Institute of Ag Professionals

Proceedings of the

2014 Crop Pest Management Shortcourse &

Minnesota Crop Production Retailers Association Trade Show

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Palmer Amaranth
Invasive Plants
What the Heck Is Going On?

Roger Becker
University of Minnesota
Today’s Menu

• Palmer Amaranth
• Mn Weed Law and You
• Canada thistle
• Buckthorn / Aphids
Palmer vs. Waterhemp

**Palmer**
- Native to the desert Southwest
- Most competitive of the Amaranth sp.
- Growth rate as fast as ~2.5”/day

**Waterhemp**
- Native to the Midwest
- 2nd most competitive of the Amaranth sp.
- Growth rate as fast as ~1.75”/day

http://www.extension.iastate.edu/CropNews/2013/0820hartzlerpope.htm  
http://southeastfarmpress.com/management/waterhem p-showing-greater-resistance-glyphosate
Also in Iowa: Harrison, Freemont, Page, Muscatine, Lee counties

In South Dakota: Buffalo county

Just a matter of time for Minnesota?

http://plants.usda.gov/core/profile?symbol=AMPA
Palmer vs. Waterhemp
35 days after seeding
Palmer vs. Waterhemp

• Herbicide resistant
  – ALS (#2),
  – PSII (#5)
  – glycines (#9)
  – HPPD (#27)
  – DNA (#3)

• Herbicide resistant
  – ALS (#2)
  – PSII (#5)
  – glycines (#9)
  – HPPD (#27)
  – PPO (#14), 2,4-D (#4)

• Both dioecious
• Both produce overwhelming nos. of seed
Hand Weeding
Hypothetical Development of Weed Resistant Populations with Repeated Control Methods / Seed Rain

5th seed rain: 60.5
4th seed rain: 4.2
3rd seed rain: 0.30
2nd seed rain: 0.02
1st seed rain: 0.001
Plant establishes: 0.0001

% Resistant Weeds

Adapted from resistance development graphic
Impacts of Herbicide Resistance to Weed Management Strategies

• As the frequency of herbicide resistant traits increase the likelihood of migration increases
  – Palmer Amaranth in MI, IN, WI via cotton seed for dairy and CRP
  – Movement via forage
  – Movement via manure
  – Movement via combine
  – Movement via pollen (yards not miles)
  – Movement via water (runoff and flooding)
  – Movement from ditch banks and field margins

Gunsolus 2014
Impacts of Herbicide Resistance to Weed Management Strategies

Gunsolus 2014
Impacts of Herbicide Resistance to Weed Management Strategies

- Herbicide Resistance
  - May eliminate effectiveness of glyphosate and other herbicide sites of action
  - Can increased production costs
  - May reduce rental income
Palmer amaranth plant from above, notice the rosette leaf pattern that is similar to a poinsettia plant
Palmer has long leaf petioles
## Palmer amaranth ID

Absence of hairs on stems and leaf surfaces

### Does the pigweed have a hairy stem?

<table>
<thead>
<tr>
<th>YES</th>
<th>NO</th>
</tr>
</thead>
</table>
| Redroot pigweed  
Smooth pigweed  
Powell amaranth | Waterhemp  
Palmer amaranth  
Spiny amaranth |

Female plants ‘bracts’ sharp and pointed – Spiny to touch
Which pigweed is it?

Pigweed identification: A pictorial guide to the common pigweeds of the great plains

Horak et al. KSU, Extension

- Redroot pigweed
- Smooth pigweed
- Powell amaranth
- Palmer amaranth
- Waterhemp
Amaranth ID

Unbranched inflorescence and prickly to the touch

Pigweed identification: A pictorial guide to the common pigweeds of the great plains
Horak et al. KSU, Extension, 1994
Palmer Amaranth Resources

Identification of the weedy pigweeds and waterhemp of Iowa

Sponsored by the Iowa Soybean Promotion Board

Donald B. Pratt
M.S. Botany, Iowa State University

Micheal D. K. Owen
Professor of Weed Science, Iowa State University

Lynn G. Clark
Associate Professor of Botany, Iowa State University

Anna Gardner
Illustrator

https://store.extension.iastate.edu/Product/pm1786-pdf
https://store.extension.iastate.edu/Product/pm1786-pdf

Palmer Amaranth Biology, Identification, and Management

Purue Extension Local Faces Committee Connections

Palmer amaranth (Amaranthus palmeri) is an aggressive, invasive weed native to the desert regions of the southwestern United States and northern Mexico. It slowly infiltrated the southeast United States and has become one of the most significant weed pests of cotton and soybean producers. What makes Palmer amaranth such a problem is that most populations are resistant to glyphosate and ALS herbicides. Recently, Palmer amaranth has been confirmed in Indiana (particularly in the northwest), Michigan, Ohio, and Illinois. This means Palmer amaranth could potentially become a major agronomic weed in Indiana and the Midwest. This publication indicates where Palmer amaranth has been found in Indiana, describes the plant’s biology, provides ways to properly identify it, and offers management strategies.

Palmer Amaranth in Indiana

In Indiana, Palmer amaranth was first confirmed in the river bottoms of Posey and Vanderburgh counties. Purdue University researchers collected Palmer amaranth seed from one of the river bottom fields. In greenhouse settings, the plants from this seed survived applications of 20 lbs. ae/acre glyphosate (equivalent of 7 gallons/acre of generic glyphosate). In the fall of 2012, 51 fields across five northwest Indiana counties were confirmed to have Palmer amaranth plant populations that were not controlled by management tactics used during that growing season. The majority of fields (and the heaviest infestations) were confirmed in Jasper County. Many of the observed fields received multiple applications of glyphosate and attempted rescue applications of PPO-inhibiting herbicides (Flexstar™, Cobra™, Ultra Blazer™, etc.).

Researchers believe Palmer amaranth was introduced to northern Indiana in dairy or beef manure from animals that were fed cotton seed hulls that came from the South that were contaminated with Palmer seed. The exact timing of the initial event is unknown, but is estimated to have happened at least two or three years ago due to the severity of infestation in multiple fields. Farm equipment, specifically combines, has and will spread Palmer amaranth seed. Wildlife can also spread the seed into new, previously uninfested fields. It is likely

Palmer Amaranth Resources

Early Season Pigweed Identification
Larry Stockel, Assistant Professor, Plant Sciences

The pigweed species are some of the most widespread and competitive summer annual weeds infesting row crops in Tennessee. These weeds can reduce yields and make harvest difficult. One management control option for pigweed is the use of herbicides. Research has shown that different pigweed species respond differently to certain herbicides. Therefore, proper early identification at growth stages when the pigweed can still be controlled is very important.

Eight species of pigweed are common in Tennessee, making it very difficult to distinguish between species in the seedling growth stages. Following are some guidelines to help with pigweed identification. It should be noted, however, that there is often physical variation within species and that some species of pigweed can cross with other species, resulting in hybrid plants. Pigweeds will not always express the specific traits of one parent species or the other, but may express a combination of both.

Smooth pigweed (Amaranthus hybridus)
- Plants will have very small fine hairs throughout.

Redroot pigweed (Amaranthus retroflexus)
- Very fine hairs are often found throughout the plant, although stems below the cotyledons can be smooth.
- Stems below cotyledons are often red.
- Leaf and stem surfaces are rough.
- The first true leaves are egg-shaped and notched at the tip. Can only be easily distinguished from smooth pigweed when mature.

Rapid growth rate:
Palmer amaranth converts CO2 in the air into sugars via photosynthesis more efficiently than corn, cotton or soybean, allowing rapid growth even under hot and dry conditions. Under ideal growing conditions, Palmer amaranth is capable of growing several inches per day (Figure 2).

Implications for management: Herbicides tend to be more effective on smaller plants. Because of Palmer’s rapid growth rate, the window of time available to make effective topical herbicide applications is very short.

Deep and diverse root system:
Palmer amaranth has a deep taproot as well as a network of finer, fibrous roots (Figure 3). Research from North Carolina has shown that Palmer amaranth can produce more and longer roots than soybean. Palmer’s roots are better than soybean roots at penetrating compacted soils.

Implications for management: Because of its rooting structure, Palmer amaranth may have more access to water and nutrients than many commonly grown crops. This contributes to Palmer amaranth’s rapid growth and competitiveness. The presence of a taproot can make it difficult to remove Palmer amaranth by hand. Broken-off stems as small as 1 inch can resprout, flower and produce seed.

Figure 1. Georgia counties confirmed to be infested with glyphosate-resistant Palmer amaranth.

Figure 2. Growth of Palmer amaranth over 52 hours.

Figure 3. The extensive Palmer amaranth root system. Photo by E. Prosko

http://extension.uga.edu/publications/detail.cfm?number=C1000
Palmer Amaranth Resources

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

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, is essential to reduce the potential for crop yield loss due to interference of Palmer amaranth.

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 pointy-tailed appearance and sometimes have a white or purple chevron on the leaf (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 (fruitule) 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.

http://www.eattheweeds.com/palmer-amaranth/
Palmer Amaranth Resources

# Palmer Amaranth Risk Assessment

<table>
<thead>
<tr>
<th>MN NWAC Risk Assessment Worksheet (04-2011)</th>
<th>Common Name</th>
<th>Latin Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Palmer Amaranth</td>
<td>Amaranthus palmeri</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Reviewer</th>
<th>Affiliation/Organization</th>
<th>Date (mm/dd/yyyy)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roger Becker</td>
<td>University of Minnesota</td>
<td>8/08/2014</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Box</th>
<th>Question</th>
<th>Answer</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Is the plant species or genotype non-native to Minnesota?</td>
<td>Yes, non-native in Minnesota. Is native to the southern U.S. and Mexico; native to North America.</td>
<td>Yes. Go to box 3.</td>
</tr>
<tr>
<td>2</td>
<td>Does the plant species pose significant human or livestock concerns or has the potential to significantly harm agricultural production?</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>A. Does the plant have toxic qualities that pose a significant risk to livestock, wildlife, or people?</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>B. Does the plant cause significant financial losses associated with decreased yields, reduced quality, or increased production costs?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Is the plant species, or a related species, documented as being a problem elsewhere?</td>
<td>Yes. Palmer amaranth is a severe problem in summer climates similar to Minnesota. (see Hager 2013; Hartzler 2014a; and Legleiter and Johnson 2013). It has not been documented as a problem in states with winter climates similar to Minnesota, but it is anticipated it will do very well since it is an annual with a seedbank and seedlings that have performed well in states with freezing winter temperatures, and portions of the growing season in Minnesota are similar to locations further south where Palmer amaranth is a severe problem.</td>
<td>Yes. Go to Box 6.</td>
</tr>
<tr>
<td>4</td>
<td>Is the plant species’ life history &amp; Growth requirements understood?</td>
<td>Yes, documented in disparate articles, but oddly no classic biology of Palmer amaranth review article could be found.</td>
<td>Blue text is provided as additional information not directed through the decision tree process for this particular risk assessment.</td>
</tr>
<tr>
<td>5</td>
<td>Gather and evaluate further information:</td>
<td>(Comments/Notes)</td>
<td></td>
</tr>
</tbody>
</table>
NWAC Risk Assessments
Recommendations 2014

Full committee votes Dec. 17 mtg.

• Palmer Amaranth
  Prohibit Eradicate
• Russian/Diffuse Knapweed
  Prohibit Eradicate
• Honeysuckle
  Restricted
  – Bell’s, Morrow’s, Tatarian, Amur
• Porcelain berry
  Restricted
• Elecampane
  Watch
• Burnet saxifrage
  Watch
The Minnesota Noxious Weed Lists By Category

Anthony Cortilet
Minnesota Department of Agriculture
Noxious and Invasive Weed Unit
Statewide Listed Noxious Weeds

21 State Prohibited Noxious Weeds
   Eradicate List – 11 Species
   Control List – 10 Species

4 State Restricted Noxious Weeds

1 Specially Regulated Plant
State Prohibited Noxious Weeds

Eradicate List

- **Yellow Starthistle** *Centaurea solstitialis*
- **Grecian Foxglove** *Digitalis lanata*
- **Oriental Bittersweet** *Celastrus orbiculatus*
- **Japanese Hops** *Humulus japonicas*
- **Dalmatian Toadflax** *Linaria dalmatica*
- **Common Teasel** *Dipsacus fullonum*
- **Cutleaf Teasel** *Dipsacus laciniatus*
- **Giant Hogweed** *Heracleum mantegazzianum*
- **Brown Knapweed** *Centaurea jacea*
- **Meadow Knapweed** *Centaurea x moncktonii*
- **Black Swallow-wort** *Cynanchum louiseae*

Yellow highlights species of importance in aglands, primarily pasture/grazing. If palmer amaranth is added, will be first of significance in row crops

Adapted from Cortilet 2014
Confirmed County Locations

**Additional Unconfirmed Reports Exist**

- Goodhue
- Metro Area
- Winona

**Oriental bittersweet**

- Koochiching
- St. Louis

**Brown knapweed**

- Koochiching
- St. Louis

**Meadow knapweed**

- Hennepin
- Ramsey

**Black swallow-wort**

- Houston
- Mower
- Olmsted
- Ramsey
- Wabasha
- Washington
- Winona

**Cutleaf teasel**

- Fillmore
- Houston

**Japanese hops**

- Kittson

**Dalmatian toadflax**

- Washington

**Grecian foxglove**

---

Yellow Star Thistle – No known locations in MN; Threat watch for MN – western and southwestern counties

Common Teasel – No known locations in MN; Threat watch for MN – Twin Cities metro, eastern and southeastern counties

Giant Hogweed – No known locations in MN; Threat watch for MN – Twin Cities metro, eastern and southeastern counties
# State Prohibited Noxious Weeds

## Control List

<table>
<thead>
<tr>
<th>Weed Name</th>
<th>Scientific Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Purple Loosestrife</td>
<td><em>Lythrum salicaria</em></td>
</tr>
<tr>
<td>Garlic Mustard</td>
<td><em>Alliaria petiolata</em></td>
</tr>
<tr>
<td>Spotted Knapweed</td>
<td><em>Centaurea stoebe</em></td>
</tr>
<tr>
<td>Leafy Spurge</td>
<td><em>Euphorbia esula</em></td>
</tr>
<tr>
<td>Wild Parsnip</td>
<td><em>Pastinaca sativa</em></td>
</tr>
<tr>
<td>Common Tansy</td>
<td><em>Tanacetum vulgare</em></td>
</tr>
<tr>
<td>Canada Thistle</td>
<td><em>Cirsium arvense</em></td>
</tr>
<tr>
<td>Musk Thistle</td>
<td><em>Carduus nutans</em></td>
</tr>
<tr>
<td>Plumeless Thistle</td>
<td><em>Carduus acanthoides</em></td>
</tr>
<tr>
<td>Narrowleaf Bittercress</td>
<td><em>Carduus acanthoides</em></td>
</tr>
</tbody>
</table>

Adapted from Cortilet 2014
Palmer Amaranth

Prohibited noxious weed in row crops

• First row crop weed on Eradicate List

• Opportunity to delay/prevent Palmer amaranthus problems in Minnesota
Knapweed Biological Control

Seedhead flies, *Urophora affinis* and *U. quadrifasciata*

Seedhead weevils, *Larinus minutus* and *L. obtusus*

Root boring weevil, *Cyphocleonus achates*

http://www.mda.state.mn.us/plants/badplants/knapweed.aspx
Biological Control of Leafy Spurge with *Aphthona lacertosa, A. nigriscutis*

- Has been very effective
- *Large, expansive fields on leafy spurge absent*
- Use of herbicides initially with *Aphthona* achieves economic levels of leafy spurge control in less time
- *Satellite populations and populations near trees still exit*

*A. lacertosa* (Hansen et al. 1997)  
*A. nigriscutis* (Hansen et al. 1997)
Prohibited - Control Noxious Weeds

Common Tansy - *Tanacetum vulgare*

Perennial – 2 - 5 feet tall

Alternate leaves that are divided into numerous narrow – toothed segments (fern like)

Yellow button-like flowers in flat-topped clusters

Reproduces by seed and rootstalks

Cortilet 2014
The Elusive Holy Grail of Weed Management - Eradication!
Surrender of General Burgoyne

John Trumbull
US Capitol Rotunda

Burgoyne surrenders to Gen. Gates

Canada thistle possibly introduced in hay brought to the US for General Burgoyne's horses
Canada Thistle - Hayden


C. thistle distribution – 1898, Pammel

Bob Hartzler, ISU
April-September Daylength Photoperiods for Mpls/St. Paul Location W093 16 N4458

- 15 hr May 19th
- 15 1/2 hr June 6th
Bacteria for biocontrol?

*Pseudomonas syringae*

Check (top left) plus 4 degrees of control

Jurg Hiltbrunner
Bugs for Biocontrol??

Thistles:
Musk $(Carduus nutans)$
Plumless $(Carduus acanthoides)$
Bull $(Cirsium vulgare)$
Canada $(Cirsium arvense)$

Major issues with native thistle susceptibility
• Six in Mn, 100’s nationally
  • i.e. such as Flodman thistle $(Cirsium flodmani)$ - to use or not??
Bugs for Biocontrol??

Agents:

Seed-heed weevil  (Rhinocyllus conicus)

Gall fly  (Larinus planus)

Seed-head fly  (Urophora cardui)

Stem weevil  (Terellia ruficauda)

Rosette weevil  (Ceutorhynchus litura)

(Syn. Hadroplontus litura)

Defoliating beetle  (Trichosirocalus horridus)

Root-crown weevil  (Cleonis pigra)
Canada Thistle - Hayden

Dioecious flowers

- Purple to white in color
- Approx. 100 flowers (?) per main shoot

• 0 to 100 seeds per flower (my interpretation)
  - Often 20 to 50 seeds per flower if male and female within 20 to 100 ft (my interpretation)
Canada Thistle - Hayden

Seed (achenes) characteristics
(data collected July 18, 29 or Aug 2 in Winnebago, Cerro Gordo, and Story Co.)

- 1 to 104 seed per head
- avg. 46 per head (white flower types lower)
- 50% of flowers bore seed
- Avg. 50% germination, 10 to 70% range
  (Small seed may have been sifter out, unclear)
  - Lot tested over time increased - 6 mo (10 to 27%) compared to 2 yr later (15 to 43%)
- Seed off plant up to 95% germ
- Germ similar across locations
- Seed in center of flower head mature last
- Achenes thin and shriveled in nonfertilized staminate flowers
Seed germination varied

- Some seed germinated in fall
  - Able to survive winter, bloom next season
- Some germinate the next spring
  - These bloom the following year
  - Spring germination in April and May, Story Co. Ia
- Seedling - cotyledons emerge
  - Frosted appearance (like Colq?)
Canada Thistle - Hayden

• Seed fed to Mallards
  – No viable seed found in droppings
  – Dissected birds
    • achenes stored in crop, destroyed in gizzard, no viable seed in intestines
• Duck survey (10 Mallards, 1 Blue-wing teal, Green wing teal, Ruddy duck, Shoveller duck - 14 total)
  – Intestine content expressed
    • No C. thistle seeds (one Potamogeton and one Polygonum lapathifolium seed found)

Water fowl likely not major contributor to spread
Canada Thistle - Hayden

Lateral roots with shoots arising typically within a foot of the soil surface

- Lateral roots system typically at 1 to 3 ft
  - Arching nature, often extending laterally and curving downward
  - Buds throughout length of laterals capable of producing shoots
  - Vertical descending roots end at water table
    - (6 to 7 ft, 8 to 9 ft, and 18 ft reported)
    - Few to no fibrous secondary roots
  - Vertical ascending structures which eventually produce shoots are stem anatomy, thus rhizomes
    - Fibrous secondary roots
Lateral root and ascending shoots

- Produced plants from 1/8” to 1/4” fragments
- Shoots from 1/2” lengths and 1/8” dia. likely to survive
- Starch, sugars, inulin and fat composition
  - August harvested lateral and ascending roots fragments little to no shoot emergence (depleted CHO)
- Tillage drives emergence from deeper depths
Seasonal Carbohydrate Levels In Hemp Dogbane Root Crowns

% Dry Weight

Month Sampled

Early bud
Mid flower
Mow, Till
Herbicide
Control window

Early bud
Mid flower
Mow, Till
Herbicide
Control window
Canada Thistle Management
Functional Groups to Resist Invasion

Roger Becker and Lee Klossner
University of Minnesota

Milt Haar
National Park Service
Former corn and soybean field. Seeded into smooth brome, fall treated with glyphosate + 2,4-D (kill existing thistle).

Prairie seed drilled and packed.
Functional Group x Canada Thistle Est.
Lamberton, MN. Canth Shoot Cnts. All Seedings Combined.

n = 24. Counts are in the seeded center area. May not characterize entire plot in the early years.
Functional Group x Canada Thistle Est.
Lamberton, MN. Canth Shoot Cnts. All Funct. Groups Combined.

n = 24. Counts are in the seeded center area. May not characterize entire plot in the early years.
Functional Group x Canada Thistle Est.
Lamberton, MN
2004 – 2012 Cycle

Canada Thistle Visual Cover

Cool only
U3 Control
U3 Clip
U3 Transline
U3 Plateau
Warm only

Small, non-competitive, usually vegetative

n = 24.
Resistance to Invasion Summary

View at the 2008 Tall Grass Prairie Conference

- **Season of planting effects variable**
  - Environment key - year to year variation in establishment of Canada thistle and natives

- **Sub-treatment effects**
  - Clopyralid most effective 2º management treatment
  - Plateau not an effective treatment
  - Clipping helps ... sometimes - depends on environment

**Functional Groups Matter**

- **Warm season only** – worst treatment
- **Cool season only** – effective especially in Spring plantings
- **Important to include cool and warm season season grasses and forbs in seed mixes**
Resistance to Invasion Summary

View by the 2014 USMIC, Duluth MN

Season of planting effects variable
- Seems to be disappearing for Canada thistle

Functional Groups Matter?
- Still important to include cool and warm season season grasses and forbs in seed mixes for a host of reasons
Canada Thistle
Seed Flight Studies
Roger Becker
University of Minnesota
Milt Haar
National Parks Service
Dilution of seed and pappi as area expands

\[ y = 308.64e^{-0.7998x} \]

\[ R^2 = 0.8926 \]
Effect of Wind of direction and distance of Canada thistle dispersal

Seeds

Pappi

88 km average daily wind run
Conclusions

§ Over 80% (83 to 89%) of wind blown pappi do not have an seed attached at 5ft distance or greater
§ Pappi and seed separate easily (deciduous)
§ 38% of total pappi productivity with normal achene attached
§ Placing a high priority and using resources to prevent seed flight may not be productive
Canada Thistle Herbicide Optimization

Roger Becker
University of Minnesota
Canada Thistle Management Trial
Transline Use Study  West Graham WMA  2004 - 2005

Rate comparisons, oz per acre

LSD (0.05)=32

% Visual Control

Spring

Fall

Rated Sept. 20, 2005
Fall ~ 1 YAT
Spring ~ 1.25 YAT

All @ 20 GPA and 0.25% Activator 90
Canada Thistle Management Trial
Transline Use Study  West Graham WMA  2004 - 2005

Gallonage comparisons

LSD (0.05)=32

Rated Sept. 20, 2005
Fall ~ 1 YAT
Spring ~ 1.25 YAT

All @ 8 oz Transline / A and 0.25% Activator 90
Canada Thistle Management Trial
Transline Use Study  West Graham WMA  2004 - 2005

Additive comparisons

Spring

- None
- Activator 0.25%
- Activator 0.5%
- MSO 0.0125%

Fall

- None
- Activator 0.25%
- Activator 0.5%
- MSO 0.0125%

LSD (0.05)=32

Rated Sept. 20, 2005
Fall ~ 1 YAT
Spring ~ 1.25 YAT

All @ 8 oz / A Transline and 20 GPA
Canada Thistle Management Trial
Spring vs. Fall, Waseca MN 2004 - 2006
Rated June 6, 2006
Fall ~ 18 MAT
Spring (Bud/Bloom) ~ 12 MAT

LSD (0.05) = 32
Defining Tolerance of Native Forbs to Herbicides

Canada Thistle Regrowth Control
Milestone Transline Sequential Trial, Rosemount MN 2007 - 2009

Product comparisons, oz per acre
All @ 20 GPA, No NIS except one M3 trt.

Sequential vs Non-sequential comparisons

% Visual Control

Jul-07 Sep-07 Nov-07 Jan-08 Mar-08 May-08 Jul-08 Sep-08 Nov-08 Jan-09 Mar-09 May-09 Jul-09 Sep-09
Defining Tolerance of Native Forbs to Herbicides
11 field trials in MN
West Newton Sand Prairie
Kurt Brownell US Army Corp
Louanne Brooks, Dow AgroSciences
Minnesota Rankings for Native Forb Tolerance to Aminopyralid and Clopyralid Herbicides

This table reflects estimates of native forb tolerance to aminopyralid (Milestone VM™) and clopyralid (Transline®) based on field observations. Generally speaking, native forbs tolerated these herbicides better with spring applications compared to fall applications. If viable seed were present in the seedbank, neither herbicide prevented seedlings of susceptible species from establishing the growing season following herbicide application. These rankings reflect our experiences as of Fall 2008 and will be updated as more data becomes available.

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Aminopyralid</th>
<th>Clopyralid</th>
<th>Family</th>
<th>Genus</th>
<th>Species</th>
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<tr>
<td>Alexanders, Golden</td>
<td>T</td>
<td>T</td>
<td>Apiaceae</td>
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<td>Marshsail (Conyza)</td>
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<td>Sunflower, Maximilian’s</td>
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<td>Vervain, Blue</td>
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<td>Verbenaceae</td>
<td>Verbena</td>
<td>hastata</td>
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<td>Vervain, Hoary</td>
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<td>Verbena</td>
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<td>Wild Indigo, White</td>
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<td>Baptisia</td>
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<td>T</td>
<td>Asteraceae</td>
<td>Achillea</td>
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</table>

**Key:**
- **T = Tolerant:** Minimal symptoms - may result in slight cupping but less than 15%. Occasionally may inhibit flowering.
- **M = Moderate tolerance:** Symptoms include cupping, yellowing, and twisted stems. Often will inhibit flowering. Plants may be stunted. May reduce stand with recovery of surviving plants the first growing season after application.
- **M - S = Moderate to Susceptible:** Severity of response has been variable ranging from moderately tolerant to susceptible depending on environment, plant age, and site characteristics.
- **S = Susceptible:** Injury greater than 75%. Injury can be severe. May kill established plants. Sensitive plants have been shown to reestablish from seedings if an adequate seedbank is present as early as the first growing season after application.

September 2008
R. Becker and M. Haar, University of Minnesota
Canada Thistle - BMP Conclusions

• Broadcast spray spring bud stage or fall
• Lower rates achieved control but started to break by yr. 2 at a faster rate
• Forb cover and presence not that sensitive to rate
Canada Thistle BMPs - Conclusions

These BMPs less consistent or reduced control

- Waiting until after the July 15\textsuperscript{th} target to optimize waterfowl production
- Spot treating / scouting delay
- Mowing too infrequent, impacts native forbs
Many native forbs tolerate Transline (clopyralid) and Milestone VM (aminopyralid)

• However, flowering and seed production may be reduced or eliminated during the treatment season(s)

• Notable exceptions - Helianthus, Rudbeckia, Ratibida - (Suns, Ruds, Rats)

• Re-establishing from the seed bank when present or from the few survivors
Canada Thistle BMPs - Conclusions

Fall application of Transline / Milestone

Best Canada thistle control, but best forb tolerance?

• Spring bud applications almost matched fall C. thistle efficacy, better forb tolerance

Spray at timings to fit most limiting factor which may be labor, etc. - things other than tolerance
Canada Thistle BMPs - Conclusions

Heavy canopy or plant litter situations
- Use 20 to 30 GPA (it’s the nozzles…)
- Higher gallonages did not improve Transline performance

Surfactant use did not consistently improve control
- Excessive surfactant rates may decrease control
- Surfactant use likely increases forb injury
- Do not use surfactant when desirable forbs present
Canada Thistle BMPs - Conclusions

Applications of Transline below labeled rates
• Wouldn’t additional herbicide applications increase damage to desired native forbs?
  • Not the case after 3 yrs of trt.

Milestone compared to Transline:
• Greater consistency of thistle control
• Improved environmental profile
• Slightly more forb injury

With either herbicide, will need sequential program - and at current labeled rates?

Other underlying factors relating to susceptibility to invasion
Ditch Hay and Pyridine Herbicides

Harvesting ditch hay

Kirkina Martirson, PhD, U of M

Harvesting ditch hay (grass and legumes growing alongside the roadways) is a common practice, especially in western Minnesota. Ditch hay provides livestock owners with forage suitable for beef cattle, dairy heifers and horses. However, in recent years, there have been several cases of significant soybean injury as a result of manure applications from livestock fed ditch hay that was treated with picloram or clopyralid. This injury has reduced grain yields, and in some cases, resulted in total yield loss.

Picloram (commonly sold as Tordon, Grazon, and Pathway) and clopyralid (commonly sold as Stinger, Curtail, and Transline) are used to control unwanted broadleaf weeds on cropland, rangeland, pastures, and along roadways. These herbicides are especially popular with local, county, and state highway departments because they control hard-to-kill noxious weeds like thistles and leafy spurge but do not kill beneficial or planted roadside grasses. Recently labeled herbicides containing the active ingredient amincloprid (commonly sold as Milestone, Milestone VM, and ForeFront RAP) are beginning to replace picloram and clopyralid in many roadside treatment programs due to increased Canada thistle control with amincloprid. Aminclorpid is in the same herbicide family as picloram and clopyralid, and poses the same potential to cause injury to broadleaf crops from contaminated manures. However, sensitive crop injury from amincloprid contaminated manure has not yet been reported in Minnesota.

When animals are fed ditch hay that has been treated with either picloram or clopyralid, these chemicals pass quickly through the animal without significant degradation and end up in the manure via the urine, usually within a day or two. Manure application to agricultural production fields is a beneficial and common practice. However, if sensitive crops (i.e. soybeans, lentils, peas, legumes, potatoes, tomatoes or peppers) are planted in fields where contaminated manure has been applied, injury or crop death can occur. Injured plants can exhibit twisting (epinasty), leaf cupping, and loss of apical dominance, resulting in short plants and abnormal side shoots.

Labels of many products containing picloram and clopyralid list restrictions that ditch hay harvesters and feeders need to be aware of:

1. Manure and urine containing these herbicides may cause injury to sensitive broadleaf plants
2. Since plant material containing these products does not break down more rapidly in compost, treated plant material containing these products should not be used in or for compost
3. Picloram and clopyralid contaminated manure and compost should not be spread on land used for growing susceptible crops. Contaminated manures may be spread onto fields that will be planted to grass crops (i.e. corn, small grain, or sorghum Sudan forage).

Herbicide labels for products containing picloram and clopyralid may have slightly different warnings or recommendations based on the product formulation and/or active ingredient concentration. Because of this, it is important to read and understand each herbicide label. Some examples of warning and recommendations for these products include: do not allow lactating dairy animals to graze treated areas within 7 days after application; meat animals should be withheld from treated fields, at least 3 days before hay harvest.

Be Aware of Potential Carryover Concerns when Using Ditch Hay

By Lizbeth Stein, Extension Educator - Crops

The harvesting of ditch hay (grass and legumes growing along roadways) has provided livestock owners with a source of forage for many years. Tight forage supplies, however, have led to a greater demand for ditch hay than usual this year. If you feed or sell ditch hay, be sure you know what, if any, herbicides were applied to the ditch hay to avoid potential herbicide carryover issues in manure from animals fed the ditch hay.

Products that contain the active ingredients picloram (i.e. Tordon®, Grazon®, and Pathway®), clompyralid (i.e. Stinger®, Curtail®, and Transline®), or amicloprid (i.e. Milestone® and ForeFront®) are used to control unwanted broadleaf weeds in cropland, rangeland, pastures, and along roadways. When animals are fed ditch hay that has been treated with these products, these chemicals pass quickly through the animal without significant degradation. Manure and urine from animals that consume grass or hay treated with these products may contain enough herbicide active ingredient to cause injury or death of sensitive broadleaf plants.

Be sure to check with the hay supplier or with the local, county, or state agency involved to see if ditch hay harvested for hay were treated with a herbicide with potential to carryover in livestock manure. A biotransformation activity recommended or required before a sensitive broadleaf crop (i.e. soybean, lentils, peas, legumes, potatoes, tomatoes or peppers) can be safely planted following application of manure from animals fed ditch hay treated with picloram, clompyralid, or amicloprid. Refer to the pesticide label for specific restrictions and recommendations.

The article "Use Caution When Harvesting and Feeding Ditch Hay", available at http://www.extension.umn.edu/distribution/hay carries this issue in greater depth. Although the article focuses on picloram and clompyralid, amicloprid (released after the publication was created) has similar potential to cause injury to sensitive broadleaf crops from contaminated manure.

Awareness and communication can go a long ways in helping prevent manure from becoming contaminated in the first place, as well as help prevent contaminated manure from causing problems in the future.
Common and Glossy Buckthorn

- 2 species in MN
- Native to Europe
- Invasive in MN
- Widely planted for hedgerows, starting in mid-1800s
- Both species (and their cultivars) are now restricted noxious weeds in MN (can’t sell or transport)

- Common buckthorn (*Rhamnus cathartica*)
- Glossy buckthorn (*Frangula alnus*)

(Heneghan et al. 2002; Schmidt and Whelan 1999)

Courtesy: Susan Burks, MnDNR
Biological Control of Soybean Aphid

Estimated loss in 2003 - $188,000,000
Biological Control of Buckthorn
CABI Europe, Delémont, Switzerland
Collaboration 2001-2012

30 specialized species on common buckthorn in Europe

- 21 Lepidoptera, 6 Hemiptera, 2 Diptera, 1 Coleoptera, and 3 Acari
  - Few appear specific to buckhorn
  - Eight potential biocontrol species studied, lack of host-specificity

Three sap-suckers psyllids high host-specificity

- *Trichohermes walkerii*, *Trioza rhamni*, *Cacopsylla rhamnicolla*
- Detected at several *R. cathartica* sites in Europe
  - Not in any of the other three *Rhamnus* sampled and in *F. alnus*
  - *Candidatus* phytoplasma *rhamni* (witches broom)
    - Survey showed not present in MN and US

Seed-feeding midge
*Wachtiella krumbholzi*
- Potential but difficult
- Can not get fruiting trees from NA, difficult to work with.

Effect of 2002 and 2003 spring control treatments on buckthorn seedling density, number of stump sprouts per crown, and density of other plant species in July, the season following treatment (Average of Eagle Lake and Battle Creek)

<table>
<thead>
<tr>
<th></th>
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<tr>
<td></td>
<td>(plants ha⁻¹)</td>
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<td>(No. crown⁻¹)</td>
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<td>(plants ha⁻¹)</td>
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<tr>
<td>C+H+B</td>
<td>3226</td>
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<td>0.0</td>
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<td>20296</td>
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<td>2957</td>
<td>4301</td>
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<td>5376</td>
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<td>LSD (0.05)</td>
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<td>428</td>
<td>0.1</td>
<td>0.1</td>
<td>709</td>
<td>2760</td>
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Spring control treatments: C+H+B – cutting + stump treatment with triclopyr + burning, C+B – cutting + burning, C+H - cutting + stump treatment with triclopyr amine, C - cutting only, nontreated – checks
Effect of 2002 and 2003 control methods common to all management seasons on buckthorn stump sprouting ability in 2003 and 2004, the season following treatment application (Average of Eagle Lake and Battle Creek)

<table>
<thead>
<tr>
<th>Management season</th>
<th>BT Stump Sprouts per Crown</th>
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<tr>
<td></td>
<td>C</td>
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<td></td>
<td>2003</td>
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<td>Spring</td>
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<tr>
<td>Summer</td>
<td>1.8</td>
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<td>Fall</td>
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<td>Winter</td>
<td>0.0</td>
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<tr>
<td>LSD (0.05)</td>
<td>0.1</td>
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Cut Stump Treatment

- Cut plant near ground and treat cut surface with a labeled herbicide.
- Read label for application instructions.

Photo by: Doug Courneya
Buckthorn Seed Longevity

Berries collected and processed

50 berries examined

- 4 seed per berry potential
  - 95.5% of that potential reached
    (191 seed of 200 potential)

- Of seed produced:
  - Avg. 2.56 plump seed / berry
    • 67% plump considered germinable
    • 33% shrunken seeds
      (non viable or at a minimum, low vigor)
Buckthorn Seed Longevity

Buried 50 seeds/bag on Nov 12, 2004

- Oak savannah
  - Enough bags buried for 9 samples to 2024
  - Baseline set of bags subjected to same procedures then assayed time 0
    - 33 % germination

- Buried at 2.5 and 12.7 cm
  - 2 locations (Hilltop and Sidehill)
    - Three reps per site
Buckthorn Seed Longevity

Bags collected May 6, 2005 and May 3, 2006
– Detritus screened out under water flow
– Contents placed in petri dishes with 100 gm clean, fine sand
– Placed in germinator @ 70/60 F day/night, 14 hr daylength (incandescent fluorescent mix)
– Kept moist and examined weekly for 13 weeks
Buckthorn Seed Longevity 1 YAT (2005)
Battle Creek Regional Park, Maplewood  MN

![Graph showing germination percentages for different depths and orientations.]

- North
- Center
- South

Germination (%)

- 2.5 cm
- 12 cm
Buckthorn Seed Longevity 1 YAT (2005) Battle Creek Regional Park, Maplewood MN

Graph showing germination percentages over time for Hilltop and Sidehill locations from 5/1 to 8/7.
Buckthorn Seed Longevity 2 YAT (2006)
Battle Creek Regional Park, Maplewood MN
Conclusions: Management study

- Cut-stump treatment with triclopyr controlled stump sprouting regardless of application timing

- Fall and winter cutting (no herbicide) controlled regrowth in buckthorn saplings ≤ 5 years in age (repeatable?)

- Integrating cut-stump treatment and prescribed burning
  - More effectively reduced buckthorn pop. density
  - Increased seedling emergence from soil seed bank of both buckthorn and native species
  - Increased species diversity

- Repeating prescribed burning reduced abundance of buckthorn - but also of other species reducing species richness and diversity
Recommendations From Mgt. Studies

Monitor after removal
- Prescribed burn targeting 2 years after removal

- Longevity study indicates seedbank quickly depleted

- Follow-up burn or spray one or two cycles should suffice

- Reseed / transplant desired species if needed
Recommendations From Mgt. Studies

Monitor after removal
  • Prescribed burn targeting 2 years after removal

  • Longevity study indicates seedbank quickly depleted

  • Follow-up burn or spray one or two cycles should suffice

  • Reseed / transplant desired species if needed
Questions?