Palmer Amaranth – 2014 Weed of Year

Palmer amaranth was chosen as weed-of-the-year for the second year in a row as a proactive approach to prevent Palmer amaranth establishment in ND. This is in continuation of education efforts in 2014 to increase land owner awareness of its extreme noxious and pernicious capability, to aid in identification, and to encourage land owners to keep a vigilant watch and kill all plants that may arise. In 2015, a concerted education effort is continuing under a program called: **Early Detection and Rapid Response**.

Early Detection: Prevention is the #1 priority. Early detection is composed of correct identification of small pigweed species (redroot pigweed, waterhemp, and Palmer amaranth) which may be difficult because of phenotypic similarities. Resource information and material showing size and shape of cotyledons, leaves, and small plants is posted on the NDSU Weed Science web site: www.ndsu.edu/weeds.
County extension educators can assist with rapid identification. We encourage land owners, agronomists, and consultants to keep a vigilant watch for this weed so if positively identified a Rapid Response program can be initiated.

Rapid Response: Rapid, effective response may save landowners and the state significant time, money and economic reduction. If Palmer amaranth was allowed to spread unchecked, eradication will become much more difficult and costly - Refer to study results below:
In February of 2008, 20,000 glyphosate-resistant (GR) Palmer amaranth seeds were sown in a 1 square meter circle to represent survival of a single GR female Palmer amaranth plant from the 2007 growing season. In Fall of 2008, Palmer amaranth was located as far as 400 ft downslope. It is believed that rainwater dispersed the seeds from the original area of introduction. In 2009, GR Palmer amaranth had expanded to reach all field boundaries, infesting 12 to 31% of total field area. In 2010, infestations reached greater than 95% of total field area. High crop yield reductions were observed 2 yr after the introduction in 2009. In 2010, three years after introduction, Palmer amaranth infestation caused a complete crop loss as it was impossible to harvest the crop. These results indicate that resistance management options such as a "zero-tolerance threshold" should be used in preventing or mitigating the spread of GR Palmer amaranth. This research demonstrates the need for proactive resistance management. Norsworthy et. al. Weed Science 62:237-249. 2014.

Rapid response will require joint cooperation and action from many parties including: NDSU specialists and county agents, agronomists, consultants, ND Dept of Ag, county weed officers, and land owners. Palmer amaranth may be added to the ND State Invasive Species list or added as a state or county noxious weed which may allow NDDOA resources to help in eradication efforts. State and county extension personal can help identify effective chemical options for whole field or spot spraying applications. Handweeding may be the most efficient method to remove individual plants or small patches but total crop and weed destruction may be necessary for large infestations, if no chemical treatment is available or if plants are too large for effective chemical control. Best Management Practices (BMPs) by crop is also available at the NDSU Weed Science web site.

Palmer Amaranth Distribution and Biology:
Palmer amaranth (*Amaranthus palmeri*) is a pigweed species that is not native to North Dakota or to the northern United States. It has become resistant to glyphosate and as a result has become well established in the southern U.S. It can spread rapidly especially in glyphosate resistant but also in conventional herbicide weed management systems. It has spread and become established in every U.S. state of the south, mid-west, and east except Minnesota and North Dakota.

Palmer amaranth is a C-4 carbon assimilating species, thrives in hot environments, and can survive, establish, and spread in the northern latitude of the U.S., including the northern plains. It was introduced to some areas (e.g. Michigan) through the spread of manure from dairy cows that were fed cotton-seed screening that included Palmer amaranth seed as a feed supplement.

Palmer amaranth seed could easily be brought into ND through various ways including:
1. Custom combines moving south to north into ND.
2. Contaminated crop seed used for seeding.
3. Transportation of contaminated hay and forage across state borders.
4. Food source for birds and bird migration.
5. Water flow - Palmer amaranth seed is small, light, and floats in water which makes water movement a primary source of spread. Waterhemp, another pigweed species, has spread in ND through water flow, especially in drown-out areas where no crop competition allows weeds to grow uninhibited.

Below are reasons why it is being called "Satan" and why growers should quickly destroy any plants found.
1. Biotypes of this weed are resistant to one or more of the following herbicide site of action groups: ALS (2), atrazine (5), glyphosate (9), and HPPD inhibitor (27) herbicides, leaving very few herbicide options available for management.

2. One of the fastest weed growth rates known - >2 inches/day.

3. Long emergence pattern from mid-May through August.

4. Can exploit even slight canopy openings.

5. Produces from 1 to 1.8 million seeds/plant.

6. Seed is short-lived and only 2% of seed is viable after 6 years but the sheer number of seeds produced by a female plant makes eradication difficult once established.

7. Female plants can grow to more than 10 feet tall with a 5-6 inch stem girth and seed heads more than 1 foot in length. Male plants are small and generally non-competitive.

8. Pulled plants can re-root and produce seed.

9. Can cause 78% yield loss in soybean, 91% in corn.

Palmer amaranth's prolonged emergence period, rapid growth rate, prolific seed production, and propensity to evolve herbicide resistance quickly makes this the most pernicious, noxious, and serious weed threat that ND farmers have ever faced.

Keys to successful management in soybean:
Palmer amaranth is one of the most difficult weeds to manage in soybean. Proper identification and early detection of Palmer amaranth will improve control and management. Use the following steps for the best management of Palmer amaranth in soybean.

Step 1. Start clean. Use tillage or an effective burndown herbicide, (Gramoxone, Liberty, Sharpen, or glyphosate + 2,4-D) prior to planting.

Step 2. Always use a PRE herbicide or premix - apply a full-rate of effective soil-residual herbicides. Include herbicides that contain the active ingredients of flumioxazin (Valor and Fierce), and sulfentrazone (Authority). Rates of sulfentrazone need to be equivalent to 8 fl oz/A of Spartan (0.25 lb ai/A). Adding metribuzin to Valor or Authority products (where allowed) will provide additional residual control.

Step 3. Effective POST herbicides (Flexstar, Cobra, Ultra Blazer or Liberty in LL soybean) must be applied before Palmer amaranth is 3-inches tall. Full rates and high spray volume is essential for all contact herbicides. Plants >3" tall will survive these herbicides. MSO adjuvant will enhance herbicide activity the most but significant contact burn to soybean may result.

Step 4. Add residual herbicides (Dual, Warrant, Outlook, or Zidua) with the POST herbicides. The residual PRE product is essential to reduce other flushes after weed kill from the POST herbicide.

Step 5. Successive POST herbicide applications may be needed. Apply to plants 3-inches or less. Cobra or Ultra Blazer can only be applied if Flexstar was used in the first POST application. MSO provides the greatest herbicide enhancement.

Step 6. Additional cultural control measures, such as hand-weeding (destroy pulled plants), should be implemented to prevent any remaining plants from going to seed in the field or surviving around field edges or along ditch banks.

Keys to successful management in corn:
Grass crops provide the best opportunity for management but due to the species' propensity to evolve herbicide resistance do not rely solely on one herbicide site of action.

There are many more herbicides labeled for control of pigweed species in corn than soybean.

Use similar steps listed in section on management in soybean with the addition:

1. Always use a PRE herbicide or premix - apply a full-rate of effective soil-residual herbicides.
A two-pass, sequential herbicide program will provide the greatest control. Apply full labeled rates of a herbicide premix or tank-mix with a minimum of 2 herbicide sites of action effective on pigweed species.

2. Effective POST herbicide: At least 2 effective POST herbicide sites of action are required and apply to weeds before 3 inches tall. A group 15 herbicide may also be tank–mixed for additional residual control. Apply with the most aggressive adjuvants for improved weed control. MSO adjuvant will enhance herbicide activity the most but corn injury may result. Refer to label for approved adjuvants.

3. Hand-weed, remove from field, and destroy any remaining plants.

Identifying characteristics

Waterhemp	Redroot pigweed	Palmer amaranth
Cotyledons: small, narrow and pointed Leaves: narrow and shiny with short petioles	Cotyledons: small, narrow and pointed Leaves: ovate/round and dull green with short petioles	Cotyledons: rounded at tip and differential size Leaves: ovate/round with long petioles with spike at tip

Palmer Amaranth – 2015 Weed of the Year

Palmer amaranth (*Amaranthus palmeri*) is a pigweed species that is not native to North Dakota or to the northern United States. It is well established in the southern U.S. It has not been identified in ND but has been introduced in the northern latitude of the U.S., demonstrating it could survive in the northern plains. It was introduced in several states through the spread of manure from dairy cows that were fed cotton by-products as a feed supplement. It could easily establish in ND through custom combines moving north into ND and several other ways of weed seed dissemination.

Palmer amaranth was chosen as weed-of-the-year as a proactive approach to increase awareness of its extreme noxious and pernicious capability, to aid in identification, and to encourage land owners to keep a vigilant watch and kill all plants that may arise. Below are some reasons why it is being called “Satan” and why growers should quickly destroy any plants found.

1. Biotypes of this weed are resistant to one or more of the following herbicide site of action groups: ALS (2), atrazine (5), glyphosate (9), and HPPD inhibitors (27) herbicides, leaving very few herbicide options available for management.
2. One of the fastest weed growth rates known - >2 inches/day.
3. Long emergence pattern from mid-May through August.
4. Can exploit even slight canopy openings.
5. Produces more than 1 million seeds/plant.
6. Seed is short-lived and only 2% of seed is viable after 6 years but the sheer number of seeds produced by a female plant makes eradication difficult once established.
7. Female plants can grow to more than 10 feet tall with a 5-6 inch stem girth and seed heads more than 1 foot in length. Male plants are small and generally non-competitive.
8. Pulled plants can re-root and produce seed.
9. Can cause 78% yield loss in soybean, 91% in corn.

Palmer amaranth’s prolonged emergence period, rapid growth rate, prolific seed production, and propensity to evolve herbicide resistance quickly makes this the biggest weed threat that ND farmers have ever faced.

Keys to successful management in soybean:
Palmer amaranth is one of the most difficult weeds to manage in soybean. Proper identification and early detection of Palmer amaranth will improve control and management. Use the following steps for the best management of Palmer amaranth in soybean.

Step 1. Start clean. Use tillage or an effective burndown herbicide, (Gramoxone, Liberty, or glyphosate + 2,4-D) prior to planting.

Step 2. Always use a PRE herbicide - apply a full-rate of effective soil-residual herbicides. Include herbicides that contain the active ingredients of flumioxazin (Valor and Fierce), and sulfentrazone (Authority). Rates of sulfentrazone need to be equivalent to 8 fl oz/A of Spartan (0.25 lb ai/A). Adding metribuzin to Valor or Authority products (where allowed) will provide additional residual control.

Step 3. Effective POST herbicides (Flexstar, Cobra, Ultra Blazer or Liberty in LL soybean) must be applied before Palmer amaranth is 3-inches tall. Full rates and high spray volume is essential for all contact herbicides. Plants >3" tall will survive these herbicides. MSO adjuvant will enhance herbicide activity the most but significant contact burn to soybean may result.

Step 4. Add residual herbicides (Dual, Warrant, Outlook, or Zidua) with the POST herbicides. The residual PRE product is essential to reduce other flushes after weed kill from the POST herbicide.

Step 5. Successive POST herbicide applications may be needed. Apply to plants 3-inches or less. Cobra or Ultra Blazer can only be applied if Flexstar was used in the first POST application. MSO provides the greatest herbicide enhancement.

Step 6. Additional cultural control measures, such as hand-weeding (destroy pulled plants), should be implemented to prevent any remaining plants from going to seed in the field or surviving around field edges or along ditch banks.

Keys to successful management in corn:
Grass crops provide the best opportunity for management but due to the species’ propensity to evolve herbicide resistance do not rely solely on one herbicide site of action.
1. PRE - two-pass (sequential) herbicide program is required. Full labeled rates of a minimum of 2 effective herbicide sites of action are required.
POST: At least 2 effective POST herbicide sites of action are required and apply to weeds before 3 inches tall. A group 15 herbicide may also be tank–mixed for additional residual control.
2. Hand-weed and destroy any remaining plants.

Identifying characteristics:

- Stem and leaf surfaces with no/few hairs
- Leaves have a symmetrical (poinsettia) arrangement
- Petioles are as long or longer than the leaf blades
- Male and female flowers are on separate plants
- Spiny bracts are at leaf axils on female plants
- Flowering structures are unbranched, and 1 to 2 feet long
- Male flowering structures are soft and spread pollen
- Female flowering structures are spiny and contain seed


Smooth stem


Symmetrical leaf arrangement


Long leaf petiole


Female plant spiny bracts


Unbranched flowering structures

Kochia - 2016 Weed of The Year

Kochia has been and remains one of the 10 worst weeds in ND from surveys conducted since 1978. Consider how the biology of kochia contributes to its persistence in weed management systems:

Kochia emergence: - Seed dormancy: None (usually) - GDD required: <50 - Days to 95% emerge.: 2 weeks - Temperature range: 40 to 100 F - Maximum emergence depth: 3.25 in. - Calendar time span: April through July - Soil conditions: Fertile/saline/drought Seedling frost tolerance: Lower teens Rooting depth: Up to 16 ft in drought	Implications: Wide genetic diversity in kochia is expressed in highly variable phenotypes: green, red, and purple colored plants, tall and narrow plants, short and round plants, and plants with wide leaves, and narrow leaves. Wide genetic diversity caused ALS (Group 2) resistance kochia biotypes to develop in the late 1980s, a short time after ALS herbicides were developed. Most kochia emerges in a 2 to 3 week time span very early in the spring. However, early spring tillage and herbicide burndown practices have selected for later emerging kochia biotypes. As a result, multiple flushes of kochia now occur from April through July. Kochia is adapted to drought conditions and saline soil and grows mostly uninhibited as it lacks competition from other plant species.
Kochia biomass production: Ratio of seed mass per unit plant mass: Foxtail = 75, Lambsquarters = 150, Kochia = 500	Implications: Kochia has one of the highest seed to plant mass ratios. This allows plants to disseminate numerous seeds that are weakly attached to light, buoyant plants that roll (tumble weed) uninhibited across fields with the wind.
Kochia carbon assimilation pathway (C3 or C4): C4 (fixes 4 carbons vs. 3 during photosynthesis)	Implications: C4 carbon assimilation physiology allows rapid kochia growth in hot temperatures and in low moisture conditions.
Herbicide resistant kochia biotypes in ND: Group 2 (ALS) = Express, Raptor, Python, etc. Group 4 (Growth reg.) = 2,4-D, dicamba, Starane Group 5 (Photosynthetic inhibitor) = atrazine Group 9 (EPSPS inhibitor) = glyphosate The mechanism of glyphosate resistance in kochia is gene amplification (i.e. plants make multiple copies of the EPSPS gene). Gene amplification can produce kochia that cannot be controlled by practical rates of glyphosate. Multiple herbicide resistant kochia in ND: Group 2 + 4. Group 2 + 9. Group 2 + 4 + 9.	Implications: Wide genetic diversity in kochia allows resistant biotypes to develop from high herbicide selection pressure (frequent use of herbicides from one site of action). 2,4-D was registered in the mid 1940s. Use of 2,4-D over 70 years has gradually depleted susceptible biotypes leaving tolerant/resistant kochia biotypes that survive the relatively low 2,4-D rates of 1 pt/A used in wheat. Fluroxypyr (Starane) resistant kochia is from over-dependence on fluroxypyr in small grains and corn. A contrasting difference between 2,4-D and glyphosate resistance in kochia is the maximum 2,4-D rate of 1 pt/A in wheat compared to the high rates of glyphosate used in tolerant RUR crops (2.25 lbs ae/A). The 1 pt/A rate of glyphosate used in the 90s now requires 2 to 4 qt/A to achieve the same level of weed control. Resistance increases in each successive kochia generation compared to the previous generation.
Pollen: Type of pollination: Cross but able to self. Length of pollen viability: Up to 12 days	Implications: Pollen from herbicide resistant kochia plants can pollinate flowers on susceptible plants to make seed resistant to herbicides.
'The chink in the armor': SHORT seed viability. % seeds viable after 1 year = 5%, 2 years = 1%	Implications: Seed from most weeds remain viable in the soil for many years. Most kochia seed is non-viable after 1 or 2 years - see next section below.
Humans have brains, weeds don't - why are weeds winning? (Ford Baldwin - U of AR) Consider effective non-chemical control strategies..... build a biological fence.	Implications: Most fences around fields have been removed and recently shelterbelts are also being removed. These structures inhibit/prevent kochia from rolling across fields. Since kochia seed dies after 1 or 2 years, why not prevent tumbling plants and deplete the soil seed bank by building a biological fence? Do this by planting 6 or 8 rows of corn or sunflower around field borders. Tall crops trap and prevent kochia plants from rolling across fields.

Crop Rotation: A crop rotation that includes a grass crop where many effective herbicides are registered can effectively control kochia and deplete the soil seed bank. Corn and small grains have the largest portfolio of herbicides to control kochia.

Chemical Control in Crops:
The most effective chemical control strategy for kochia includes PRE followed by POST herbicides. Many PRE corn and soybean herbicides can effectively control kochia if activated by rain. Except for corn and small grains, all other crops have very few POST herbicides to effectively control kochia and timely POST applications to small plants are required for maximum activity.
**See pages 112, 114, and 116 in the ND Weed Control Guide for effective herbicides for kochia control.

Herbicides for kochia control:
Corn: atrazine, dicamba, flumioxazin, fluroxypyr, isoxaflutole, mesotrione/tembotrione/topramezone + atrazine, pyroxasulfone, saflufenacil, and Liberty in Liberty Link corn. *See pages 21-23 for additional herbicide information in corn.*

Soybean: bentazon + MSO adjuvant (split applications- see paragraphs E3-E4 on page 81 and F5-F6 on page 83), flumioxazin, fomesafen, metribuzin, sulfentrazone, saflufenacil and Liberty (LL corn). *See pages 30-31 for additional herbicide information in soy.*

Dry bean: bentazon + MSO adjuvant (split applications- see paragraphs E3-E4 on page 81 and F5-F6 on page 83), fomesafen, sulfentrazone. *See pages 32-33 for additional herbicide information in dry beans.*
***Warning** - Most remaining herbicides that control herbicide-resistant kochia in soybean and dry beans are Group 14 (PPO Inhibitors). Over-use of PPO herbicides will quickly increase the development of PPO resistance and result in kochia biotypes with multiple resistance: glyphosate + ALS + PPO. This multiple-resistant kochia will require some creativity to control - as Albert Einstein said, "We cannot solve (this) problem with the same level of thinking that was used to create it."*

Horseweed - 2017 Weed Of The Year

Horseweed, also called marestail (Conyza canadensis), is a winter annual or summer annual weed that is native to North America. In North Dakota, horseweed is most troublesome when it emerges in the fall, overwinters as a rosette, and then elongates (bolts) in early spring. In contrast, in some Midwest states, spring-emerging horseweed has been more troublesome because of late emergence in May and June. Horseweed's wide emergence window often allows it to escape preplant and PRE herbicides. In addition, many POST herbicides do not provide effective horseweed control. Thus, it is imperative that horseweed be controlled in the fall, the spring burndown, and with spring residual herbicides to control later-emerging weeds.

Horseweed typically grows 3 to 6 feet tall and can produce up to 200,000 seeds per plant. Similar to dandelion, horseweed seed is attached to a white pappus that is easily dispersed several hundred yards by wind. It has been reported that up to 91% of the fall-emerging plants survive until spring. Over-wintering rosettes will start to bolt fairly early in the spring. **Horseweed is much easier to control in the rosette stage than the bolting stage.**

History

Horseweed tends to thrive in no-till systems, but is more easily controlled using conventional tillage. Plants that emerge in the fall are typically killed easily with spring tillage. An Indiana survey showed horseweed was found in 61% of no-till fields, 24% in reduced-till fields, and 8% in conventional-till fields. It has been shown that tilling the top 0.25 inch of soil provides about 95% horseweed control.

Horseweed's ability to emerge in the fall and throughout the growing season allows it to be very competitive with crops. An Ohio State University study showed the effect of horseweed on soybean yields:

- 51 bu/A where the burndown treatment failed to control emerged plants.
- 57 bu/A where the burndown treatment was effective, but there was no residual herbicide.
- 65 bu/A where the burndown was effective and residual herbicides were used.

Resistance

Horseweed biotypes are tolerant/resistant to many herbicide groups: 2, 3, 6, 8, 9, 14, 15, and 27. Glyphosate-resistant horseweed has been found in several locations in North Dakota. 2,4-D has been a common product used to control horseweed in many states. Some states now indicate that 2,4-D is not as effective as it once was. Thus, it is important to use multiple modes of action to control horseweed and not rely on one herbicide year after year. It is critical that growers not rely on glyphosate alone to control horseweed.

Control

Horseweed is most easily controlled in the fall. Therefore, control efforts should always begin in the fall. Consider rotation restrictions when selecting fall or spring herbicides.

Fall applications:

- Glyphosate + 2,4-D with/without (w/o) Sharpen
- Glyphosate + Sharpen
- Glyphosate + dicamba (follow crop rotation restrictions)
- Glyphosate + Valor + 2,4-D (consider applying Valor separate from glyphosate + 2,4-D to avoid antagonism from rapid burn on foliage)

Wheat

Preplant or PRE: Glyphosate + 2,4-D or with Sharpen

POST: 2,4-D + Starane Flex w/o SU, Huskie/Huskie Complete, GoldSky, Kochiavore, PerfectMatch, WideMatch, and Weld.

Dry pea

Preplant or PRE: Glyphosate + Sharpen w/o Spartan or Glyphosate + Metribuzin

POST: Basagran (2 pt/A required for 80% control) + MSO

Soybean

Fall: Glyphosate + 2,4-D w/o Sharpen

Preplant or PRE:

- Glyphosate + 2,4-D ester (7 day plantback for ester)
- Glyphosate + Sharpen (plantback interval: 0 day – 1 oz; 14 days – 1.5 oz; 30 days – 2 oz; 60 days – 3 oz). Tank mixing Sharpen with Group 14 herbicides may increase the plantback interval.
- Glyphosate + 2,4-D + Sharpen (follow plantback intervals)
- 2,4-D + Gramoxone + Metribuzin
- Apply residual herbicide: Spartan, Valor, or Metribuzin

POST:

- Basagran - 2 pt required for 80% control
- FirstRate - will not control ALS-resistant plants
- Dicamba - only apply approved dicamba formulations in dicamba-resistant soybeans
- LL Soybeans - Liberty

Horseweed control summary:

1) Apply effective herbicides in the fall.
2) Apply residual herbicides in the spring.
3) Apply herbicides to rosette horseweed plants. Bolted plants are much more difficult to control.
4) Apply herbicides in at least 10-15 gallons per acre.
5) Apply Sharpen or Sharpen + Spartan with MSO + AMS.