

Waterhemp Management

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Minnesota and Southern Minnesota Beet Sugar
Cooperative

NDSU

EXTENSION

UNIVERSITY OF MINNESOTA
EXTENSION

Between Herman and Wheaton MN, 2014

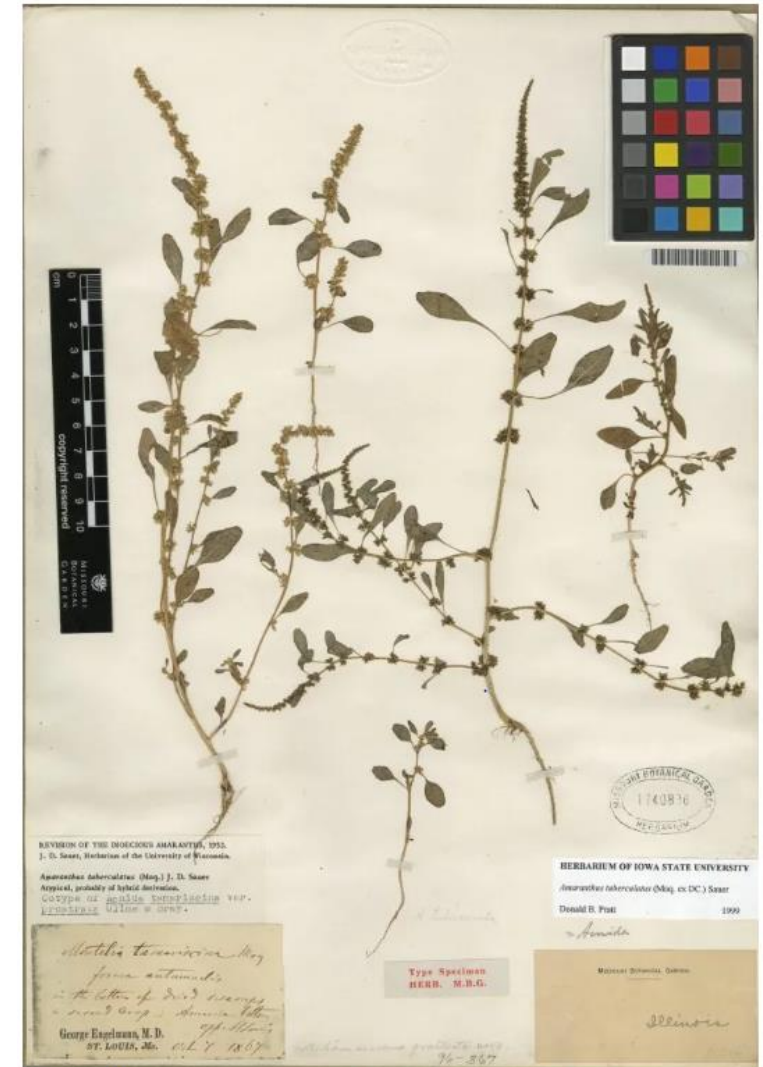
2014 Sugarbeet Field

- Thought it was redroot pigweed
- Water from the creek flooded the north west part of the field
- Creek is connected to the Niemakle Lake / watershed
- Waterfowl production area
- Waterhemp impeded soybean harvest in 2012
- Sugarbeet weed control research in 2013, 2014, and 2015



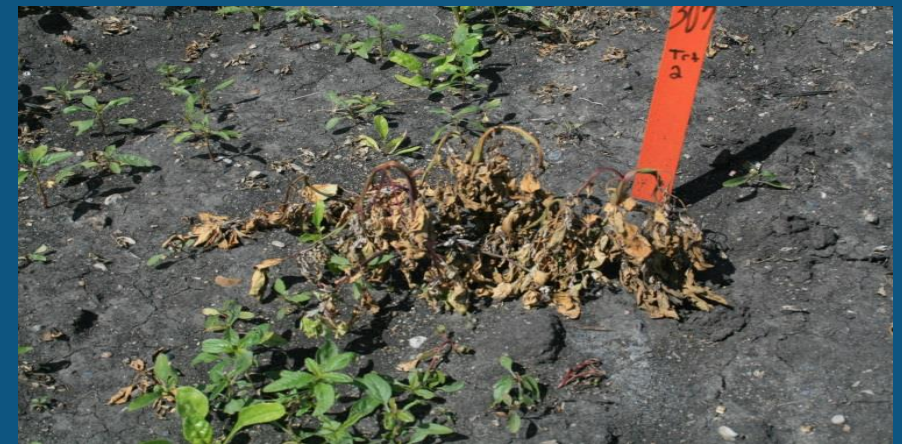
Waterhemp's journey from wetland habitat to agricultural

- Waterhemp is native to North America
- Common along the flood plains of southern and western Illinois (Sauer 1957)
- Compare genetic make-up of plants in fields to those in herbariums and museums
- Mutations in genes related to drought tolerance, rapid growth, and herbicide resistance
- Herbicide-resistant mutations (2 of 7) were discovered in plants from natural habitats
- Others have suggested hybridization with other pigweed species has improved its adaptation to MN soils



A 155-year-old waterhemp herbarium specimen from the Missouri Botanical Garden Herbarium. Credit: Julia Kreiner, University of British Columbia

Repeat Roundup PM + NIS + AMS applications, Herman MN, 2014



Does PowerMax control waterhemp in Grant and Kandiyohi Counties, MN?

| Treatment | Rate | Herman, 2014 | Lake Lillian, 2017 | Lake Lillian, 2017 |
|------------------|---------|--------------------|--------------------|--------------------|
| | fl oz/A | -----Count/m2----- | | |
| Roundup PowerMax | 28 | 101 | 192 | 116 |
| Control | 0 | 432 | 727 | 792 |



Number of waterhemp per meter square, June 6, 2017, Lake Lillian, MN

YES. 77% control at Herman and 76% control at Lake Lillian

Increasing the rate or repeat applications does not improve control

Repeat Roundup PM + NIS + AMS applications, Herman MN, 2014

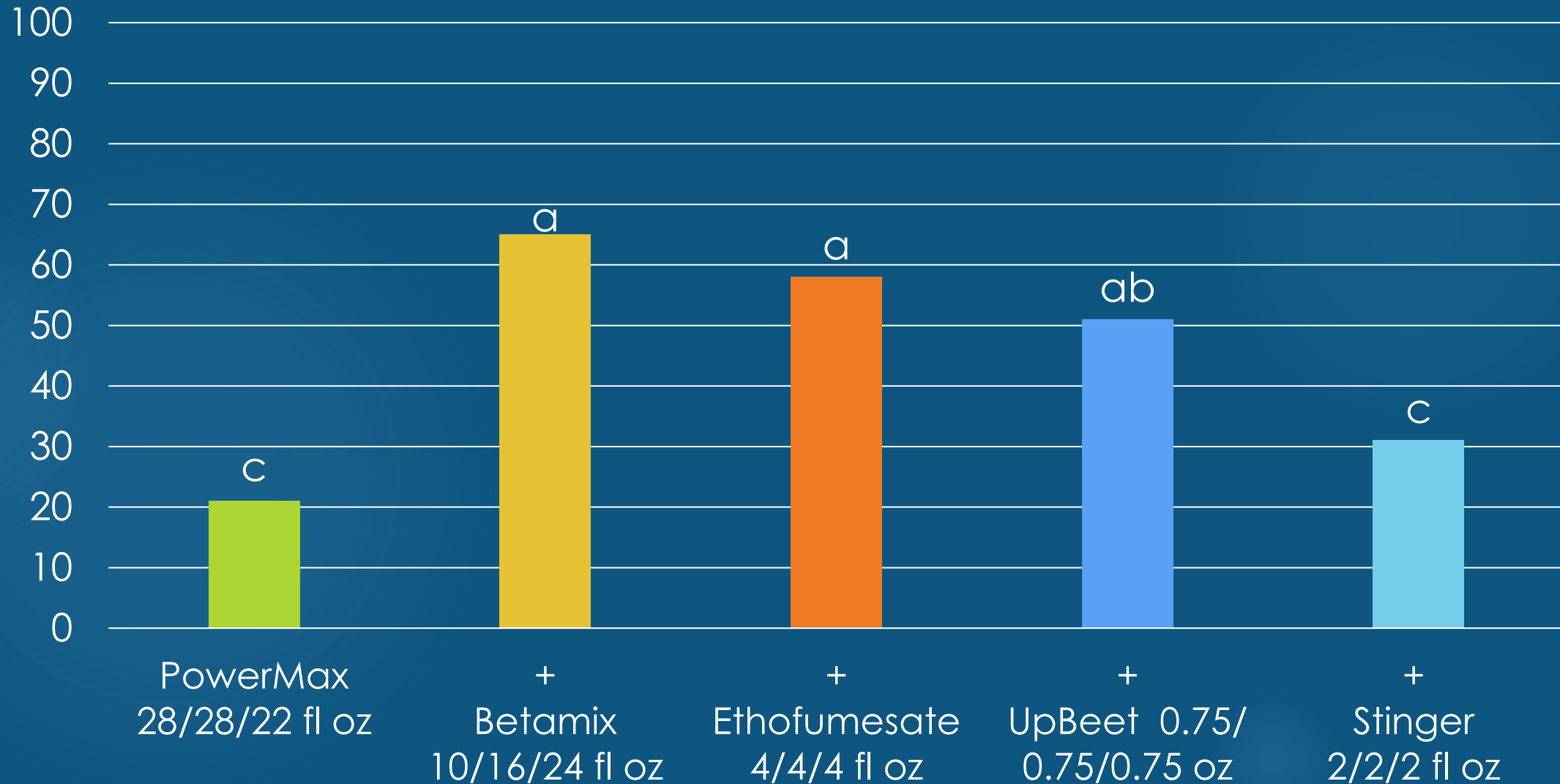


Repeat Roundup PM + NIS + AMS applications, Herman MN, 2014



RESULTS - Postemergence

Waterhemp Control – Aug. 27, 2014

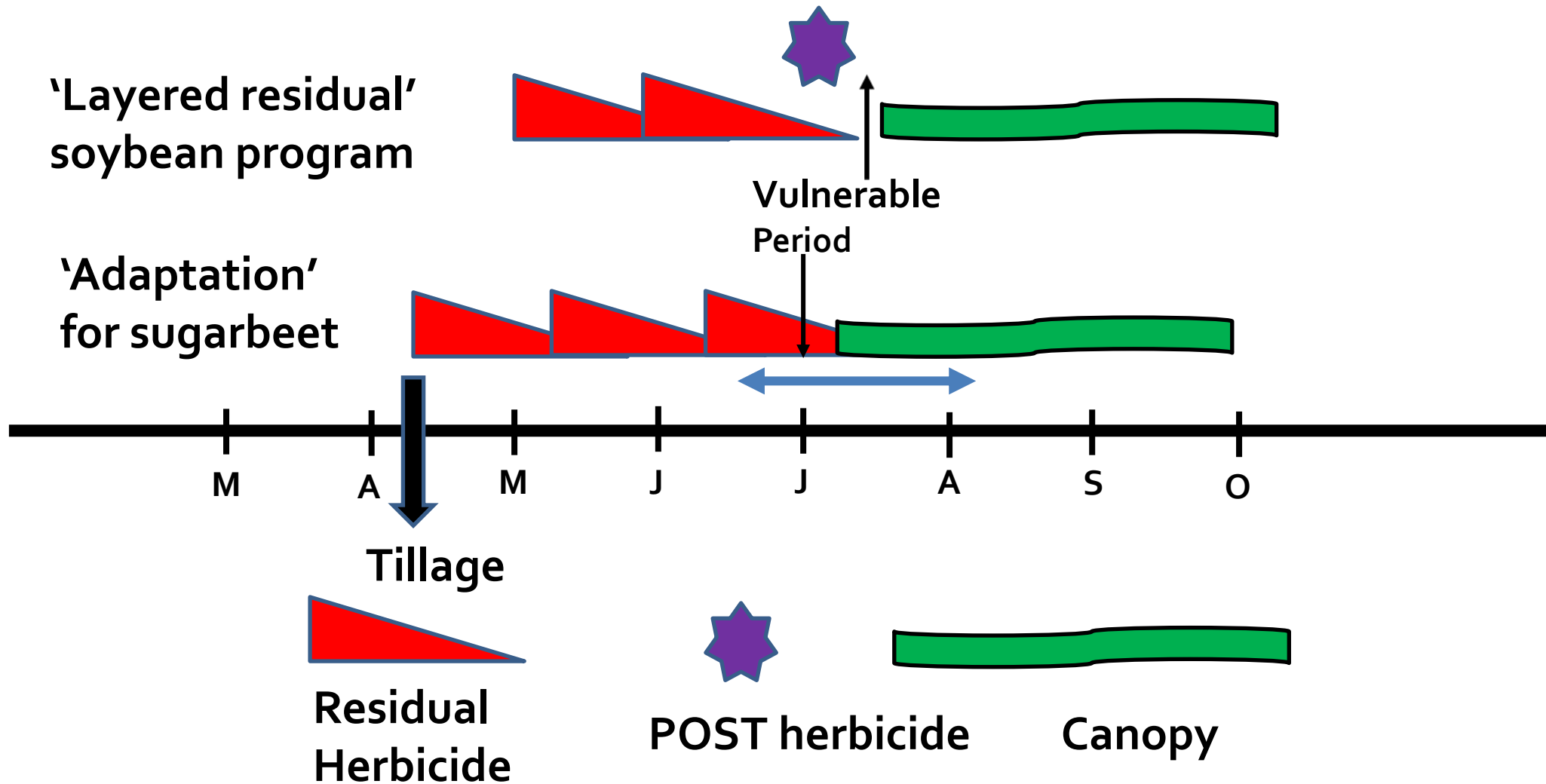


Waterhemp Control Program in Sugarbeet

| Planting Date | Recommendation |
|--|--|
| Sugarbeet plant in April or May | PRE. Dual Magnum at 0.5 to 0.75 pt/A, ethofumesate at 2 to 6 pt/A or Dual Magnum at 0.5 pt/A plus ethofumesate at 2 pt/A |
| | Split lay-by application (early postemergence / postemergence). Chloroacetamide herbicides applied at 2-lf sugarbeet fb 6- to 8-lf sugarbeet |
| June | Continue to scout fields for waterhemp. Control escapes with Ultra Blazer (Section 18ee), Liberty with the Redball™ 915 hooded sprayer (24c), or inter-row cultivation |
| July | Electric Discharge Systems (WeedZapper™) |
| August / September | Hand remove waterhemp |

Layered Residual Herbicides

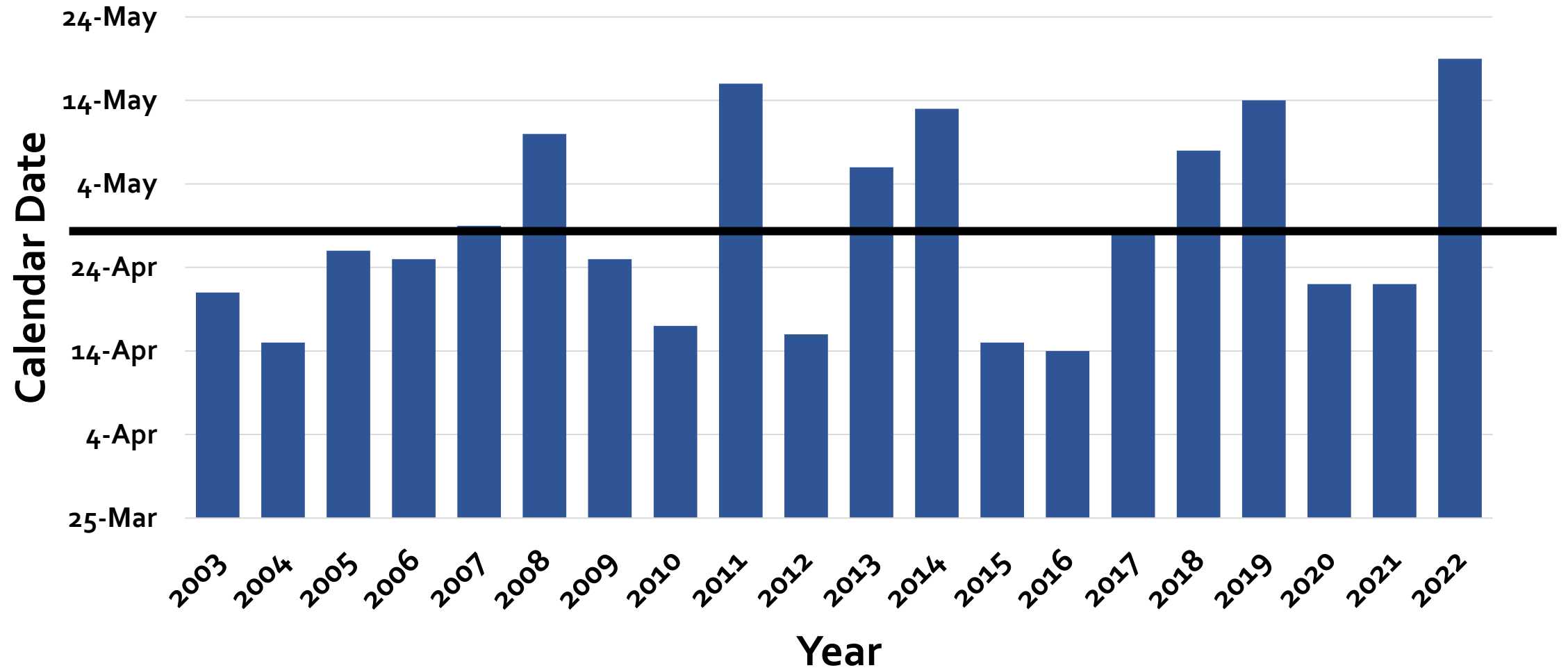
Objective: Prolong PRE activity until canopy fills



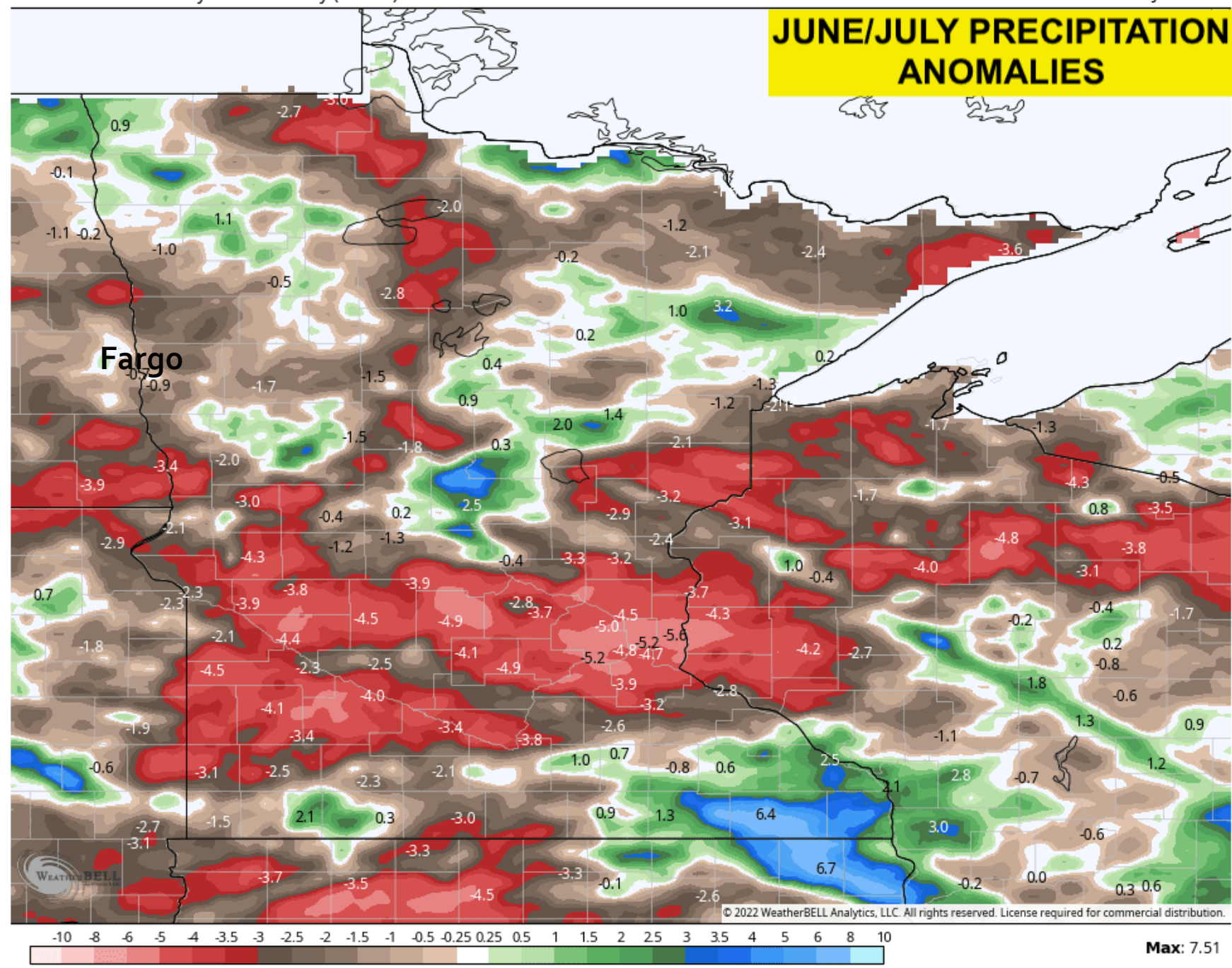




Average sugarbeet plant date, Southern MN Beet Sugar Coop, 2003 to 2022

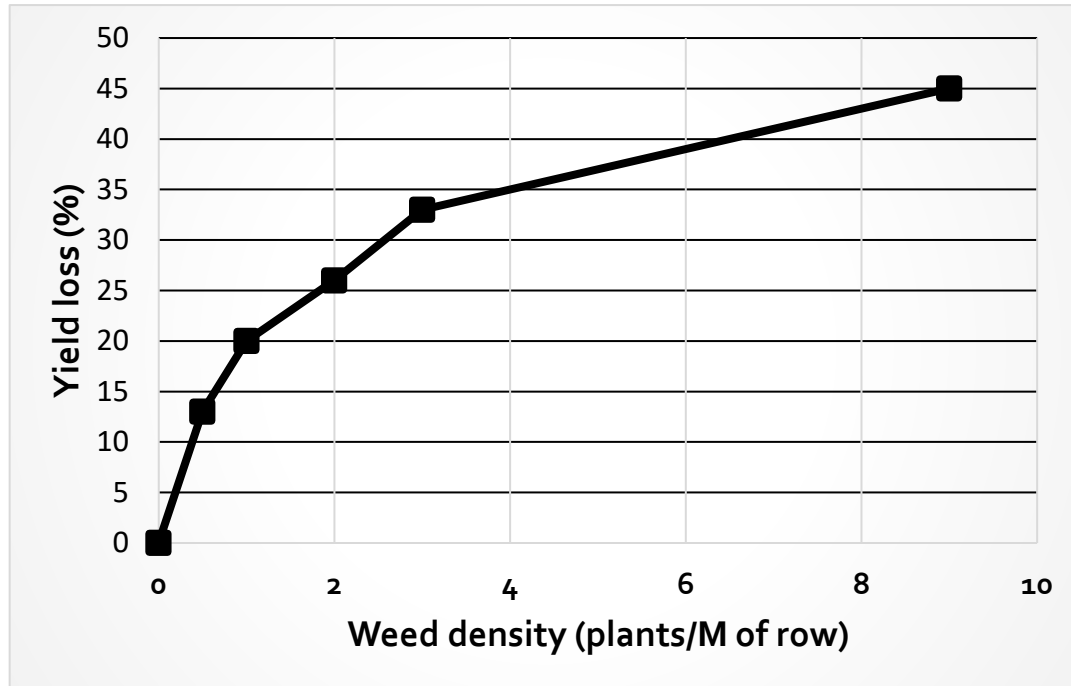


JUNE/JULY PRECIPITATION ANOMALIES



Bring Me the News
 Meteorologist Sven
 Sundgaard
<https://bringmethenews.com/minnesota-weather/july-2022-in-minnesota-was-hotter-windier-and-drier-than-normal>

Redroot pigweed reduced sugarbeet root yield, Evans and Dexter, 1978



Planting date, environment and weed emergence in sugarbeet (Evans and Dexter, 1978)

| Weed | Extractable sucrose per acre | | |
|--------------------------|------------------------------|--------|-----------|
| | Glyndon | Fargo | Crookston |
| | -----% loss----- | | |
| 3 pigweed plants / M row | 44 | 6 | 1 |
| Plant | May 10 | May 4 | April 28 |
| Sugarbeet emergence | May 23 | May 16 | May 11 |
| Pigweed emergence | May 18 | May 19 | May 18 |

- Root yield loss even when redroot pigweed were spaced 6.7 feet
- Planting date influences weed interference

Waterhemp control from soil residual herbicides applied PRE, EPOST and POST

| Trt | Etho or Etho + DM PRE | Herbicide Treatment |
|-----|-----------------------|---|
| 1 | No | PM ₃ + etho / PM ₃ + Ultra Blazer |
| 2 | No | PM ₃ + etho + Outlook / PM ₃ + etho + Outlook |
| 3 | No | PM ₃ + etho + Warrant / PM ₃ + etho + Warrant |
| 4 | No | PM ₃ + etho + Outlook / PM ₃ + etho + Warrant |
| 5 | Yes | PM ₃ + etho / PM ₃ + Ultra Blazer |
| 6 | Yes | PM ₃ + etho + Outlook / PM ₃ + etho + Outlook |
| 7 | Yes | PM ₃ + etho + Warrant / PM ₃ + etho + Warrant |
| 8 | Yes | PM ₃ + etho + Outlook / PM ₃ + etho + Warrant |

Waterhemp control 90, 94, and 59 days after plant, 2022

| Trt | Etho or Etho + DM PRE | Herbicide Treatment ^a | Moorhead, MN | Sabin, MN | Blomkest, MN |
|-----|-----------------------|---|--------------|-----------|--------------|
| | | | % | % | % |
| 1 | No | PM ₃ + etho / PM ₃ + Ultra Blazer | 63 c | 84 c | 63 ab |
| 2 | No | PM ₃ + etho + Outlook / PM ₃ + etho + Outlook | 89 b | 97 ab | 36 e |
| 3 | No | PM ₃ + etho + Warrant / PM ₃ + etho + Warrant | 96 ab | 98 ab | 54 bc |
| 4 | No | PM ₃ + etho + Outlook / PM ₃ + etho + Warrant | 99 a | 98 ab | 51 cd |
| 5 | Yes | PM ₃ + etho / PM ₃ + Ultra Blazer | 98 a | 90 bc | 71 a |
| 6 | Yes | PM ₃ + etho + Outlook / PM ₃ + etho + Outlook | 99 a | 98 ab | 43 de |
| 7 | Yes | PM ₃ + etho + Warrant / PM ₃ + etho + Warrant | 99 a | 99 a | 49 cd |
| 8 | Yes | PM ₃ + etho + Outlook / PM ₃ + etho + Warrant | 99 a | 99 a | 54 bc |
| | | LSD (0.10) | 9 | 9 | 9 |

^aDestiny HC plus Amsol liquid AMS at 1.5 pt/A plus 2.5% v/v accept PM₃ plus Ultra Blazer, Prefer 90 at 0.25% v/v plus Amsol liquid AMS.

POST, Moorhead, Aug 12



POST, Sabin, Sept 15



PRE/POST, Moorhead, Aug 12



PRE/POST, Sabin, Sept 15



POST, rep 2, July 15



PRE/POST, rep 2, July 15



POST, Blomkest, July 25



PRE/POST, Blomkest, July 25

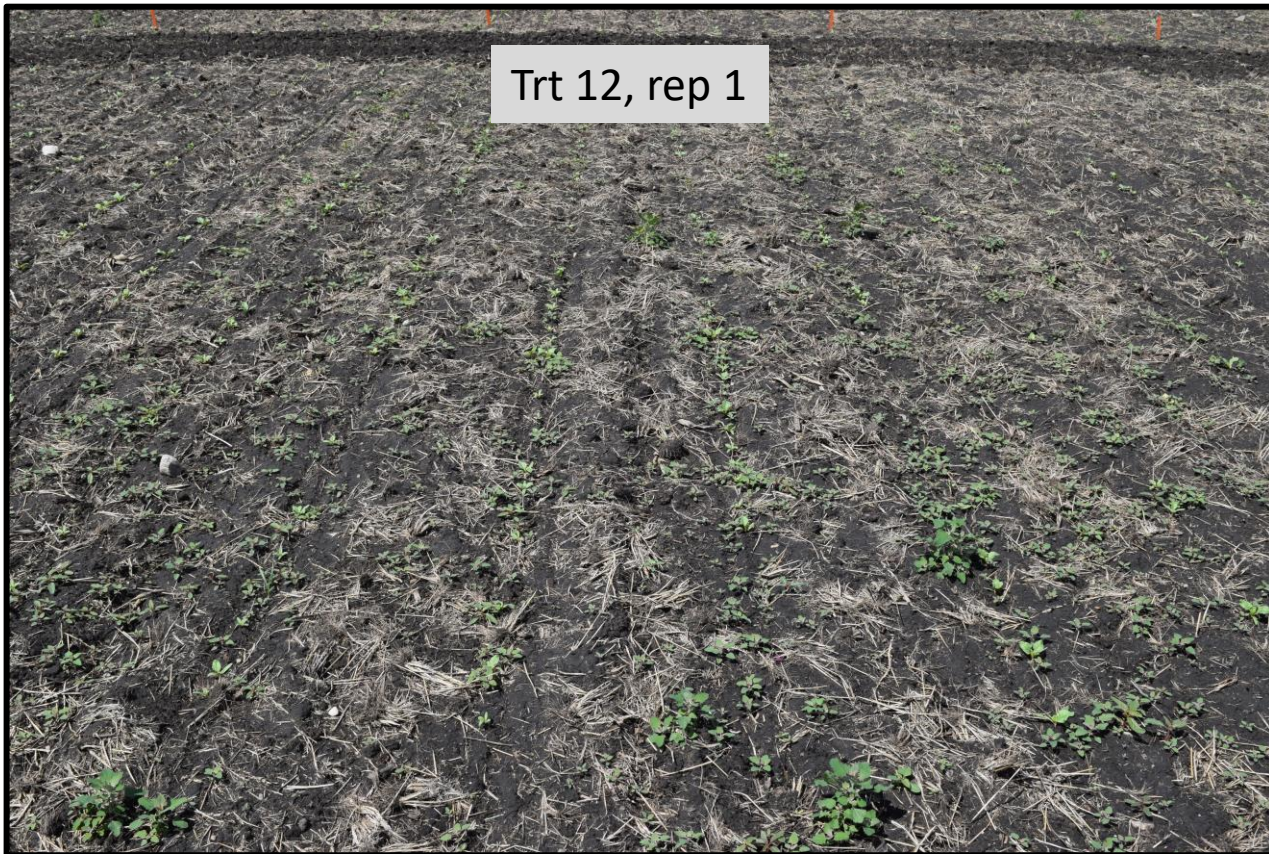


Waterhemp control 90, 94, and 59 days after plant, 2022.

| Ethofumesate or Etho + DM PRE | Herbicide Treatment ^a | Moorhead, MN | Sabin, MN | Blomkest, MN |
|----------------------------------|---|-----------------|--------------|-----------------|
| | | % | % | % |
| No | PM ₃ + etho / PM ₃ + Ultra Blazer | 63 c | 84 c | 63 ab |
| No | PM ₃ + etho + Outlook / PM ₃ + etho + Warrant | 99 a | 98 ab | 51 cd |
| Yes | PM ₃ + etho / PM ₃ + Ultra Blazer | 98 a | 90 bc | 71 a |
| Yes | PM ₃ + etho + Outlook / PM ₃ + etho + Warrant | 99 a | 99 a | 54 bc |
| | LSD (0.10) | 9 | 9 | 9 |

Ethofumesate at 6 pt/A PRE, Blomkest, MN,

- Evaluation, 19 DAP, June 15, 2022



Ethofumesate at 6 pt/A PRE, Blomkest, MN,

- No POST soil residual herbicides applied in experiment



Trt 12, rep 2, July 15



Trt 12, rep 3, July 25

Rainfall (inch) in the first 10 days after residual herbicide application, 2022

| | Moorhead, MN | Sabin, MN | Blomkest, MN |
|-------|--------------|-----------|--------------|
| | (in) | (in) | (in) |
| PRE | 1.0 | 0.5 | 0.9 |
| EPOST | 1.7 | 0.4 | 0.0 |
| POST | 1.8 | 2.4 | 0.5 |
| Total | 4.5 | 3.3 | 1.4 |

Plant May 24, May 19 and May 27, respectively

Rainfall chronology at Blomkest

PRE May 27, 2022

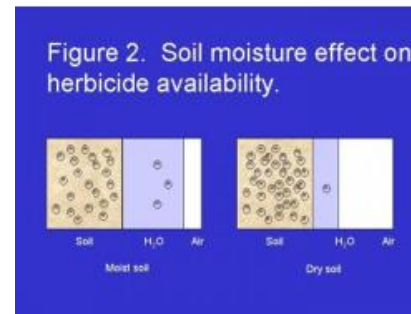
- 0.79 inch fell on May 30;
 - Midnight to 5:00AM – 0.00
 - 5:00AM to 7:00AM – 0.04
 - 8:00AM to 9:00AM – 0.27
 - 9:00AM to 10:00AM – 0.17
 - 10:00AM to noon – 0.10
 - 1:00PM to 5:00PM – 0.01
 - 6:00PM to 7:00PM – 0.18
 - 7:00PM to 8:00PM – 0.02
 - 8:00PM to midnight – 0.00

- Hypothesis: rainfall and rainfall intensity influence herbicide activation into soil
- First need to wet the soil surface before water will infiltrate
- 0.5 inch – Dual Magnum
- 0.75 inch – Ethofumesate
- Why more? Solubility and K_{OC}
- DM 'covers' for etho until it rains
- **Are there other options?**

Ethofumesate and Dual Magnum are complimentary

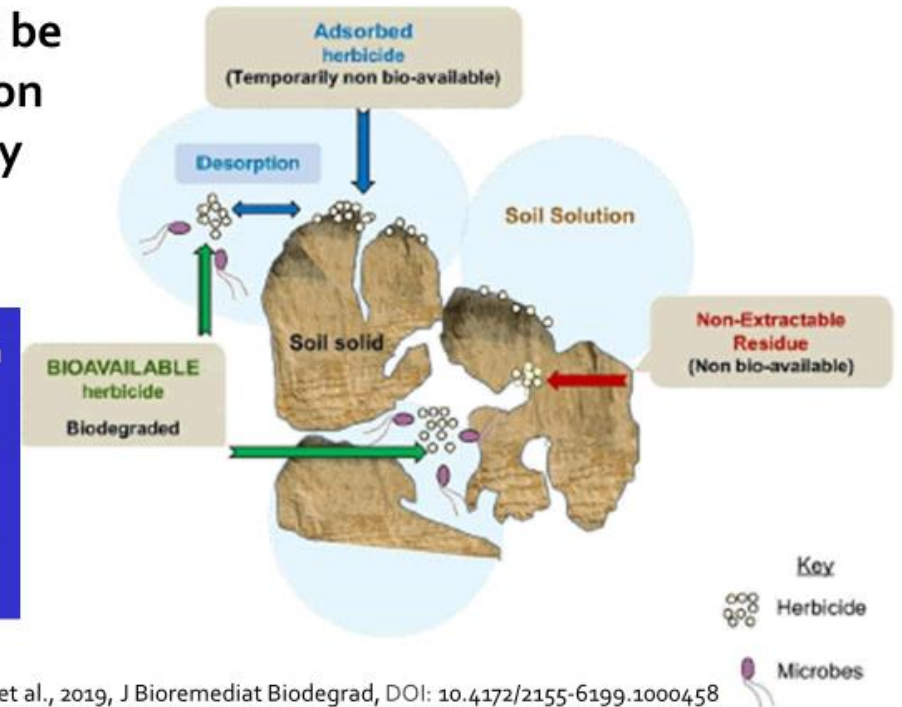
| Herbicide | Absorptivity | Water Solubility |
|---------------|------------------------------|------------------|
| | ^a K _{OC} | (ppm) |
| Acetochlor | 200 | 233 |
| Outlook | 155 | 1,174 |
| S-metolachlor | 200 | 488 |
| Ethofumesate | 340 | 110 |
| Treflan | 7,000 | 0.3 |
| Dicamba | 2 | 4,500 |

Herbicides must be in the soil solution to be taken up by seeds, roots, or shoots



Hartzler, Professor Emeritus, ISU

Kanissery, et al., 2019, J Bioremediat Biodegrad, DOI: 10.4172/2155-6199.1000458



^a The K value represents the ratio of herbicide bound to soil collides versus what is free in the water. Thus, the higher the K value the greater the adsorption to soil colloids.

**Depends on how the manufacturer conducts the experiment. Half-life varies with soil characteristics and environment.

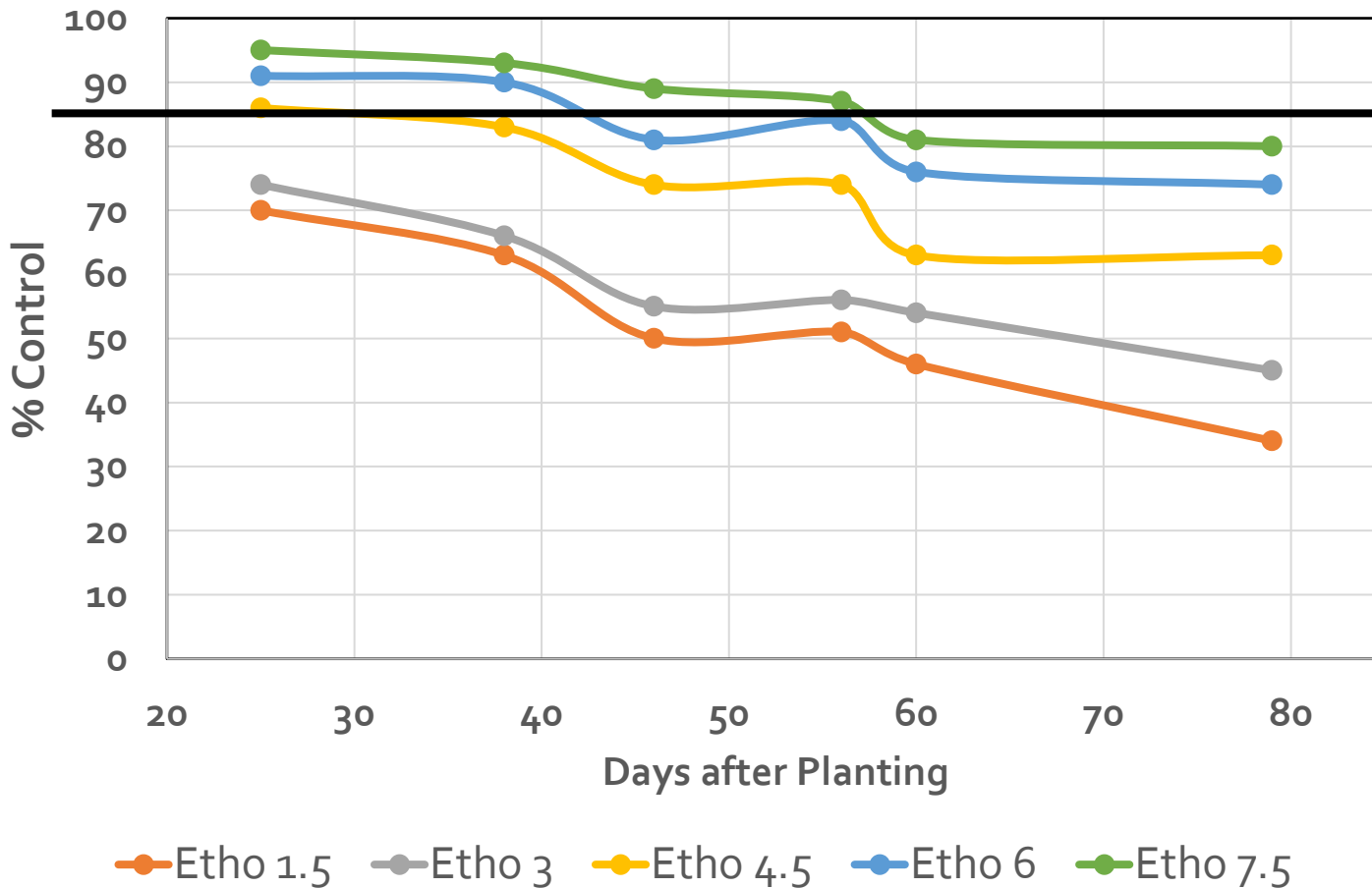
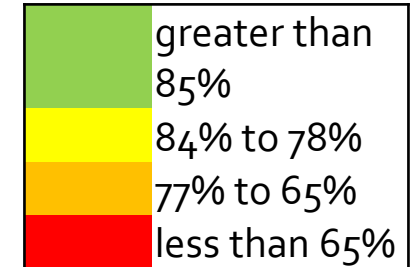
Comparison of PPI and PRE ethofumesate at 3.75 to 4.0 lb/A, 1973-1986

| Nortron application | 4 of 7 locations Rrpw cntl | 3 of 7 locations Rrpw cntl |
|---------------------|----------------------------------|----------------------------------|
| | % | % |
| PPI | 97 | 91 |
| PRE | 79 | 93 |
| LSD (0.05) | 11 | NS |

From Dr. Dexter's presentation for PLSC 350, 2012

Waterhemp control in response to ethofumesate PRE, Blomkest MN, 2020

Sublethal rates: full control for less time or less than full control?

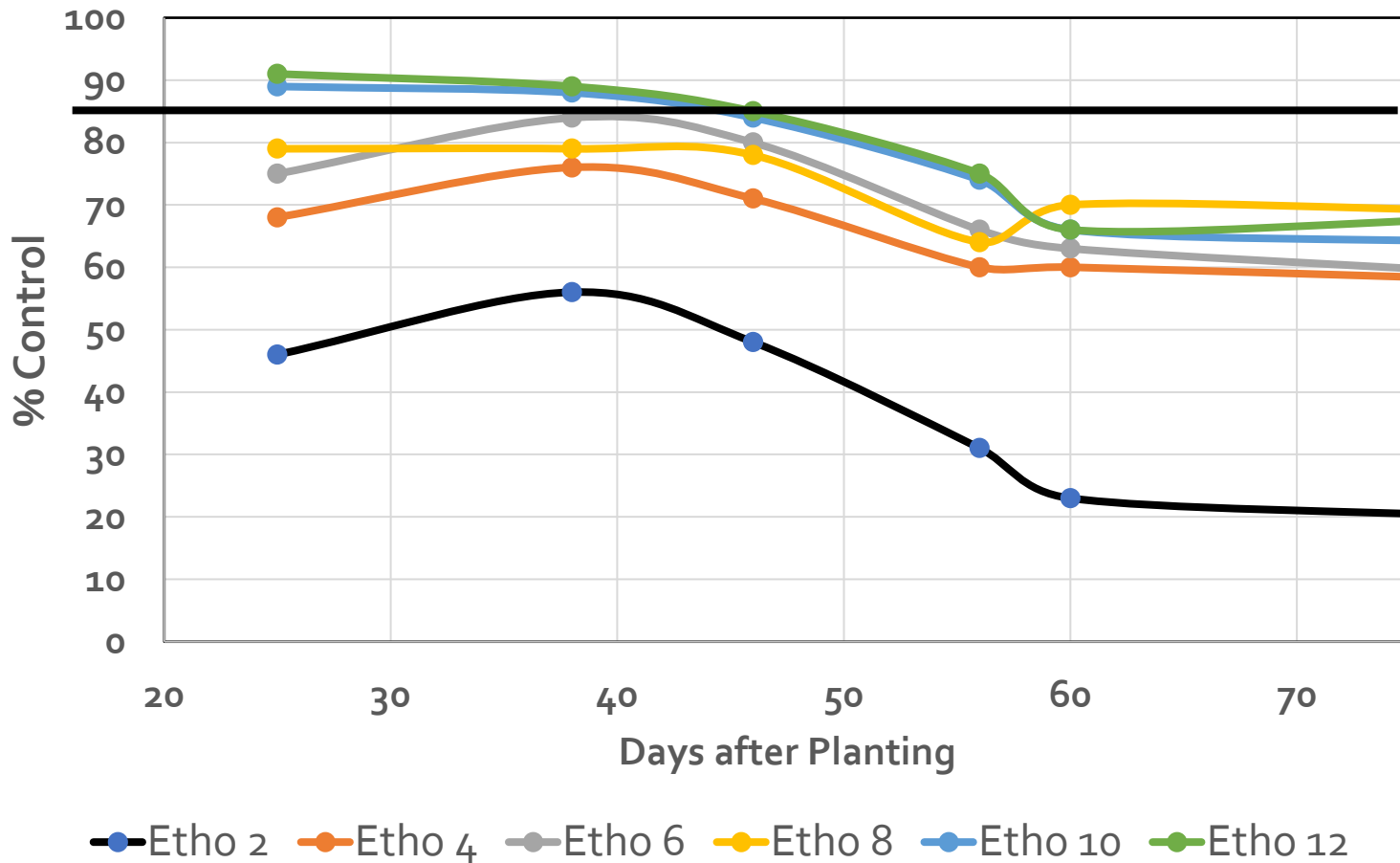
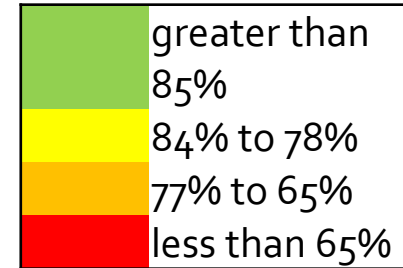


| | Days after planting | | | | | |
|----------|---------------------|----|----|----|----|----|
| | 25 | 38 | 46 | 56 | 60 | 79 |
| Etho 1.5 | 70 | 63 | 50 | 51 | 46 | 34 |
| Etho 3 | 74 | 66 | 55 | 56 | 54 | 45 |
| Etho 4.5 | 86 | 83 | 74 | 74 | 63 | 63 |
| Etho 6 | 91 | 90 | 81 | 84 | 76 | 74 |
| Etho 7.5 | 95 | 93 | 89 | 87 | 81 | 80 |

| Calendar date | Rainfall (inch) | Total Rainfall (inch) |
|---------------|-----------------|-----------------------|
| May 9 | 0.7 | 0.7 |
| May 26 | 1.7 | 2.4 |
| June 10 | 0.3 | 2.7 |
| June 25 | 1.3 | 4.0 |
| July 10 | 3.8 | 7.8 |

Waterhemp control in response to ethofumesate PPI, Moorhead MN, 2022

Sublethal rates: full control for less time or less than full control?



| | Days after planting | | | | | |
|---------|---------------------|----|----|----|----|----|
| | 22 | 28 | 38 | 45 | 52 | 72 |
| Etho 2 | 46 | 56 | 48 | 31 | 23 | 20 |
| Etho 4 | 68 | 76 | 71 | 60 | 60 | 58 |
| Etho 6 | 75 | 84 | 80 | 66 | 63 | 59 |
| Etho 8 | 79 | 79 | 78 | 64 | 70 | 69 |
| Etho 10 | 89 | 88 | 84 | 74 | 66 | 64 |
| Etho 12 | 91 | 89 | 85 | 75 | 66 | 68 |

| Calendar date | Rainfall (inch) | Total Rainfall (inch) |
|---------------|-----------------|-----------------------|
| June 8 | 0.9 | 0.9 |
| June 23 | 1.7 | 2.6 |
| July 8 | 1.9 | 4.5 |
| July 23 | 4.5 | 9.0 |
| Aug 7 | 1.6 | 10.6 |

BMPs for waterhemp control in sugarbeet

1. Plant sugarbeet into fields with documented field history
2. Categorize sugarbeet fields as either low, moderate, or heavy for waterhemp pressure
 - Apply ethofumesate + Dual Magnum / EPOST / POST on low and medium pressure fields
 - Apply ethofumesate at 5 to 7.5 pt/A / EPOST / POST on heavy waterhemp pressure fields and fields with heavy previous crop residue
 - Consider incorporating ethofumesate
3. Use a weed control program in the crop sequences that compliments your program in sugarbeet
4. Crop rotation restrictions to sugarbeet are dependent on environmental conditions **and** the label

The Crop Sequence with Sugarbeet

Corn rotate to Sugarbeet

^a& = premix; + = tank-mix

Products with crop rotation restrictions preventing sugarbeet planting the following year

| Preemergence | months | Postemergence ^a | months |
|---|--------|---|--------|
| Verdict (dimethenamid-P & saflufenacil (15&14)) | NCS | Acuron GT (meto&meso&bicycle&glyph (15, 27, 27, 9)) | 18 |
| Anthem Maxx (pyroxasulfone & fluthiacet) (15 & 14) | 15 | Armezon Pro (topramezone & dimethenamid-P) (27 & 15) | 18 |
| Corvus (isoxaflutole, thiencazuron & safener) (27&2) | 17 | Halex GT (glyphosate & S-metolachlor & mesotrione) (9 & 15 & 27) | 18 |
| Acuron Flexi (S-metolachlor, mesotrione, bicyclopyrone & safener) (15 & 27 & 27) | 18 | Harness Max (acetochlor & mesotrione) (15&27) | 18 |
| Balance Flexx (isoxaflutole & safener) (27) | 18 | Realm Q (rimsulfuron & mesotrione & safener) (2 & 27) | 18 |
| Resicore / Resicore XL (acetochlor, mesotrione & clopyralid) (15 & 27 & 4) | 18 | Maverick (mesotrione, clopyralid & pyroxasulfone) (27,4,15) | 18 |
| Atrazine (5) | 2 CS | Sinate (topramezone & glufosinate (27 & 10) + atrazine (need LL Corn)) | 18 |
| Surestart II (acetochlor, flumetsulam & clopyralid) (15 & 2 & 4) | 26 | | |



Soybean rotate to Sugarbeet

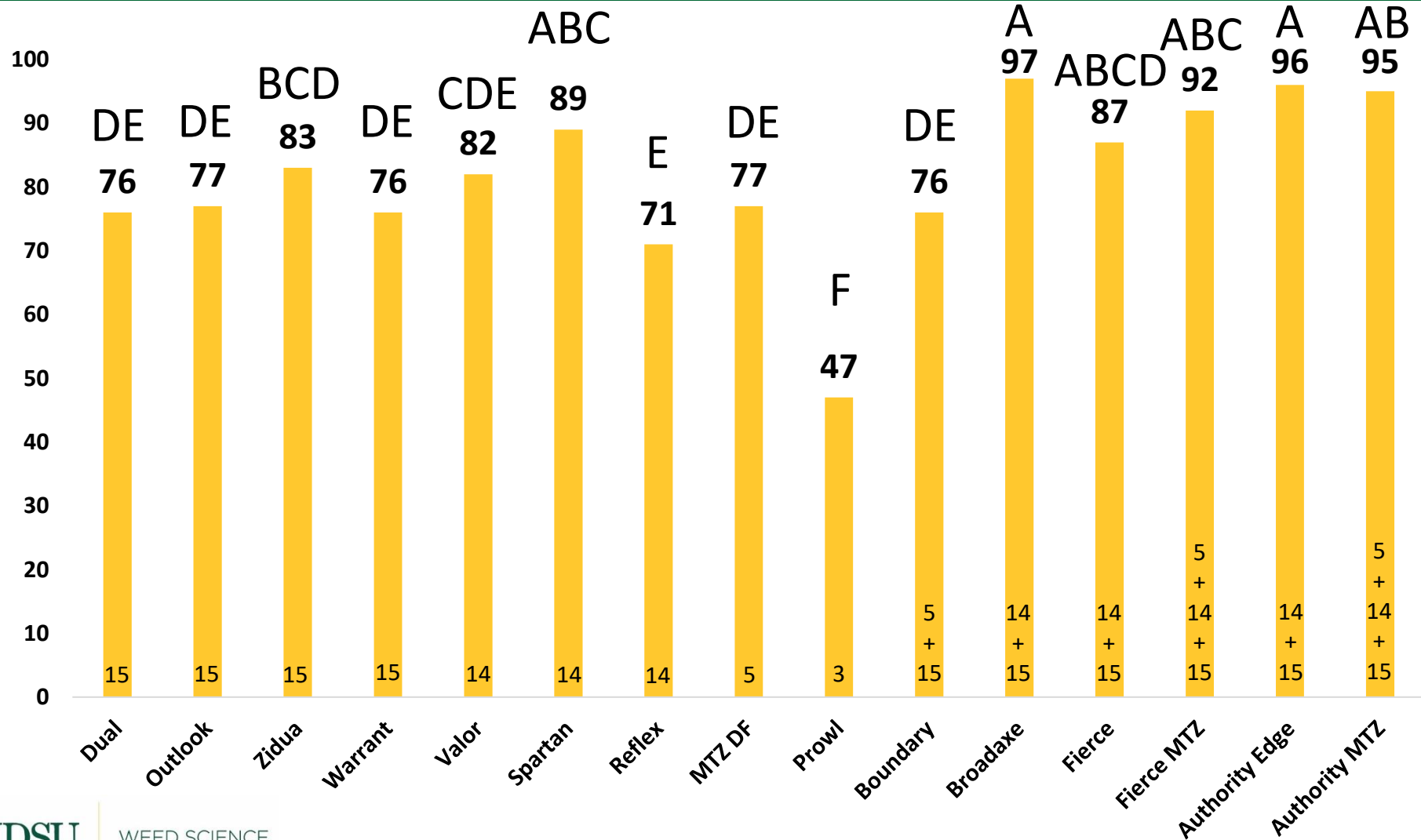
Products with crop rotation restrictions

^a& = premix; + = tank-mix
^bwith soil testing



| Preemergence | months | Postemergence ^a | months |
|--|--------------------|---|--------|
| XtendiMax / Engenia (dicamba) (need XtendiMax soybean | NCS | Flexstar GT fomesafen & glyphosate) (14 & 9) | 18 |
| Fierce *pyroxasulfone & flumioxazin) (15 & 14) | 12 | | |
| Boundary (S-metolachlor & metribuzin) (15 & 5) | 18 | | |
| Fierce MTZ (pyroxasulfone & flumioxazin & metribuzin | 18 | | |
| Authority Edge (sulfentrazone & pyroxasulfone) (14 & 15) | 24 | | |
| Authority First / Sonic (sulfentrazone & chloransulam) (14 & 2) | 30 | | |
| Sonic (sulfentrazone & chloransulam (14 & 2) | 30 ^b | | |
| Surveil (flumioxazin & chloransulam) (14 & 2) | 30 ^b | | |
| Authority MTZ (sulfentrazone & metribuzin) (14, 15 & 5) | 36/24 ^b | | |
| BroadAxe XC (S-metolachlor & sulfentrazone) (15& 14) | 36 | | |
| Zidua Pro (pyroxasulfone, saflufenacil & imazethapyr) (15 & 14 & 2) | 40 | | |

Palmer amaranth Control 4 Weeks After Planting



Ultra Blazer

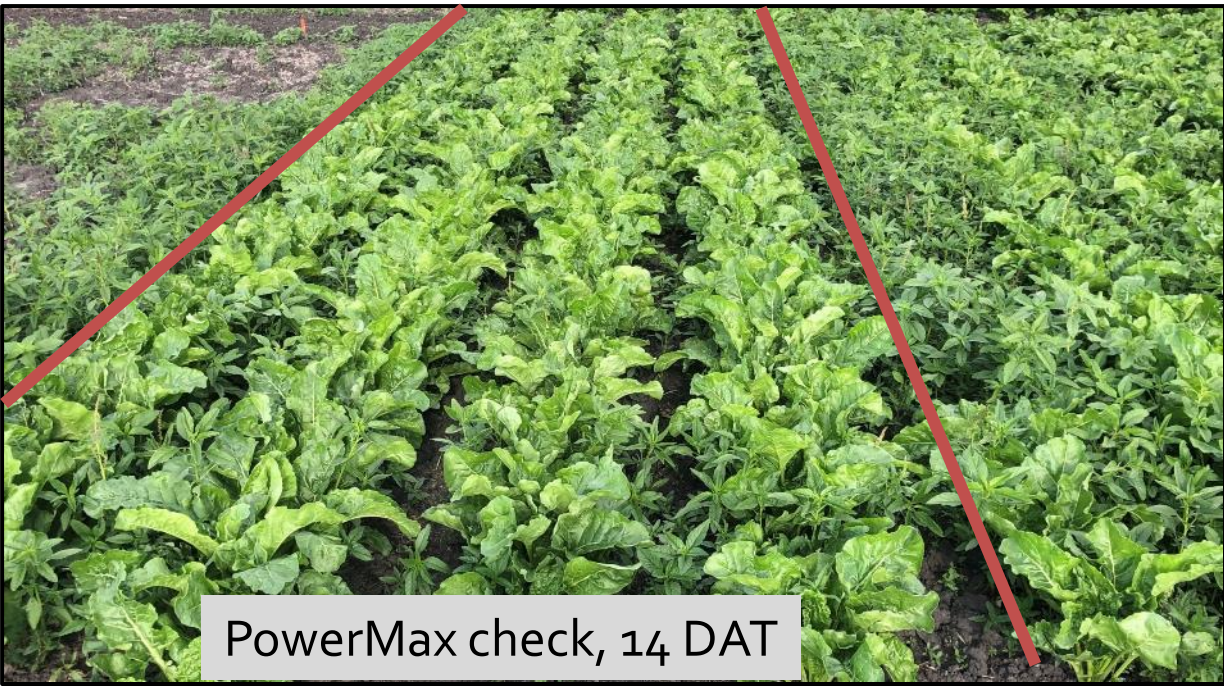
Acifluorfen was applied on over 65,000 acres following Environmental Protection Agency (EPA) approval of a Section 18 emergency exemption in 2021 and 2022

- A single Ultra Blazer application at 16 fl oz/A alone or with NIS on greater than 6-leaf sugarbeet stage.
- Ultra Blazer alone or in mixtures with PowerMax(3) and AMS.
- Target waterhemp up to 4-inch
- Apply Ultra Blazer in afternoon hours on days with maximum daytime air temperatures greater than 85F.
- Application before 6 leaf sugar beet will result in crop injury and potential yield loss.
- 95% of survey respondents (2021) indicated the emergency exemption was beneficial and contributed to overall weed management

2022 (and 2023) Ultra Blazer program objectives

Improve sugarbeet safety; increase waterhemp control

- Revisit repeat applications (Ultra Blazer fb Ultra Blazer at 12 fb 12 fl oz/A)
- Evaluate crop oil concentrate with Ultra Blazer
- Nozzles and spray volume to improve coverage and waterhemp control



PowerMax check, 14 DAT



Ultra Blazer + PowerMax + NIS, 14 DAT



Ultra Blazer + NIS, 14 DAT

Sugarbeet necrosis and growth reduction 14 DAT in response to treatment across locations, 2019 and 2020

| Treatment | Rate | Sugarbeet injury | |
|--|-------------|------------------|---------------|
| | | 2019 | 2020 |
| | fl oz/A | --% -- | --%-- |
| PowerMax + NIS / PowerMax + NIS ^a | 28/28 | 3a | 5 a |
| Ultra Blazer + NIS ^b | 16 | 21 ab | 10 a |
| Ultra Blazer + PowerMax + NIS ^b | 16 + 28 | 39 c | 17 abc |
| Ultra Blazer + Stinger + NIS ^b | 16 + 4 | 16 ab | 13 a |
| Ultra Blazer + PowerMax + Stinger + NIS ^b | 16 + 28 + 4 | 41 c | 25 bc |
| P-Value | | 0.0120 | 0.0145 |

^aPrefer go non-ionic surfactant at 0.25% v/v, CHS Agronomics, Inver Grove Heights, MN.
^bPrefer go non-ionic surfactant at 0.125% v/v, CHS Agronomics, Inver Grove Heights, MN.

Sugarbeet injury in response to treatment, across three greenhouse runs, 2020-2021

| | | Necrosis | G. Reduction | Fr. Wt. Reduct. ^b |
|---------------------------------------|-------------|----------|--------------|------------------------------|
| Treatment ^a | Rate | 7 DAT | 14 DAT | 14 DAT |
| | --fl oz/A-- | --%-- | --%-- | --%-- |
| Ultra Blazer | 8 | 48 bc | 55 b | 63 ab |
| Roundup PowerMax (K-salt, loaded) | 28 | 2 d | 9 d | (3) c |
| Touchdown Hi Tech (K-salt, no load) | 28 | 1 d | 10 d | (24) d |
| Cornerstone 5 Plus (IPA-salt, loaded) | 28 | 0 d | 9 d | (11) c |
| Ultra Blazer + PowerMax | 8 + 28 | 67 a | 74 a | 73 a |
| Ultra Blazer + Touchdown Hi Tech | 8 + 28 | 43 c | 44 c | 52 b |
| Ultra Blazer + Cornerstone 5 Plus | 8 + 28 | 52 b | 57 b | 61 ab |
| Control | | 0 d | 8 d | - |
| P-Value | | <0.0001 | <0.0001 | <0.0001 |

^aTreatments contained Prefer 90 Non-ionic surfactant at 0.125% v/v.

^bAbbreviations: Fr. Wt. Reduct. = Fresh Weight Reduction as a percent of the control; (), greater than 100%.



Ultra Blazer + NIS



Ultra Blazer + PowerMax3

Hendrum, MN
4 DAT



Ultra Blazer + COC



PowerMax3 / PowerMax3



Ultra Blazer + NIS, 14 DAT

Murdock, MN



Ultra Blazer + NIS, 23 DAT



Ultra Blazer + PowerMax3, 14 DAT



Ultra Blazer + PowerMax3, 23 DAT

Injury and yield in response to treatment, across locations, 2022

| Treatment | Rate | Necrosis | Growth Reduction | Root Yield | Sucrose | Recoverable Sucrose |
|---|-------------------------------|----------|------------------|------------|---------|---------------------|
| | --fl oz/A-- | --%-- | --%-- | --TPA-- | --%-- | --lb/A-- |
| Ultra Blazer + NIS ^a | 16 + 0.25% | 12 b | 11 cd | 29.8 bc | 16.4 | 8,452 ab |
| Ultra Blazer + NIS / Ultra Blazer + NIS | 12 + 0.125% / 12 + 0.125% | 53 a | 18 ab | 30.2 ab | 16.4 | 8,643 a |
| Ultra Blazer + crop oil concentrate ^b | 16 + 0.25% | 16 b | 15 bc | 30.5 ab | 16.3 | 8,617 a |
| PowerMax3 + Ultra Blazer + AMS ^c | 25 + 16 + 2.5% v/v | 22 b | 24 a | 28.9 cd | 16.3 | 8,155 b |
| PowerMax3 + Ultra Blazer + NIS + AMS | 25 + 16 + 0.25% + 2.5% v/v | 22 b | 22 ab | 28.5 d | 16.3 | 8,070 b |
| PowerMax3 + NIS / PowerMax3 + NIS ^d | 25 / 25 | 0 c | 5 d | 31.4 a | 16.4 | 8,788 a |

^a Prefer 90 non-ionic surfactant

^b Prime Oil, Winfield United, St. Paul, MN.

^c PowerMax3 and Amsol Liquid AMS, Winfield United, St. Paul, MN.

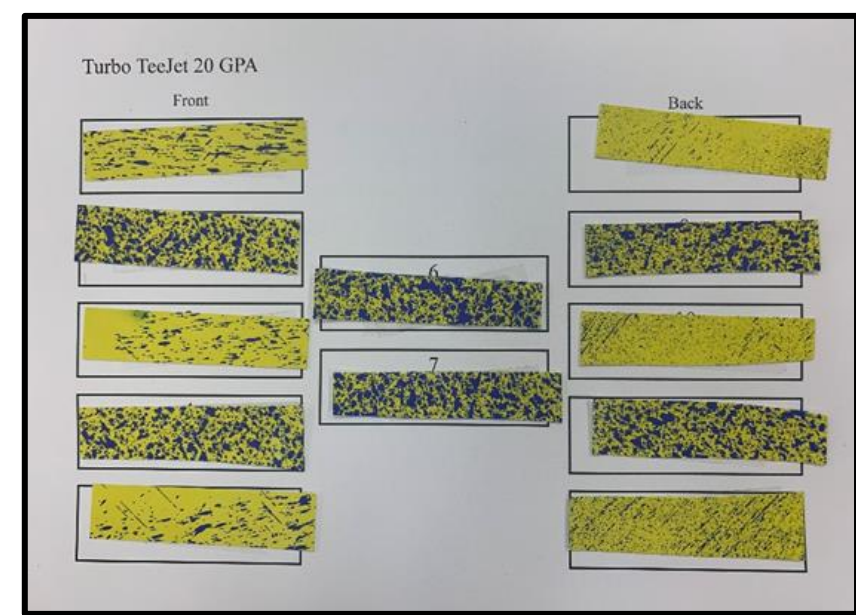
^d Prefer 90 NIS at 0.25%v/v.



Ultra Blazer in 2023

Using our acquired knowledge of spray quality for Cercospora leaf spot control on weed control

- Spray nozzles
- Spray volume



| | Necrosis ¹ | | G Reduction | | WH Control ² | |
|---------------|-----------------------|--------|-------------|--------|-------------------------|--------|
| Nozzle | 15 gpa | 20 gpa | 15 gpa | 20 gpa | 15 gpa | 20 gpa |
| XR TeeJet | 33 abc | 38 ab | 19 a | 20 a | 60 c | 80 a |
| AIXR | 23 c | 23 c | 8 c | 8 c | 64 c | 68 c |
| Turbo TeeJet | 28 bc | 30 bc | 15 ab | 13 bc | 69 bc | 78 ab |
| Turbo TwinJet | 26 c | 43a | 10 bc | 19 a | 83 a | 81 a |

¹Necrosis and growth reduction 13 DAT

²Waterhemp control 41 DAT

Moorhead MN, 2022

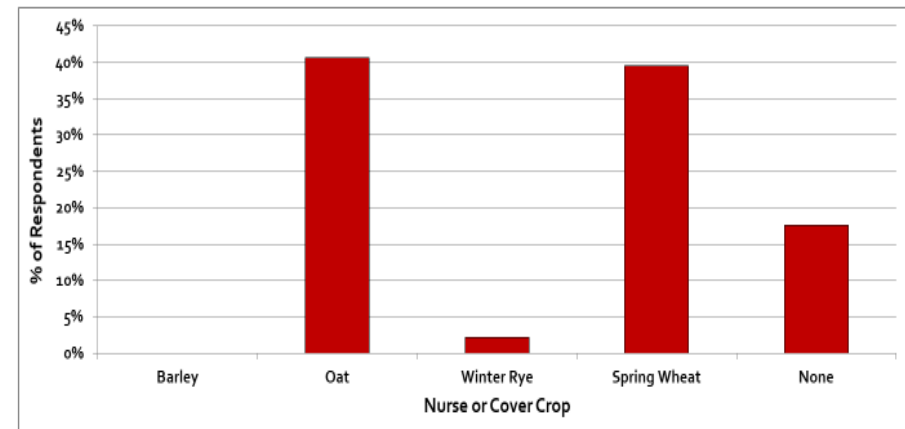


A few more points

Sugarbeet acres with nurse or cover crops has steadily increased since 2014

| Cooperative | Nurse or Cover Crops ¹ | |
|-----------------------|-----------------------------------|--------------------|
| | Sugarbeet acres | % with cover crops |
| ACS ¹ | 111,863 | 27 |
| Minn-Dak ² | 69,867 | 88 |
| SMBSC ³ | 98,897 | 82 |
| Total/Weighted | 280,627 | 44 |

82% of Southern Minnesota Beet Sugar Coop growers seeded a cover or nurse crop with sugarbeet in 2020



¹2020 sugarbeet acres

²Data from Joe Hastings and Kathy Wang

³Data from Emma Burt

⁴Data from Mark Bloomquist and from Turning Point Survey conducted at 2020 Willmar Grower Seminars



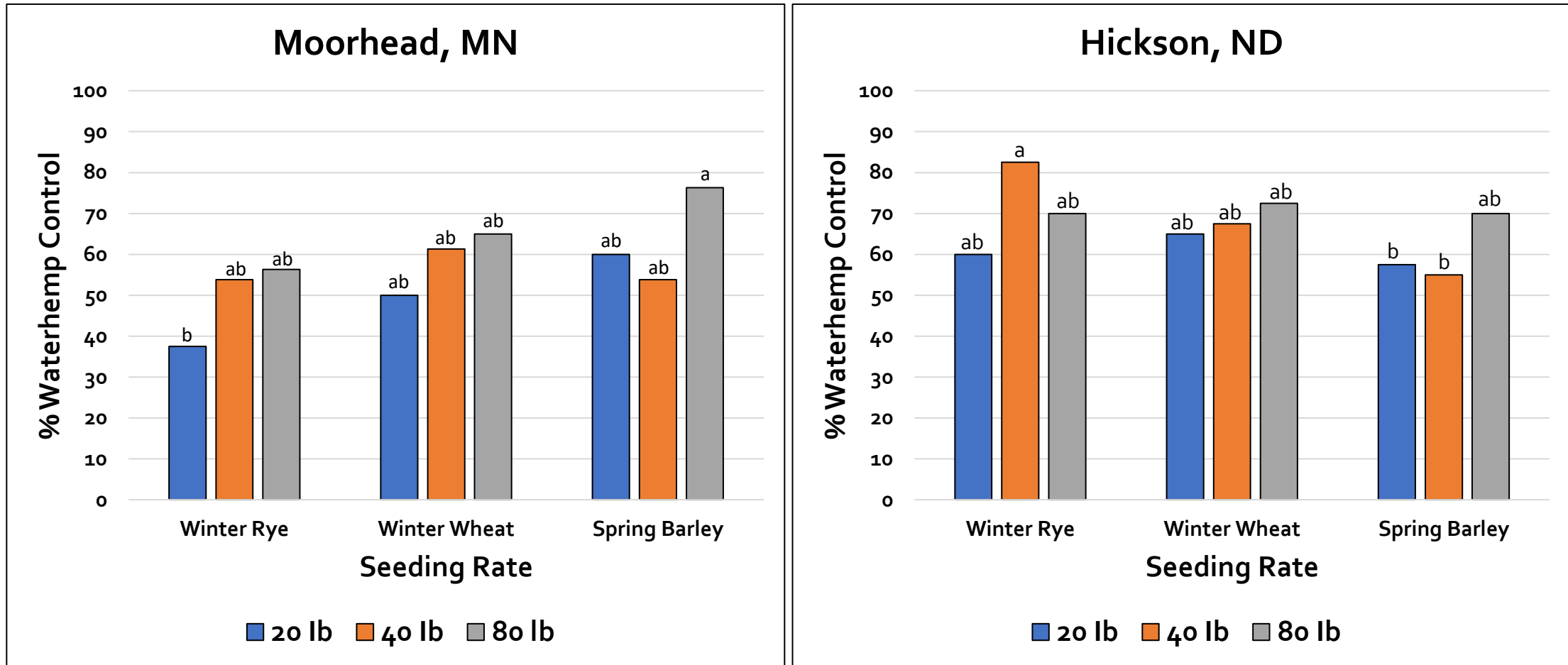
Cover and Nurse Crops for weed suppression

Materials and Methods:

- Factorial Treatment Arrangement
- Factor A = Cereal Grain Winter Wheat, Winter Rye, Barley, (spring plant)
- Factor B = Seeding Rate (0, 20, 40, 80 lb)
- Sugarbeet plant in April or May

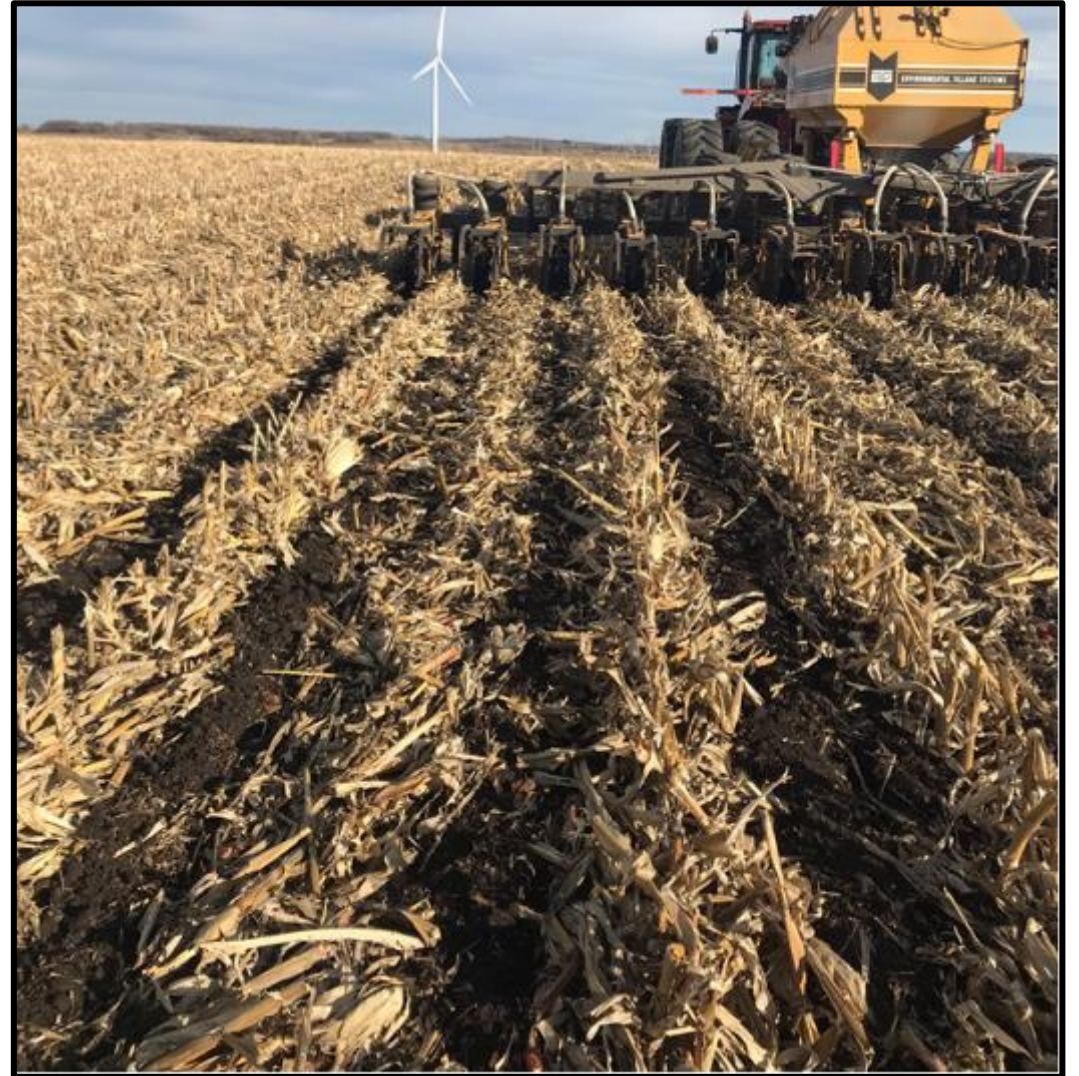
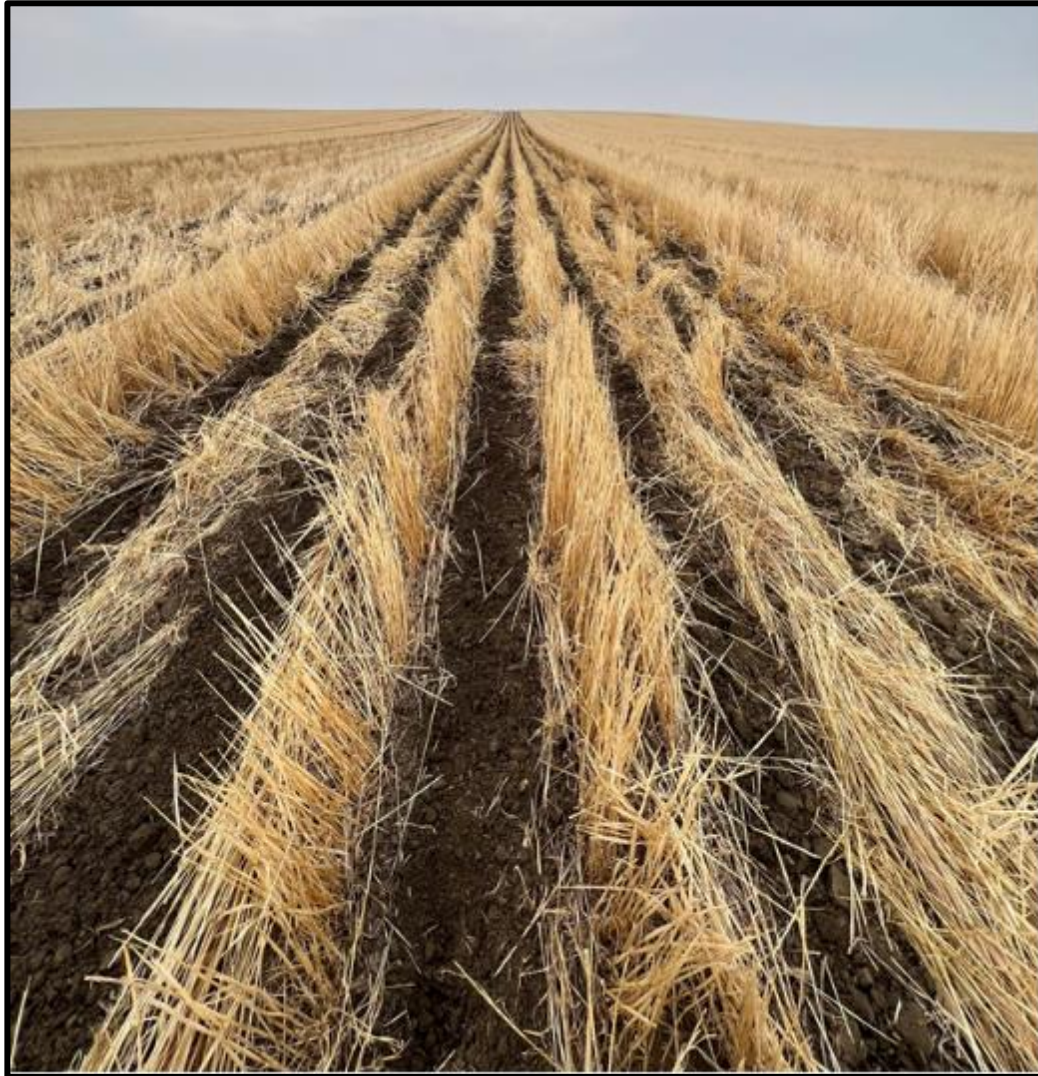
Courtesy of Aaron Hoppe

Visual Percent Waterhemp Control, Moorhead, MN and Hickson, ND, July 2021^a



^acover crops were terminated with PowerMax mixed with ethofumesate and S-metolachlor at 32+6+16 fl oz/A

Some growers are trying strip-tillage



Strip-Tillage may create weed shifts

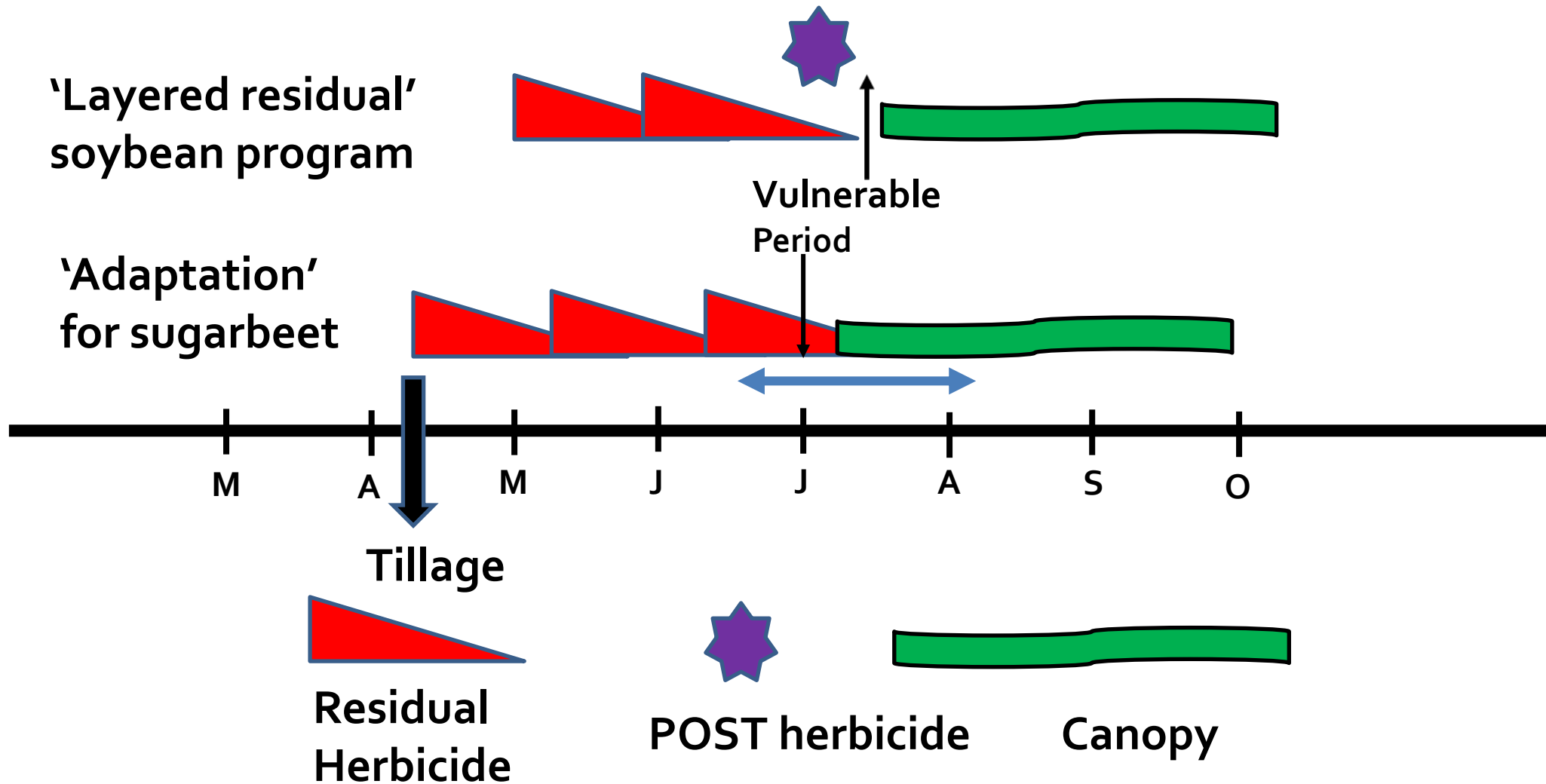
- Strips are made in the fall and freshened in the spring before plant
- We observed winter annual and early emerging summer annual weed escapes in 2022
- Kochia (or other early germinating summer annuals) may get too large before glyphosate application
- Will recommend paraquat after planting and before sugarbeet emergence to control early-emerging weeds

Courtesy of Aaron Hoppe



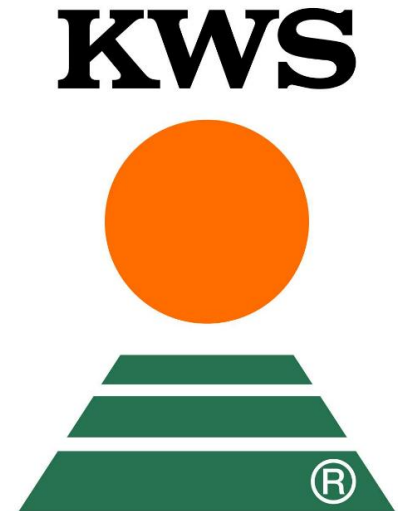
Layered Residual Herbicides

Objective: Prolong PRE activity until canopy fills

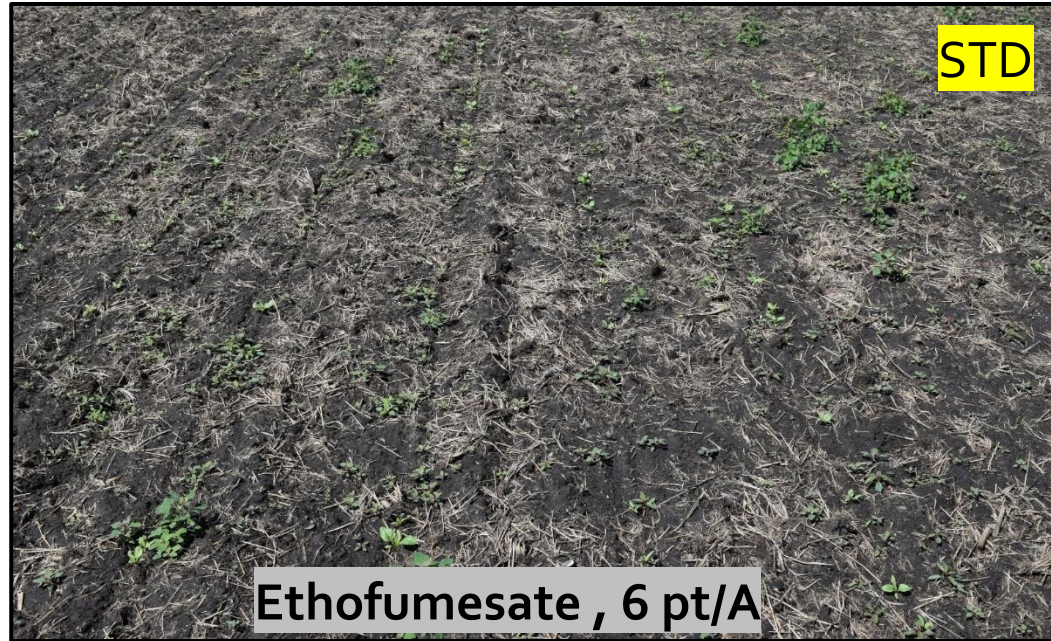


Dicamba and glufosinate compliment sugarbeet herbicides

- Ethofumesate PRE requires significant rainfall to activate
 - Our producers are incorporating etho to improve early season waterhemp control
 - Cover and nurse crops potentially are in conflict with PRE herbicides
 - Dual Magnum PRE may cause injury, especially on low OM peaks
 - Dicamba compliments ethofumesate PRE
- Glufosinate provides consistent waterhemp control
 - A closer
 - Spray weeds less than 3-inch tall
 - Spray when sunny, humid, and two hours after sunrise
 - Stewardship practices so Liberty is relevant in the future



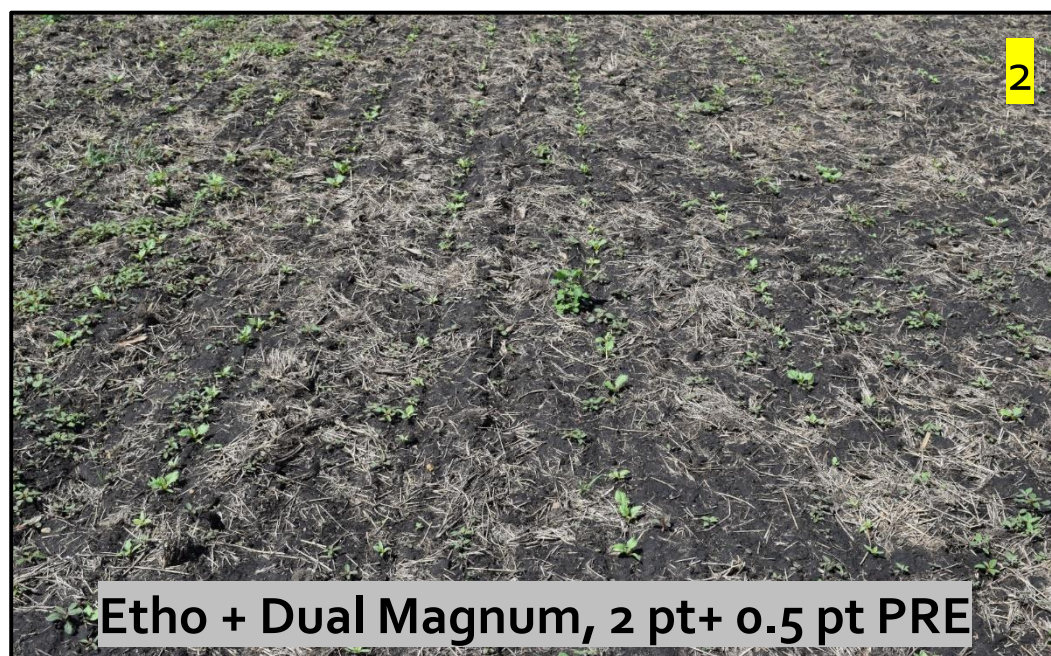
PRE control, Blomkest, MN, 19 DAP



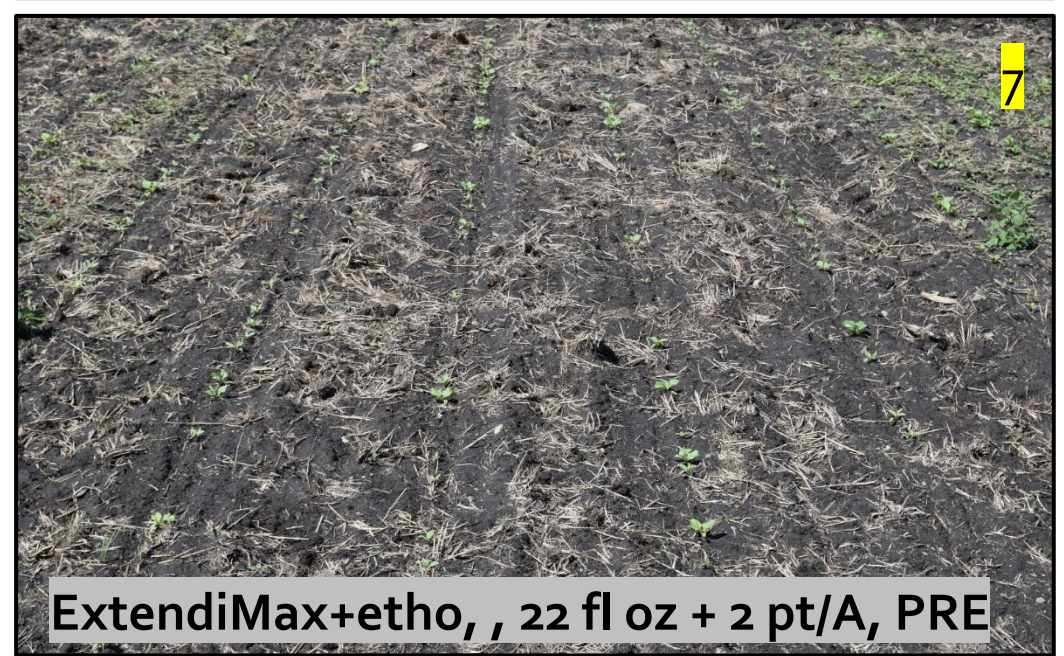
Ethofumesate , 6 pt/A



ExtendiMax, 22 fl oz/A, PRE



Etho + Dual Magnum, 2 pt+ 0.5 pt PRE



ExtendiMax+etho, , 22 fl oz + 2 pt/A, PRE



STD

Etho+DM/PM₃+etho+Outlook/PM₃+etho+Warrant



EM / PM₃+etho / Liberty



PM₃+XM / PM₃+Liberty



XM+Etho/PM₃+etho+Outlook / Liberty



Forward Looking Statement - Disclaimer

This presentation may contain forward-looking statements based on current assumptions and forecasts made by Bayer management. Various known and unknown risks, uncertainties and other factors could lead to material differences between the actual future results, financial situation, development or performance of the company and the estimates given here. These factors include those discussed in Bayer's public reports which are available on the Bayer website at <http://www.bayer.com/>. The company assumes no liability whatsoever to update these forward-looking statements or to conform them to future events or developments.

Thank you for your attention and your continued support

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