2015 Sweet Corn Weed Management Update

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Herbicide Resistance Issues

Driving some of the field corn market new products

- **Influencing product coming online for sweet corn**

Part of resistance managment is to diversify modes of action (MOA) used

- **Identifies how a herbicide kills a weed**
- **Weed Science Society of America (WSSA) website**

http://wssa.net

Resources from WSSA (Weed Science Society of America)

http://wssa.net/

Summary of Herbicide Mechanism of Action According to the Weed Science Society of America (WSSA)

1 Acetyl CoA Carboxylase (ACCase) Inhibitors

Aryloxyphenoxypropionate (FOPs) cyclohexanedione (DIMs) and phenylpyrazolin (DENs) herbicides inhibit the enzyme acetyl-CoA carboxylase (ACCase), the enzyme catalyzing the first committed step in *de novo* fatty acid synthesis (Burton 1989; Focke and Lichtenthaler 1987). Inhibition of fatty acid synthesis presumably blocks the production of phospholipids used in building new membranes required for cell growth. Broadleaf species are naturally resistant to cyclohexanedione and aryloxyphenoxy propionate herbicides because of an insensitive ACCase enzyme. Similarly, natural tolerance of some grasses appears to be due to a less sensitive ACCase (Stoltenberg 1989). An alternative mechanism of action has been proposed involving destruction of the electrochemical potential of the cell membrane, but the contribution of this hypothesis remains in question.

2 Acetolactate Synthase (ALS) or Acetohydroxy Acid Synthase (AHAS) Inhibitors

Imidazolinones, pyrimidinylthiobenzoates, sulfonylaminocarbonyltriazolinones, sulfonylureas, and triazolopyrimidines are herbicides that inhibit acetolactate synthase (ALS), also called acetohydroxyacid synthase (AHAS), a key enzyme in the biosynthesis of the branched-chain amino acids isoleucine, leucine, and valine (LaRossa and Schloss 1984). Plant death results from events occurring in response to ALS inhibition and low branched-chain amino acid production, but the actual sequence of phytotoxic processes is unclear.

3 15 23 Mitosis Inhibitors

Benzamide, benzoic acid (DCPA), dinitroaniline, phosphoramidate, and pyridine herbicides (Group 3) are examples of herbicides that bind to tubulin, the major microtubule protein. The herbicide-tubulin complex inhibits polymerization of microtubules at the assembly end of the protein-based microtubule but has no effect on depolymerization of the tubule on the other end (Vaughn and Lehnen 1991), leading to a loss of microtubule structure and function. As a result, the spindle apparatus is absent, thus preventing the alignment and separation of chromosomes during mitosis. In addition, the cell plate can not be formed. Microtubules also function in cell wall formation. Herbicide-induced microtubule loss may cause the observed swelling of root tips as cells in this region neither divide nor elongate.

The carbamate herbicides, carbetamide, chlorpropham, and propham (23), are examples of herbicides that inhibit cell division and microtubule organization and polymerization.

Acetamide, chloroacetamide, oxyacetamide, and tetrazolinone herbicides (Group 15) are examples of herbicides that are currently thought to inhibit very long chain fatty acid (VLCFA) synthesis (Husted et al. 1966; Böger et al. 2000). These compounds typically affect susceptible weeds before emergence, but do not inhibit seed germination.

4

Synthetic Auxins

Benzoic acids, phenoxycarboxylic acids, pyridine carboxylic acids, and quinoline carboxylic acids (Group 4) are herbicides that act similar to that of endogenous auxin (IAA) although the true mechanism is not well understood. The specific cellular or molecular binding site relevant to the action of IAA and the auxin-mimicking herbicides has not been identified. Nevertheless, the primary action of these compounds appears to affect cell wall plasticity and nucleic acid metabolism. These compounds are thought to acidify the cell wall by stimulating the activity of a membrane-bound ATPase proton pump. The reduction in apoplasmic pH induces cell elongation by increasing the activity of enzymes responsible for cell wall loosening. Low concentrations of auxin-mimicking herbicides also stimulate RNA polymerase, resulting in subsequent increases in RNA, DNA, and protein biosynthesis. Abnormal increases in these processes presumably lead to uncontrolled cell division and growth, which results in vascular tissue destruction. In contrast, high concentrations of these herbicides inhibit cell division and growth, usually in meristematic regions that accumulate photosynthate assimilates and herbicide from the phloem. Auxin-mimicking herbicides stimulate ethylene evolution which may in some cases produce the characteristic epinastic symptoms associated with exposure to these herbicides.

5 **6** **7**

Photosystem II Inhibitors

Phenylcarbamates, pyridazinones, triazines, triazinones, uracils (Group 5), amides, ureas (Group 7), benzothiadiazinones, nitriles, and phenylpyridazines (Group 6), are examples of herbicides that inhibit photosynthesis by binding to the Q_B-binding niche on the D1 protein of the photosystem II complex in chloroplast thylakoid membranes. Herbicide binding at this protein location blocks electron transport from Q_A to Q_B and stops CO_2 fixation and production of ATP and $NADPH_2$ which are all needed for plant growth. However, plant death occurs by other processes in most cases. Inability to reoxidize Q_A promotes the formation of triplet state chlorophyll which interacts with ground state oxygen to form singlet oxygen. Both triplet chlorophyll and singlet oxygen can abstract hydrogen from unsaturated lipids, producing a lipid radical and initiating a chain reaction of lipid peroxidation. Lipids and proteins are attacked and oxidized, resulting in loss of chlorophyll and carotenoids and in leaky membranes which allow cells and cell organelles to dry and disintegrate rapidly. Some compounds in this group may also inhibit carotenoid biosynthesis (fluometuron) or synthesis of anthocyanin, RNA, and proteins (propanil), as well as effects on the plasmalemma (propanil) (Devine et al. 1993).

8 **16**

Fatty Acid and Lipid Biosynthesis Inhibitors

Benzofuranes (WSSA Group 16), phosphorodithioates (Group 8), and thiocarbamates (Group 8) are examples of herbicides that are known inhibitors of several plant processes including: 1) biosynthesis of fatty acids and lipids which may account for reported reductions in cuticular wax deposition, 2) biosynthesis of proteins, isoprenoids (including gibberellins), and flavonoids (including anthocyanins), and 3) gibberellin synthesis inhibition which may result from the inhibition of kaurene synthesis. Photosynthesis also may be inhibited (Gronwald 1991). A currently viable hypothesis that may link all these effects involves the conjugation of acetyl coenzyme A and other sulfhydryl-containing biomolecules by thiocarbamate sulfoxides (Casida 1974; Fuerst 1987). The sulfoxide forms may be the active herbicides (Ashton and Crafts 1981).

9

Enolpyruvyl Shikimate-3-Phosphate (EPSP) Synthase Inhibitors

Glycines (glyphosate) are herbicides that inhibit 5-enolpyruvylshikimate-3-phosphate (EPSP) synthase (Amrhein 1980) which produces EPSP from shikimate-3-phosphate and phosphoenolpyruvate in the shikimic acid pathway. EPSP inhibition leads to depletion of the aromatic amino acids tryptophan, tyrosine, and phenylalanine, all needed for protein synthesis or for biosynthetic pathways leading to growth. The failure of exogenous addition of these amino acids to completely overcome glyphosate toxicity in higher plants (Duke and Hoagland 1978; Lee 1980) suggests that factors other than protein synthesis inhibition may be involved. Although plant death apparently results from events occurring in response to EPSP synthase inhibition, the actual sequence of phytotoxic processes is unclear.

10

Glutamine Synthetase Inhibitors

Phosphinic acids (glufosinate and bialophos) inhibit activity of glutamine synthetase (Lea 1984), the enzyme that converts glutamate and ammonia to glutamine. Accumulation of ammonia in the plant (Tachibana 1986) destroys cells and directly inhibits photosystem I and photosystem II reactions (Sauer 1987). Ammonia reduces the pH gradient across the membrane which can uncouple photophosphorylation.

11 **12** **13** **27**

Carotenoid Biosynthesis Inhibitors

Amides, anilidex, furanones, phenoxybutan-amides, pyridiazinones, and pyridines (Group 12) are examples of compunds that block carotenoid biosynthesis by inhibition of phytoene desaturase (Bartels and Watson 1978; Sandmann and Böger 1989). Carotenoids play an important role in dissipating the oxidative energy of singlet O_2 ($^1O_2$). In normal photosynthetic electron transport, a low level of photosystem II reaction center chlorophylls in the first excited singlet state transform into the excited triplet state (^{3}Chl). This energized ^{3}Chl can interact with ground state molecular oxygen (O_2)to form $^1O_2$. In healthy plants, the energy of $^1O_2$ is safely quenched by carotenoids and other protective molecules. Carotenoids are largely absent in fluridone-treated plants, allowing $^1O_2$ and ^{3}Chl to abstract a hydrogen from an unsaturated lipid (e.g. membrane fatty acid, chlorophyll) producing a lipid radical. The lipid radical interacts with O_2 yielding a peroxidized lipid and another lipid radical. Thus, a self-sustaining chain reaction of lipid peroxidation is initiated which functionally destroys chlorophyll and membrane lipids. Proteins also are destroyed by $^1O_2$. Destruction of integral membrane components leads to leaky membranes and rapid tissue desiccation.

Callistemones, isoxazoles, pyrazoles, and triketones (Group 27) are examples of herbicides that inhibit *p*-hydroxyphenyl pyruvate dioxygenase (HPPD), which converts *p*-hydroxymethyl pyruvate to homogentisate. This is a key step in plastoquinone biosynthesis and its inhibition gives rise to bleaching symptoms on new growth. These symptoms result from an indirect inhibition of carotenoid synthesis due to the involvement of plastoquinone as a cofactor of phytoene desaturase.

Recent evidence suggests that clomazone (Group 13) is metabolized to the 5-keto form of clomazone which is herbicidally active. The 5-keto form inhibits 1-deoxy-D-xyulose 5-phosphate synthase (DOXP), a key component to plastid isoprenoid synthesis. Clomazone does not inhibit geranylgeranyl pyrophosphate biosynthesis (Croteau 1992; Weimer 1992).

Amitrole (Group 11) inhibits accumulation of chlorophyll and carotenoids in the light (Ashtakala, 1989), although the specific site of action has not been determined. Precursors of carotenoid synthesis, including phytoene, phytofluene, carotenes, and lycopene accumulate in amitrole-treated plants (Barry and Pallett 1990), suggesting that phytoene desaturase, lycopene cyclase, imidazoleglycerol phosphate dehydratase, nitrate reductase, or catalase may be inhibited. Other research (Heim and Larrinua 1989), however, indicates that the histidine, carotenoid, and chlorophyll biosynthetic pathways probably are not the primary sites of amitrole action. Instead, amitrole may have a greater effect on cell division and elongation than on pigment biosynthesis.

Aclonifen (Group 11) appears to act similar to carotenoid inhibiting/bleaching herbicides; but the exact mechanism of action in unknown.

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Protoporphyrinogen Oxidase (PPG oxidase or Protox) Inhibitors

Diphenylethers, *N*-phenylphthalimides, oxadiazoles, oxazolidinediones, phenylpyrazoles, pyrimidindiones, thiadiazoles, and triazolinones are herbicides that appear to inhibit protoporphyrinogen oxidase (PPG oxidase or Protox), an enzyme of chlorophyll and heme biosynthesis catalyzing the oxidation of protoporphyrinogen IX (PPGIX) to protoporphyrin IX (PPIX). Protox inhibition leads to accumulation of PPIX, the first light-absorbing chlorophyll precursor. PPGIX accumulation apparently is transitory as it overflows its normal environment in the thylakoid membrane and oxidizes to PPIX. PPIX formed outside its native environment probably is separated from Mg chelatase and other pathway enzymes that normally prevent accumulation of PPIX. Light absorption by PPIX apparently produces triplet state PPIX which interacts with ground state oxygen to form singlet oxygen. Both triplet PPIX and singlet oxygen can abstract hydrogen from unsaturated lipids, producing a lipid radical and initiating a chain reaction of lipid peroxidation. Lipids and proteins are attacked and oxidized, resulting in loss of chlorophyll and carotenoids and in leaky membranes which allows cells and cell organelles to dry and disintegrate rapidly (Duke 1991).

17 25 26

Potential Nucleic Acid Inhibitors or Non-descript mode of action

Several herbicides have been identified as having an unknown mode of action including organic arsenicals (Group 17), arylaminopropionic acids (Group 25), and other non-classified herbicides (Group 26).

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Dihydropteroate Synthetase Inhibitors

The carbamate herbicide, asulam, appears to inhibit cell division and expansion in plant meristems, perhaps by interfering with microtubule assembly or function (Fedtke 1982; Sterrett and Fretz 1975). Asulam also inhibits 7,8-dihydropteroate synthase, an enzyme involved in folic acid synthesis which is needed for purine nucleotide biosynthesis (Kidd et al. 1982; Veerasekaran et al. 1981).

19

Auxin Transport Inhibitors

Phthalamates (naptalam) and semicarbazones (diflufenzopyr) are compounds that inhibit auxin transport. These compounds inhibit polar transport of naturally occurring auxin, indoleacetic acid (IAA) and synthetic auxin-mimicking herbicides in sensitive plants. Inhibition of auxin transport causes an abnormal accumulation of IAA and synthetic auxin agonists in meristematic shoot and root regions, disrupting the delicate auxin balance needed for plant growth. When diflufenzopyr is applied with dicamba, it focuses dicamba's translocation to the meristematic sinks, where it delivers effective weed control at reduced dicamba rates and across a wider range of weed species. Sensitive broadleaf weeds exhibit rapid and severe plant hormonal effects (e.g., epinasty) after application of the mixture; symptoms are visible within hours, and plant death usually occurs within a few days. Symptomology, in sensitive annual grasses, is characterized by a stunted growth. Tolerance in corn occurs through rapid metabolism of diflufenzopyr and dicamba.

20 21 28 29

Cellulose Inhibitors

Benzamides (WSSA Group 21), nitriles (Group 20), and triazolocarboxamides (Group 28) are herbicides that inhibit cell wall biosynthesis (cellulose) in susceptible weeds (Heim et al. 1990). Alkylazine (Group 29) herbicides inhibit cellulose biosynthesis (Myers et al. 2009).

22

Photosystem I Inhibitors

Bipyridyliums are examples of herbicides that accept electrons from photosystem I and are reduced to form an herbicide radical. This radical then reduces molecular oxygen to form superoxide radicals. Superoxide radicals then react with themselves in the presence of superoxide dismutase to form hydrogen peroxides. Hydrogen peroxides and superoxides react to generate hydroxyl radicals. Superoxides and, to a lesser extent, hydrogen peroxides may oxidize SH (sulfhydryl) groups on various organic compounds within the cell. Hydroxyl radical, however, is extremely reactive and readily destroys unsaturated lipids, including membrane fatty acids and chlorophyll. Hydroxyl radicals produce lipid radicals which react with oxygen to form lipid hydroperoxides plus another lipid radical to initiate a self-perpetuating chain reaction of lipid oxidation. Such lipid hydroperoxides destroy the integrity of cell membranes allowing cytoplasm to leak into intercellular spaces which leads to rapid leaf wilting and desiccation. These compounds can be reduced/oxidized repeatedly (Dodge 1982).

24

Oxidative Phosphorylation Uncouplers

Dinitrophenols (dinoterb) are herbicides that uncouple the process of oxidative phosphorylation causing almost immediate membrane disruption and necrosis.

NC

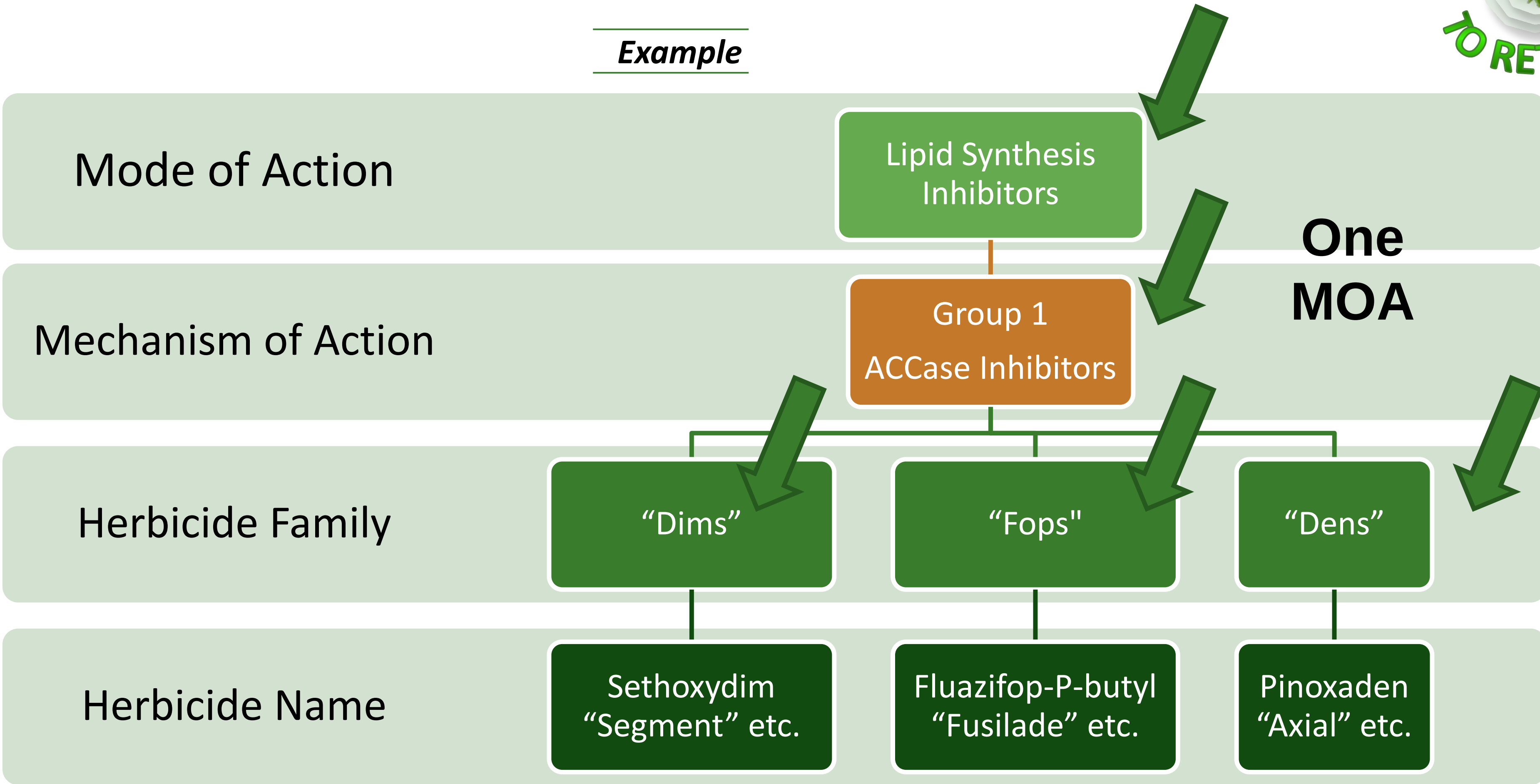
Not Classified

These herbicides have not been classified by HRAC or WSSA.

Classification Hierarchy

CLICK HERE TO RETURN

Example



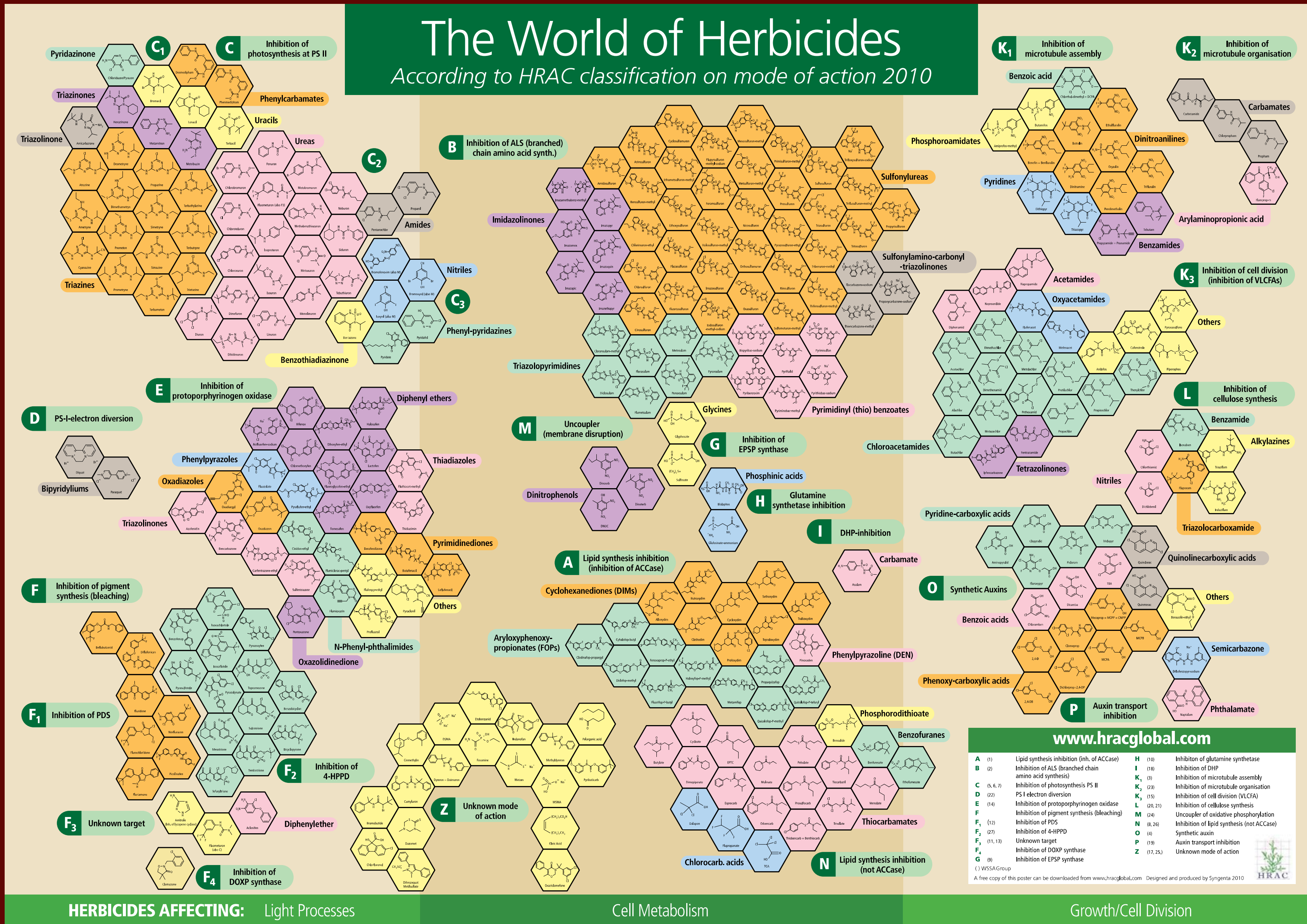
Herbicide Resistance Issues

Herbicde Resistance Action Committee (hrac) website

http://www.hracglobal.com

- Best all in one spot reference of herbicide MOA
- Can enlarge view, very inclusive
- Numbering/lettering system to identifty MOA
- MOA numbers are on labels now

Herbicide Mode Of Action



http://www.hracglobal.com

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Herbicide Mode Of Action

Note Site of Action Column.

Lists MOA number / letter

HERBICIDE RESISTANT WEEDS - MINNESOTA

Common Name	Scientific Name	Reported Occurrence	Site of Action	Actives	Trade Names (examples)
Common Lambsquarters	*Chenopodium album*	1982	Photosystem 2 inhibitors (C1/5)	atrazine	Aatrex, Fenatrol, Atranex; etc.
Velvetleaf	*Abutilon theophrasti*	1991	Photosystem 2 inhibitors (C1/5)	atrazine	Aatrex, Fenatrol, Atranex; etc.
Redroot Pigweed	*Amaranthus retroflexus*	1991	Photosystem 2 inhibitors (C1/5)	atrazine	Aatrex, Fenatrol, Atranex; etc.
Common Waterhemp	*Amaranthus tuberculatus (syn. Rudis)*	1994, 2007	ALS inhibitors (B/2) **AND** Glycines (G/9)	(ALS) imazethapyr; imazapyr; thifensulfuron-methyl **AND** (Glycine) glyphosate	(ALS) Pursuit, Arsenal, Harmony - (Glycine) RoundUp
Wild Oat	*Avena fatua*	1991	ACCase inhibitors (A/1)	diclofop-methyl	
Kochia	*Kochia scoparia*	1994	ALS inhibitors (B/2)	imazethapyr; thifensulfuron-methyl; tribenuron-methyl	Pursuit, Harmony, Express
Common Cocklebur	*Xanthium strumarium*	1994	ALS inhibitors (B/2)	imazethapyr	Pursuit
Giant Foxtail	*Setaria faberi*	1996	ALS inhibitors (B/2)	(ALS) imazethapyr; nicosulfuron; primisulfuron-methyl	Pursuit, Accent, Beacon
Robust White Foxtail	*Setaria viridis var. robusta-alba*	1996, 1999	ALS inhibitors (B/2) **AND** ACCase inhibitors (A/1)	(ALS) imazethapyr; nicosulfuron; primisulfuron-methyl **AND** (ACCase) fenoxaprop-P-ethyl; fluazifop –P-butyl	(ALS) Pursuit, Accent, Beacon (ACCase) Puma, Acclaim, Fusilade
Yellow Foxtail	*Setaria lutescens*	1997	ALS inhibitors (B/2)	imazethapyr	Pursuit
Purple Robust Foxtail	*Setaria viridis var. robusta-purpurea*	1999	ACCase inhibitors (A/1)	fenoxaprop-P-ethyl; fluazifop –P-butyl; sethoxydim	Puma, Acclaim, Fusilade, Poast
Common Ragweed	*Ambrosia artemisiifolia*	1998, 2008	ALS inhibitors (B/2) **AND** Glycines (G/9)	(ALS) imazethapyr; imazapyr; cloransulam-methyl; primisulfuron-methyl **AND** (Glycine) glyphosate	(ALS) Pursuit, Arsenal, Telar, Beacon (Glycine) RoundUp
Giant Ragweed	*Ambrosia trifida*	2006, 2008	ALS inhibitors (B/2) **AND** Glycines (G/9)	(ALS) cloransulam-methyl **AND** (Glycine) glyphosate	(ALS) Beacon (Glycine) RoundUp

Compiled by Tony Cortilet, MNA. Data obtained from the International Survey of Herbicide Resistant Weeds – Weed Science Society of America: http://www.weedscience.org/Summary/Country.aspx
01/07/2014

New Sweet Corn Herbicides

Mesotrione showing up in a lot of new package mixtures

- Various companies
- In part for resistance management for things like waterhemp
  - FMC Solstice
  - DuPont Revulin
  - Syngenta Acuron, SYN-A205

New Sweet Corn Herbicides

FMC

Anthem 2.15 SEM = 2.15 lb ai

- 2.087 pyroxasulfone (Zidua Grp 15)
- 0.063 fluthiacet-methyl (Cadet Grp 14)

Anthem ATZ 4.5 SEM = 4.505 lb ai

- 0.485 pyroxasulfone
- 0.014 fluthiacet-methyl
- 4.006 atrazine (Grp 5)

Solstice 4 FL (F9387) = 4.0 lb ai

- 0.216 fluthiacet-methyl
- 3.784 mesotrione (Grp 27)

SEM – soluble emulsion

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New Sweet Corn Herbicides

Anthem and Anthem ATZ

2013 labeled PRE and POST (up to V4 corn)

- **PRE many grass and broadleaf weeds**
- **POST many broadleaf weeds**
- **Higher rates w/ higher soil texture, OM**
  - **Pyroxasulfone longer residual than other K Group Herbicides (Grp 3, 15, 23)**
- **POST speckling apps. to wet foliage**
- **18-month replant restriction all crops except corn**

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New Sweet Corn Herbicides

Anthem and Anthem ATZ

- Anthem
  - pkg. mix pyroxasulfone (Zidua) + fluthiacet (Cadet)
  - 7-13 fl oz/A PRE
  - 5-12 POST (Processing ONLY)
  - 40 day PHI
- Anthem ATZ
  - adds atrazine to the pkg. mix
  - PRE 1.75 to 4 pt/A, POST 1.5 to 3 pts/A
  - 45 day PHI

Sweet Corn Herbicides

Cadet (fluthiacet)

Used alone is for processing ONLY

- POST
  - 0.6-0.9 fl oz/A
    - Do not exceed 1.25 fl oz/A per year
  - V2 to tasseling
  - Velvetleaf and several other broadleaves
  - Add COC or NIS
  - 40-day PHI

In Anthem, Anthem ATZ which are labeled for fresh market

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New Sweet Corn Herbicides

Solstice 4 FL (F9387) = 4.0 lb ai

- 0.216 fluthiacet-methyl
- 3.784 mesotrione (Grp 27)

POST broadleaf weeds up to V8 corn

- 2.5 to 3.15 fl oz/A (0.078 to 0.098 lb ai/A)
  - 0.25% v/v NIS
    - COC alone on sweet corn improve weed control dry conditions but may increase injury
    - COC 1% v/v + UAN,AMS on field corn
  - Amaranth group, cocklebur, velvetleaf, ragweeds (higher rates), vol. potatoes
  - Temporary leaf speckling or bleaching in some varieties
  - 10 mo. rotation to soybeans, 18 mo. other crops

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New Sweet Corn Herbicides

DuPont Revulin™ Q – 2012

- Do not add AMS/UAN for sweet corn
- Always add 0.25 % NIS
  - COC only if dry (COC ↑ risk of injury)
    - COC, AMS/UAN for field corn
  - Since can not add AMS or UAN
    - Weeds < 5 in. target
    - Add atrazine if allowed
  - Broadcast up to 12 in. tall or <= 5 lf collars
  - Drop nozzles up to 18 inches

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New Sweet Corn Herbicides

DuPont Revulin™ Q –

(DPX-UKU48 dry formulation)

- 3.4 to 4 oz/A POST
  - Accent (nicosulfuron Grp 2)
  - Callisto (mesotrione Grp 27)
  - Safener (isoxadifen-ethyl)
- NIS only for sweet corn
- COC, AMS/UAN for field corn

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New Sweet Corn Herbicides

Syngenta (new PRE herbicides)

- Acuron 3.34 SC (SYN-A197) – 2015?
  - metolachlor + mesotrione + bicyclopyrone + atrazine (Grp 3, 27, 27, 5)
- SYN-A205 – 2016?
  - metolachlor + mesotrione + bicyclopyrone
  - Both include benoxacor (safener)
  - Bicyclopyrone lower use rate than mesotrione and improves large-seeded broadleaf control
  - Grasses, amaranth, lambsquarter, common and giant ragweed

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Impact, Armezon (topramezone)

POST in field corn, sweet corn, pop corn

- 1^{o} broadleaf weed control
- 2^{o} partial grass control
  - Synergized by atrazine

- Rate: 0.5 to 0.75 oz/A
  - Can go to 1 oz, prefer 0.75 to reduce carryover
  - If can, TM with 0.5 lb atrazine, control Similar to 1 oz/A
- Adjuvant: MSO or COC plus nitrogen additive
- PHI 45 days

Zidua® 0.85 WDG

BASF PRE or PPI

- pyroxasulfone (Zidua Grp 15/K_3)
- 1.0-4 oz/A
- Apply before or after planting before crop emergence, or at spiking up to V4 (4 leaf collars visible)
  - Will not control emerged weeds
- Seed at least 1 inch deep
- Do not exceed
  - 2.75 oz/A per season on coarse soils
  - 5 oz/A per season on other soils
- 37-day PHI

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Starane Ultra® 2.8 L

Dow Agrosciences

Starane Ultra® 2.8 L (ae), 1.5 EC phasing out

- Fluroxypyr
- 0.4 fl oz/A PRE
- POST broadcast (up to V4)
  - No additives used alone
  - Use directed spray beyond V4
- Volunteer potato (can apply sequentials)
  - preplant to emerged potato 4-8 in.
  - POST suppression to emerged potato 4-8 in.
- 31-day PHI

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Capreno on Sweet Corn?

Bayer Capreno® POST

Sweet corn on 4-3-09 label

Sweet corn is NOT on 5-12 label

- 2.88 lbs. tembotrione (Grp 27)
- 0.57 lb. thiencarbazone-methyl (Corvus) (Grp 2)

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Capreno on Sweet Corn?

Bayer Capreno® POST

Sweet corn on the old 4-3-09 Label

- 3 fl oz/A
- 1 qt. of COC per 25 gals + 1.5 qt./A UAN or 1.5 lb./A AMS
- After V1and before V6
- Do not use with Lorsban®, Counter®, Dyfonate®, Thimet®, or other OPs
- 18-month rotation restriction for other vegetable crops

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Callisto Pkg. Mix Changes

PRE's

45 day PHI

Lumax 3.94, 2.5 to 3 qts/A

- 2.68 *S*-metolachlor + 1.0 atrazine + 0.268 mesotrione lb ai per gallon

now Lumax EZ, 2.7 to 3.25 qts/A

- EZ = 2.49 metolachlor + 0.94 atrazine + 0.249 mesotrione lb ai per gallon

Callisto Pkg. Mix Changes

PRE's

Lexar 3.7, now Lexar EZ

Both 3 to 3.5 qts

- 4 qt = 1.74 *S*-metolachlor + 1.74 atrazine + 0.224 mesotrione lb ai per gallon

60 day PHI

RUP because contain atrazine

Callisto Pkg. Mix Changes

PRE's

Camix 3.67 replaced by Zemax

Same amounts of:

3.34 *S*-metolachlor + 0.33 mesotrione lb ai per gallon

Apply 2.0 qt/A if < 3% OM

2.4 qt/A if >= 3% OM

45 day PHI

(do not apply POST, labeled in field corn but can injury sweet corn)

Callisto Pkg. Mix Changes

POST

Callisto Xtra 20 to 24 fl oz/A

45 day PHI

- 3.2 lb atrazine + 0.5 mesotrione lb ai per gallon

New Sweet Corn Herbicides

DuPont Revulin™ Q –

(DPX-UKU48 dry formulation)

- 3.4 to 4 oz/A POST
  - Accent (nicosulfuron Grp 2)
  - Callisto (mesotrione Grp 27)
  - Safener (isoxadifen-ethyl)
- NIS only for sweet corn
- COC, AMS/UAN for field corn

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New Sweet Corn Herbicides

DuPont Revulin™ Q – 2015

- Do not add AMS/UAN for sweet corn
- Always add 0.25 % NIS
  - COC only if dry (COC ↑ risk of injury)
    - COC, AMS/UAN for field corn
  - Since can not add AMS or UAN
    - Weeds < 5 in. target
    - Add atrazine if allowed
  - Broadcast up to 12 in. tall or <= 5 lf collars
  - Drop nozzles up to 18 inches

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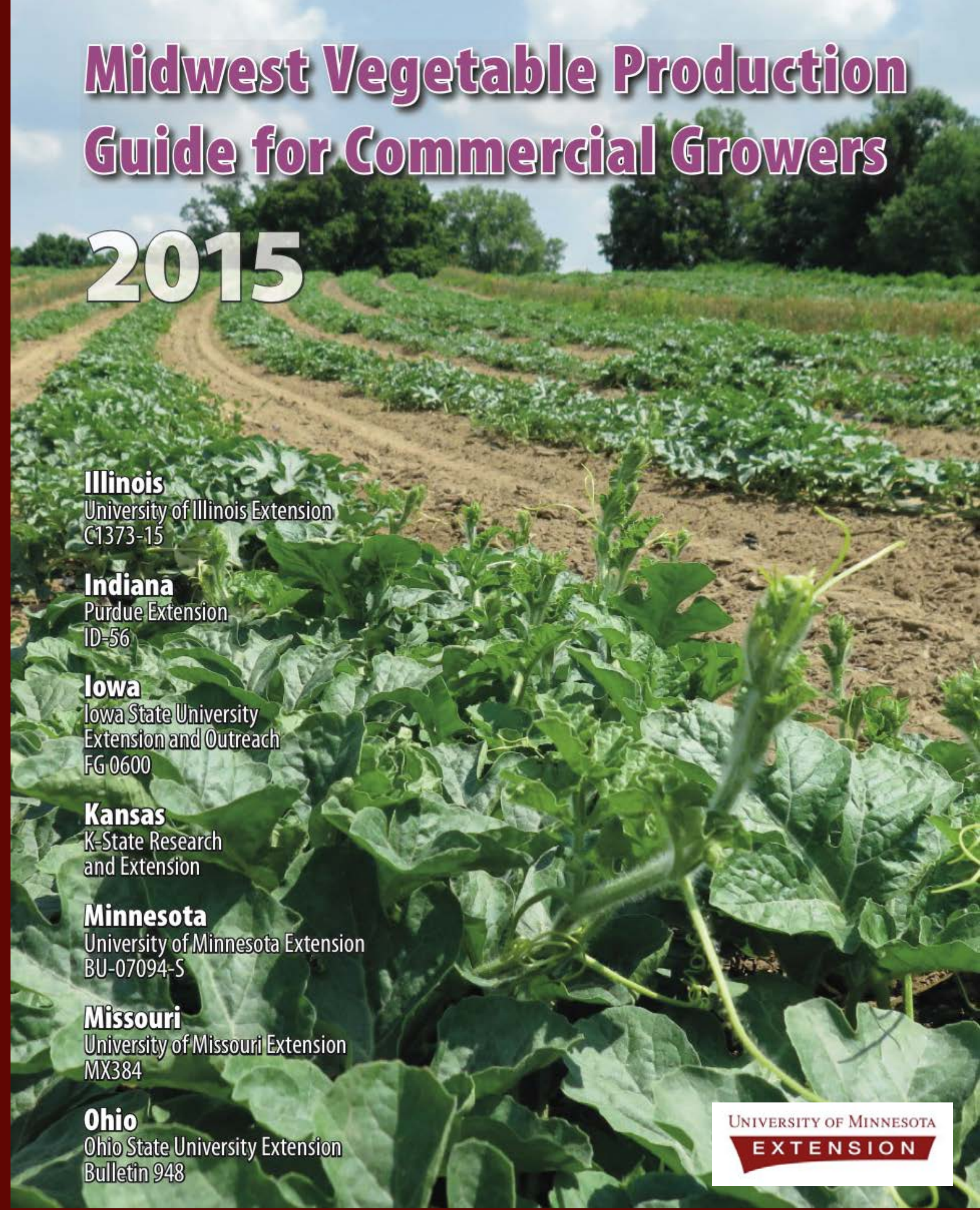
Sweet Corn Weed Mgt. 2015

http://mwveguide.org

U of M contributions

Roger Becker
Vince Fritz
Bill Hutchison
Eric Burkness
Carl Rosen



Soil Applied Herbicide Options

Preemergence options

Annual grasses and some broadleaves:

- Acetochlor products (Harness, Surpass, Degree, Breakfree, TopNotch)
- Metolachlor products (Brawl, Brawl II, Dual Magnum, Dual II Magnum, Charger Basic, Cinch)
- Define, Dimethenamid-P, Outlook, Micro-Tech, Prowl H2O, Eradicane, Zidua

Annual broadleaves and some grasses:

- Atrazine, Princep

Annual broadleaves:

- Callisto

Soil Applied Herbicide Options

PRE package mixtures

– grasses and broadleaves

- Anthem, Anthem ATZ
- Acetochlor + atrazine (Breakfree ATZ, Breakfree ATZ Lite, Degree Xtra, FullTime, Harness Xtra, Keytone)
- Metolachlor + atrazine (Bicep Lite II Magnum, Cinch ATZ, Charger Max ATZ)
- Bullet or Lariat (Micro-Tech + atrazine)
- Dimethenamid-P
- G-Max Lite (Outlook + atrazine)
- Solstice
- Zemax (Camix), Lumax EX, Lexar EZ

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Postemergence Herbicide Options

Annual grasses

- Accent*, Accent Q*
- Poast, Poast Plus
- Option*

* Activity on grasses and broadleaves

Annual broadleaves

- Aim
- Atrazine*
- Basagran
- Cadet
- Callisto
- Impact, Amerzon*
- Laudis*
- Permit, Sandea
- Starane
- Stinger
- 2,4-D

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Postemergence Herbicide Options

POST Package Mixtures
- Grasses and broadleaves

- Anthem, Anthem ATZ
- Callisto Xtra
- Laddok (atrazine + Basagran)
- Priority (Aim + Permit / Sandea)
- Revulin Q (Accent + Callisto + Safener)

Postemergence Herbicide Options

Annual grasses

- Poast on Poast Tolerant lines
  - Non-GMO (trait derived thru breeding selections)

Annual broadleaves and grasses

- Roundup Ready on tolerant lines
- Liberty on on tolerant lines
  - Both stacked with Bt traits in some cases
  - Be absolutely sure DOES have glufosinate or glyphosate trait before spraying

Liberty 280 SL on Sweet Corn

Bayer supplemental label thru 2016

- EPA Reg. No. 264-829 Supplemental label
  - Expires 11/05/16, issued 11/21/2013
- 50 day PHI, 55 PHI for stover
- Apply from emergence until 24” tall or the V-7 stage (whichever comes first)
- 20 fl oz/A w/ AMS
- Two applications per growing season max
  - Sequential should be at least 10 days apart
  - 40 fl oz/A per growing season max
- If used in a burndown application, NO post emergence applications allowed

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Liberty 280 SL on Sweet Corn

Bayer supplemental label good thru 2016 (cont.)

- A silicone-based antifoam agent may be added if needed
- DO NOT
  - Apply if corn shows injury from prior herbicide applications or environmental stress (drought, excessive rainfall, etc.)
  - Apply through any type of irrigation system
  - In nitrogen fertilizer as a carrier

2014 Sweet Corn Herbicide Screen

- Planted May 30 2014
  - 120 lb N Urea incorporated
- PRE applied June 3, 2014
- POST applied June 27, 2014 (2 to 4 inch weeds)
- RCB, 3 reps, 10 x 27 ft plots, 4 - 30 in. rows
- East 2 rows GSS 1477, West 2 rows Jubilee
- 23,000/A

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2014 Sweet Corn Herbicide Screen

DuPont Revulin™ Q (DPX-UKU48 dry formulation)

- 3.4 and 4 oz/A rate POST
  - nicosulfuron + mesotrione + safener (isoxadifen-ethyl)
  - NIS = Preference, AMS = Amsul AMS, COC used in the study
  - Will be labeled just with NIS on sweet corn

Breakfree 6.4 EC = acetochlor underlay

Sharpen (saflufenacil) labeled on all corn EXCEPT sweet corn

2014 Sweet Corn Weed Control

Waseca MN

Becker, Fritz, Rohwer, Hoverstad, Miller, Kinkaid

		% Growth Reduction					
		GSS 1477			Jubilee		
Herbicide Trt.	Product Rate/A (oz/A unless otherwise designated)	7/02	7/10	7/24	7/02	7/10	7/24
Accent + Callisto + Safe + COC	0.65 + 2.5 + 0.25 + 1.2 pt	8.3	16.7	0.0	5.0	9.0	0.0
Accent + Callisto + Safe + COC + AMS	0.65 + 2.5 + 0.25 + 1.2 pt + 2 lbs	0.0	1.7	0.0	0.0	4.0	0.0
Accent + Callisto + Safe + NIS + AMS	0.65 + 2.5 + 0.25 + 4.8 + 2 lbs	0.0	1.0	0.0	5.0	4.3	0.0
Accent + Callisto + Safe + COC + AMS + atra	0.65 + 2.5 + 0.25 + 1.2 pt + 2 lbs + 1 pt	8.3	7.3	0.0	8.3	9.7	0.0
Accent + Callisto + Safe + COC	0.77 + 2.94 + 0.296 + 1.2 pt	6.7	13.3	0.0	5.0	6.7	0.0
Accent + Callisto + Safe + COC + AMS	0.77 + 2.94 + 0.296 + 1.2 pt + 2 lbs	0.0	4.4	0.0	0.0	14.5	0.0
Accent + Callisto + Safe + NIS + AMS	0.77 + 2.94 + 0.296 + 4.8 + 2 lbs	9.3	8.3	0.0	4.3	6.7	0.0
Accent + Callisto + Safe + COC + AMS + atra	0.77 + 2.94 + 0.296 + 1.2 pt + 2 lbs + 1 pt	0.0	4.0	0.0	0.0	4.0	0.0
(Breakfree) Accent + Callisto + Safe + COC + AMS	(1.5 pt) 0.65 + 2.5 + 0.25 + 1.2 pt + 2 lbs	9.3	5.0	0.0	4.0	4.0	0.0
(Breakfree) Accent + Callisto + Safe + COC + AMS + atra	(1.5 pt) 0.65 + 2.5 + 0.25 + 1.2 pt + 2 lbs + 1 pt	6.0	11.0	0.0	5.0	6.7	0.0
(Breakfree) Laudis + MSO + 28% UAN	(1.5 pt) 3 + 1.2 pt + 2 pt	4.3	2.7	0.0	2.7	0.0	0.0
(Breakfree) Impact + MSO + 28% UAN	(1.5 pt) 1 + 1.2 pt + 2 pt	8.3	0.0	0.0	8.3	2.7	0.0
(Breakfree) Capreno	(1.5 pt) 3	0.0	3.3	0.0	1.7	6.0	0.0
(Breakfree) Sharpen	(1.5 pt) 2	0.0	0.0	0.0	0.0	0.0	0.0
(Anthem)	(10)	0.0	2.7	0.0	0.0	2.7	0.0
Solstice + COC + AMS	3 + 1.2 pt + 1.28 lb	0.0	2.7	0.0	0.0	5.7	0.0
(Anthem) Solstice + COC + AMS	(10) 3 + 1.2 pt + 1.28 lb	1.7	4.0	0.0	1.7	6.0	0.0
(Anthem ATZ) Solstice + COC + AMS	(1 qt) 3 + 1.2 pt + 1.28 lb	0.0	2.7	0.0	0.0	2.3	0.0
(Acuron [SYN-A197])	3 qt	1.7	0.0	0.0	2.7	0.0	0.0
(SYN-A205)	2.25 qt	1.7	9.0	0.0	2.7	6.7	0.0
Untreated Check	--	1.7	11.7	0.0	0.0	8.3	0.0
	LSD @ P=0.05	NS	NS	NS	NS	NS	NS

(PRE) POST 2-4 in. weeds. Contain atrazine

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2014 Sweet Corn Weed Control

Waseca MN

Becker, Fritz, Rohwer, Hoverstad, Miller, Kinkaid

		% Clorosis						% Necrosis			
		GSS 1477			Jubilee			GSS 1477		Jubilee	
Herbicide Trt.	Product Rate/A (oz/A unless otherwise designated)	7/02	7/10	7/24	7/02	7/10	7/24	7/10	7/24	7/10	7/24
Accent + Callisto + Safe + COC	0.65 + 2.5 + 0.25 + 1.2 pt	8.3	15.0	3.3	12.7	6.7	6.0	0.0	16.7	0.0	10.3
Accent + Callisto + Safe + COC + AMS	0.65 + 2.5 + 0.25 + 1.2 pt + 2 lbs	6.0	6.7	4.0	16.0	10.3	7.0	0.0	8.0	0.0	11.7
Accent + Callisto + Safe + NIS + AMS	0.65 + 2.5 + 0.25 + 4.8 + 2 lbs	10.0	6.7	4.0	7.3	10.0	5.3	0.0	6.0	0.0	5.0
Accent + Callisto + Safe + COC + AMS + atra	0.65 + 2.5 + 0.25 + 1.2 pt + 2 lbs + 1 pt	2.7	4.7	3.7	2.7	3.3	5.7	0.0	6.3	0.0	5.7
Accent + Callisto + Safe + COC	0.77 + 2.94 + 0.296 + 1.2 pt	9.3	3.7	2.7	10.0	4.7	4.0	0.0	8.0	0.0	8.7
Accent + Callisto + Safe + COC + AMS	0.77 + 2.94 + 0.296 + 1.2 pt + 2 lbs	5.4	6.0	2.1	7.5	10.4	5.6	0.0	7.7	0.2	11.2
Accent + Callisto + Safe + NIS + AMS	0.77 + 2.94 + 0.296 + 4.8 + 2 lbs	12.0	3.0	3.3	5.3	2.7	0.0	0.0	12.3	0.0	9.7
Accent + Callisto + Safe + COC + AMS + atra	0.77 + 2.94 + 0.296 + 1.2 pt + 2 lbs + 1 pt	10.0	3.7	4.7	4.3	2.0	2.7	5.0	11.7	0.0	9.0
(Breakfree) Accent + Callisto + Safe + COC + AMS	(1.5 pt) 0.65 + 2.5 + 0.25 + 1.2 pt + 2 lbs	12.7	16.0	4.7	6.3	6.0	3.3	0.0	7.0	0.0	4.0
(Breakfree) Accent + Callisto + Safe + COC + AMS + atra	(1.5 pt) 0.65 + 2.5 + 0.25 + 1.2 pt + 2 lbs + 1 pt	10.0	15.3	9.3	16.3	24.7	12.7	0.0	4.0	0.0	4.0
(Breakfree) Laudis + MSO + 28% UAN	(1.5 pt) 3 + 1.2 pt + 2 pt	9.0	1.7	0.0	14.0	0.0	0.3	0.7	12.7	0.7	6.3
(Breakfree) Impact + MSO + 28% UAN	(1.5 pt) 1 + 1.2 pt + 2 pt	10.0	4.3	2.3	20.7	7.7	6.0	0.0	6.3	0.0	5.0
(Breakfree) Capreno	(1.5 pt) 3	8.7	5.3	3.3	12.7	8.0	6.7	2.7	8.0	0.0	7.7
(Breakfree) Sharpen	(1.5 pt) 2	12.3	3.3	1.3	5.7	6.0	2.3	0.0	14.3	0.0	8.7
(Anthem)	(10)	6.7	4.3	2.0	4.3	2.0	1.3	0.0	14.3	0.0	13.0
Solstice + COC + AMS	3 + 1.2 pt + 1.28 lb	16.0	7.7	1.7	20.3	12.7	8.3	5.0	16.0	5.0	19.0
(Anthem) Solstice + COC + AMS	(10) 3 + 1.2 pt + 1.28 lb	6.7	3.0	0.7	9.3	4.7	0.0	0.0	15.3	0.0	11.0
(Anthem ATZ) Solstice + COC + AMS	(1 qt) 3 + 1.2 pt + 1.28 lb	16.7	6.3	4.3	12.7	1.7	1.7	2.7	7.3	1.7	5.3
(Acuron [SYN-A197])	3 qt	1.7	3.0	4.0	2.3	1.3	0.7	0.0	10.3	1.7	7.7
(SYN-A205)	2.25 qt	9.0	11.7	3.0	4.0	3.7	1.3	0.0	16.0	0.0	10.7
Untreated Check	--	0.7	3.0	0.0	0.7	1.7	0.7	5.0	28.3	0.7	28.3
(PRE) POST 2-4 in. weeds. Contain atrazine	LSD @ P=0.05	NS	NS	NS	13.2	12.1	NS	NS	10.6	NS	8.4

Color denotes	Sign. higher injury than lowest value using P=0.05 LSDs, P=0.10
Color denotes	Sign. higher injury than lowest value using P=0.05 LSDs, P=0.05
Color denotes	Sign. higher injury than lowest value using P=0.05 LSDs, P=0.01

2014 Sweet Corn Weed Control

Waseca MN

Becker, Fritz, Rohwer, Hoverstad, Miller, Kinkaid

Herbicide Trt.	Product Rate/A (oz/A unless otherwise designated)	% Control Gift 7/02	Gift 7/10	Gift 7/24	Gift 8/27	Yeft 7/24	Yeft 8/27
Accent + Callisto + Safe + COC	0.65 + 2.5 + 0.25 + 1.2 pt	15.0	40.7	45.7	40.0	36.7	48.0
Accent + Callisto + Safe + COC + AMS	0.65 + 2.5 + 0.25 + 1.2 pt + 2 lbs	38.3	82.3	93.3	86.3	61.3	76.7
Accent + Callisto + Safe + NIS + AMS	0.65 + 2.5 + 0.25 + 4.8 + 2 lbs	15.0	81.7	99.7	96.7	55.0	71.7
Accent + Callisto + Safe + COC + AMS + atra	0.65 + 2.5 + 0.25 + 1.2 pt + 2 lbs + 1 pt	39.3	84.3	96.3	82.7	76.7	85.3
Accent + Callisto + Safe + COC	0.77 + 2.94 + 0.296 + 1.2 pt	63.0	92.0	95.7	90.3	80.3	90.0
Accent + Callisto + Safe + COC + AMS	0.77 + 2.94 + 0.296 + 1.2 pt + 2 lbs	13.4	64.8	91.8	90.2	23.1	61.9
Accent + Callisto + Safe + NIS + AMS	0.77 + 2.94 + 0.296 + 4.8 + 2 lbs	11.7	63.7	87.0	69.7	54.3	70.7
Accent + Callisto + Safe + COC + AMS + atra	0.77 + 2.94 + 0.296 + 1.2 pt + 2 lbs + 1 pt	36.7	87.7	97.0	98.3	88.0	90.0
(Breakfree) Accent + Callisto + Safe + COC + AMS	(1.5 pt) 0.65 + 2.5 + 0.25 + 1.2 pt + 2 lbs	99.0	99.3	99.0	98.3	96.7	97.3
(Breakfree) Accent + Callisto + Safe + COC + AMS + atra	(1.5 pt) 0.65 + 2.5 + 0.25 + 1.2 pt + 2 lbs + 1 pt	99.7	100.0	100.0	99.0	99.0	99.3
(Breakfree) Laudis + MSO + 28% UAN	(1.5 pt) 3 + 1.2 pt + 2 pt	96.3	95.0	98.0	94.3	96.3	96.3
(Breakfree) Impact + MSO + 28% UAN	(1.5 pt) 1 + 1.2 pt + 2 pt	91.7	96.7	98.0	96.0	96.7	95.7
(Breakfree) Capreno	(1.5 pt) 3	97.3	93.0	98.0	94.0	89.7	94.3
(Breakfree) Sharpen	(1.5 pt) 2	99.7	98.0	99.0	96.3	99.0	98.3
(Anthem)	(10)	85.7	92.3	95.7	90.0	92.3	90.7
Solstice + COC + AMS	3 + 1.2 pt + 1.28 lb	21.7	15.0	45.0	25.0	36.7	40.0
(Anthem) Solstice + COC + AMS	(10) 3 + 1.2 pt + 1.28 lb	94.3	89.3	94.7	92.0	93.0	94.0
(Anthem ATZ) Solstice + COC + AMS	(1 qt) 3 + 1.2 pt + 1.28 lb	100.0	99.3	99.7	99.0	94.7	98.0
(Acuron [SYN-A197])	3 qt	100.0	99.7	100.0	99.7	100.0	99.0
(SYN-A205)	2.25 qt	99.7	99.3	99.0	99.0	99.0	100.0
Untreated Check	--	0.0	0.0	0.0	0.0	0.0	0.0
	LSD @ P=0.05	30.4	22.1	16.8	20.6	29.3	24.9

(PRE) POST 2-4 in. weeds. Contain atrazine

Color denotes: Sign. lower control than best trts. using P=0.05 LSDs, P=0.01

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2014 Sweet Corn Weed Control

Waseca MN

Becker, Fritz, Rohwer, Hoverstad, Miller, Kinkaid

Herbicide Trt.	Product Rate/A (oz/A unless otherwise designated)	% Control Corw 7/02	Corw 7/10	Corw 7/24	Corw 8/27	Wibw 7/02	Wibw 7/10	Wibw 7/24	Wibw 8/27	Rrpw 7/02	Rrpw 7/10	Rrpw 7/24	Rrpw 8/27
Accent + Callisto + Safe + COC	0.65 + 2.5 + 0.25 + 1.2 pt	10.0	46.7	35.0	46.7	5.0	66.3	68.3	93.3	10.0	99.0	88.3	100.0
Accent + Callisto + Safe + COC + AMS	0.65 + 2.5 + 0.25 + 1.2 pt + 2 lbs	25.0	60.0	80.0	55.7	13.3	69.7	55.0	85.0	38.3	87.7	100.0	99.7
Accent + Callisto + Safe + NIS + AMS	0.65 + 2.5 + 0.25 + 4.8 + 2 lbs	10.0	62.7	75.0	58.3	5.0	75.3	70.0	90.0	10.0	94.3	93.3	100.0
Accent + Callisto + Safe + COC + AMS + atra	0.65 + 2.5 + 0.25 + 1.2 pt + 2 lbs + 1 pt	32.7	98.0	100.0	99.0	36.7	99.3	100.0	100.0	40.0	99.0	100.0	100.0
Accent + Callisto + Safe + COC	0.77 + 2.94 + 0.296 + 1.2 pt	50.0	70.3	76.7	64.0	36.3	84.3	86.7	100.0	63.3	86.0	93.3	90.0
Accent + Callisto + Safe + COC + AMS	0.77 + 2.94 + 0.296 + 1.2 pt + 2 lbs	7.6	65.7	52.0	66.2	3.3	39.4	35.3	84.3	7.7	99.3	100.0	100.0
Accent + Callisto + Safe + NIS + AMS	0.77 + 2.94 + 0.296 + 4.8 + 2 lbs	26.7	83.3	88.3	77.7	30.0	66.3	63.3	75.0	33.3	73.0	80.0	81.7
Accent + Callisto + Safe + COC + AMS + atra	0.77 + 2.94 + 0.296 + 1.2 pt + 2 lbs + 1 pt	26.7	86.7	79.7	87.7	20.0	71.7	48.0	80.0	36.7	99.0	100.0	100.0
(Breakfree) Accent + Callisto + Safe + COC + AMS	(1.5 pt) 0.65 + 2.5 + 0.25 + 1.2 pt + 2 lbs	79.3	96.3	94.0	90.7	84.7	88.0	83.3	88.3	99.7	99.0	100.0	100.0
(Breakfree) Accent + Callisto + Safe + COC + AMS + atra	(1.5 pt) 0.65 + 2.5 + 0.25 + 1.2 pt + 2 lbs + 1 pt	96.3	100.0	96.7	100.0	99.7	99.0	95.0	100.0	100.0	99.0	100.0	100.0
(Breakfree) Laudis + MSO + 28% UAN	(1.5 pt) 3 + 1.2 pt + 2 pt	68.0	99.7	100.0	100.0	85.7	87.0	65.7	89.3	98.3	99.0	100.0	100.0
(Breakfree) Impact + MSO + 28% UAN	(1.5 pt) 1 + 1.2 pt + 2 pt	76.7	99.3	100.0	100.0	86.7	89.0	82.7	94.0	100.0	99.0	96.7	100.0
(Breakfree) Capreno	(1.5 pt) 3	100.0	100.0	100.0	100.0	100.0	81.0	95.0	96.3	100.0	99.0	100.0	100.0
(Breakfree) Sharpen	(1.5 pt) 2	100.0	100.0	100.0	100.0	100.0	99.3	100.0	99.0	100.0	99.0	100.0	100.0
(Anthem)	(10)	58.3	31.7	53.3	25.0	46.7	20.0	0.0	41.7	93.3	63.0	93.3	91.7
Solstice + COC + AMS	3 + 1.2 pt + 1.28 lb	20.0	68.3	80.7	89.7	11.7	64.7	53.3	90.0	18.3	97.7	100.0	100.0
(Anthem) Solstice + COC + AMS	(10) 3 + 1.2 pt + 1.28 lb	87.7	91.7	86.7	89.0	99.0	88.0	68.3	92.3	99.7	99.0	100.0	100.0
(Anthem ATZ) Solstice + COC + AMS	(1 qt) 3 + 1.2 pt + 1.28 lb	100.0	100.0	100.0	100.0	100.0	99.0	100.0	100.0	100.0	99.0	100.0	100.0
(Acuron [SYN-A197])	3 qt	100.0	100.0	100.0	100.0	100.0	99.0	100.0	100.0	100.0	99.0	100.0	100.0
(SYN-A205)	2.25 qt	100.0	98.3	100.0	100.0	100.0	96.3	96.7	99.0	100.0	99.0	100.0	100.0
Untreated Check	--	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
(PRE) POST 2-4 in. weeds. Contain atrazine	LSD @ P=0.05	28.4	17.6	23.6	27.9	34.1	33.1	42.2	25.4	39.3	24.9	16.5	14.5

Color denotes: Sign. lower control than best trts. using P=0.05 LSDs, P=0.01

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Common purslane pressure very sporadic. Do not use to determine product efficacy. May give insight to potential activity.

2014 Sweet Corn Weed Control

Waseca MN

Becker, Fritz, Rohwer, Hoverstad, Miller, Kinkaid

		% Control			
		Copl			
Herbicide Trt.	Product Rate/A (oz/A unless otherwise designated)	7/02	7/10	7/24	8/27
Accent + Callisto + Safe + COC	0.65 + 2.5 + 0.25 + 1.2 pt	15.0	47.5	43.3	60.0
Accent + Callisto + Safe + COC + AMS	0.65 + 2.5 + 0.25 + 1.2 pt + 2 lbs	22.5	35.0	38.3	42.5
Accent + Callisto + Safe + NIS + AMS	0.65 + 2.5 + 0.25 + 4.8 + 2 lbs	15.0	73.3	75.0	70.0
Accent + Callisto + Safe + COC + AMS + atra	0.65 + 2.5 + 0.25 + 1.2 pt + 2 lbs + 1 pt	57.5	88.0		
Accent + Callisto + Safe + COC	0.77 + 2.94 + 0.296 + 1.2 pt	10.0	20.0	15.0	5.0
Accent + Callisto + Safe + COC + AMS	0.77 + 2.94 + 0.296 + 1.2 pt + 2 lbs	15.0	60.0		
Accent + Callisto + Safe + NIS + AMS	0.77 + 2.94 + 0.296 + 4.8 + 2 lbs	15.0	67.5	25.0	
Accent + Callisto + Safe + COC + AMS + atra	0.77 + 2.94 + 0.296 + 1.2 pt + 2 lbs + 1 pt	22.5	76.5	66.7	70.0
(Breakfree) Accent + Callisto + Safe + COC + AMS	(1.5 pt) 0.65 + 2.5 + 0.25 + 1.2 pt + 2 lbs	100.0	89.0	100.0	
(Breakfree) Accent + Callisto + Safe + COC + AMS + atra	(1.5 pt) 0.65 + 2.5 + 0.25 + 1.2 pt + 2 lbs + 1 pt	100.0			
(Breakfree) Laudis + MSO + 28% UAN	(1.5 pt) 3 + 1.2 pt + 2 pt	100.0		100.0	
(Breakfree) Impact + MSO + 28% UAN	(1.5 pt) 1 + 1.2 pt + 2 pt	100.0		100.0	
(Breakfree) Capreno	(1.5 pt) 3	100.0		65.0	
(Breakfree) Sharpen	(1.5 pt) 2	100.0			
(Anthem)	(10)	88.3	46.7	80.0	75.0
Solstice + COC + AMS	3 + 1.2 pt + 1.28 lb	15.0	48.3	25.0	
(Anthem) Solstice + COC + AMS	(10) 3 + 1.2 pt + 1.28 lb	100.0			
(Anthem ATZ) Solstice + COC + AMS	(1 qt) 3 + 1.2 pt + 1.28 lb	100.0			
(Acuron [SYN-A197])	3 qt	100.0	90.0		
(SYN-A205)	2.25 qt	100.0			
Untreated Check	--	0.0	0.0	0.0	
	LSD @ P=0.05	22.5	48.5	44.9	NS

(PRE) POST 2-4 in. weeds. Contain atrazine

Color denotes: Sign. lower control than best trts. using P=0.05 LSDs, P=0.05

Color denotes: Sign. lower control than best trts. using P=0.05 LSDs, P=0.01

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2014 Sweet Corn Atrazine Replacement Trial

- Planted May 29, 2014
  - GG-641, 120 lb N Urea incorporated
- PRE applied May 29, 2014
- POST applied June 26, 2014
  - (2 to 4 inch weeds)
- RCB, 4 reps, 10 x 27 ft plots, 4 - 30 in. rows
- POST 40 lb/A Agrotain N July 18, 2014
- 23,000/A
- (Capreno not promoted, Sharpen not labeled on sweet)

Regional Atrazine Replacement Study on Sweet Corn
Waseca MN 2014 Becker, Fritz, Rohwer, Hoverstad

Trt.	Product (PRE) POST*	Rate/A	Cult.	Stand /A	Barren stalks/A	Ears/A	Fr wt. ton/A
				Harvest 9/3/2014			
1	(Atrazine)	(1.98 qt)		22651.2	1415.7	18186.3	4.681
2	(Atrazine) Atrazine + Callisto + COC	(1.98 qt) 0.45 qt + 3 fl oz + 0.8 qt		21017.7	1306.8	18077.4	5.192
3	Atrazine + Callisto + COC	0.75 qt + 3 fl oz + 0.8 qt		23522.4	980.1	18839.7	4.429
4	Impact + MSO + UAN - Cult V 4-5	1 fl oz + 0.8 qt + 1 qt	Yes	19819.8	1197.9	17097.3	5.011
5	Impact + MSO + UAN	1 fl oz + 0.8 qt + 1 qt		20582.1	1415.7	16335.0	4.710
6	Laudis + MSO + UAN - Cult V 4-5	3 fl oz + 0.8 qt + 1 qt	Yes	21453.3	544.5	20146.5	6.128
7	Laudis + MSO + UAN	3 fl oz + 0.8 qt + 1 qt		21453.3	980.1	19819.8	5.278
8	Impact + Basagran + COC + Cult V 4-5	1 fl oz +1 qt + 0.8 qt	Yes	21780.0	980.1	18077.4	4.516
9	Impact + Basagran + COC	1 fl oz +1 qt + 0.8 qt		23304.6	762.3	20255.4	4.525
10	Impact + Accent + COC + UAN + Cult V 4-5	1 fl oz + 0.65 fl oz + 0.8 qt + 1 qt	Yes	21888.9	1089.0	19166.4	5.776
11	Impact + Accent + COC + UAN	1 fl oz + 0.65 fl oz + 0.8 qt + 1 qt		22977.9	762.3	20146.5	6.032
12	(Capreno) + Cult V 4-5	(3 fl oz)	Yes	22651.2	1197.9	19384.2	4.635
13	(Capreno)	(3 fl oz)		20582.1	435.6	17859.6	4.130
14	(Sharpen) + Cult V 4-5	(2 fl oz)	Yes	23413.5	871.2	19275.3	4.610
15	(Sharpen)	(2 fl oz)		22106.7	0.0	20146.5	5.004
16	Handweed + Cult V2, V4, and Layby	--	Yes	23086.8	653.4	19384.2	4.396
		LSD @ P=0.05		NS	NS	NS	NS

* applied Outlook @ 18 oz/APRE to all plots

Color denotes:
- Sign. more than lowest value at P=0.10 (green: Barren stalks/A for Trt. 1, 2, 3, 4, 5, 7, 8, 10, 12, 14)
- Sign. lower than highest yield at P=0.10 (orange: Ears/A for Trt. 4, 5)

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Regional Atrazine Replacement Study on Sweet Corn

Waseca MN 2014 Becker, Fritz, Rohwer, Hoverstad

Trt.	Product (PRE) POST*	Rate/A	Cult.	July 2 Wibw	July 10 Wpm	July 24 Wibw	Aug 27 Wibw	July 2 Vele	July 10 Vele
1	(Atrazine)	(1.98 qt)		100.0	97.5	96.3	92.3	99.5	97.3
2	(Atrazine) Atrazine + Callisto + COC	(1.98 qt) 0.45 qt + 3 fl oz + 0.8 qt		100.0	100.0	100.0	100.0	100.0	100.0
3	Atrazine + Callisto + COC	0.75 qt + 3 fl oz + 0.8 qt		63.0	98.8	100.0	100.0	65.0	100.0
4	Impact + MSO + UAN - Cult V 4-5	1 fl oz + 0.8 qt + 1 qt	Yes	22.5	57.0	54.8	77.8	32.5	97.5
5	Impact + MSO + UAN	1 fl oz + 0.8 qt + 1 qt		3.0	39.8	46.3	53.8	35.0	91.0
6	Laudis + MSO + UAN - Cult V 4-5	3 fl oz + 0.8 qt + 1 qt	Yes	33.8	83.8	79.0	88.3	45.0	96.3
7	Laudis + MSO + UAN	3 fl oz + 0.8 qt + 1 qt		49.8	75.3	67.5	85.5	35.0	97.5
8	Impact + Basagran + COC + Cult V 4-5	1 fl oz +1 qt + 0.8 qt	Yes	92.8	97.5	100.0	100.0	96.8	100.0
9	Impact + Basagran + COC	1 fl oz +1 qt + 0.8 qt		98.0	93.8	100.0	93.3	82.3	100.0
10	Impact + Accent + COC + UAN + Cult V 4-5	1 fl oz + 0.65 fl oz + 0.8 qt + 1 qt	Yes	0.0	58.8	39.5	81.0	33.3	96.0
11	Impact + Accent + COC + UAN	1 fl oz + 0.65 fl oz + 0.8 qt + 1 qt		0.0	48.8	48.8	70.8	36.7	100.0
12	(Capreno) + Cult V 4-5	(3 fl oz)	Yes	80.8	56.3	73.8	84.5	100.0	96.3
13	(Capreno)	(3 fl oz)		72.8	67.5	52.5	82.0	100.0	100.0
14	(Sharpen) + Cult V 4-5	(2 fl oz)	Yes	100.0	92.5	96.3	100.0	100.0	100.0
15	(Sharpen)	(2 fl oz)		100.0	100.0	100.0	99.5	100.0	100.0
16	Handweed + Cult V2, V4, and Layby	--	Yes	22.5	22.5	100.0	97.5	2.5	0.0
		LSD @ P=0.05		37.2	25.7	34.4	11.9	44.4	6.1

* applied Outlook @ 18 oz/APRE to all plots

Color denotes: Sign. lower than best control at P=0.01

Regional Atrazine Replacement Study on Sweet Corn

Waseca MN 2014 Becker, Fritz, Rohwer, Hoverstad

Trt.	Product (PRE) POST*	Rate/A	Cult.	July 2 Gift	July 10 Gift	July 24 Gift	Aug 27 Gift
1	(Atrazine)	(1.98 qt)		100.0	99.8	100.0	98.0
2	(Atrazine) Atrazine + Callisto + COC	(1.98 qt) 0.45 qt + 3 fl oz + 0.8 qt		100.0	100.0	100.0	97.8
3	Atrazine + Callisto + COC	0.75 qt + 3 fl oz + 0.8 qt		98.3	97.0	97.5	93.8
4	Impact + MSO + UAN - Cult V 4-5	1 fl oz + 0.8 qt + 1 qt	Yes	100.0	100.0	100.0	99.8
5	Impact + MSO + UAN	1 fl oz + 0.8 qt + 1 qt		98.8	100.0	99.3	100.0
6	Laudis + MSO + UAN - Cult V 4-5	3 fl oz + 0.8 qt + 1 qt	Yes	98.0	98.8	99.3	98.8
7	Laudis + MSO + UAN	3 fl oz + 0.8 qt + 1 qt		99.8	99.3	99.8	97.8
8	Impact + Basagran + COC + Cult V 4-5	1 fl oz +1 qt + 0.8 qt	Yes	95.3	98.5	100.0	98.5
9	Impact + Basagran + COC	1 fl oz +1 qt + 0.8 qt		97.8	99.3	98.5	97.0
10	Impact + Accent + COC + UAN + Cult V 4-5	1 fl oz + 0.65 fl oz + 0.8 qt + 1 qt	Yes	98.8	100.0	99.0	99.8
11	Impact + Accent + COC + UAN	1 fl oz + 0.65 fl oz + 0.8 qt + 1 qt		99.8	100.0	100.0	98.0
12	(Capreno) + Cult V 4-5	(3 fl oz)	Yes	99.0	97.3	99.3	99.3
13	(Capreno)	(3 fl oz)		99.5	99.0	99.3	97.0
14	(Sharpen) + Cult V 4-5	(2 fl oz)	Yes	99.3	99.0	96.3	98.5
15	(Sharpen)	(2 fl oz)		100.0	100.0	99.3	97.8
16	Handweed + Cult V2, V4, and Layby	--	Yes	97.8	98.8	100.0	98.5
		LSD @ P=0.05		2.4	NS	NS	NS

* applied Outlook @ 18 oz/APRE to all plots

Color denotes:
- Sign. lower than best control at P=0.05
- Sign. lower than best control at P=0.10

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Regional Atrazine Replacement Study on Sweet Corn

Waseca MN 2014 Becker, Fritz, Rohwer, Hoverstad

				July 10	July 2	July 10	July 2	July 24	Aug 27	July 24	Aug 27
Trt.	Product (PRE) POST*	Rate/A	Cult.	% SR	% GR	% GR	% Chloro	% Chlor	% Chlor	% Nec	% Nec
1	(Atrazine)	(1.98 qt)		0.0	0.0	0.8	0.0	0.0	0.0	0.0	0.0
2	(Atrazine) Atrazine + Callisto + COC	(1.98 qt) 0.45 qt + 3 fl oz + 0.8 qt		0.8	9.3	15.3	0.0	0.0	0.0	0.0	0.0
3	Atrazine + Callisto + COC	0.75 qt + 3 fl oz + 0.8 qt		0.0	13.8	11.5	0.0	0.0	0.0	0.0	0.0
4	Impact + MSO + UAN - Cult V 4-5	1 fl oz + 0.8 qt + 1 qt	Yes	0.0	23.0	20.8	0.0	0.0	0.0	0.0	0.0
5	Impact + MSO + UAN	1 fl oz + 0.8 qt + 1 qt		0.0	5.0	8.3	0.0	0.0	0.0	0.0	0.0
6	Laudis + MSO + UAN - Cult V 4-5	3 fl oz + 0.8 qt + 1 qt	Yes	0.0	4.8	9.5	0.0	0.0	0.0	0.0	0.0
7	Laudis + MSO + UAN	3 fl oz + 0.8 qt + 1 qt		0.0	12.5	11.8	0.0	0.0	0.0	0.0	0.0
8	Impact + Basagran + COC + Cult V 4-5	1 fl oz +1 qt + 0.8 qt	Yes	0.0	8.8	9.3	0.0	0.0	0.0	0.0	0.0
9	Impact + Basagran + COC	1 fl oz +1 qt + 0.8 qt		0.0	13.0	20.0	0.0	0.0	0.0	0.0	0.0
10	Impact + Accent + COC + UAN + Cult V 4-5	1 fl oz + 0.65 fl oz + 0.8 qt + 1 qt	Yes	0.0	7.0	5.3	0.0	0.0	0.0	0.0	0.0
11	Impact + Accent + COC + UAN	1 fl oz + 0.65 fl oz + 0.8 qt + 1 qt		0.0	15.0	8.8	0.0	0.0	0.0	0.0	0.0
12	(Capreno) + Cult V 4-5	(3 fl oz)	Yes	0.0	11.8	9.8	0.0	0.0	0.0	0.0	0.0
13	(Capreno)	(3 fl oz)		0.0	1.3	1.3	0.0	0.0	0.0	0.0	0.0
14	(Sharpen) + Cult V 4-5	(2 fl oz)	Yes	0.0	8.8	4.0	0.0	0.0	0.0	0.0	0.0
15	(Sharpen)	(2 fl oz)		0.0	14.5	12.3	0.0	0.0	0.0	0.0	0.0
16	Handweed + Cult V2, V4, and Layby	--	Yes	0.0	15.0	12.8	0.0	0.0	0.0	0.0	0.0
	* applied Outlook @ 18 oz/APRE to all plots	LSD @ P=0.05		NS	NS	10.9	NS	NS	NS	NS	NS

Color denotes: Sign. more injury vs. lowest value at P=0.05

University of Minnesota Extension

Regional Atrazine Replacement Study on Sweet Corn

Waseca MN 2014 Becker, Fritz, Rohwer, Hoverstad

Trt.	Product (PRE) POST*	Rate/A	Cult.	Harvest 9/3/2014 Stand /A	Barren stalks/A	Ears/A	Fr wt. ton/A
1	(Atrazine)	(1.98 qt)		22651.2	1415.7	18186.3	4.681
2	(Atrazine) Atrazine + Callisto + COC	(1.98 qt) 0.45 qt + 3 fl oz + 0.8 qt		21017.7	1306.8	18077.4	5.192
3	Atrazine + Callisto + COC	0.75 qt + 3 fl oz + 0.8 qt		23522.4	980.1	18839.7	4.429
4	Impact + MSO + UAN - Cult V 4-5	1 fl oz + 0.8 qt + 1 qt	Yes	19819.8	1197.9	17097.3	5.011
5	Impact + MSO + UAN	1 fl oz + 0.8 qt + 1 qt		20582.1	1415.7	16335.0	4.710
6	Laudis + MSO + UAN - Cult V 4-5	3 fl oz + 0.8 qt + 1 qt	Yes	21453.3	544.5	20146.5	6.128
7	Laudis + MSO + UAN	3 fl oz + 0.8 qt + 1 qt		21453.3	980.1	19819.8	5.278
8	Impact + Basagran + COC + Cult V 4-5	1 fl oz +1 qt + 0.8 qt	Yes	21780.0	980.1	18077.4	4.516
9	Impact + Basagran + COC	1 fl oz +1 qt + 0.8 qt		23304.6	762.3	20255.4	4.525
10	Impact + Accent + COC + UAN + Cult V 4-5	1 fl oz + 0.65 fl oz + 0.8 qt + 1 qt	Yes	21888.9	1089.0	19166.4	5.776
11	Impact + Accent + COC + UAN	1 fl oz + 0.65 fl oz + 0.8 qt + 1 qt		22977.9	762.3	20146.5	6.032
12	(Capreno) + Cult V 4-5	(3 fl oz)	Yes	22651.2	1197.9	19384.2	4.635
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14	(Sharpen) + Cult V 4-5	(2 fl oz)	Yes	23413.5	871.2	19275.3	4.610
15	(Sharpen)	(2 fl oz)		22106.7	0.0	20146.5	5.004
16	Handweed + Cult V2, V4, and Layby	--	Yes	23086.8	653.4	19384.2	4.396
		LSD @ P=0.05		NS	NS	NS	NS

* applied Outlook @ 18 oz/APRE to all plots

Color denotes:
- Sign. more than lowest value at P=0.10 (green: barren stalks values for Trt. 1, 2, 3, 4, 5, 7, 8, 10, 12, 14)
- Sign. lower than highest yield at P=0.10 (orange: ears values for Trt. 4, 5)

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Roundup Resistance

Horseweed (marestail)

- only weed with confirmed glyphosate resistance

Spreading rapidly west from Delaware

Other possible suspects

- Common lambsquarters
- Common ragweed
- Common waterhemp

The evolution of resistance is inevitable, but:

- When?
- How rapidly it will spread?
- Economic impact and management implications?

Roundup Resistance

Horseweed (marestail), Giant ragweed, Waterhemp

Other possible suspects

- **Common lambsquarters (tolerance)**
- **Common ragweed**

The evolution of resistance is inevitable, but:

- **When?**
- **How rapidly it will spread?**
- **Economic impact and management implications?**

GMO Era in Sweet Corn Weed Management?

Roundup resistant processing crops

Have we missed the boat?

Palmer Amaranth
Invasive Plants
What the Heck Is Going On?

Roger Becker
University of Minnesota
2014 Crop Pest Management Shortcourse

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

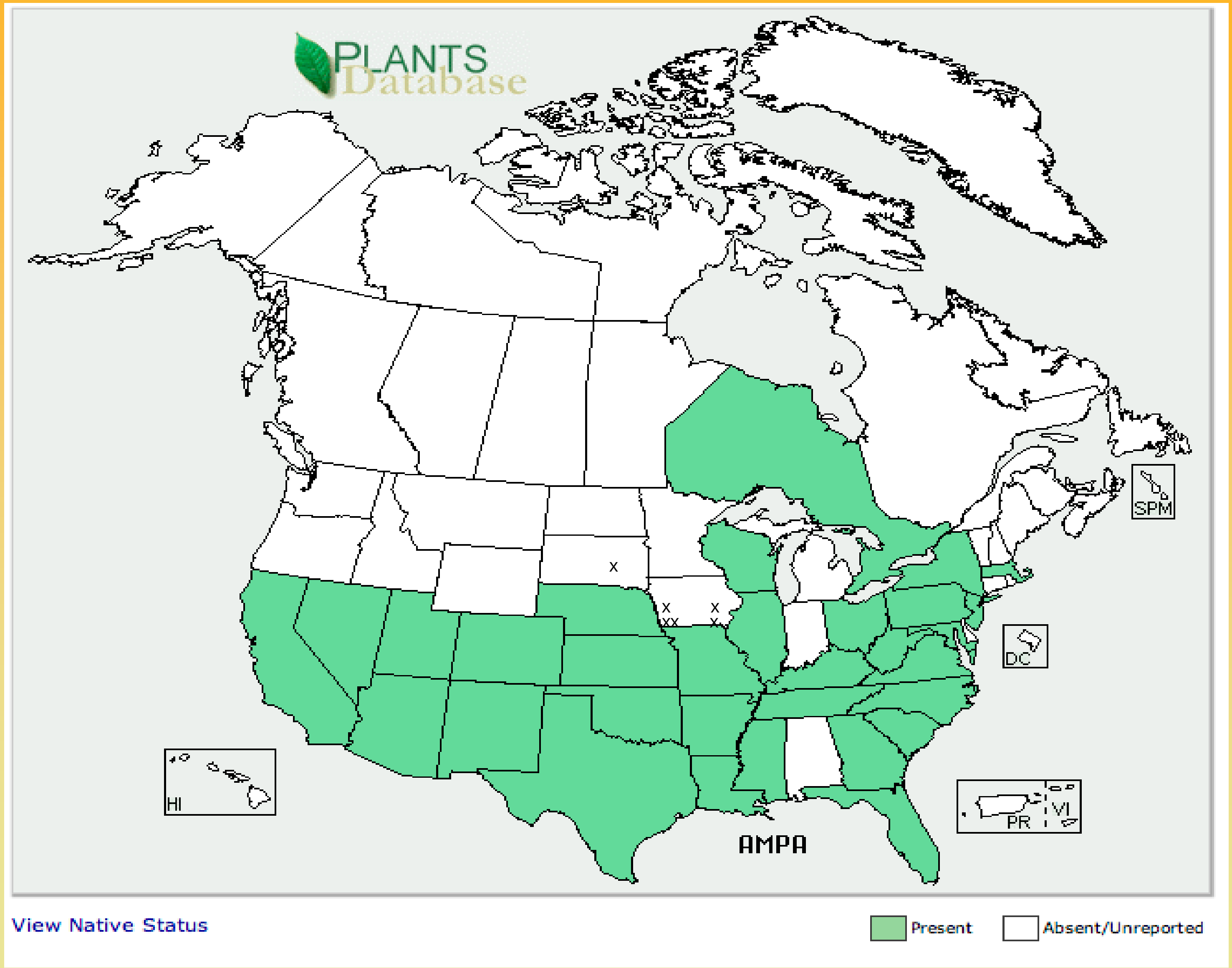
http://southeastfarmpress.com/management/waterhemp-showing-greater-resistance-glyphosate

Palmer Amaranth Distribution

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)

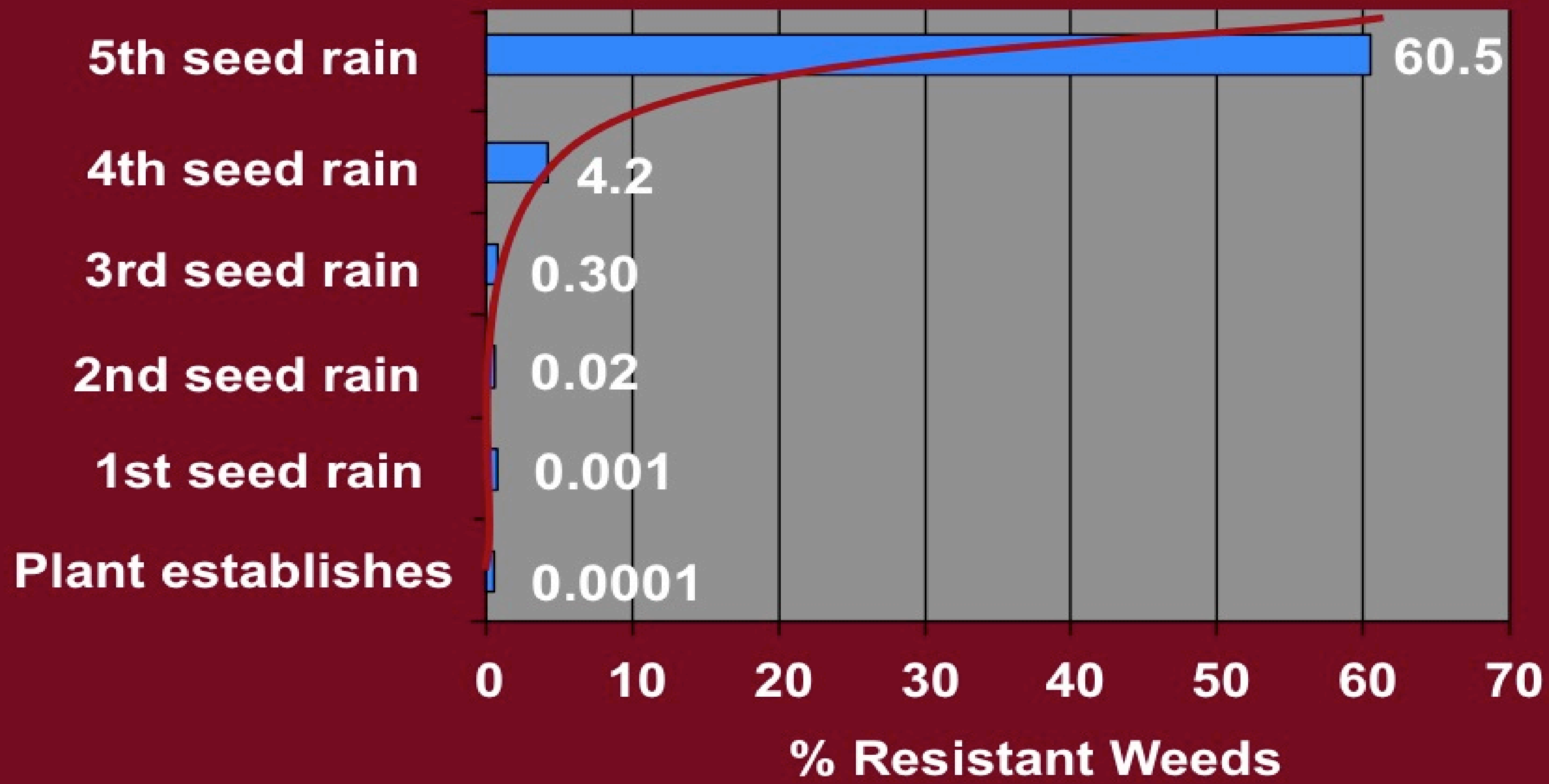
Herbicide resistant

- 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



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

Impacts of Herbicide Resistance to Weed Management Strategies



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

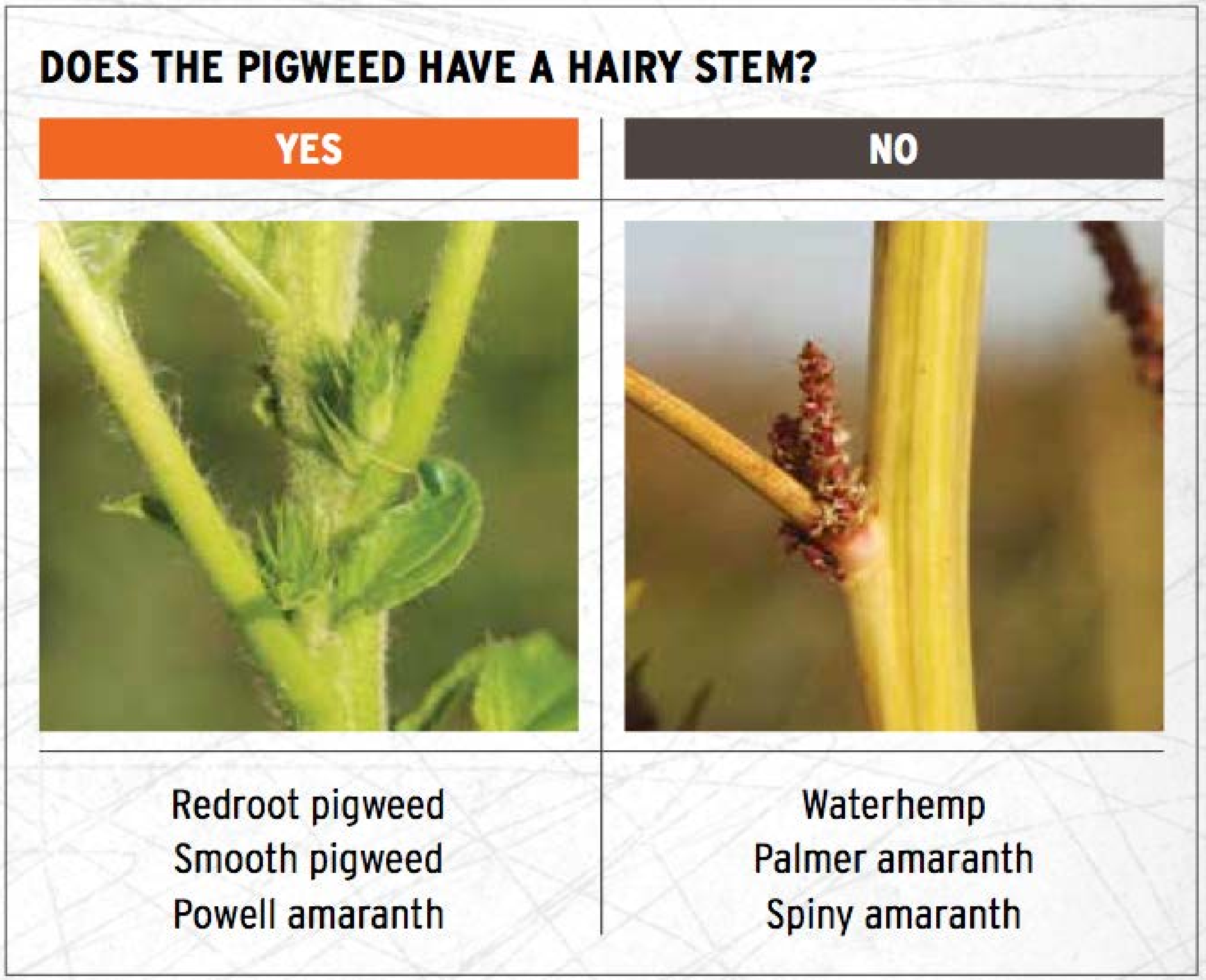
Palmer amaranth plant from above, notice the rosette leaf pattern that is similar to a poinsettia plant

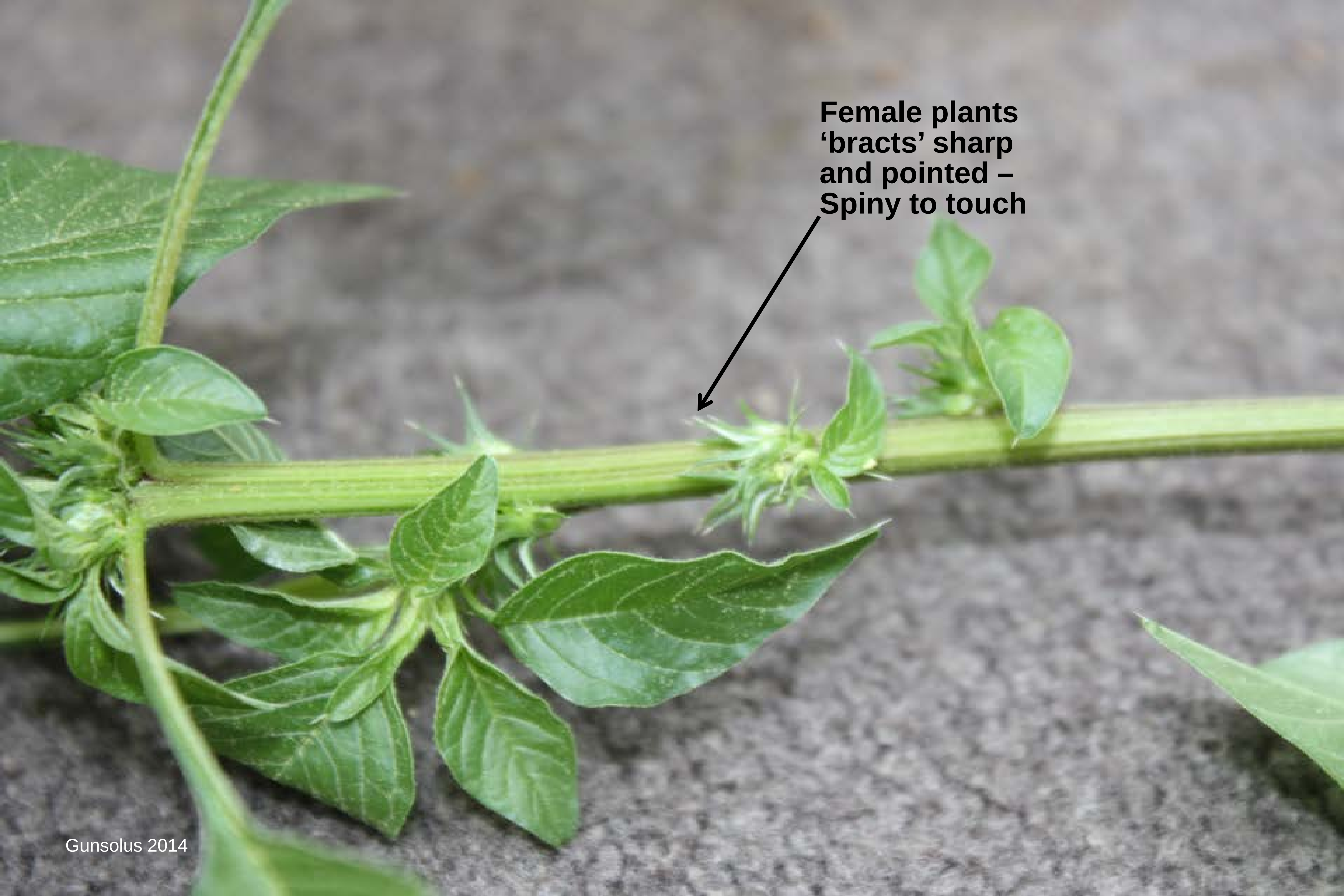
Palmer has long leaf petioles

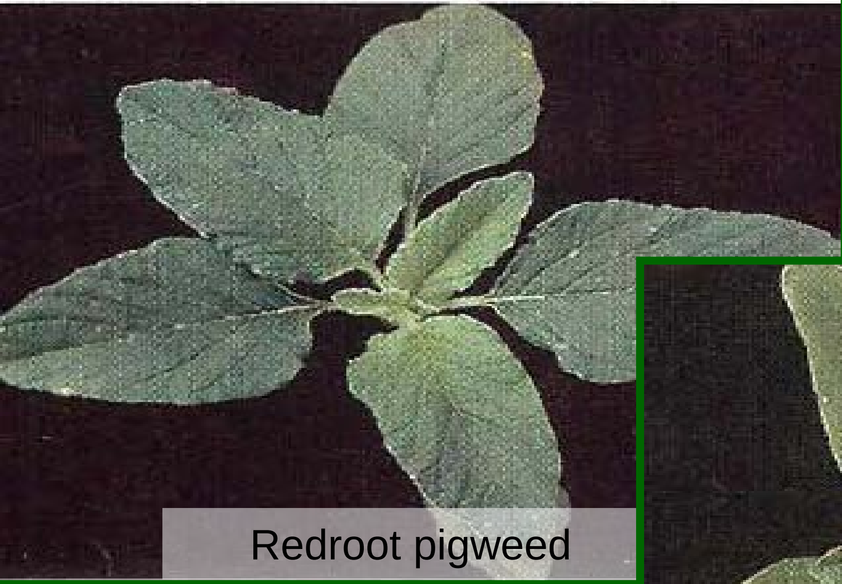
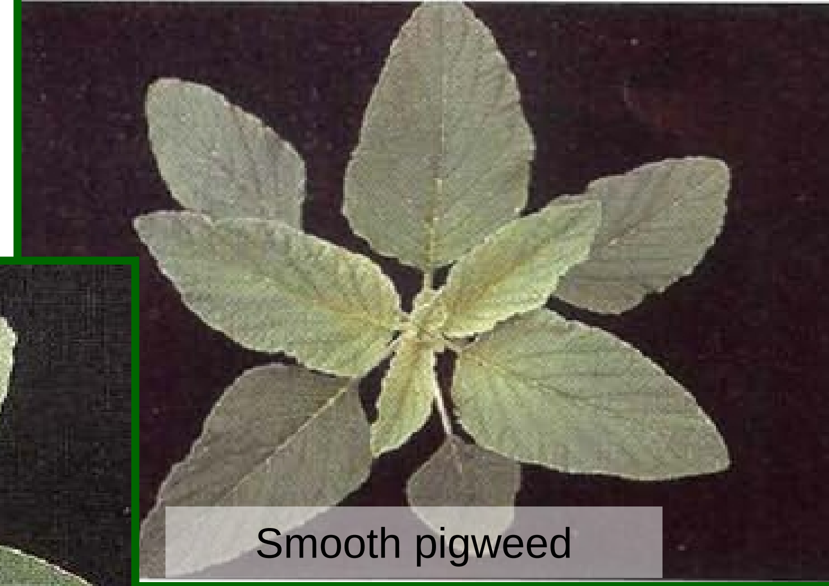
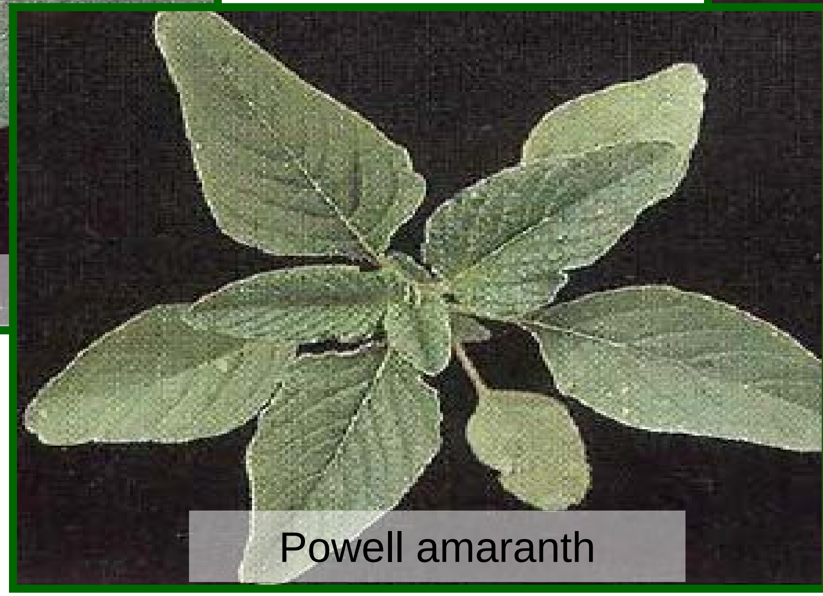
Gunsolus 2014

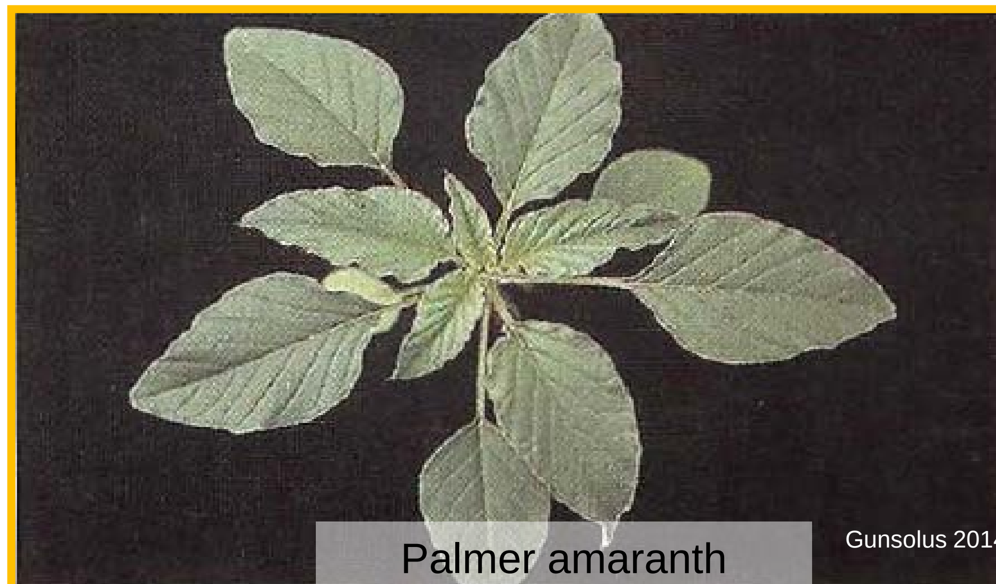
Palmer amaranth ID

Absence of hairs on stems and leaf surfaces

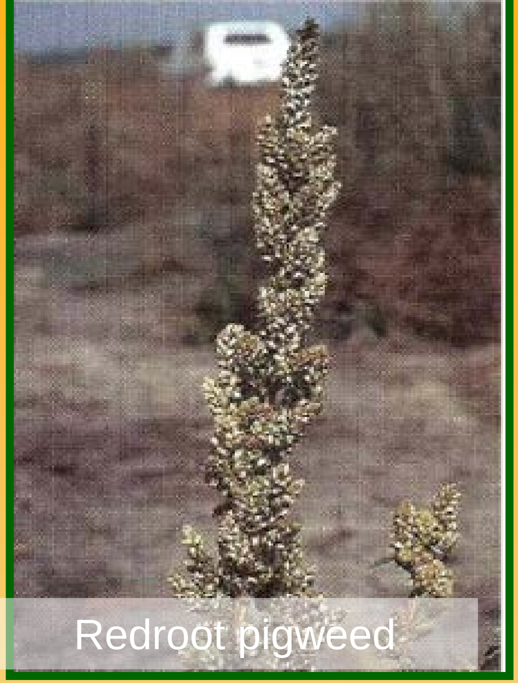



Female plants
'bracts' sharp
and pointed –
Spiny to touch
Gunsolus 2014


Redroot pigweed

Smooth pigweed

Powell amaranth

Waterhemp

Palmer amaranth
Gunsolus 2014

Amaranth ID


Redroot pigweed


Powell amaranth


Smooth pigweed

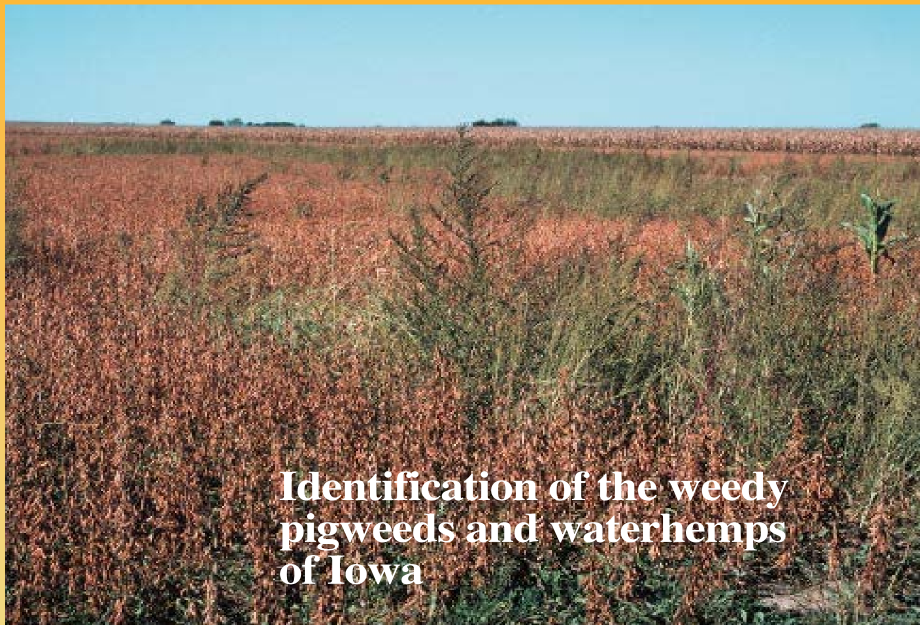

Waterhemp


Palmer amaranth

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 waterhemps 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-pdfhttps://store.extension.iastate.edu/Product/pm1786-pdf

IOWA STATE UNIVERSITY
University Extension

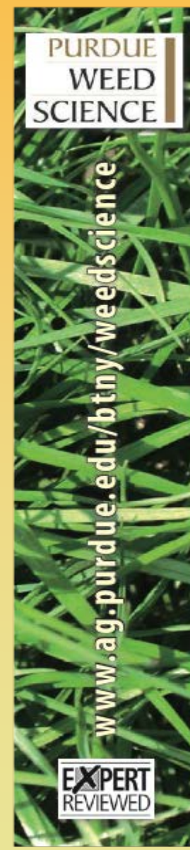
Pm-1786 April 1999

PURDUE EXTENSION | LOCAL FACES COUNTLESS CONNECTIONS

WS-51

Palmer Amaranth Biology, Identification, and Management

Authors:
Travis Legleiter
Bill Johnson



Palmer amaranth (*Amaranthus palmeri*) is an aggressive, invasive weed native to the desert regions of the southwest 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

Photos by Travis Legleiter, except Figures 7 and 8 by Tom Sinnot, Superior Ag Resources.

https://www.extension.purdue.edu/extmedia/WS/WS-51-W.pdf

Palmer Amaranth Resources

UT Extension
W069

Early Season Pigweed Identification

Larry Steckel, Assistant Professor, Plant Sciences

Figure 1. Smooth pigweed prior to seedhead emergence.

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 to 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.
- First leaves are rounded with small notch at leaf tips. **(Figure 2)**
- Leaf and stem surfaces are rough.
- Easily distinguished from redroot pigweed only in mature stages.

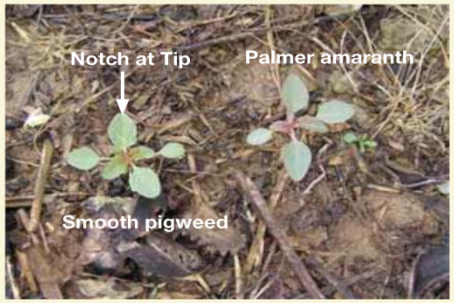


Figure 2. Smooth pigweed and Palmer amaranth in the seedling stage.

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.

Slender pigweed, also known as Green pigweed (*Amaranthus gracilis*) or (*Amaranthus viridis)*
- Seedlings are hairless.
- The first true leaves are egg-shaped and notched at the tip.

THE UNIVERSITY of TENNESSEE

http://www.utcrops.com/weeds/early season pigweed Identification.htm

UGA extension

The Biology and Ecology of Palmer Amaranth: Implications for Control

Lynn M. Sosnoskie, Theodore M. Webster, A. Stanley Culpepper, Jeremy Kichler

Palmer amaranth is a highly competitive weed of field corn, cotton, peanut and soybean and has been confirmed to be resistant to glyphosate in nearly every agronomic county in Georgia (Figure 1). Glyphosate-resistant (GR) Palmer amaranth's establishment and spread has been assisted by its rapid growth rate, extensive rooting structure, high seed production, physical seed movement (man, animal, water) and by pollen (wind) dispersal. Growers must understand the biology and ecology of GR Palmer amaranth if effective control is to be achieved.

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

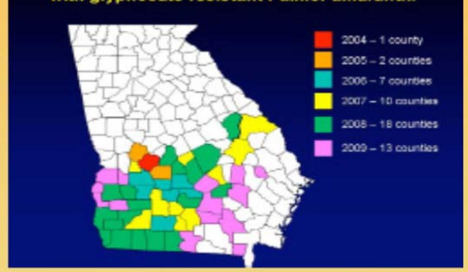


Figure 2. Growth of Palmer amaranth over 52 hours.

Rapid growth rate:
Palmer amaranth converts CO_2 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 3. The extensive Palmer amaranth root system. Photo by E. Prostko

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

Palmer Amaranth Resources

UNIVERSITY OF ILLINOIS
WEED SCIENCE
DEPARTMENT OF CROP SCIENCES
weeds.cropsci.illinois.edu

8/15/2013

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

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

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

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

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

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

Identification

Immature plants

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

Mature plants

Palmer amaranth plants are either male or female; male plants produce only pollen while female plants produce only seed. The terminal inflorescence of male and female plants is generally unbranched and very long (Figure 3). Female Palmer amaranth plants have a long terminal inflorescence (10 to 24 inches) with flowers containing 5 spatulate-shaped tepals. The tepals are about twice the length of the seed, and the seed capsule (utricle) 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://bulletin.ipm.illinois.edu/wp-content/uploads/2013/09/Guidelines-for-the-Identification-and-Management-of-Palmer-amaranth2.pdf

Eat The Weeds
and other things, too

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Palmer Amaranth

by GREEN DEANE
in FLOUR/STARCH,GRAIN/NUTS/SEEDS,GREENS/POT HERB,PLANTS,VEGETABLE

Glyphosate resistant Palmer Amaranth, photo by FireFlyForest.com

A farmer's headache is not necessarily a forager's delight.

Palmer Amaranth (*Amaranthus Palmeri*) has been a foraged food for a long time. It was used extensively by the native American population with at least seven tribes preparing it a wide variety of ways. More on that in a moment.

Amaranth, in general, is a good wild food. It occupies the middle ground between excellent and poor. When collected very young Amaranth is a dietary analogue to spinach, which is a relative. At the meristem stage, still young and tender because the cells are still growing, it's a tasty green usually boiled. Later it becomes a source of grain. These stages, however, are dynamic, changing and they change at different rates with different species of amaranth. Some amaranths stay more palatable longer than others. More so, depending upon growing conditions, amaranth can also accumulate high levels of nitrates and oxalates making them less than desirable to eat, for you or livestock.

Palmer Amaranth doesn't stay young and tender too long. It converts CO2 into sugars more efficiently than corn, cotton or soybean. This allows for rapid growth even when it's hot and dry because it also produces a large taproot that is studier than that of soybeans or corn and can

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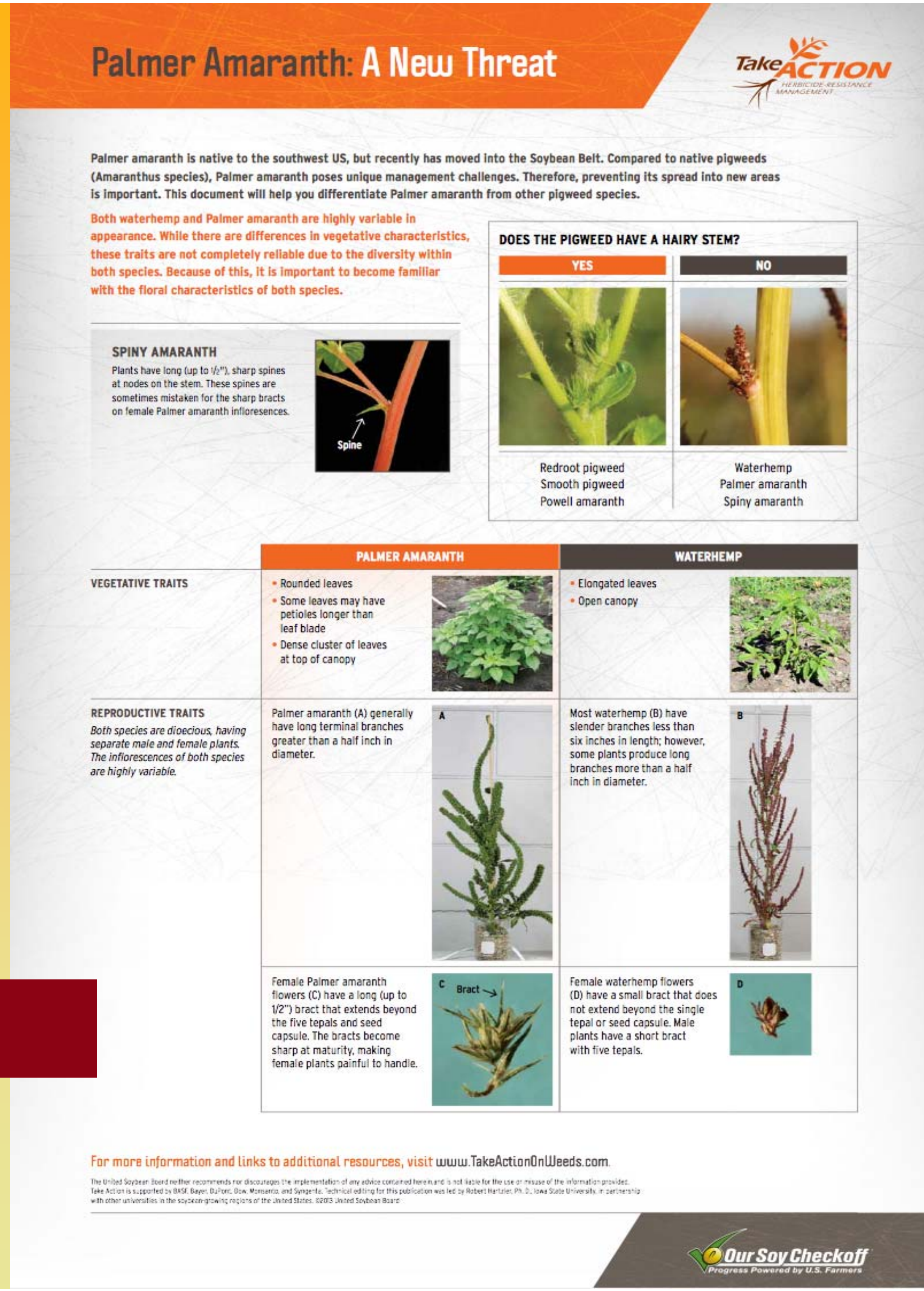

http://takeactiononweeds.com/wp-content/uploads/2014/01/palmer-amaranth-identification-poster.pdf

Palmer Amaranth

Prohibited noxious weed in row crops

- First row crop weed on Eradicate List

- Opportunity to delay/prevent Palmer amaranthus problems in Minnesota if / when it arrives

State Prohibited Noxious Weeds

Eradicate List

Yellow Starthistle*	*Centaurea solstitialis*
Grecian Foxglove	*Digitalis lanata*
Oriental Bittersweet	*Celastrus orbicaulatus*
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

Questions?