# Metribuzin Safety in Soybean in Western ND & Resistance Mechanisms in Weeds

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# Topic

- **Preview 2.1 SC – Soybean**
  **(Conventional till, Irrigated, Sandy soil)**
- **Ways weeds overcome the effects of herbicides.**
- **Conclusions**

# Preview 2.1 SC — Soybean

- 3 .35 lbs ai per gallon: 2 .23 lbs. metribuzin + 1 .12 lbs. sulfentrazone
- MAX use rate is 26 fl oz = 0.45 lbs. metribuzin + 0.23 lbs. sulfentrazone
- DO NOT use on soils classified as sand with <1% OM
- PRE-EMERGENCE: 30d before planting up to 3d after planting, <u>but before seed germinates.</u>
- Severe injury if applied after crop emergence.
- DO NOT use on any soybean varieties known to be sensitive to injury from metribuzin or sulfentrazone.
- Injury can occur in  pH greater than 7.5

# Site: Nesson Valley

- Irrigated (Lake Sakakawea)
- Conventional tillage
- Lihen loamy fine sand
- 7.7 – 7.9 soil pH (top 6”)
- OM is 1.6 – 2%
- **Plot 10 x 30 ft, 30” rows**

Objective: Evaluate crop safety of metribuzin and other metribuzin containing products on troublesome soils (eg. high pH, low % OM).

# Nesson Valley Irrigated Research Farm

- June 1, Soybean planted
- June 2-4, 1.08” rain
- June 5, Preemergence application, TJ80015, 15 GPA
- June 7, Soybean emergence
- June 8, Irrigated 0.5”

| | Rain | Linear irrigation |
|---|---|---|
| June | 2.02” | 5.75” |
| July | 1.65” | 7.5” |
| | 3.67” | 13.35 |

= 17.0” total, from JUNE-JULY

Seeds already germinated at time of PRE app

# Expected injury symptoms from metribuzin

# Expected injury symptoms from metribuzin

# Results

**No noticeable injury at emergence in all treated plots**

# Results – 15 DAE

# Results – 15 DAE

# Results – 15 DAE


Preview 2.1 @ 14 fl oz

# Results – 15 DAE


Preview 2.1 @ 16 fl oz

# Results – 15 DAE

# Results – 15 DAE

# Results – 15 DAE

# Results – 15 DAE

# Results – 15 DAE


Roundup Pmax @ 32 fl oz (burndown)

# Results – 36 DAE

# Results – 36 DAE

# Results – 36 DAE

# Results – 36 DAE

# Results – 36 DAE

# Results – 36 DAE

# Results – 36 DAE

# Results – 36 DAE

# Results – 36 DAE

**No yield data due to a heavy hail event on August 1, 2023**

# Preview 2.1

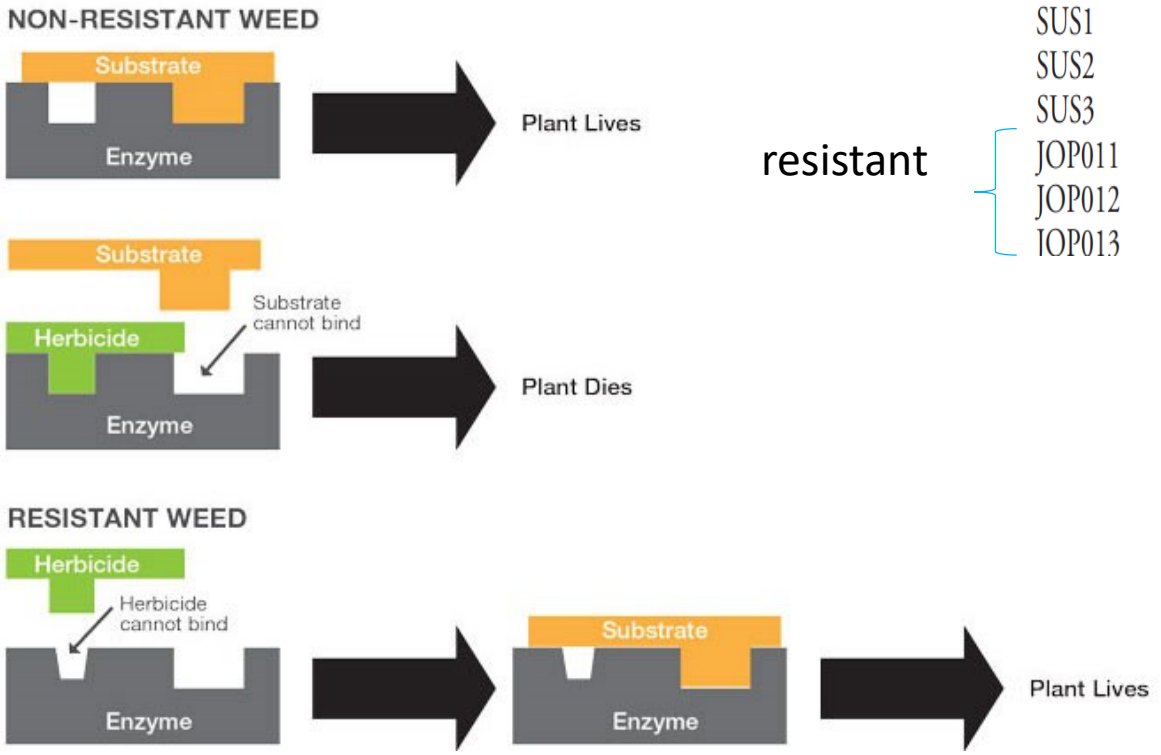
- Soybean showed little to no injury
  (interveinal chlorosis & necrosis)
- Injury rating ranged from 0 to 15%, and average <5%.
- Injury was inconsistent across replications.
- Yield data needed (need a trial repeat).
- Need to test in dryland no till, narrow row spacing.
- Metribuzin can be a tool for weed control in the right soil characteristics/properties in western ND.

# Herbicide Resistance Mechanisms in Weeds

- **Enzyme gene amplification**
- **Change in target enzyme conformation (point mutation)**
- **Reduced herbicide absorption and translocation**
- **Metabolism of herbicide molecule to non-toxic forms**
- **Rapid tissue necrosis**
- ***Avoidance/weed shifts***

# *Mechanisms of Herbicide Resistance in Weeds*

- **Change in target enzyme conformation (point nucleotide mutation)**



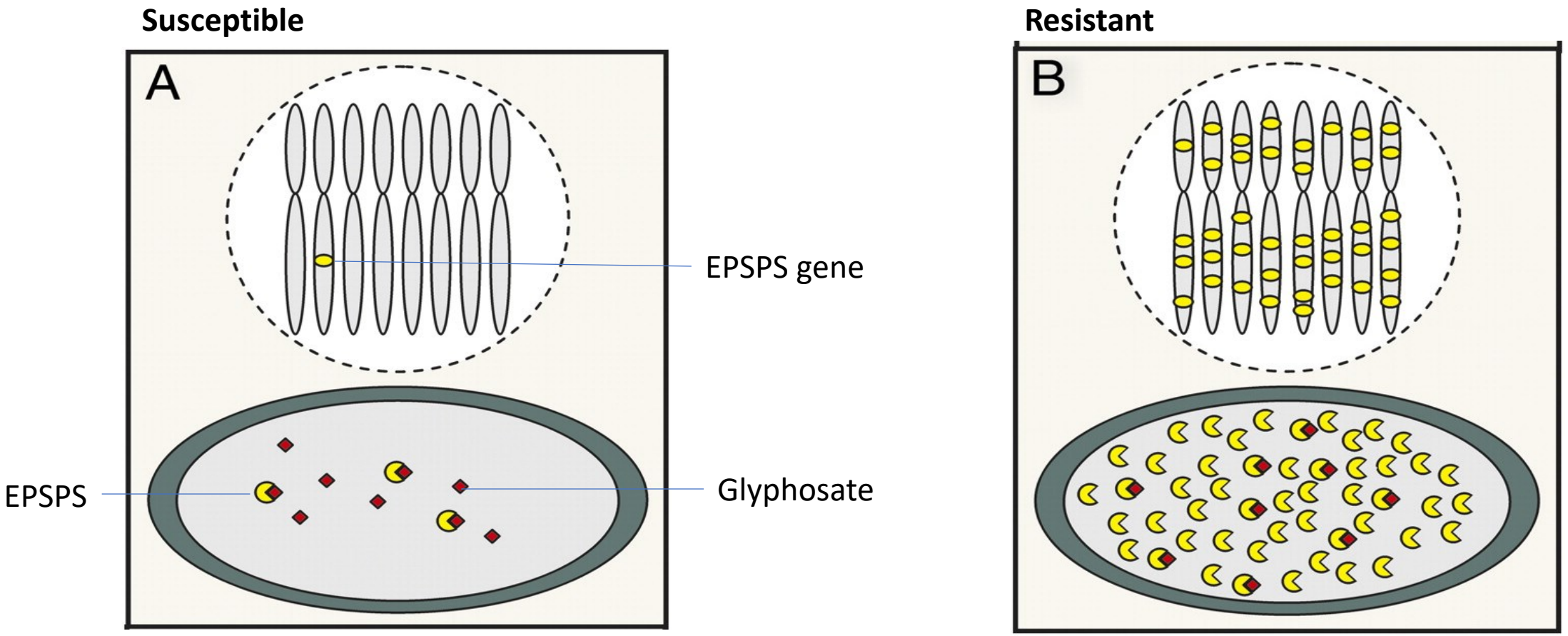

resistant

Table 4. Nucleotide bases and derived amino acid sequences of a fragment of *ALS* gene from susceptible and multiple herbicide-resistant kochia accessions from Montana, showing a single nucleotide mutation (bold and underlined codon) at $Pro_{197}$ residue.[a]

| Reference *ALS* gene sequence of kochia[b] | ACG Thr | GGG Gly | CAG Gln | GTG Val | **CCG Pro** | CGG Arg | CGA Arg | ATG Met | ATT Ile | GGG Gly | ACG Thr |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Amino acid positions | 193 | 194 | 195 | 196 | 197 | 198 | 199 | 200 | 201 | 202 | 203 |
| SUS1 | ACG | GGG | CAG | GTG | **CCG** | CGG | CGA | ATG | ATT | GGG | ACG |
| SUS2 | ACG | GGG | CAG | GTG | **CCG** | CGG | CGA | ATG | ATT | GGG | ACG |
| SUS3 | ACG | GGG | CAG | GTG | **CCG** | CGG | CGA | ATG | ATT | GGG | ACG |
| JOP011 | ACG | GGG | CAG | GTG | **CAG** | CGG | CGA | ATG | ATT | GGG | ACG |
| JOP012 | ACG | GGG | CAG | GTG | **CAG** | CGG | CGA | ATG | ATT | GGG | ACG |
| JOP013 | ACG | GGG | CAG | GTG | **CAG** | CGG | CGA | ATG | ATT | GGG | ACG |

# *Mechanisms of Herbicide Resistance in Weeds*

- **Gene amplification**



# *Mechanisms of Herbicide Resistance in Weeds*

- **<u>Reduced herbicide absorption</u>, reduced translocation and vacuolar sequestration**

thicker cuticles and increased number of trichomes/leaf hairs

## $^{14}$C-Glyphosate Absorption and Translocations

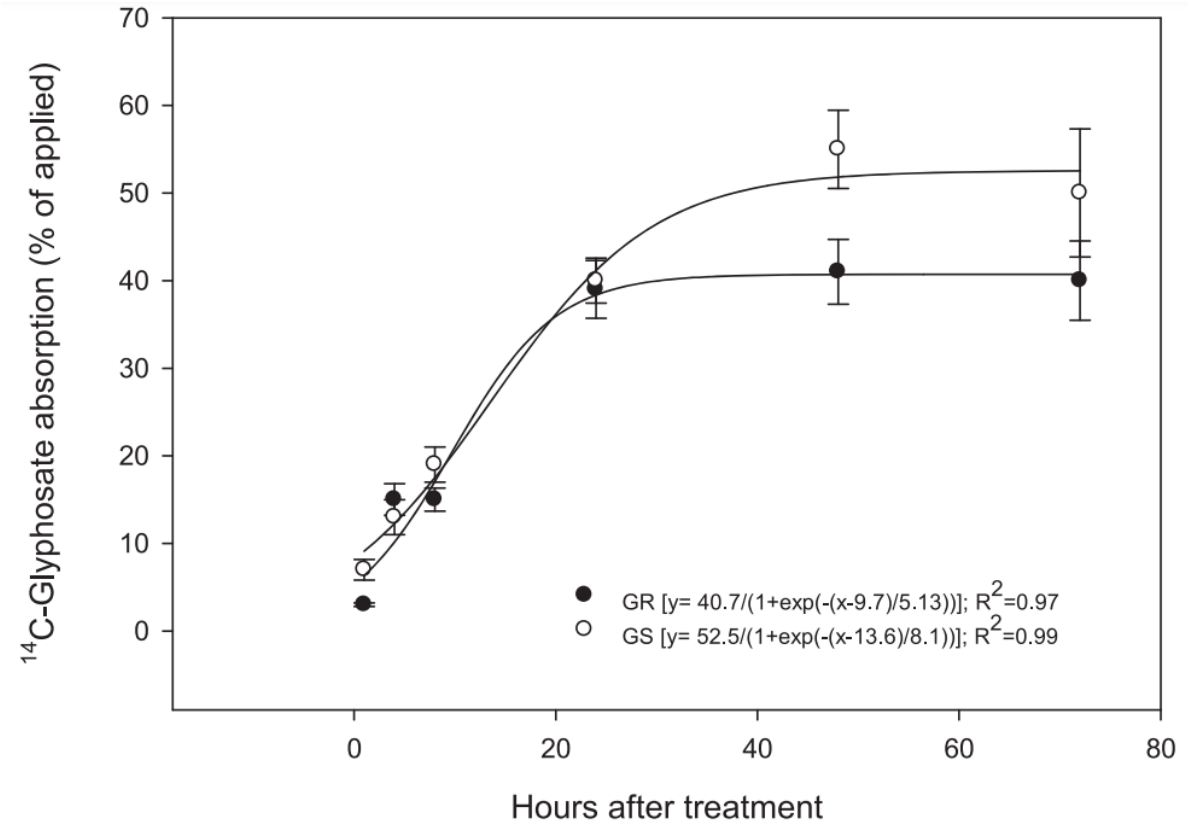



Figure 1. Absorption pattern of $^{14}$C-glyphosate in glyphosate-resistant (GR) and -susceptible (GS) tall waterhemp (*Amaranthus tuberculatus*) populations. Vertical bars represent standard error of mean. From Nandula et al. (2013). Note the six time points.

# *Mechanisms of Herbicide Resistance in Weeds*

- **Reduced translocation and vacuolar sequestration**

## $^{14}$C-Glyphosate Translocations

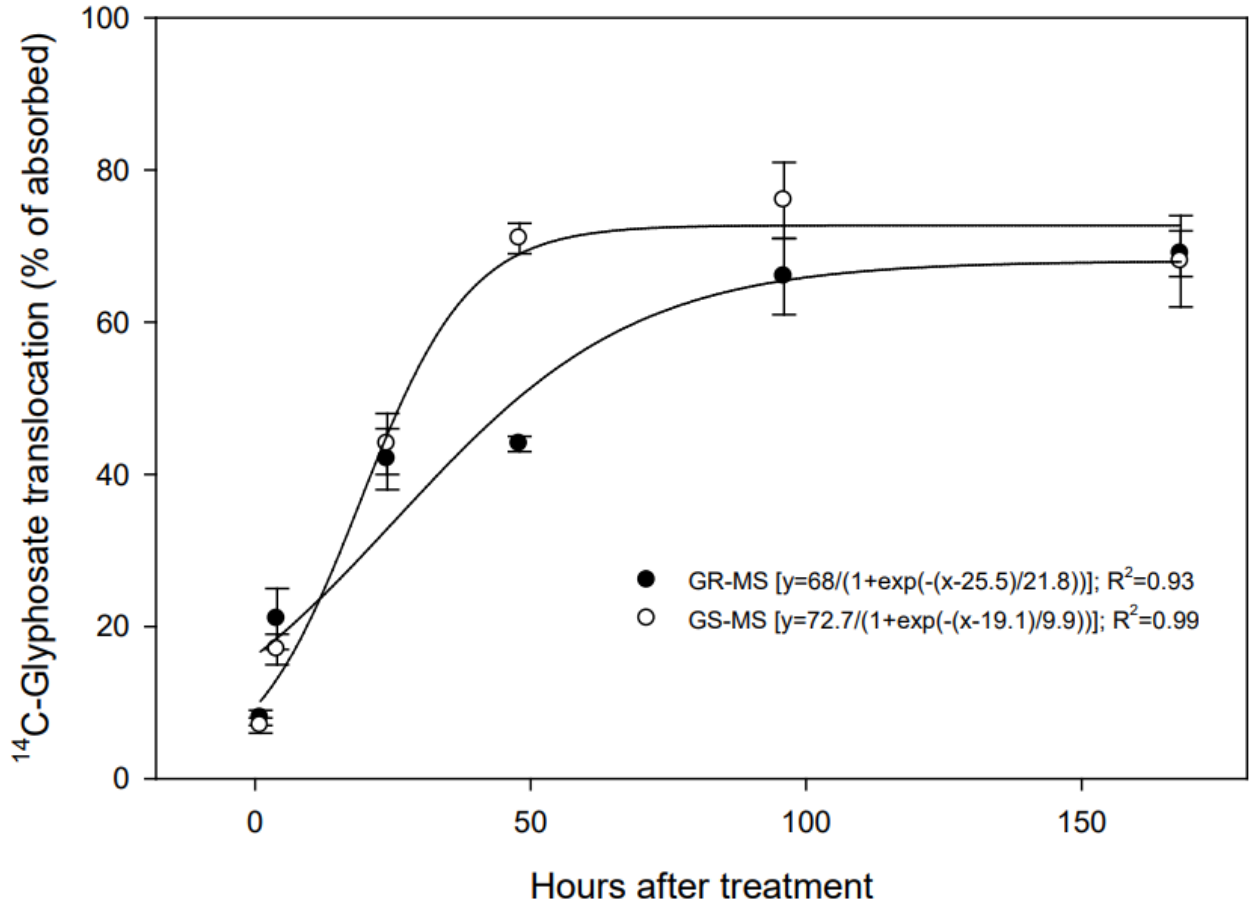



Figure 3. Translocation of $^{14}$C-glyphosate in glyphosate-resistant (closed circles) and susceptible (open circles) giant ragweed biotypes. Vertical bars represent standard error of mean (n = 4).

# *Mechanisms of Herbicide Resistance in Weeds*

- **Reduced translocation and vacuolar sequestration**

**Table 1**
Paraquat in leaf protoplasts isolated from paraquat-treated plants. Four independent experiments were conducted and in each experiment 15–20 protoplast preparations were combined for paraquat quantification.

| Experiment (E) | Biotype (B) | Paraquat content (μg) | Chlorophyll content (mg) | Paraquat/Chl (μg/mg) | R/S ratio on Chl basis | Protein content (mg) | Paraquat/Protein (μg/mg) | R/S ratio on protein basis |
|---|---|---|---|---|---|---|---|---|
| I | | | | | | | | |
| | R | 4.56 | 3.07 | 1.5 | 2.0 | | | |
| | S | 2.74 | 3.65 | 0.75 | | | | |
| II | | | | | | | | |
| | R | 13.14 | 7.64 | 1.72 | 2.4 | 63.5 | 0.207 | 2.4 |
| | S | 5.33 | 7.41 | 0.72 | | 60.5 | 0.088 | |
| III | | | | | | | | |
| | R | 9.28 | 4.37 | 2.12 | 3.0 | 59.3 | 0.156 | 2.7 |
| | S | 3.14 | 4.46 | 0.7 | | 53.3 | 0.059 | |
| IV | | | | | | | | |
| | R | 4.44 | 2.54 | 1.75 | 3.6 | 34.0 | 0.131 | 3.4 |
| | S | 1.16 | 2.41 | 0.48 | | 30.1 | 0.037 | |
| E | | | | $P = 0.55$ | | | $P = 0.04$ | |
| B | | | | $P < 0.01$ | | | $P < 0.01$ | |

# *Mechanisms of Herbicide Resistance in Weeds*

- **Metabolism of herbicide molecule to non-toxic forms**
- **Herbicide molecule become less toxic and more soluble**

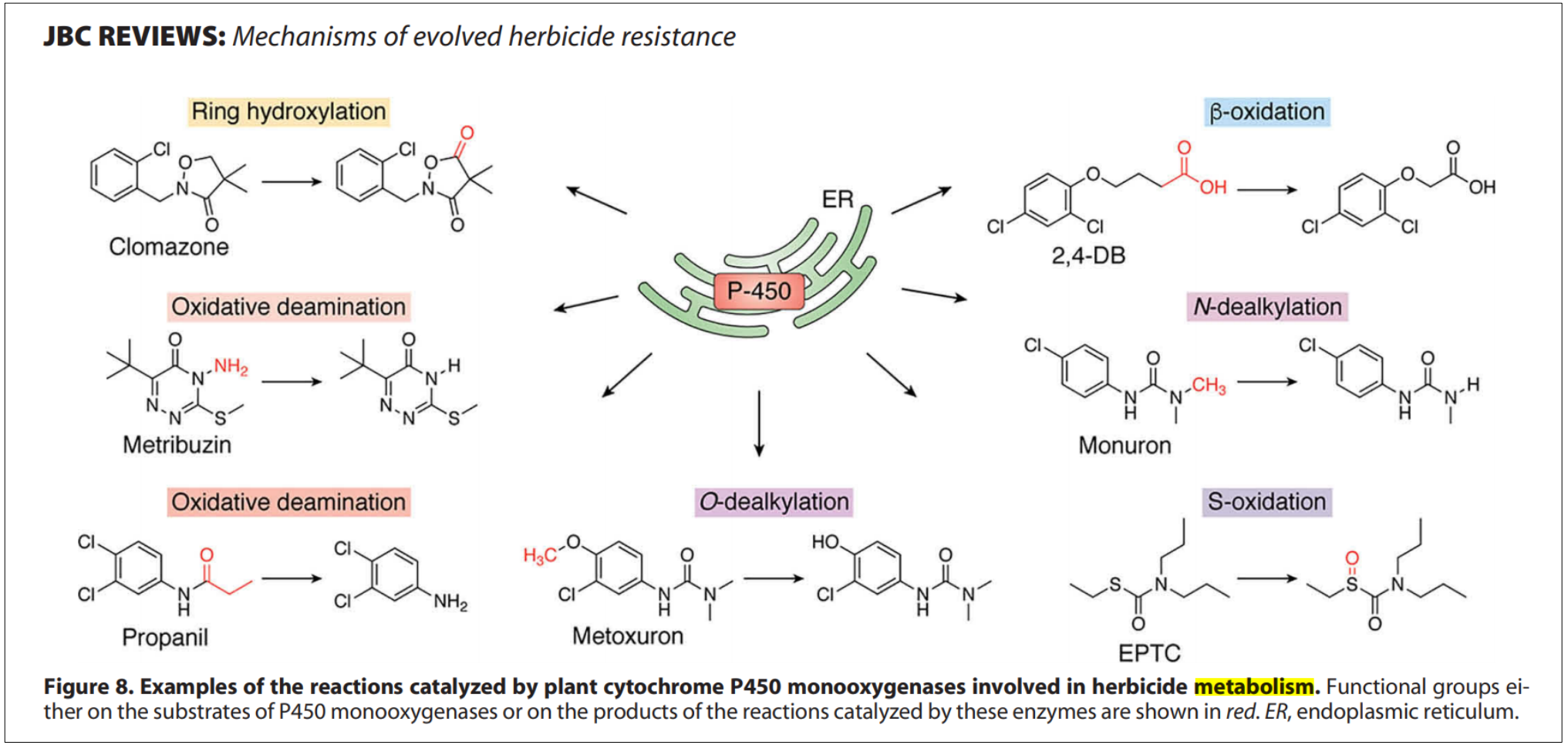
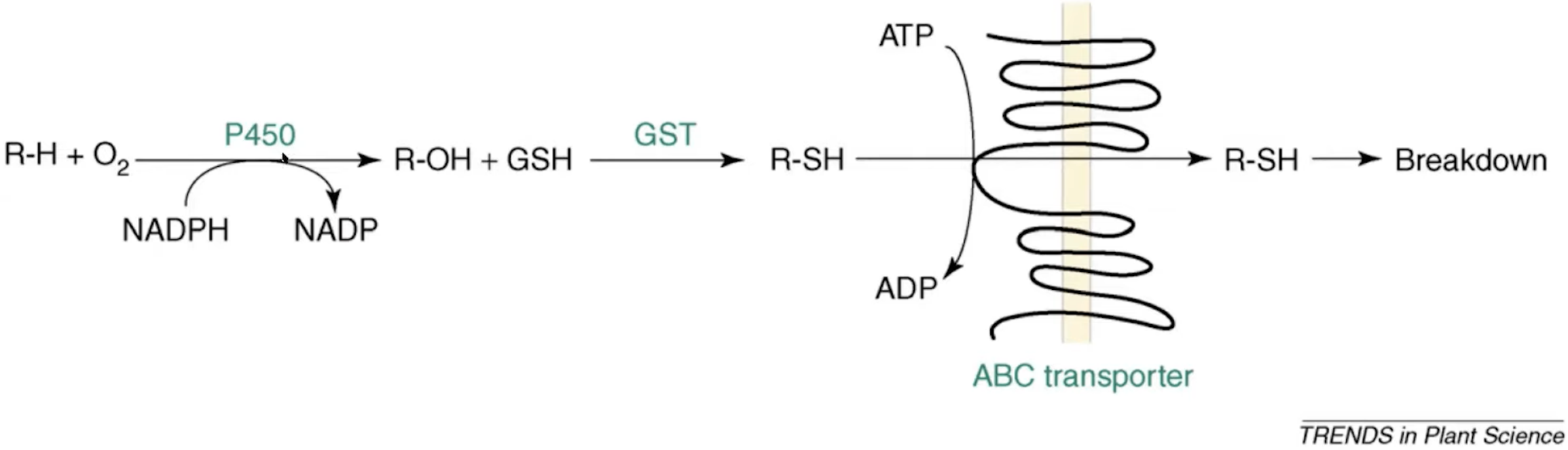



**Figure 8. Examples of the reactions catalyzed by plant cytochrome P450 monooxygenases involved in herbicide metabolism.** Functional groups either on the substrates of P450 monooxygenases or on the products of the reactions catalyzed by these enzymes are shown in *red*. *ER*, endoplasmic reticulum.

# *Mechanisms of Herbicide Resistance in Weeds*

- **Metabolism of herbicide molecule to non-toxic forms**




Phase I Phase II Phase III Phase IV

P. Tranel, 2022

# *Mechanisms of Herbicide Resistance in Weeds*

- **Rapid tissue necrosis**

"Phoenix Phenomenon"

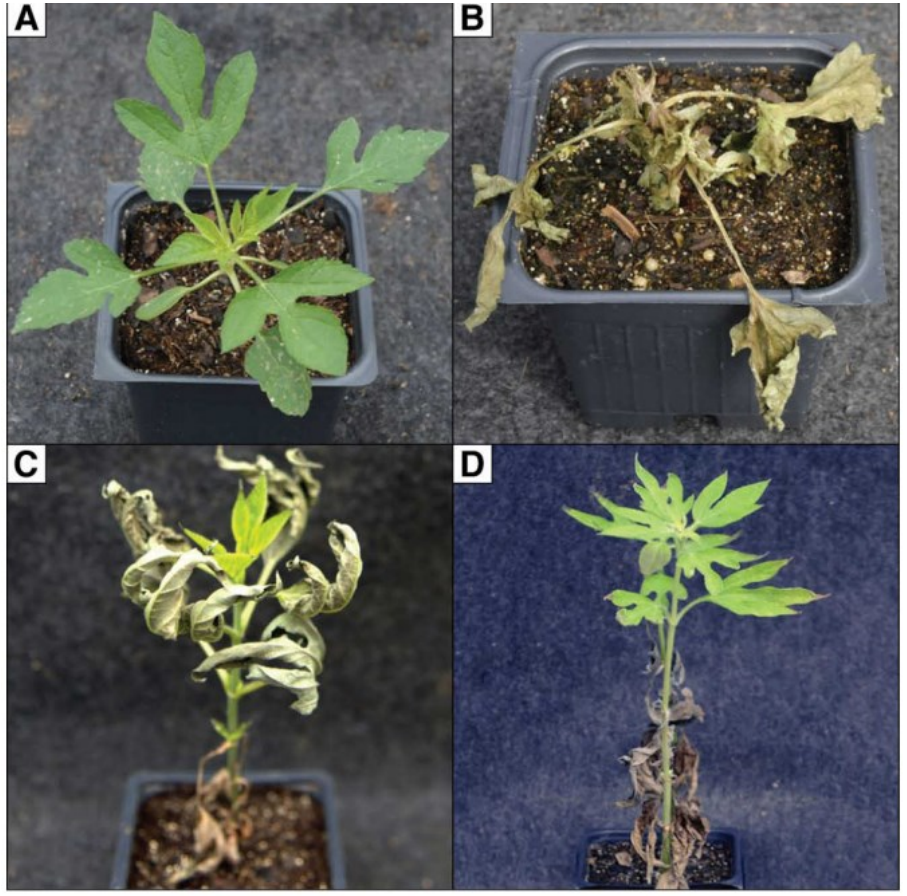
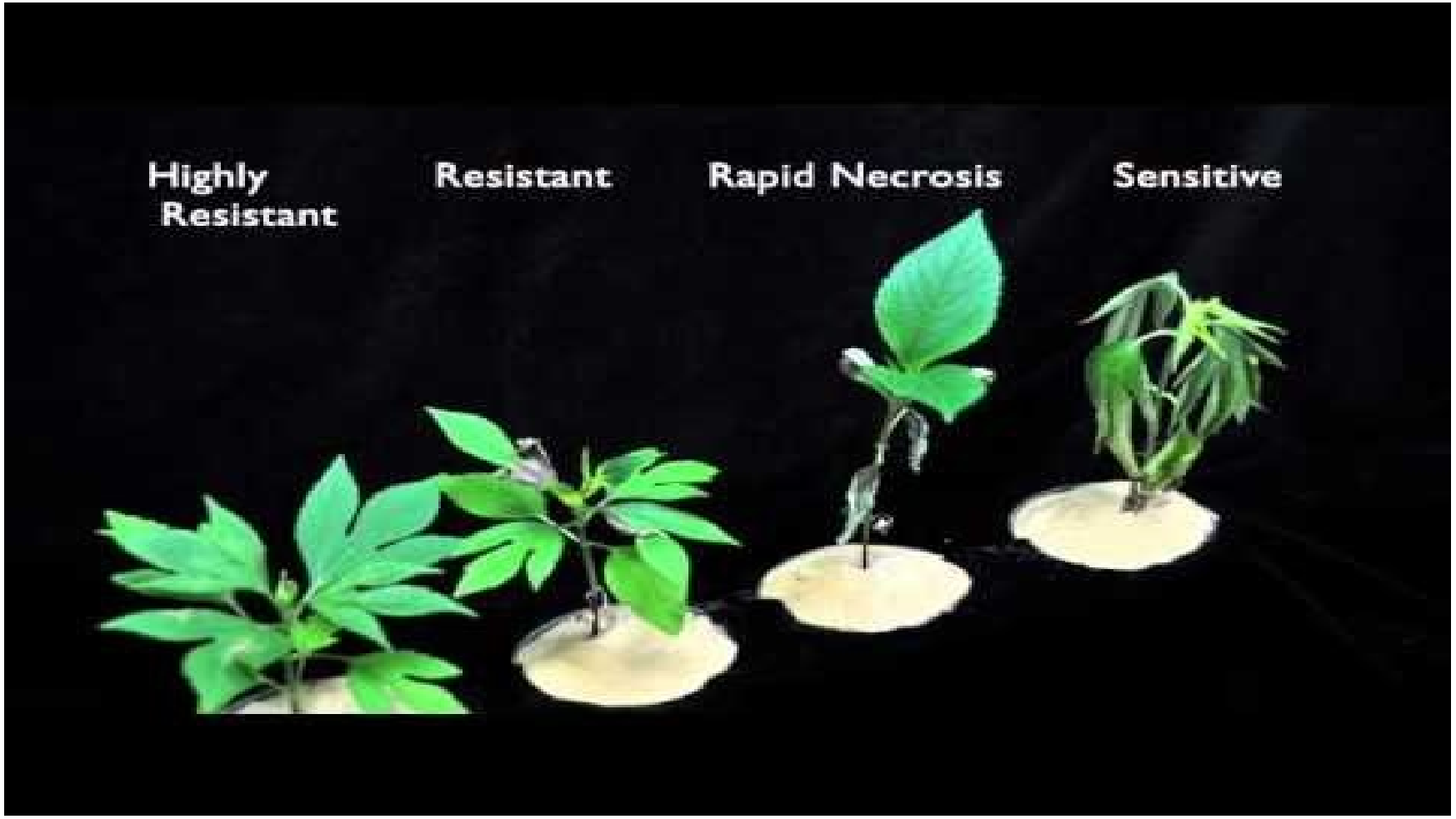



**Figure 6. The phoenix phenomenon in plants treated with glyphosate.** Both giant ragweed (*Ambrosia trifida*) biotypes were sprayed with 0.7 kg/hectare glyphosate. Shown is glyphosate-susceptible *A. trifida* at 2 days (*A*) and 21 days (*B*) after glyphosate treatment, behaving like most plants treated with glyphosate. Growth stops, but no injury is observed for the first few days. Shown is glyphosate-resistant *A. trifida* at 2 days (*C*) and 21 days (*D*) after glyphosate treatment. In plants exhibiting the phoenix phenomenon, older leaves desiccate very rapidly, trapping most of the glyphosate in dead tissues, and the new shoots emerge undamaged from the glyphosate treatment. Cover image from Ref. 93 with permission from John Wiley & Sons, Inc.

# *Mechanisms of Herbicide Resistance in Weeds*

- **Rapid tissue necrosis**

"Phoenix Phenomenon"



- **Avoidance (weed shifts)**

The kochia biotype that predominated where isoxaflutole was applied PRE had elevated levels of seed dormancy and required higher alternating temperatures to release dormancy than untreated control kochia.

The greater seed dormancy resulted in the later germination.

In addition, as soil temperatures increased through the spring, the isoxaflutole concentration in soil declined quickly.

Late-emerging kochia seedlings had a better chance to survive and reproduce, resulting in a population shift.

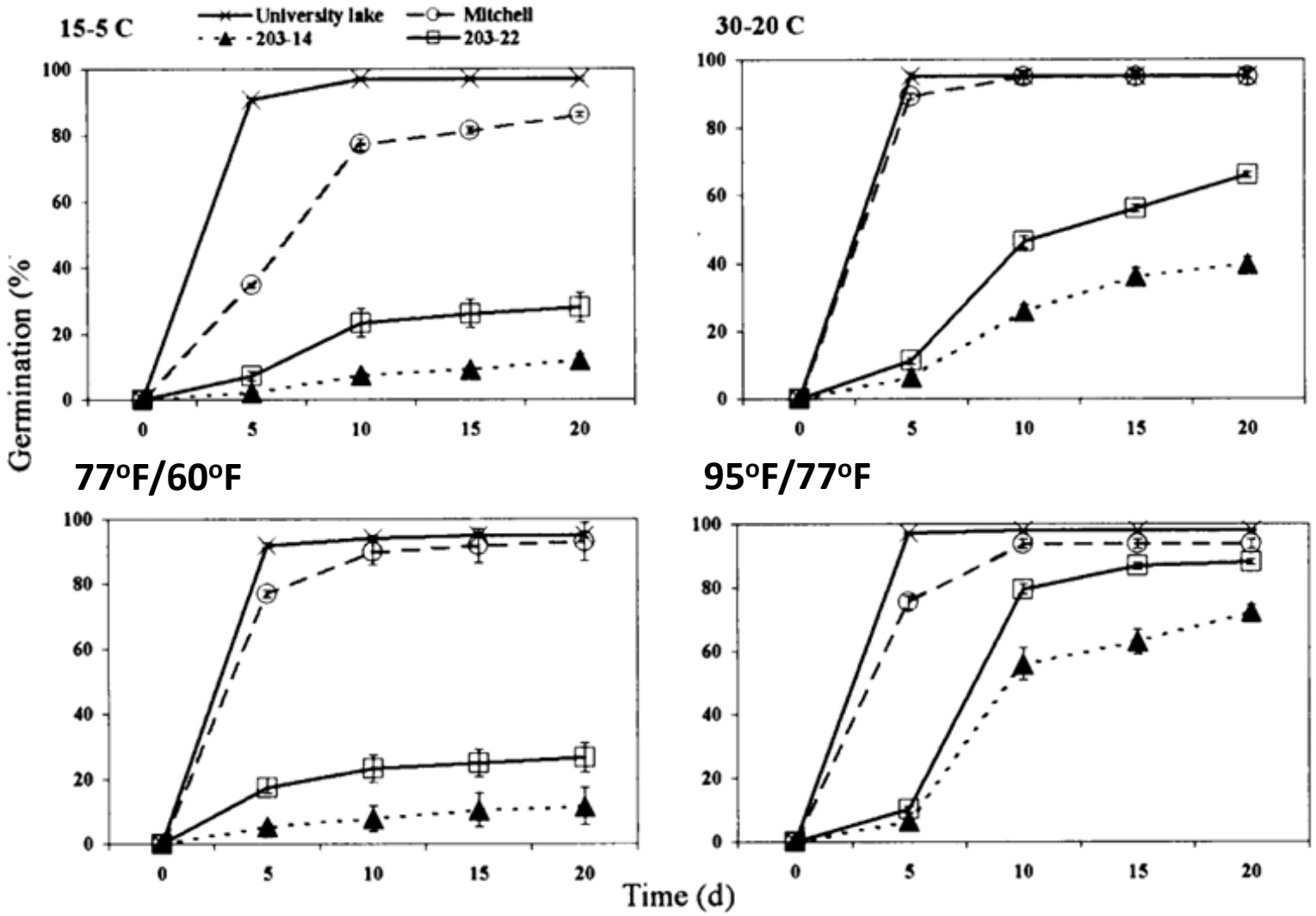



Figure 2. Cumulative germination over time of tested kochia seeds with alternating day/night temperatures (vertical bars indicate standard error).

Sbatella et. Al. 2010

# *Effective Weed Herbicide Resistance Management*

- Acknowledge that weeds have an arsenal of very unique ways to combat our weed management practices.

- If possible know what type of resistance is in the field, will determine weed management strategy and tools.

- Scout fields for efficacy on weeds. Collect tissue samples from escapes and send for analysis to confirm or rule out resistance.
  - Send leaf tissue samples to the National Genotyping Center to confirm/determine type of resistance.

# Thank you!

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Photo by Dr. C. Keene

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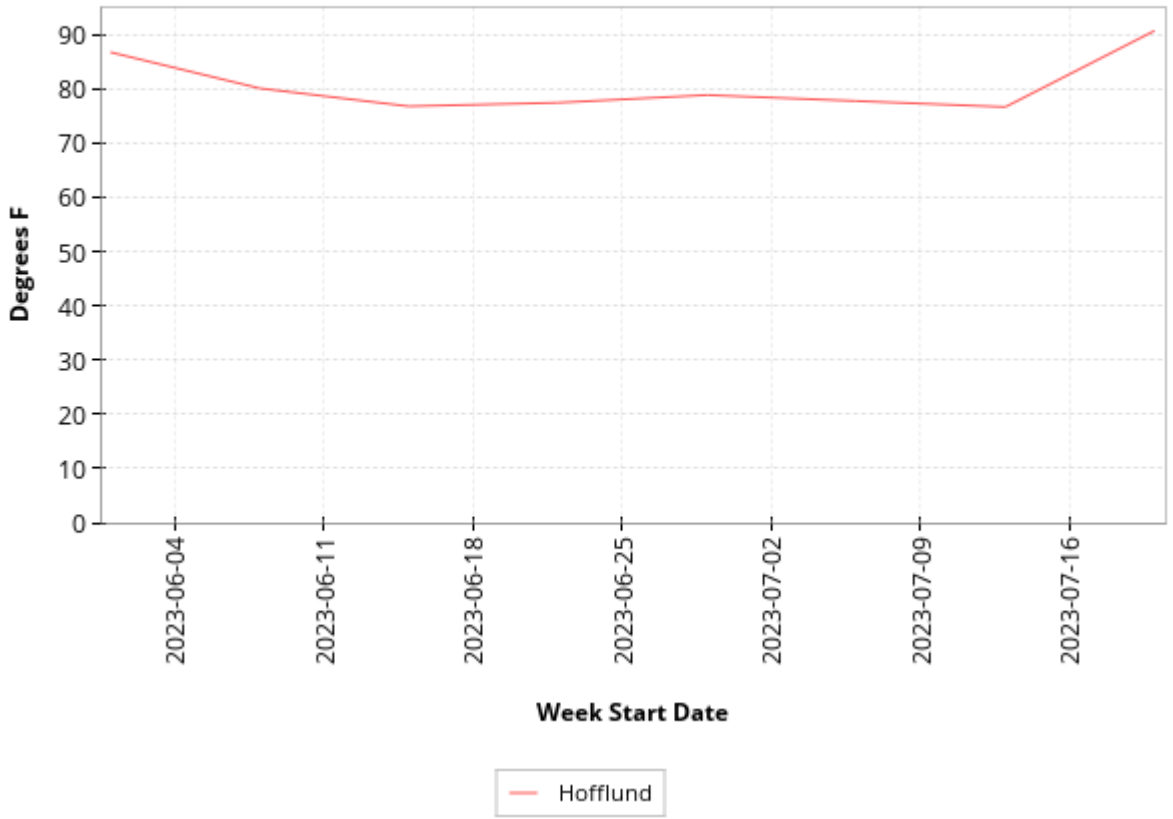
## Weekly Average Maximum Air Temperature

(2023-06-01 - 2023-07-20)

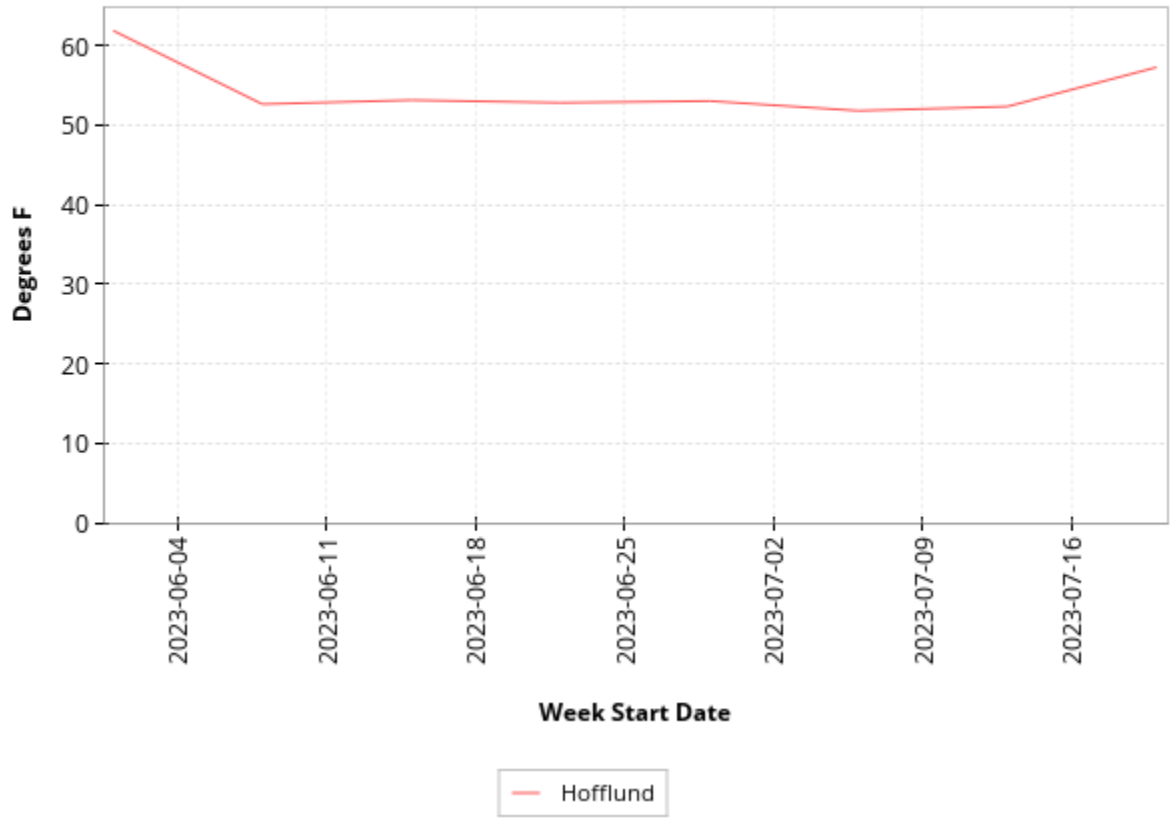
North Dakota Agricultural Weather Network (NDAWN)




## Weekly Average Minimum Air Temperature

(2023-06-01 - 2023-07-20)

North Dakota Agricultural Weather Network (NDAWN)



## Weekly Average Air Temperature

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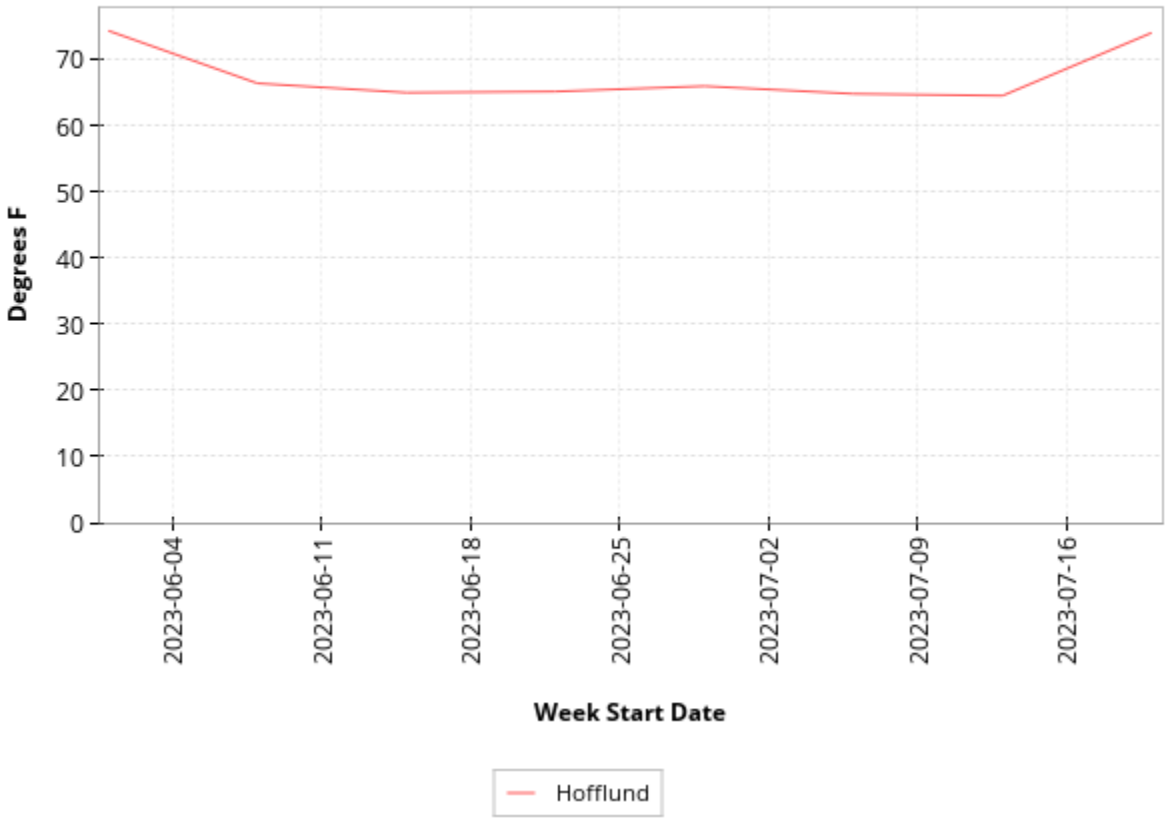


## Weekly Average Bare Soil Temperature (4in Depth)

(2023-06-01 - 2023-07-20)

North Dakota Agricultural Weather Network (NDAWN)