyphosate or paraquat (Gramoxone®) can be applied preplant to kill emerged weeds.
3. Polyethylene mulch will help with in-row suppression of purple nutsedge, but yellow nutsedge can penetrate through polyethylene mulch. Thus, the best option for yellow nutsedge control is PRE or preplant applications of Vapam® or Sandea®.
4. If nutsedge has emerged in row middles, an early-season POST application of imazosulfuron (League®) at 4.0 to 6.4 ounces per acre or halosulfuron-methyl (Sandea®) at 0.5 to 1.0 ounces per acre can be made. But either of these applications must occur early in the season, due to a 48- and 57-day preharvest interval for League® and Sandea®, respectively. Neither product should be allowed to contact the melon crop or the plastic.
5. Lastly, glyphosate may be applied to row middles for emerged nutsedge, but applications must be made with a hooded sprayer or a shielded sprayed to avoid contact with the crop. Follow label instructions.

Note: A single tillage is not recommended for control of mature nutsedge. Tillage will kill foliar parts of the nutsedge, but it will spread tubers across a field. Glyphosate is a better option and has been demonstrated to reduce tuber production of both purple and yellow nutsedge (Webster et al. 2008).

The use of specific product names is for the convenience of readers. It does not represent endorsement of a particular product or company. No conflicts of interest exist for authors. This document was prepared in a collaborative effort between researchers at North Carolina State University and the University of Arkansas. Similar publications will be available from their respective institutions.

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