Weed Management Challenges in 2022 Due to the 2021 Crop Season

(aka Weeds, Herbicide Persistence, Back to Basics)

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2022 NDSU

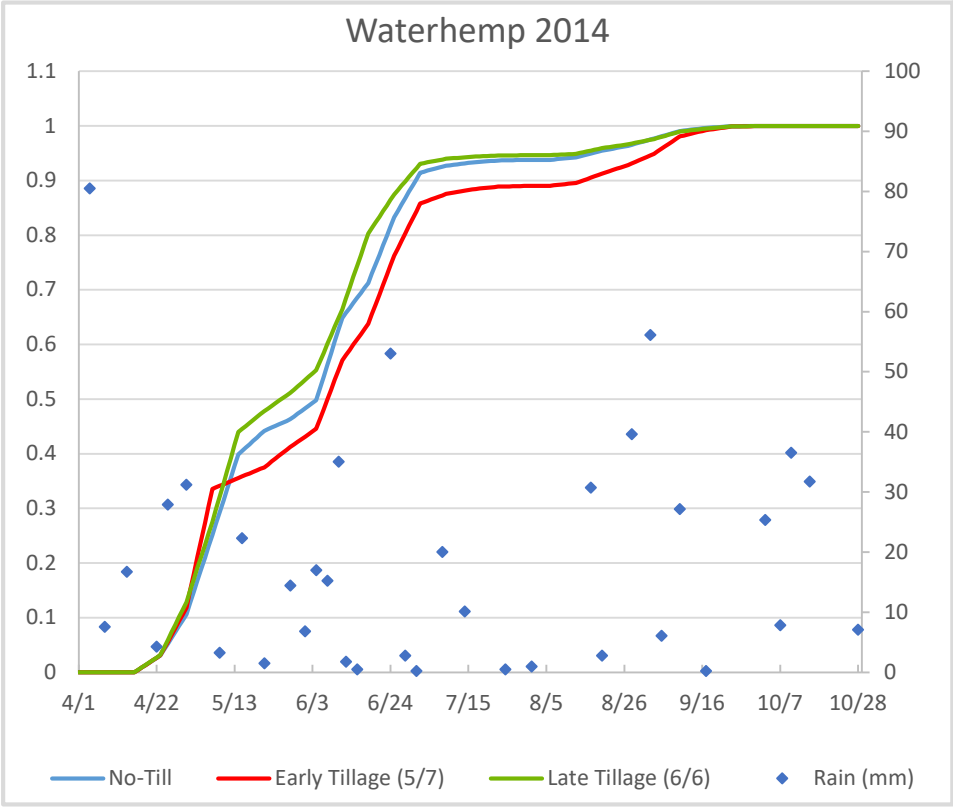
Advanced Crop Advisors Workshop

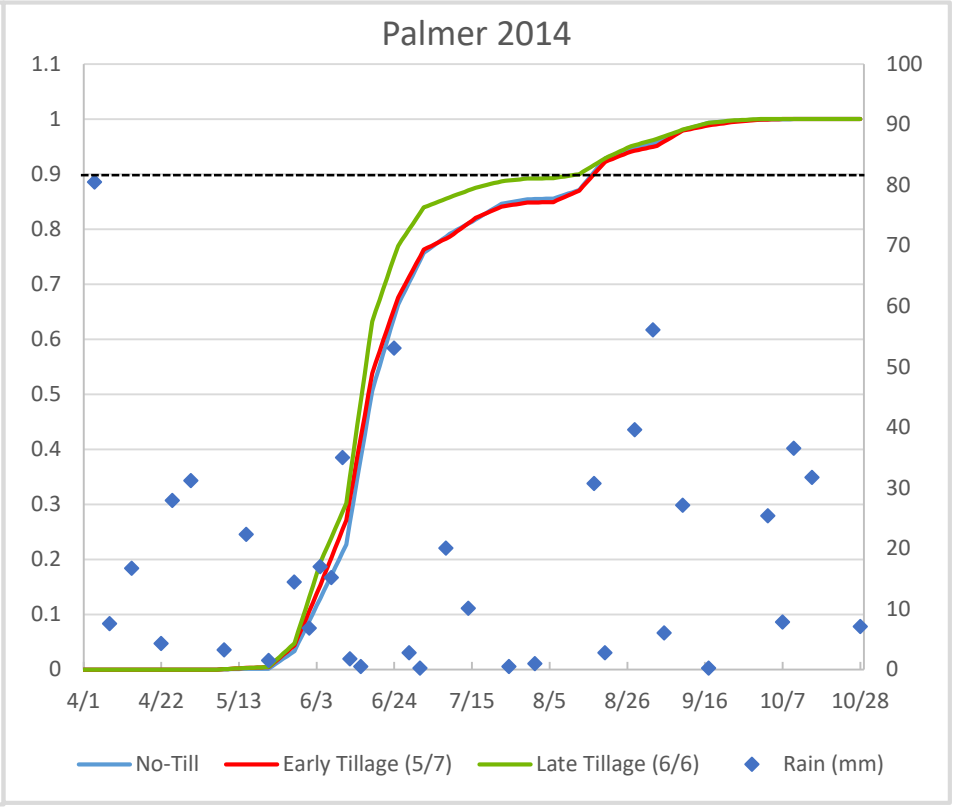
NDSU North Dakota State University

General Thoughts on Weed Pressure in 2021

- Drought conditions conducive for weed escapes
  - Kochia, lambsquarters, green foxtail, waterhemp (late)
- Late summer/fall precipitation
  - Increased winter annual weed pressure (horseweed)
- Weed pressure in 2022 shouldn't be dramatically different
  - Expect earlier emergence (we actually have moisture)
- Main emphasis should be on residual herbicides and timely applications
  - Overall, most weeds have short germination window
    - 90% emergence over a few weeks

Cumulative Emergence and Rainfall Events





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Weed Science

Herbicide Carryover Concerns in 2022

Basic Rules for Managing Potential Herbicide Carryover

- ***Follow the herbicide label!***
  - Always use proper rates and application timings.
  - Always follow re-cropping intervals.
- Use common sense and previous experience.
- Inquire with herbicide manufacturer for products of greatest concern.

NDSU Weed Guide: Pages 102-103

Y15. Crop Rotation Restrictions for North Dakota

Herbicide	Alf-alfa	Bar-ley	Can-ola	Corn	CRP grss	Dry bean	Field pea	Flax	Oat	Edibl Leg.[1]	Pot-ato	Saff lowr	Soy-bean	Sgr-beet	Sun-flwr	HRS/ Drm
	months after application (d = days)															
Acuron/Flexi	18/10	4	18	0	18	18	18	18	10	18	10	18	10	18	18	4
Acuron GT	10a	4.5	18	0	18	18	18	18	4.5	18	10	18	10	18	18	4.5
Ally Extra (e) (0.3 oz/A)	22e	10	22	22	6	22e	22e	22	10	22e	22	10	22	22b	10	1/10
Anthem/Max	10	11	18	0	18	11	6-8	18	11	6-8[1]	4	18	0	15	4	4
Anthem Flex (r)	10	11	18	0	18	11	6	18	11	6	4	18	0	12	4	1
Armezon/Pro	9	3/4n	9	0	18	9n	9	18	3/4n	18	9	18	9	18	9	3/4n
Atrazine* (0.38 lb ai)	NCS	NCS	NCS	0	NCS	NCS	NCS	NCS	NCS	NCS	NCS	NCS	10	NCSb	NCS	NCS
(0.38-0.5 lb ai)	2CS	NCS	2CS	0	2CS	2CS	2CS	NCS	2CS	2CS	NCS	2CS	10	2CSb	2CS	2CS
(0.5-1 lb ai)	2CS	2CS	2CS	0	2CS	2CS	2CS	2CS	2CS	2CS	2CS	2CS	10	2CSb	2CS	2CS
Authority Assist	12	9.5	40b	10	12	4	4	26	18	4/12[1]	26	18	0	40b	18	4
Authority Elite	12	4.5	12	10	12	0	0	12	12	0/12[1]	4	12	0	36b	0	4.5
Authority First/Sonic	12	12	24	10	30b	12	12	30b	12	30b	18	30b	0	30b	30b	4
Authority MTZ	12	4	24	10	12	12	18	18	18	18	12	18	0	24b	12	4
Authority Supreme (r)	12	11	24	10	18	9	0	0	12	9	4	18	0	24	0	4
Autumn Super (i)	18	9j	18	1	18	18	18	18	18	18	18	18	2	24	18	3
Balance Flexx (j)	10	6	18	0	18	18	18	18	6	18	6	6	6	18	10	6
Banvel* (0.5 lb ai)	NCS	3d/oz	NCS	NCS	0h	NCS	NCS	NCS	3d/oz	NCS	NCS	NCS	45 d	NCS	NCS	3d/oz
(>0.5 lb ai)	NCS	NCS	NCS	NCS	0h	NCS	NCS	NCS	NCS	NCS	NCS	NCS	90 d	NCS	NCS	3d/oz
Beyond	9	18t	18	8.5	9	0	0	18	9	9	18t	18	0	18t	9	3
Boundary	4.5	8	12	4	12	12	8	12	12	12	0	12	0	18	12	8
BroadAxe XC	12	4.5	12	10	12	12	0	12	12	0/12[1]	4	12	0	36b	0	4.5
Capreno (i)	18	10	18	0	18	18	18	18	18	18	18	18	10	18	18	4
Callisto/GT	10	4	10	0	18	18	10g	0	0	18	10	18	10	18	10	4
Callisto Xtra	NCS	NCS	NCS	0	18	18	18g	NCS	18	18	NCS	18	NCS	18	NCS	NCS
Clarity* (0.5 lb ai)	4	22 d	4	4	0h	4	4	4	22 d	4	4	4	4	4	4	22 d
(>0.5 lb ai)	6	44 d	6	6	0h	6	6	6	44 d	6	6	6	6	6	6	44 d

Herbicide Fate in Soils

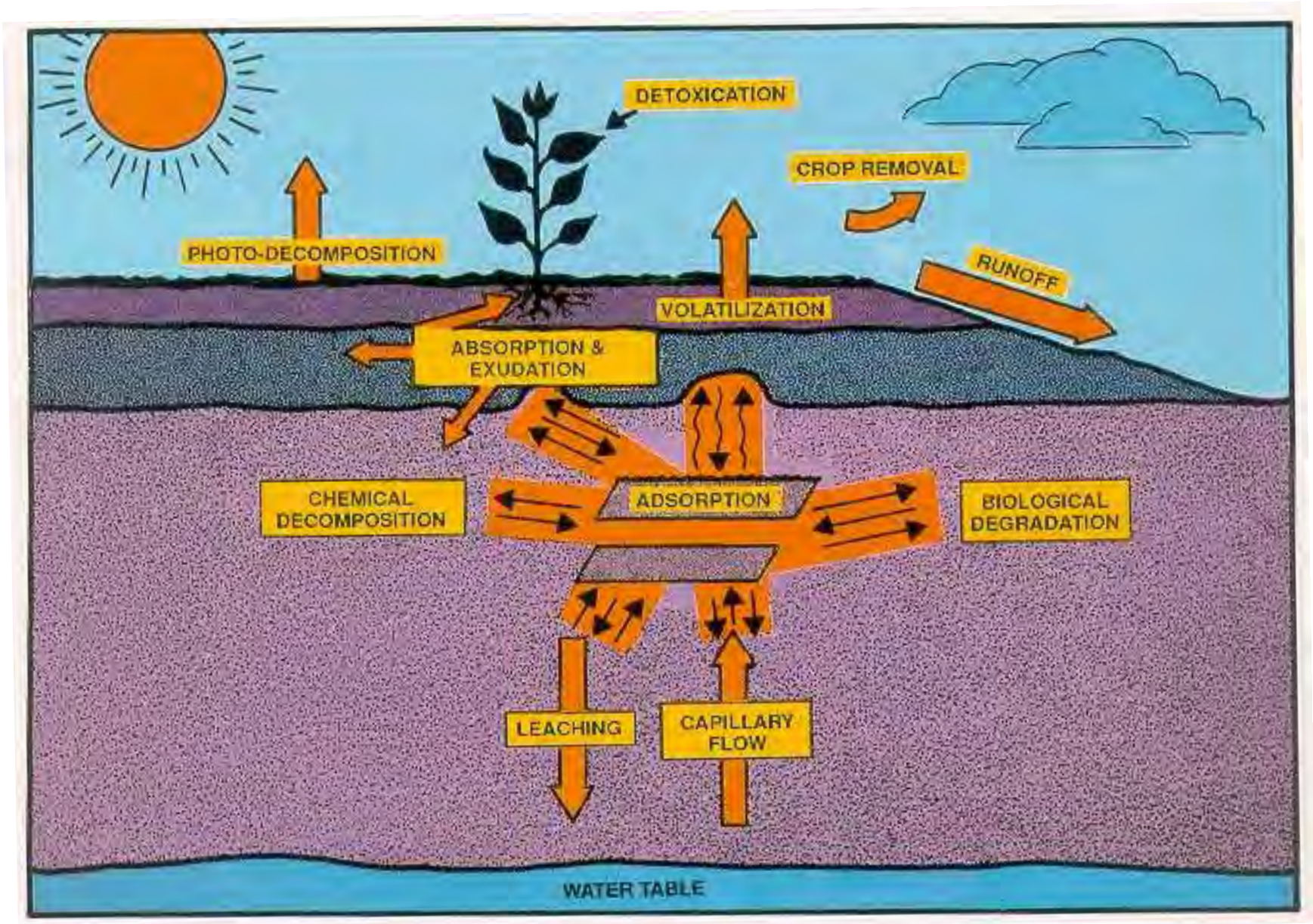
Three General Processes

1) **Adsorption** – attachment to soil particles and organic matter

2) **Movement** - runoff, leaching, tile flow, volatilization, plant uptake

3) **Degradation** – photodecomposition (photolysis), microbial, chemical degradation

Herbicide Fate is Complex Process



General Rules for Herbicide Breakdown
(Pages 100-104 in ND Weed Guide)

1. Many herbicides are broken down in soil by microbial decomposition. In addition, SUs and triazines are broken down by chemical reactions like acid hydrolysis.

2. Herbicide molecules must be free from binding to soil particles or organic matter for soil microorganisms to degrade.

3. Most herbicide molecules are more tightly adsorbed to soil particles in dry soils than moist soils.

4. Chemical degradation of herbicides in soil is affected by soil pH. Acid hydrolysis nearly ceases at soil pH above 6.8.

Degradation

- Processes
  - Photodecomposition (photolysis)
  - Chemical degradation
  - Microbial

- Degradation depends on the environment
  - Temperature and moisture are the most critical
  - No breakdown when temperatures reach freezing
  - Warm and moist conditions accelerate breakdown

DEGRADATION

- Photodecomposition – the adsorption of light resulting in an unstable molecule
  - Herbicides vary greatly in susceptibility
    - Some DNA herbicides
    - Reduced by soil incorporation

DEGRADATION

- Chemical degradation – several types of chemical reactions
  - Hydrolysis
  - Oxidation-reduction
  - Formation of salts
  - Formation of chemical complexes

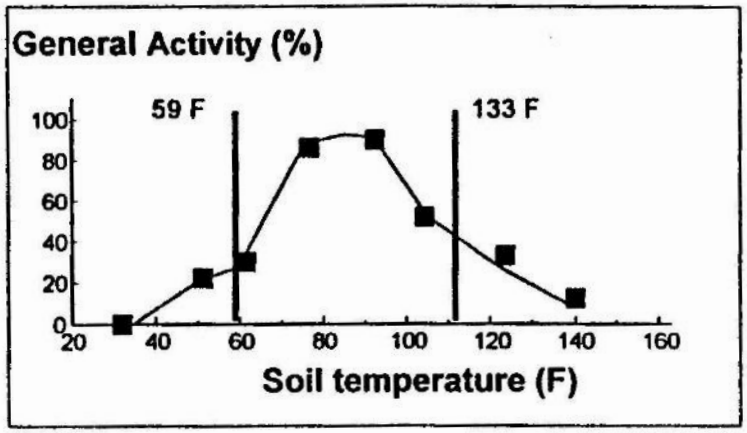
DEGRADATION

- Microbial Degradation
  - Microbes involved:
    - Bacteria
    - Fungi
    - Actinomycetes
  - All are enzyme mediated processes
    - Dehalogenation
    - Dealkylation
    - Amide or ester hydrolysis
    - Beta-oxidation
    - Ring hydroxylation
    - Ring cleavage

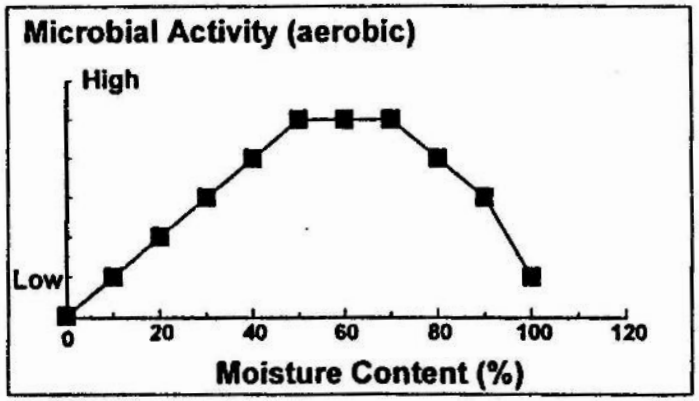
DEGRADATION

- Microbial Degradation cont.
  - Soil factors that affect microbial metabolism
    - Favorable moisture (50-100% of field capacity)
    - Aeration (Well aerated)
    - Mild temperature (80 to 90 F)
    - pH (6.5-8)
    - OM content (Slight increases with OM content)

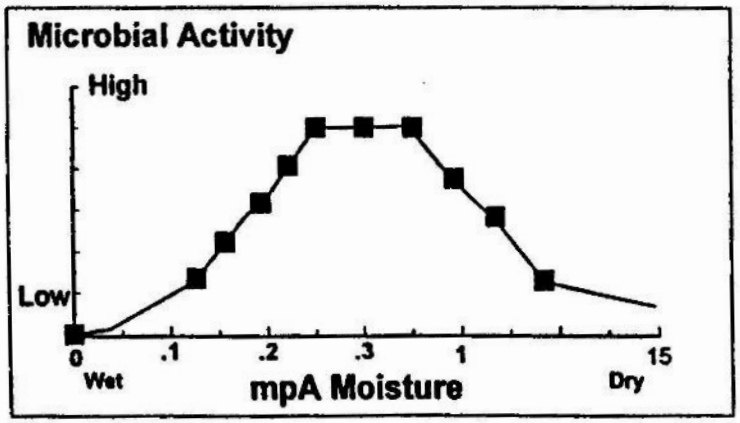
Temperature and Microbial Activity



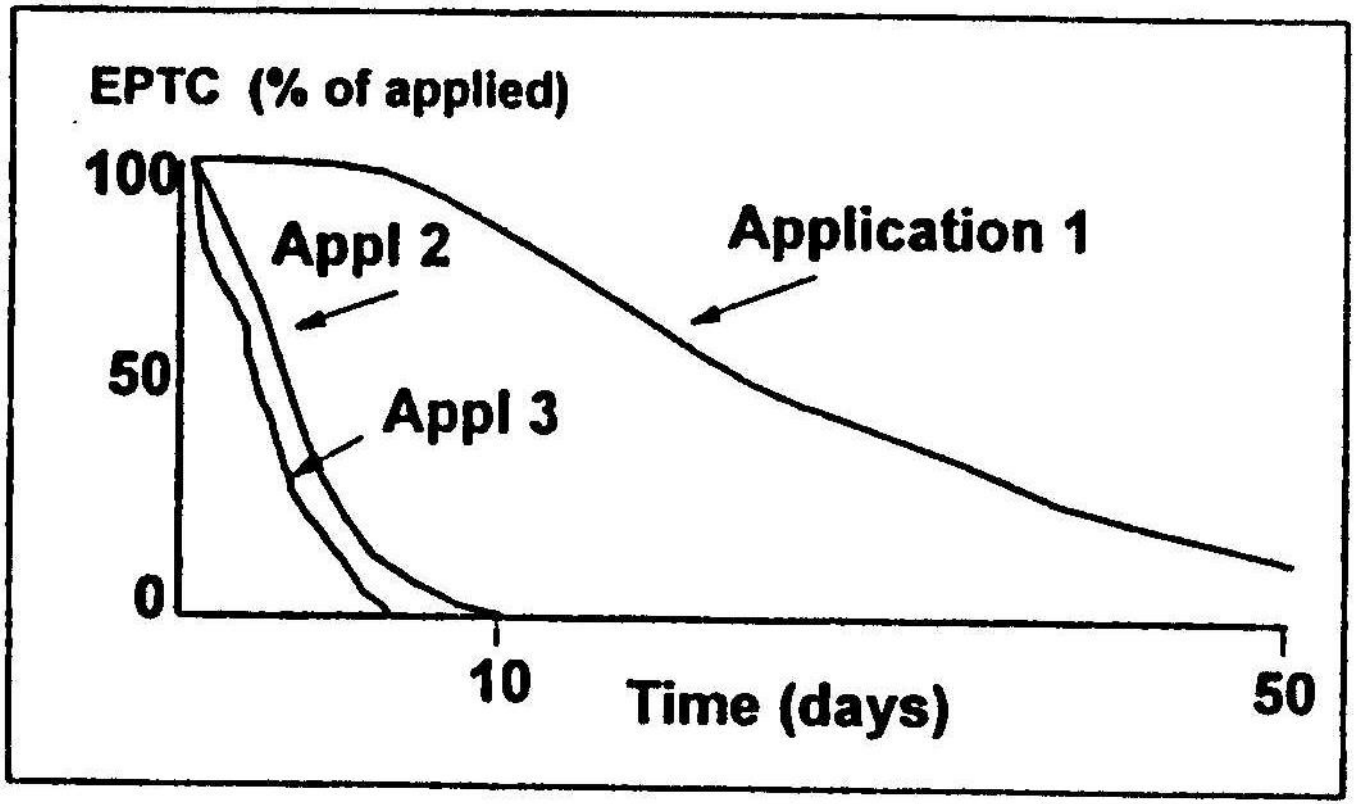
Moisture and Microbial Activity



Moisture and Microbial Activity



Buildup of Specific Soil Microbial Populations



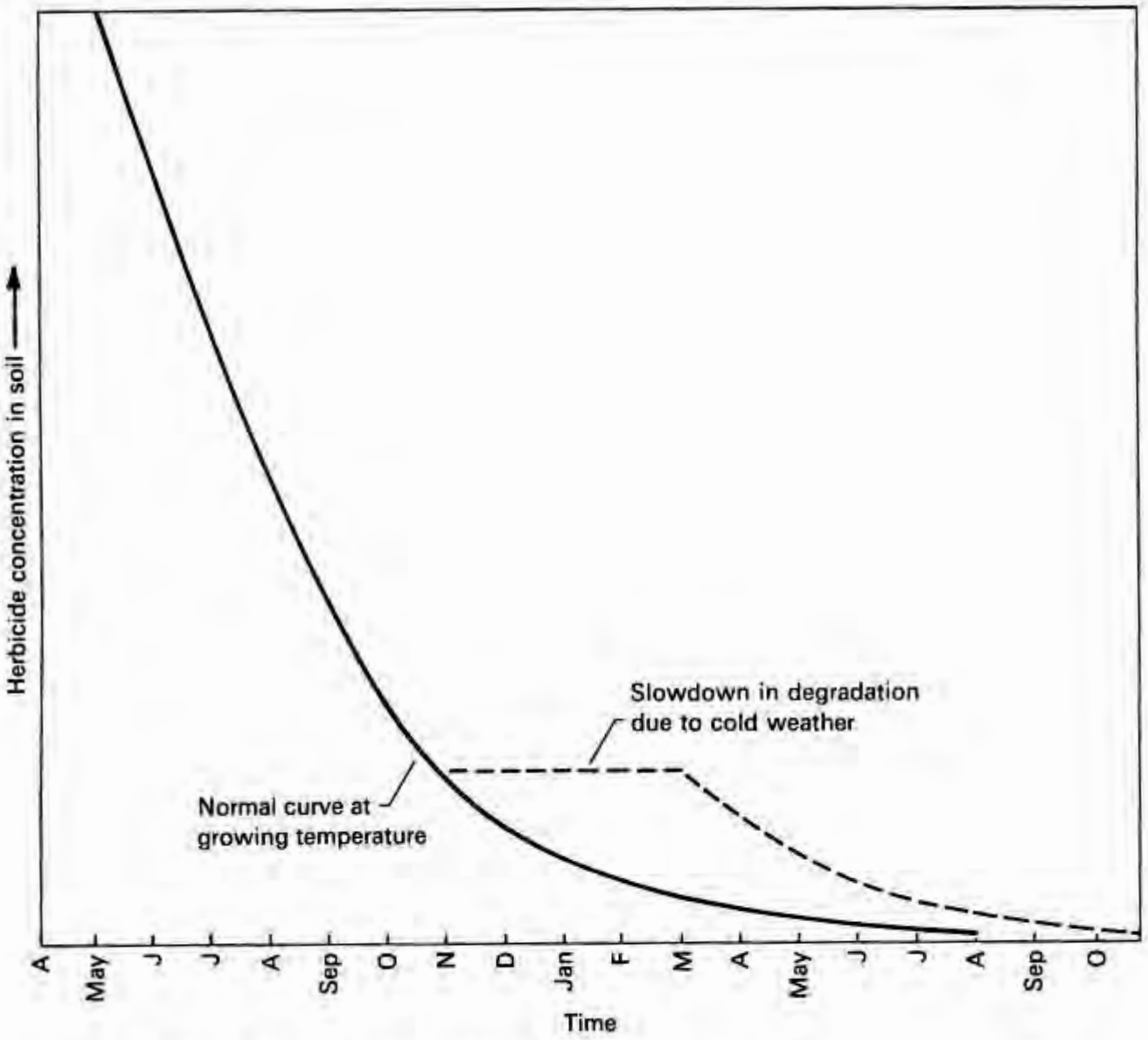
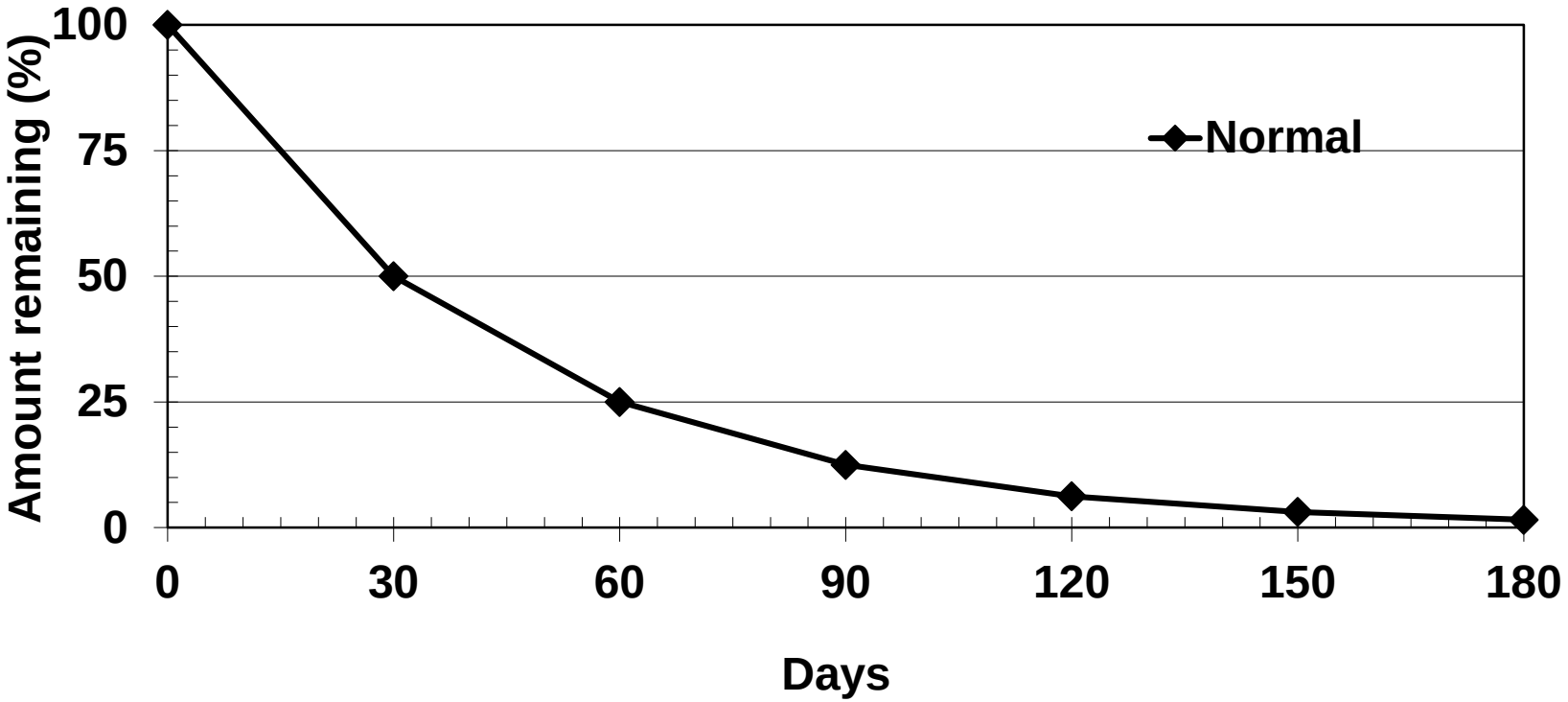


Figure 5.7. Herbicide degradation pattern over a year. Degradation rates during the winter are considerably lower than during the summer.

Herbicide Persistence

Half-life: the amount of time needed to degrade half of the herbicide present



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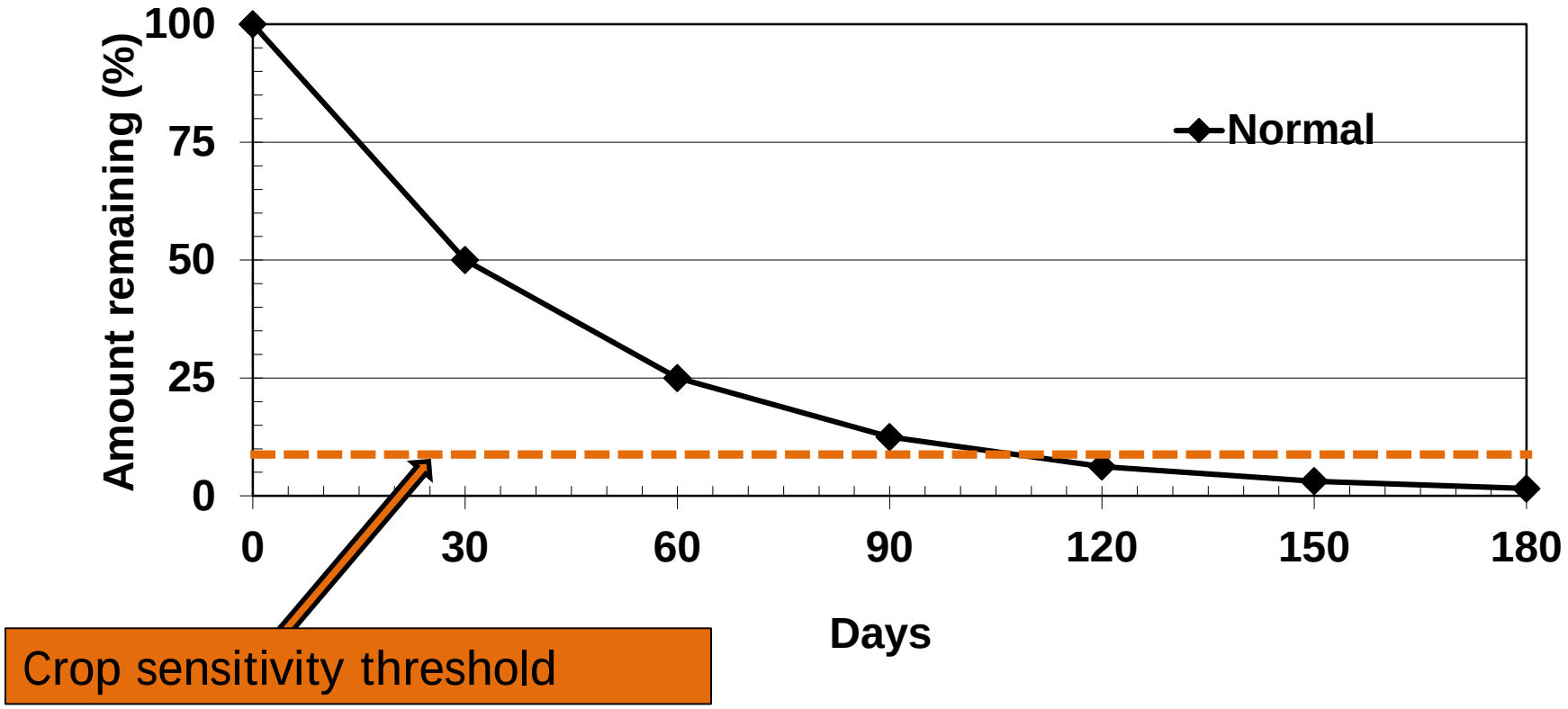

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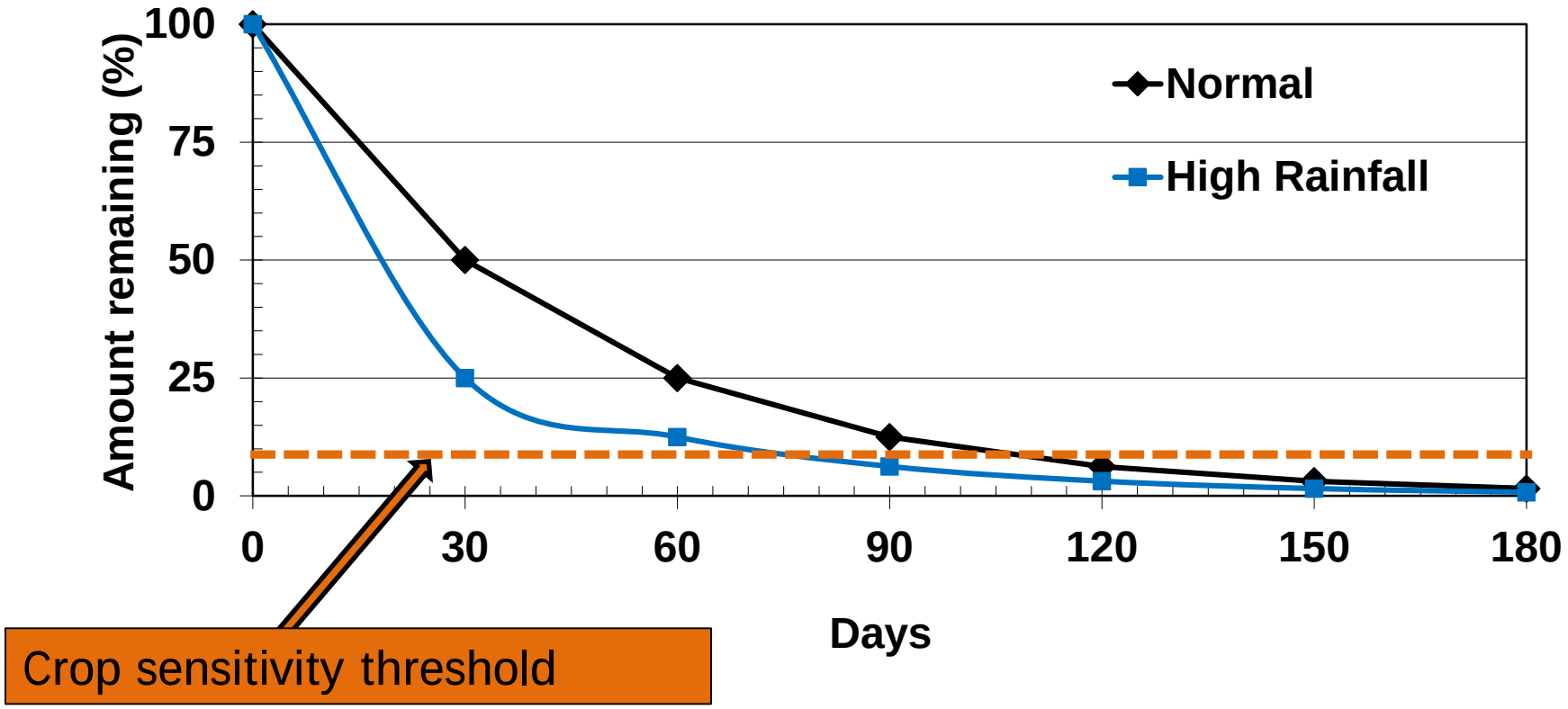

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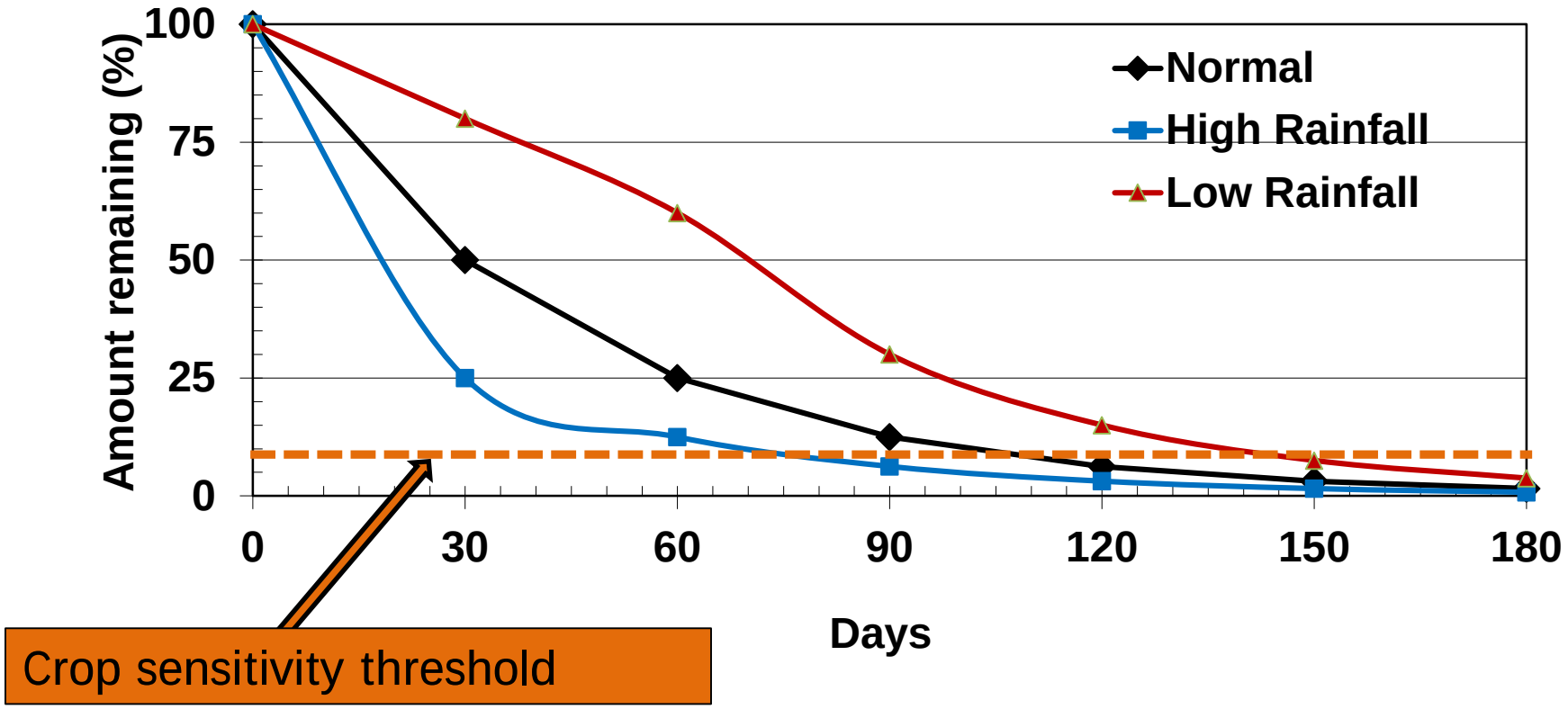


Herbicide Half-Lives

Herbicide	Half-Life (in days)
Dicamba	5
EPTC (Eptam)	6-30
2,4-D	10
Metribuzin (Sencor)	30-60
Clopyralid (Stinger)	40
Trifluralin (Treflan)	45
Atrazine	60
Imazethapyr (Pursuit)	60-90
Triallate (Far-Go)	82
Imazapyr (Arsenal)	25-142
Picloram (Tordon)	90-300

Soil Breakdown for Select Herbicides

- Primarily microbial
  - Some HPPD herbicides
  - Fomesafen
  - Sulfentrazone
  - Imidazolinones
- Primarily hydrolysis
  - Triazines
  - Sulfonylureas

Imi (imazamox), TPS (cloransulam), mesotrione

1. Broken down by microbes - not broken down by hydrolysis.

2. Not degraded in anaerobic (waterlogged soil) conditions.

3. Not volatile, not photodegraded, not leached beyond 12 inches.

4. Weakly bound to soil but strongly bound to OM.

5. Degradation increases in soils with pH above 6.5 (Imi) or 7 (TPS) because herbicide molecules are not adsorbed and are in soil solution for plant uptake and microbial breakdown

SU and Triazines

Most SU herbicides are:

1. Not leached, nor volatile, nor broken down by photodegradation.

Triazines will leach and photodegrade

2. Affected by pH. Water solubility increases as pH increases.

3. Broken down primarily by acid hydrolysis. Microbial degradation is very slow.

4. Non-microbial hydrolysis for most residual SU herbicides ceases at soil pH above 6.8.

Other Herbicides of Concern

- Clopyralid (Stinger)
  - 40 day half-life
    - 12 to 70 day range
  - Only microbial degradation
- Pyrasulfotole (Huskie)
  - 5 to 31 day half life (longer in coarse soils)
  - Primarily microbial
    - No photodecomposition
    - No chemical hydrolysis
- Tembotrione (Laudis)
  - Primarily microbial degradation

Other Herbicides of Concern

- Fomesafen (Flexstar/Reflex)
  - 100 day half-life
  - Microbial and anaerobic degradation
- Sulfentrazone (Spartan)
  - 121 to 302 day half-life
  - Primarily microbial degradation
    - No photodecomposition
- Products with 18+ month interval applied in 2020
  - Dry August 2020 through August 2021

Why the difference in carryover?

- Differences in:
  - Herbicide application rates
  - Herbicide application timings
  - Rainfall
  - Temperature
  - Soil texture
  - Soil pH
  - Cover crop seeding method/depth
  - Cover crop cultivar differences

Widematch Label (clopyralid & fluroxypyr)

Crop Rotation Intervals
Residues of WideMatch in treated plant tissues, including the treated crop or weeds, which have not completely decayed may affect succeeding susceptible crops.

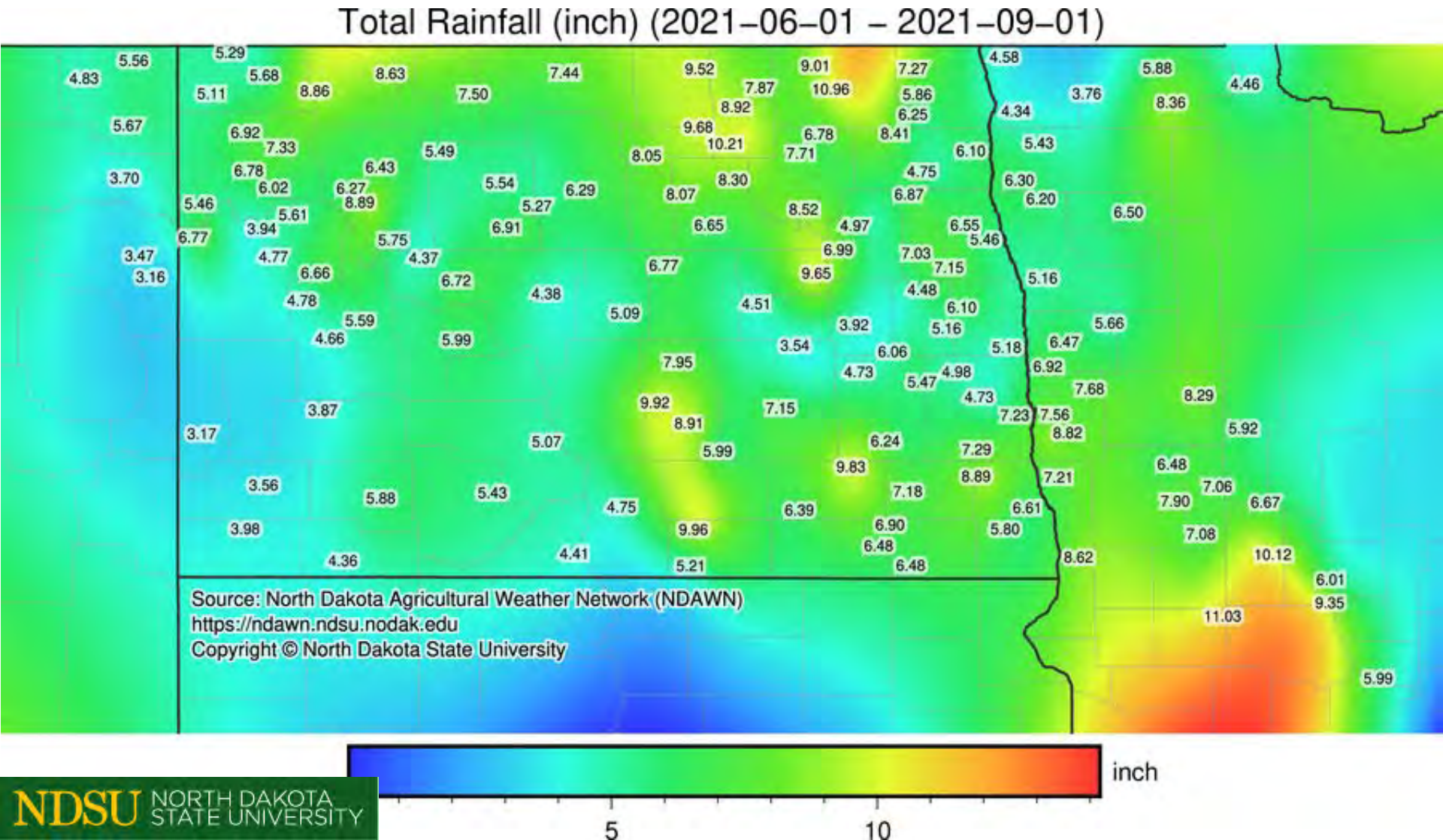
Crop Rotation Intervals for All States Except Idaho, Nevada, Oregon, Utah and Washington

Note: Numbers in parenthesis and † refer to footnotes following tables.

Rotation Crops (1)	Rotation Interval†
barley, grasses, field corn, oats, sweet corn, wheat	Anytime
canola (rapeseed), cole crops (*Brassica* species), flax, garden beet, popcorn, spinach, sugarbeet, turnip	120 days
alfalfa, asparagus, dry beans, field peas (2), grain sorghum, mint, onions, safflower, soybeans, strawberries, sunflower	10.5 months
chick peas, lentils, potatoes (including potatoes grown for seed), and broadleaf crops grown for seed (excluding *Brassica* species)	18 months

1. A field bioassay is recommended prior to planting any broadleaf crops that are not listed. Do not rotate to unlisted crops prior to 10.5 months following application.
2. For rotation to field peas in 10.5 months, precipitation must be greater than 7.0 inches during the 10.5 months following application of WideMatch and greater than 5.5 inches during the June 1 through August 31 time period following application. Otherwise, rotation to field peas is recommended 18 months following application.

Total Rainfall June 1 to September 1



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Laudis Label (tembotrione)

ROTATIONAL CROP RESTRICTIONS

If a corn crop has been destroyed by hail or other means soon after a LAUDIS Herbicide application, field corn, sweet corn, or popcorn can be replanted immediately after a LAUDIS Herbicide application. See chart below for rotational interval to all other crops after a LAUDIS Herbicide application. Planting at shorter than specified intervals will result in injury to the rotational crop.

Table 3. Rotational Crop Guidelines

Immediate	4 months	8 months	10 months	11 months	12 months	18 months
Field corn Sweet corn Popcorn	Cereal grains (except corn and sorghum) Sugarcane Grass grown for seed Timothy	Soybean Onion[3]	Sorghum Peas Rice Cotton Potatoes Canola Alfalfa Tomato Snapbeans Sugar beets[1, 2] Sunflowers Dry beans[1] (types and varieties for commercial production except those listed under 18 months)	Peanut	Tobacco	Cucurbits Dry beans (red kidney, cranberry bean, non-commercial "garden" types and varieties) All other crops[4]

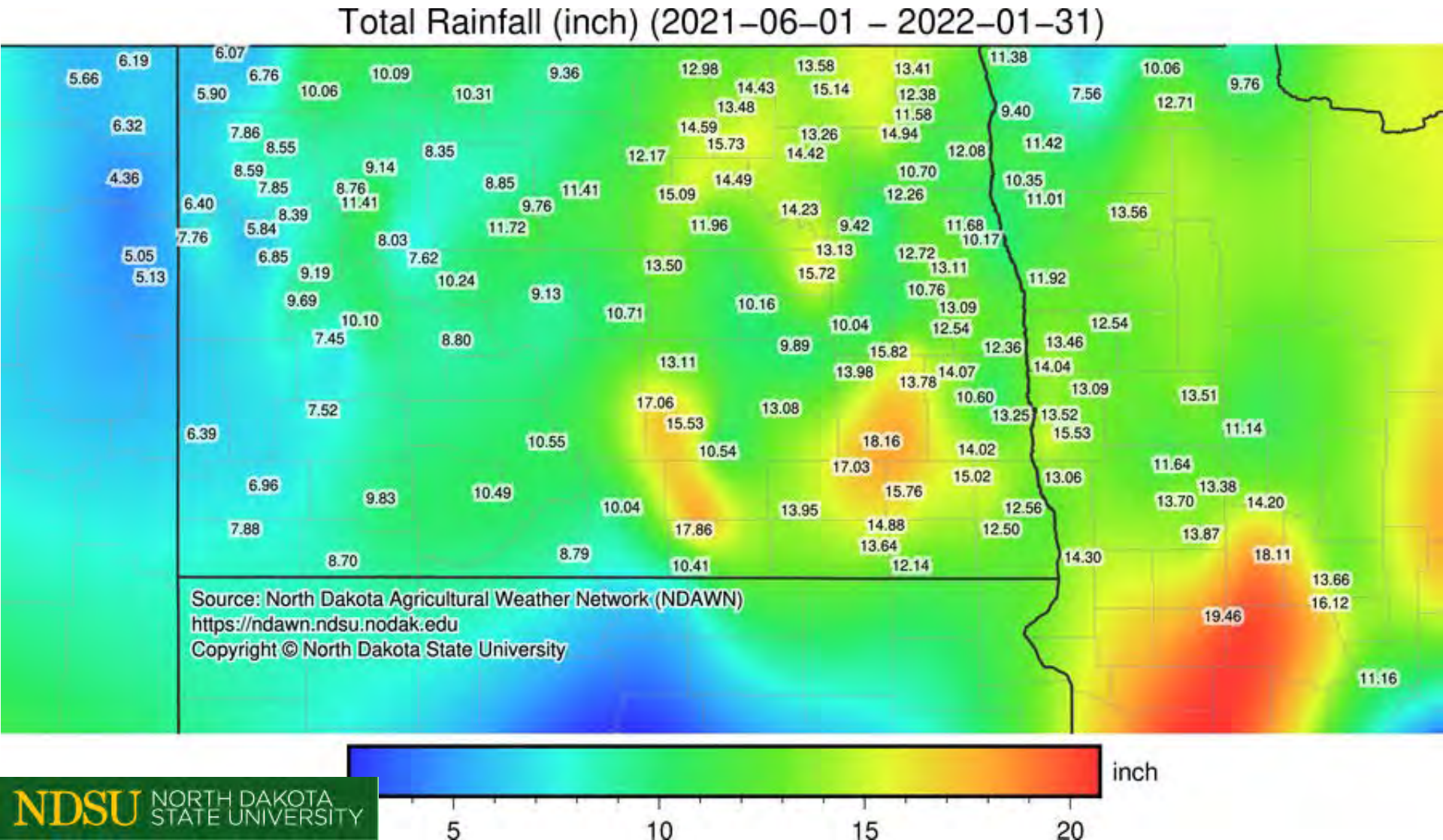
[1] Cumulative precipitation between application of LAUDIS Herbicide and replanting to sugar beets or dry beans must total 20 inches. Furrow or flood irrigation cannot be included in the total. The amount of cumulative precipitation required before planting a rotational crop is in addition to the required rotational interval given in months.

[2] Thorough tillage should follow the crop in which LAUDIS Herbicide was used and precede the rotation to sugar beets.

[3] This plantback interval requires that onion crops be grown under irrigated conditions. The plantback interval for non-irrigated onion is 18 months.

[4] All other crops may be seeded only after the completion of a successful bioassay after a LAUDIS Herbicide application. Refer to the "Field/Small Scale Bioassay" section.

Total Rainfall June 1 to February 1



Major Factors (in rank order)

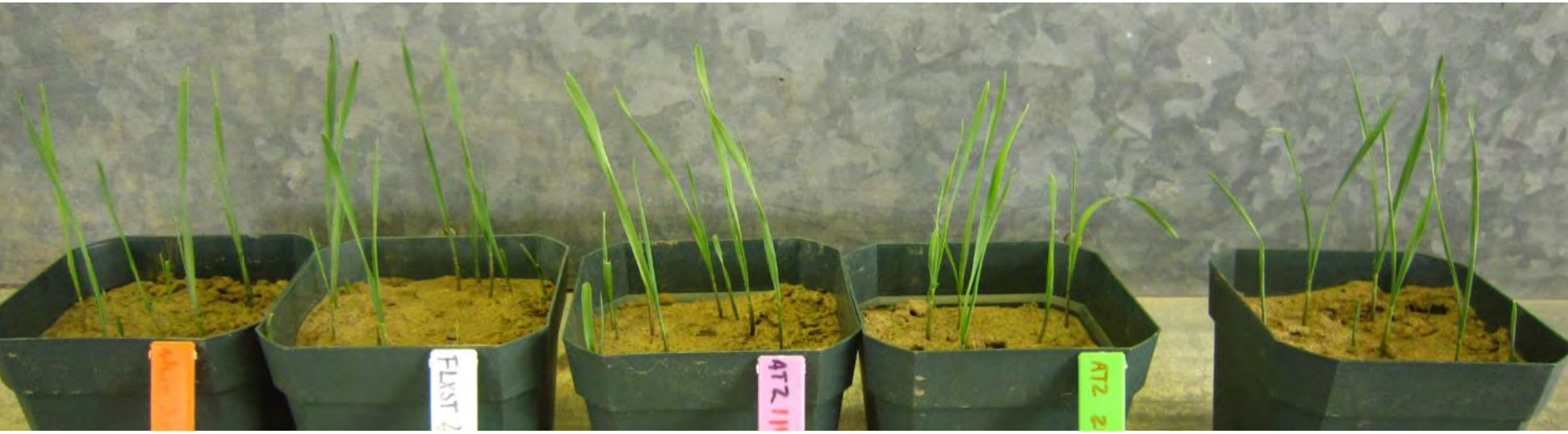
1) Environment (rainfall, temperature, soil type)
2) Herbicide Chemistry
   - Ex. Pursuit or Prefix followed by Brassicas don't work in the same year.
   - Easy to fall into SOA groups, but must go down to specific active ingredients.
3) Herbicide application date
4) Herbicide application rate
5) Crop planting date
6) Crop planting method?
7) Crop cultivar?

Tillage prior to seeding crop?

*Rankings estimated by Mike Plumer and B. Young

Wheat Bioassay

Soil Type:
Silt loam
~2% OM
pH 7



Callisto 3oz	*Flexstar 24oz*	*Atrazine 1 lb*	*Atrazine 2 lb*	*No Herbicide*
July 21	**July 21**	**July 21**	**July 6**	
Date of Application				

Rainfall since July 6: 2.25”
Rainfall since July 21: 1.25”

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Soil sampling: 8/8/12
Photo: 8/20/12

Wheat Bioassay

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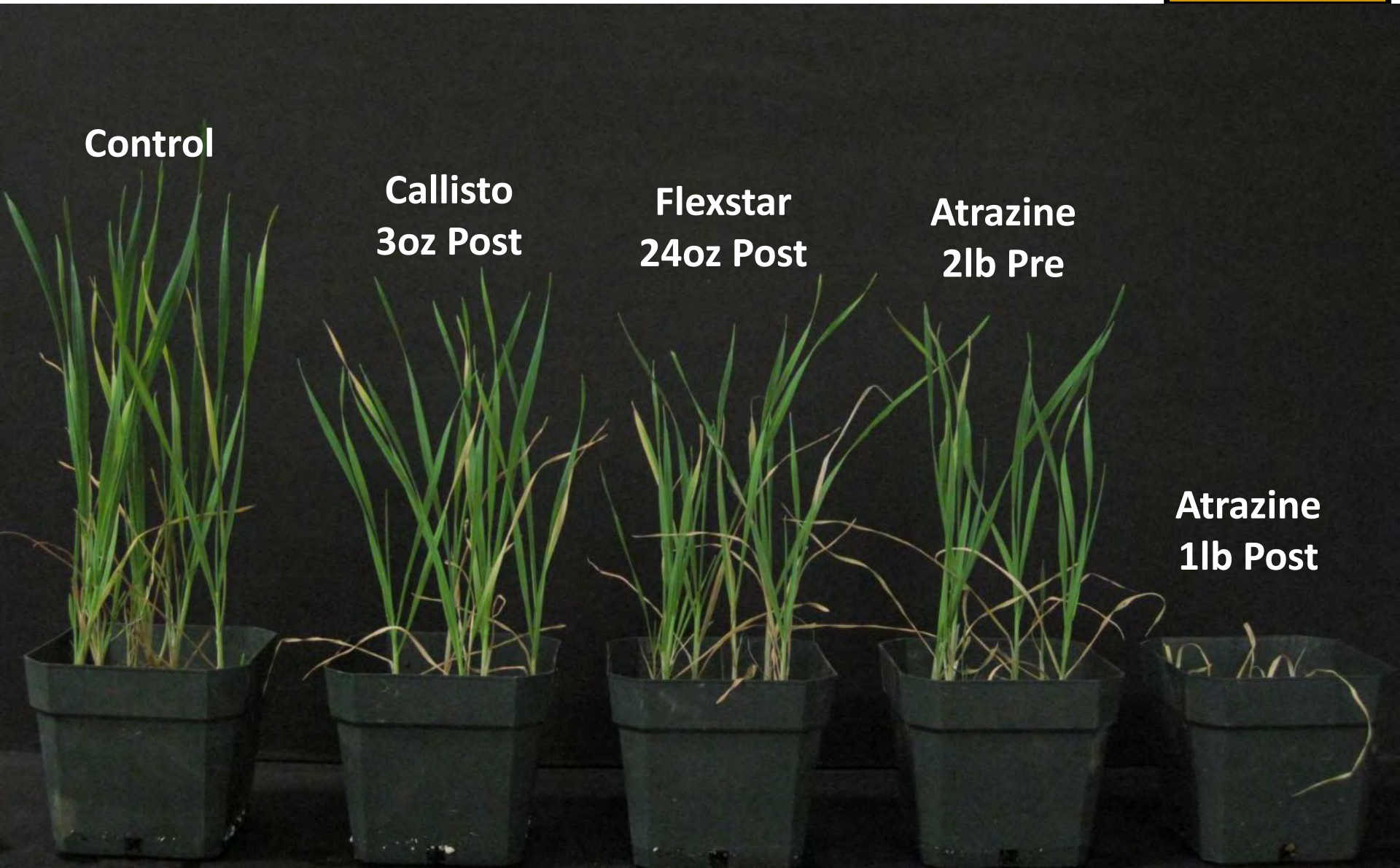
Silt loam
~2% OM
pH 7



Basic Rules for Managing Potential Herbicide Carryover

- ***Follow the herbicide label!***
  - Always use proper rates and application timings.
  - Always follow re-cropping intervals.
- Use common sense and previous experience.
- Inquire with herbicide manufacturer for products of greatest concern.

Parting Thoughts on Herbicide Carryover

- Tillage can reduce carryover potential.
- Carryover won't be uniform across the fields, but will likely follow application patterns.
- Injury symptoms may be delayed until 2-3 leaves develop.
- Brush up on herbicide MOA injury symptoms.

Herbicide Carryover

Any persisting questions?

Crop Response Concerns

- Soil residual herbicides
  - PPO herbicides at full rates
  - Herbicide combinations
    - PPO + chloroacetamide
    - PPO + PPO (saflufenacil)
- POST applications
  - PPO herbicides at full rates
  - Herbicide combinations
    - Glyphosate (2x rates) + PPO (full rates)
    - Glyphosate (2x rates) + ALS + PPO (full rates)
  - Adjuvant systems?

Postemergence Soybean Herbicide Injury

Nontreated

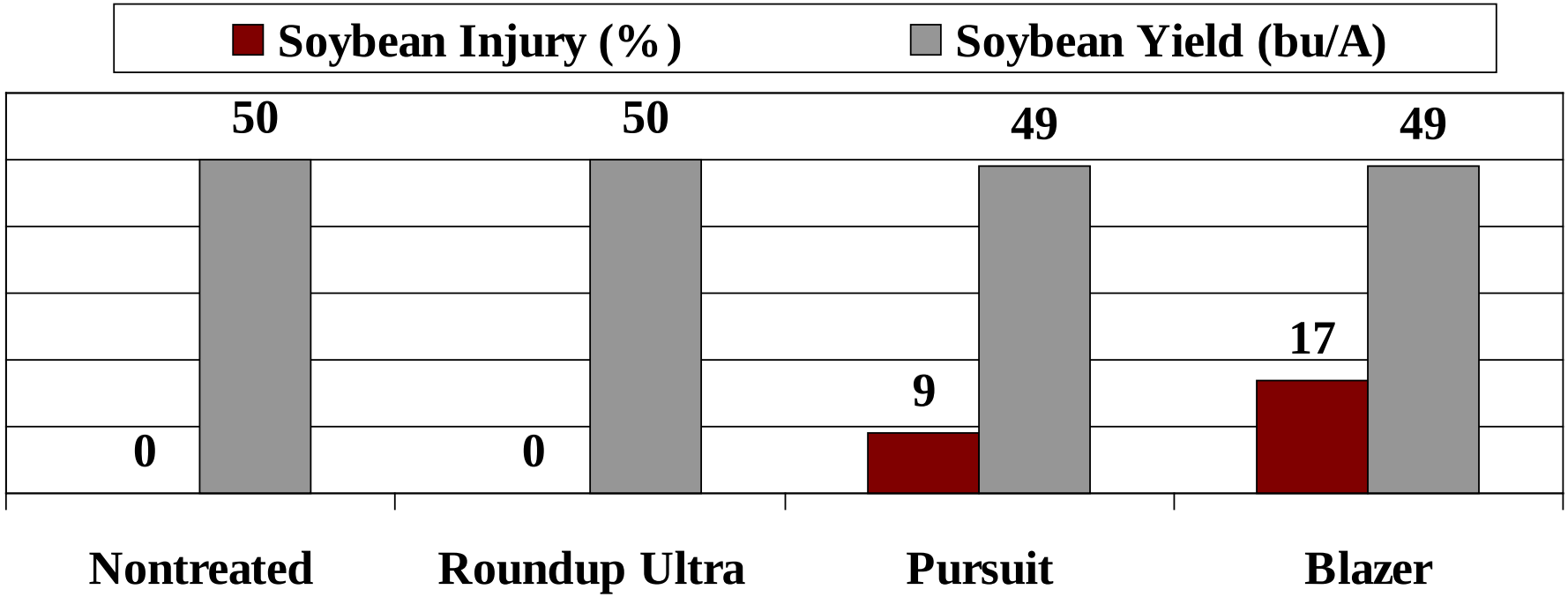
Glyphosate: chlorosis of newly emerging trifoliates

Pursuit: purple veins on leaves; plants may be slightly stunted

Blazer: speckling on leaves; some leaf tissue turns brown

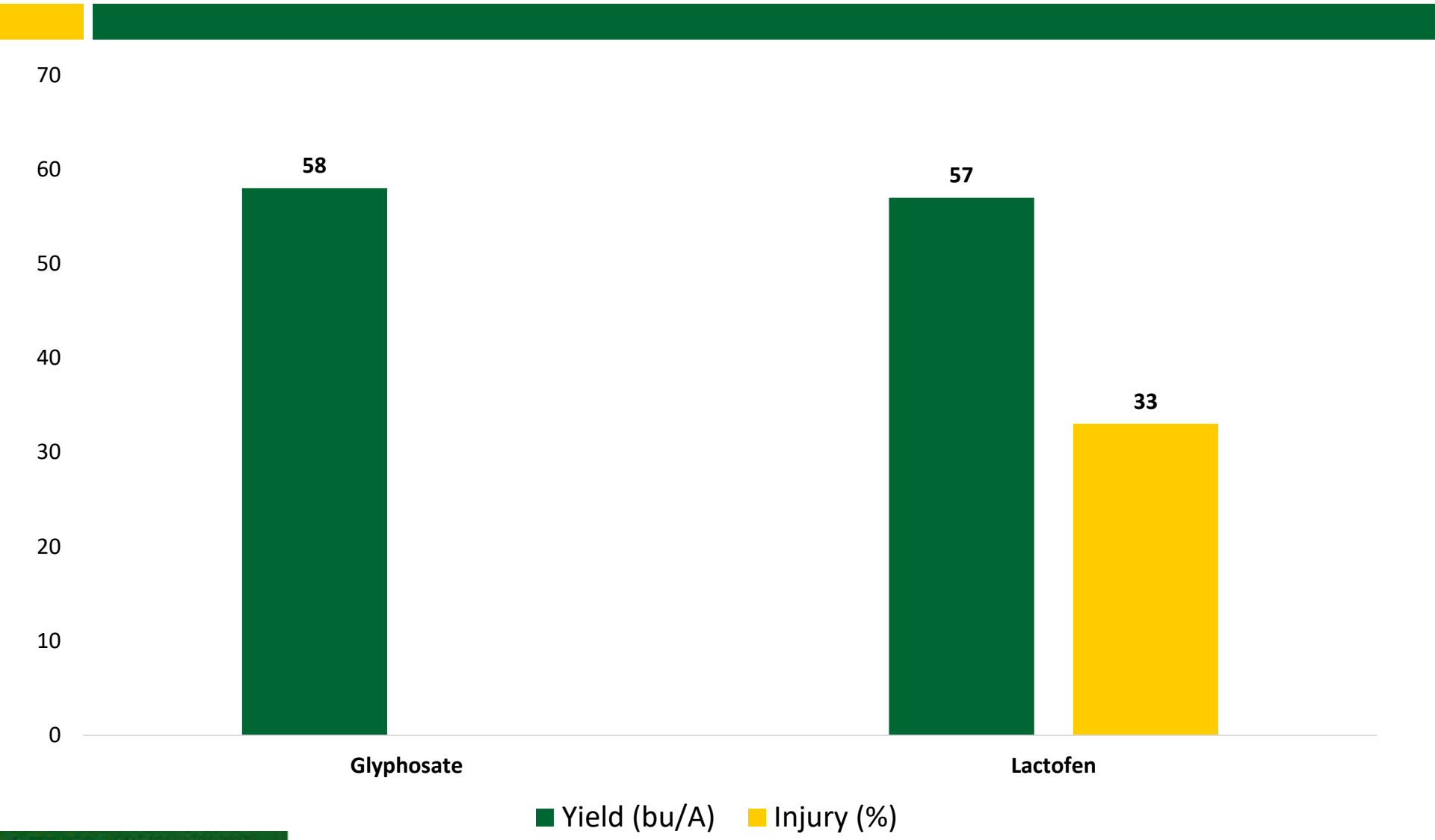
Illinois/Iowa Yields Project

Figure 2. Soybean Injury and Yield Following Postemergence Herbicide Applications

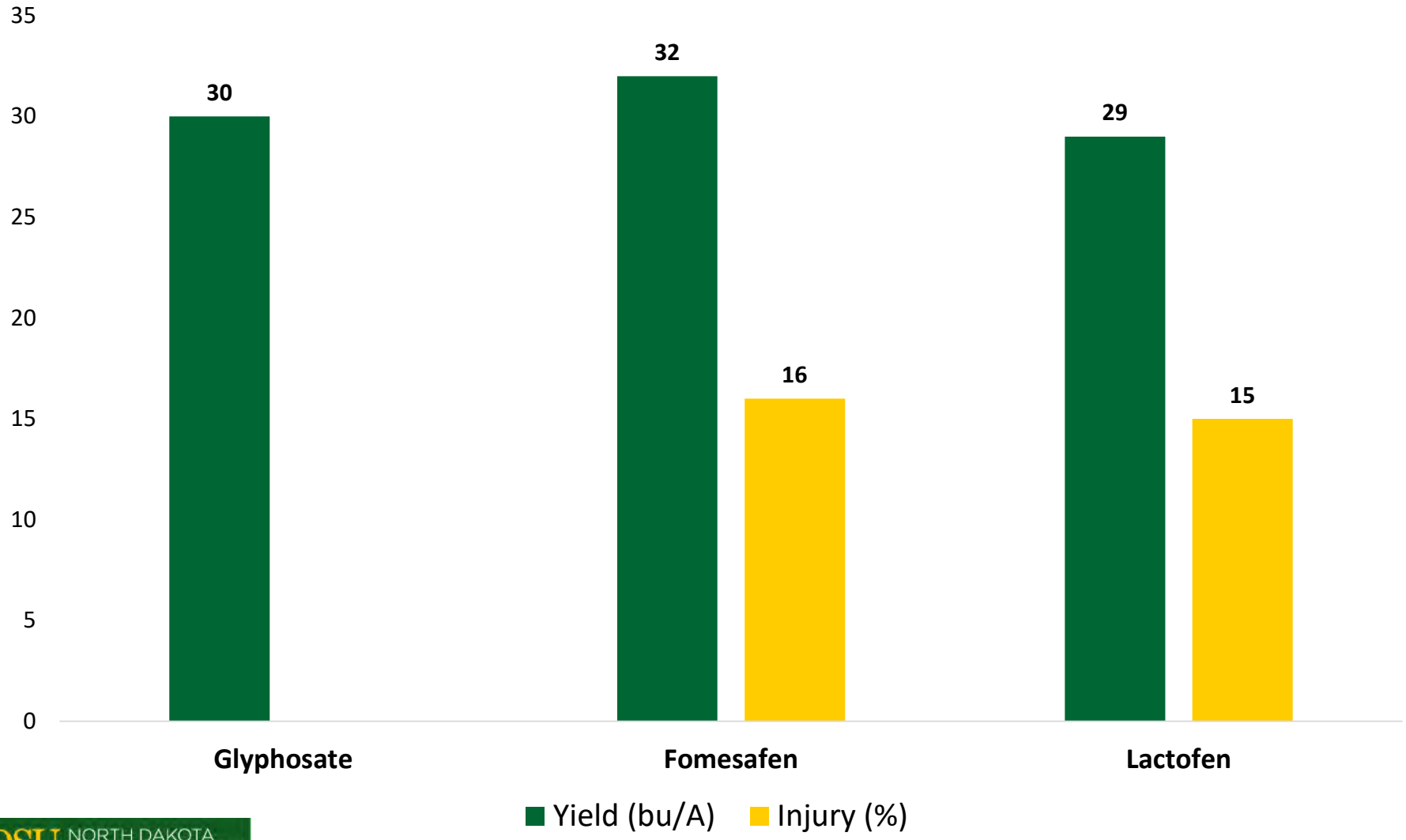


*Soybean injury (5 to 7 days after application) and soybean yield are averaged over all locations, years, application timings and planting dates.

2020 Soybean Trial at Prosper, ND



2021 Soybean Trial at Prosper, ND



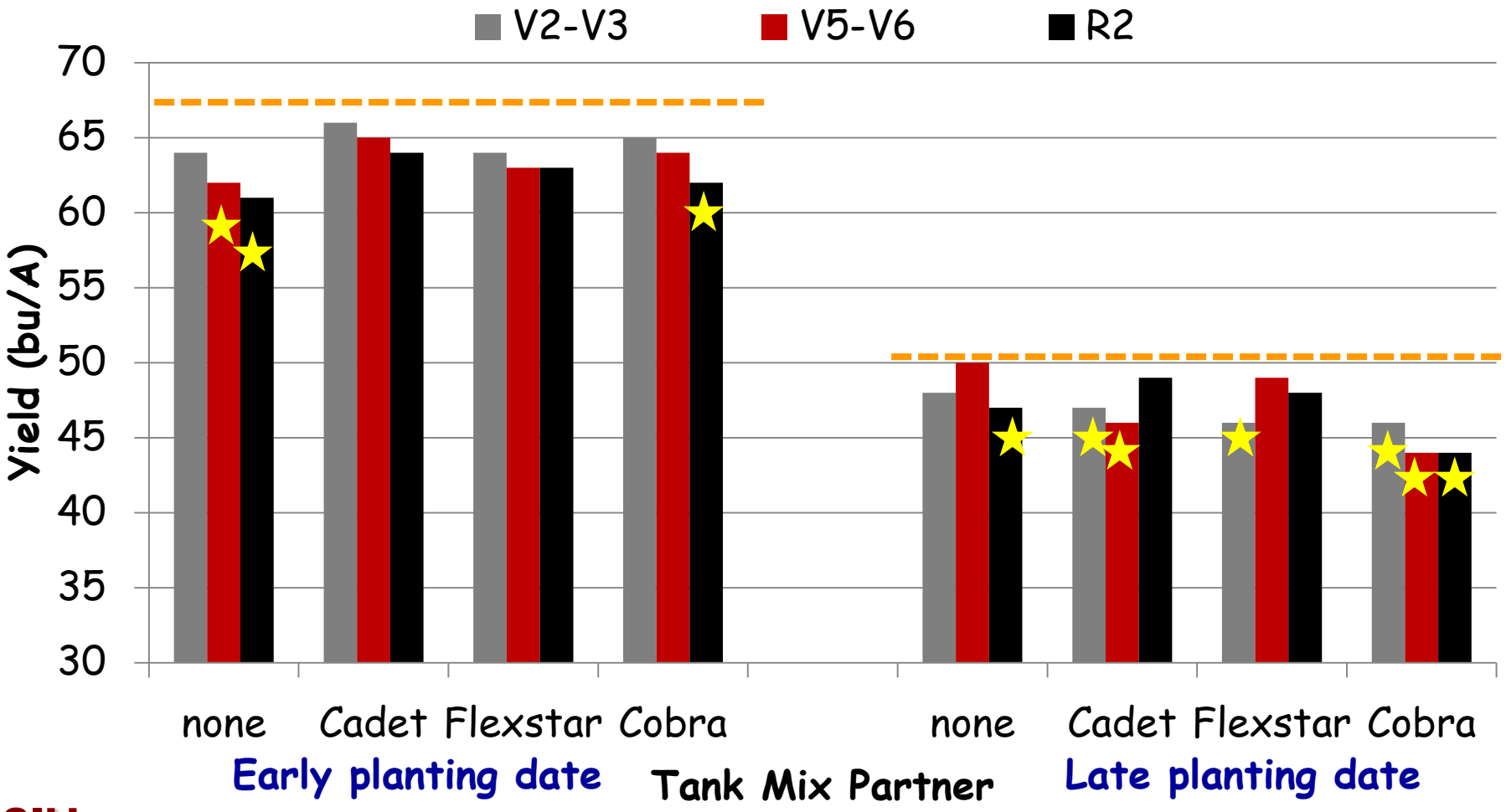
Illinois/Iowa Yields Project

Table 1. Management Factors Influencing Soybean Yield Reductions.

Management Factor	Number of Occurrences	Percent of Total Observations
Postemergence Herbicide	(288 total applications)	------ % ------
Roundup Ultra (1 qt/A)	0	0
Pursuit (4 fl oz/A)	5	1.7
Blazer (1.5 pt/A)	5	1.7
Planting Date		
Early (~May 1)	3	1.0
Late (~June 1)	7	2.4
Application Timing		
Postemergence (V2-3)	2	0.7
Late postemergence (V5-6)	8	2.8
Late POST timing and late planting date	6	2.1
Total incidences of yield reduction	10	3.5

SIU Yield by Tank-Mix Partner and Application Timing

Weed-Free Trial



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Best Management Practices for Herbicide-Resistant Weeds

Cultural

- ❑ Increase crop rotation diversity
- ❑ Integrate cover crops
- ❑ Stay clean
  - ◘ Clean equipment
  - ◘ Weed-free crop seed

Mechanical

- ❑ Use tillage when appropriate
- ❑ Mowers and electricity?

Chemical

- ❑ Integrate diverse herbicide sites of action
- ❑ Tank mixtures in foliar applications
- ❑ Soil residual herbicides – ***Preferred!***
  - ◘ Overlapping residual herbicides a must on species with multiple resistance

Optimize all herbicide applications!

Influence of Spray pH on Saflufenacil

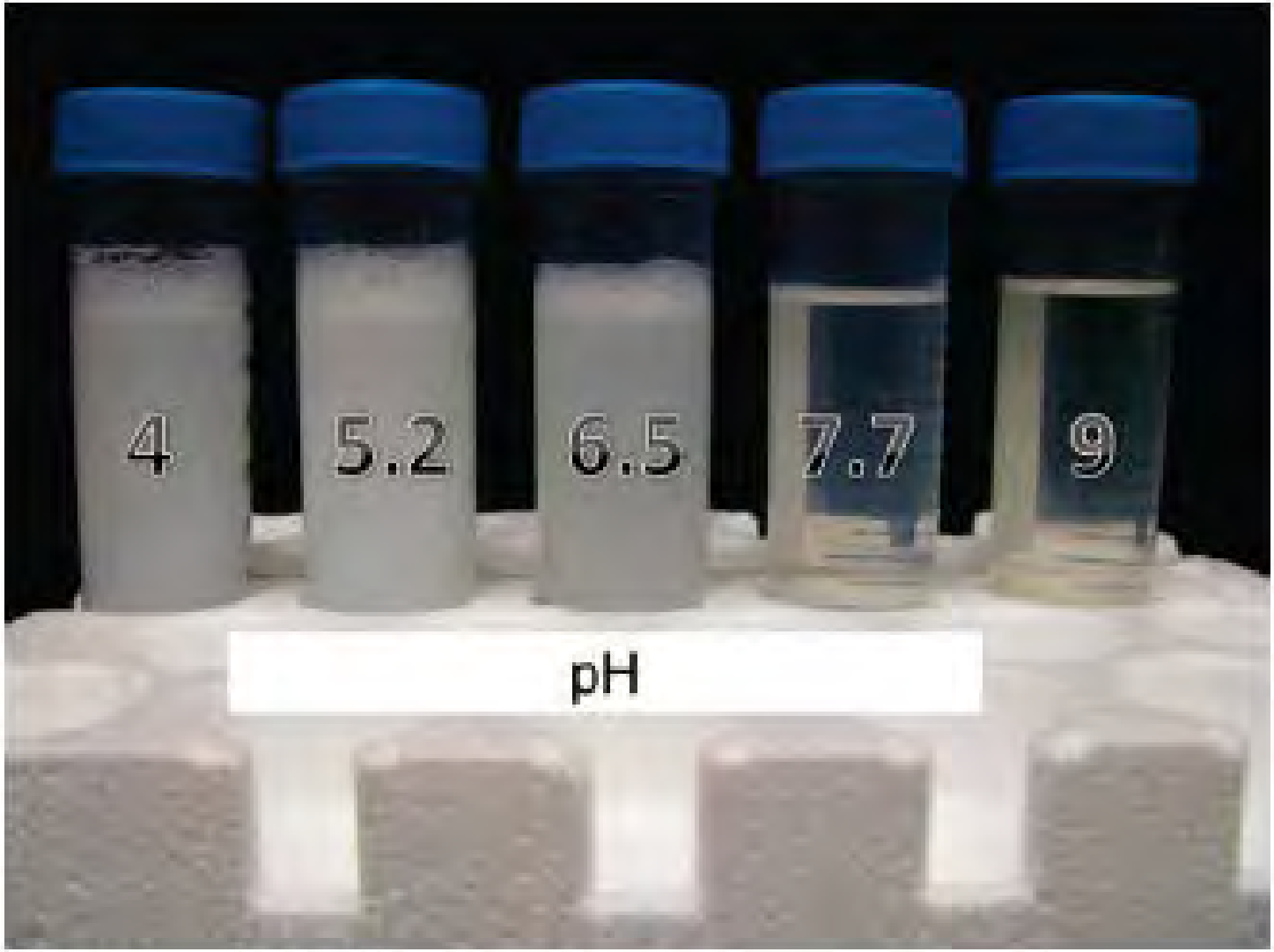
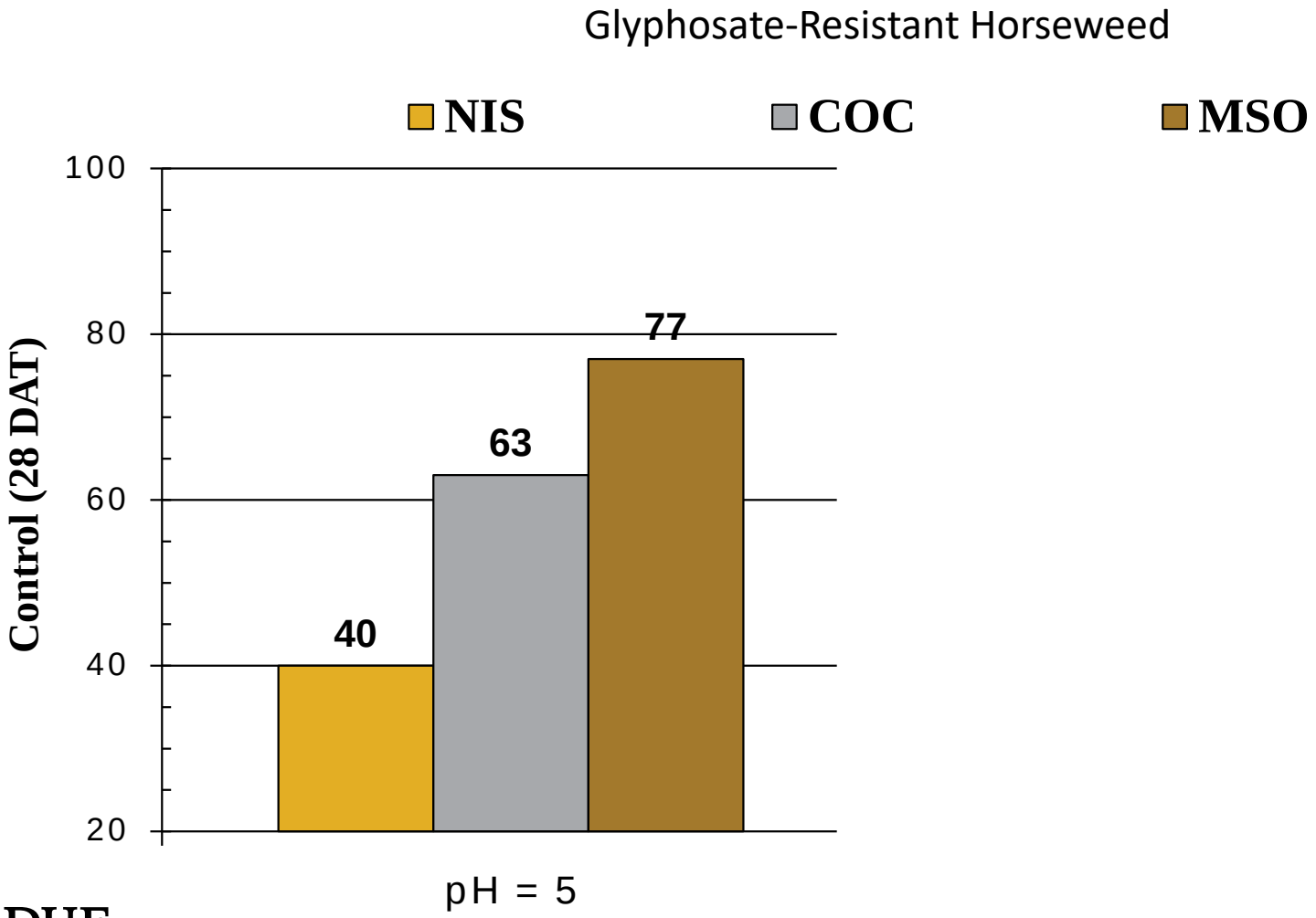


Figure 1. Visual observation of saflufenacil solubility at five pH levels.

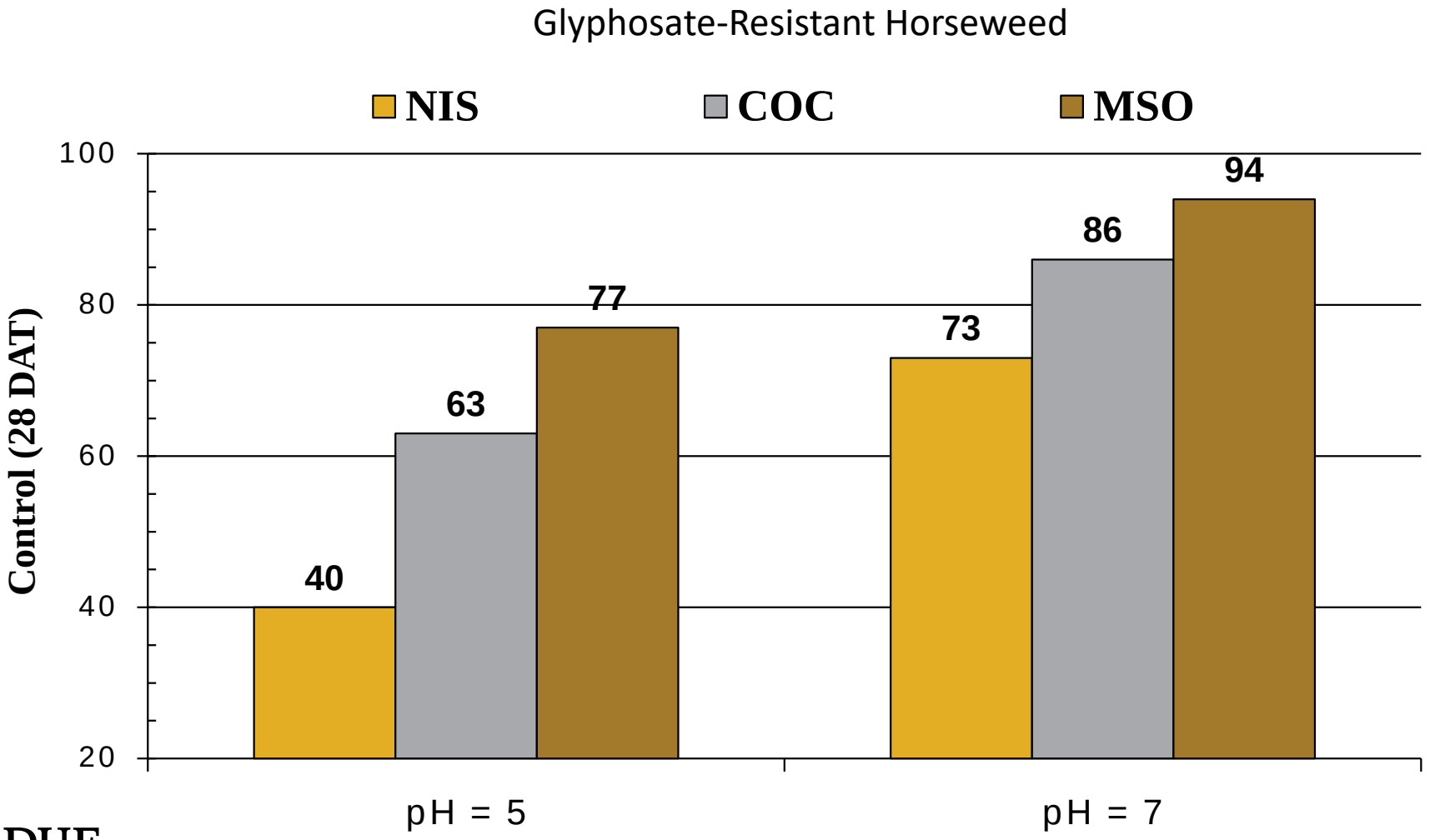
Spray pH and Adjuvant Influence on Saflufenacil + Glyphosate



Saflufenacil (12.5 g/ha); Glyphosate (840 g/ha), Touchdown HiTech

Study code: 09-YRC-BDtankmix

Spray pH and Adjuvant Influence on Saflufenacil + Glyphosate



Saflufenacil (12.5 g/ha); Glyphosate (840 g/ha), Touchdown HiTech

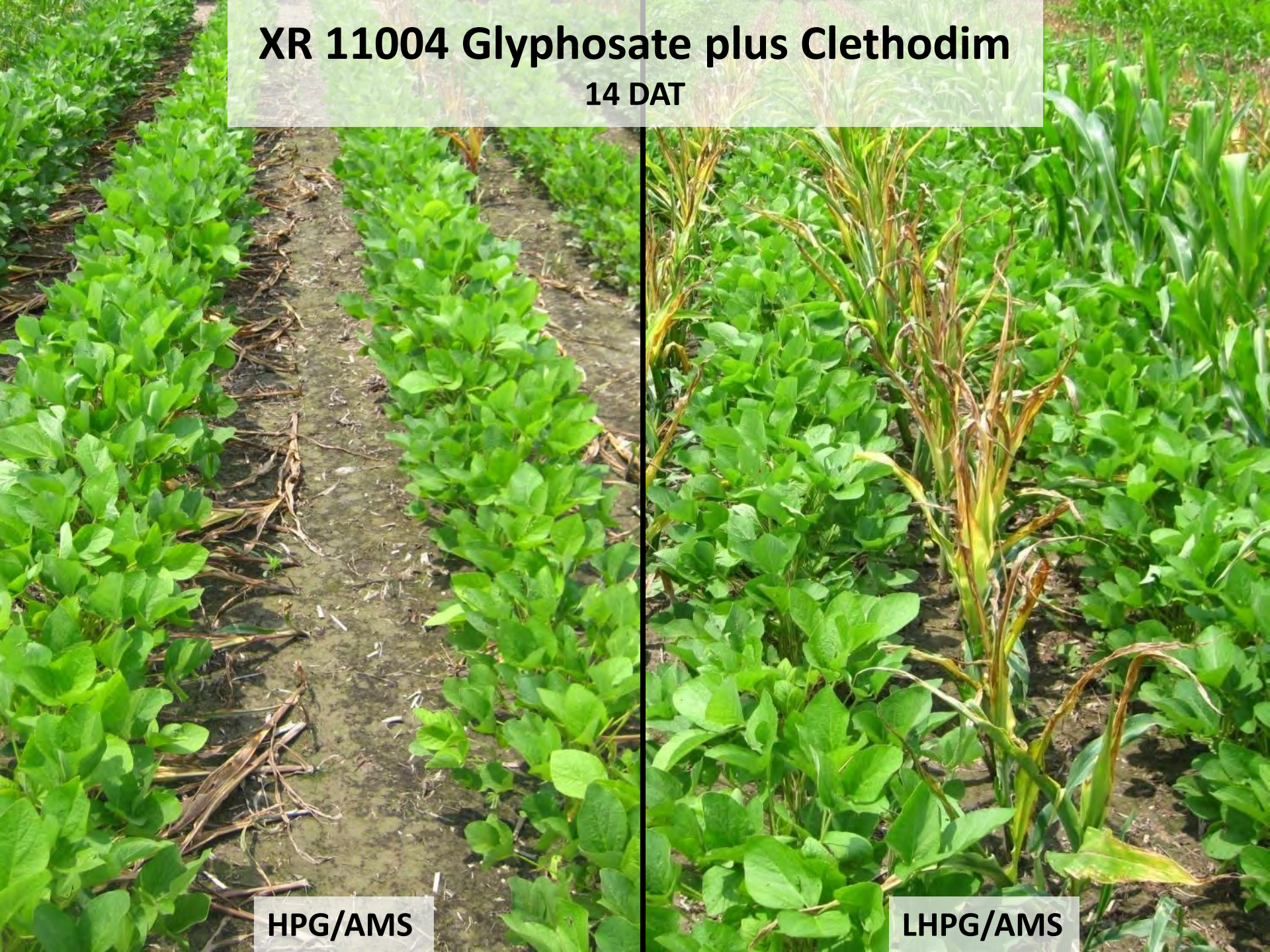
Study code: 09-YRC-BDtankmix

Volunteer Glyphosate-Resistant Corn

Surfactants and the "built-in" adjuvant system of glyphosate products is not sufficient to optimize all herbicides.

XR 11004 Glyphosate plus Clethodim

14 DAT

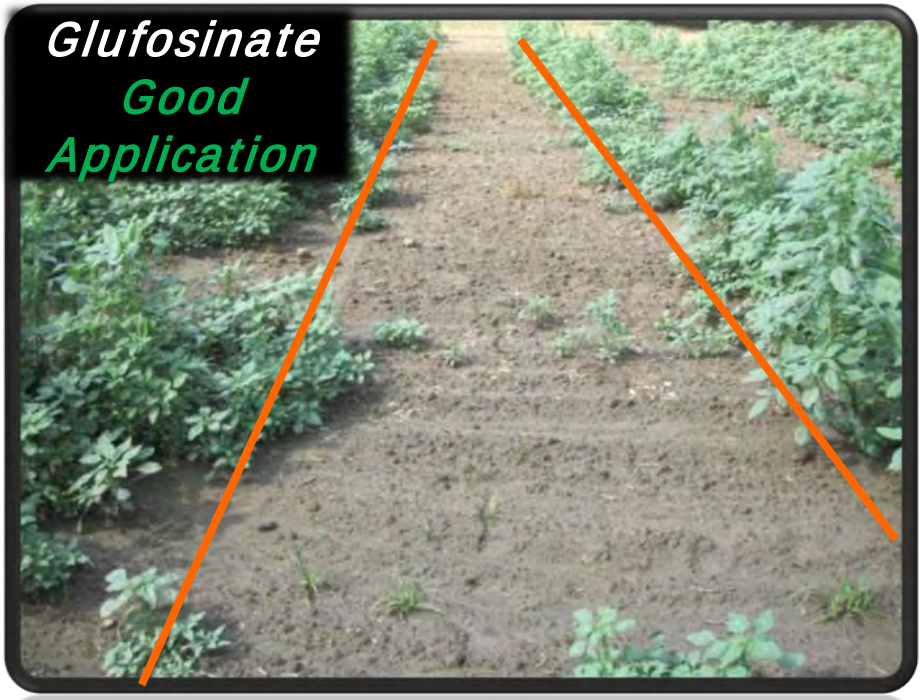


Adjuvant Chemistry

Drift Control Agents / Deposition Aids

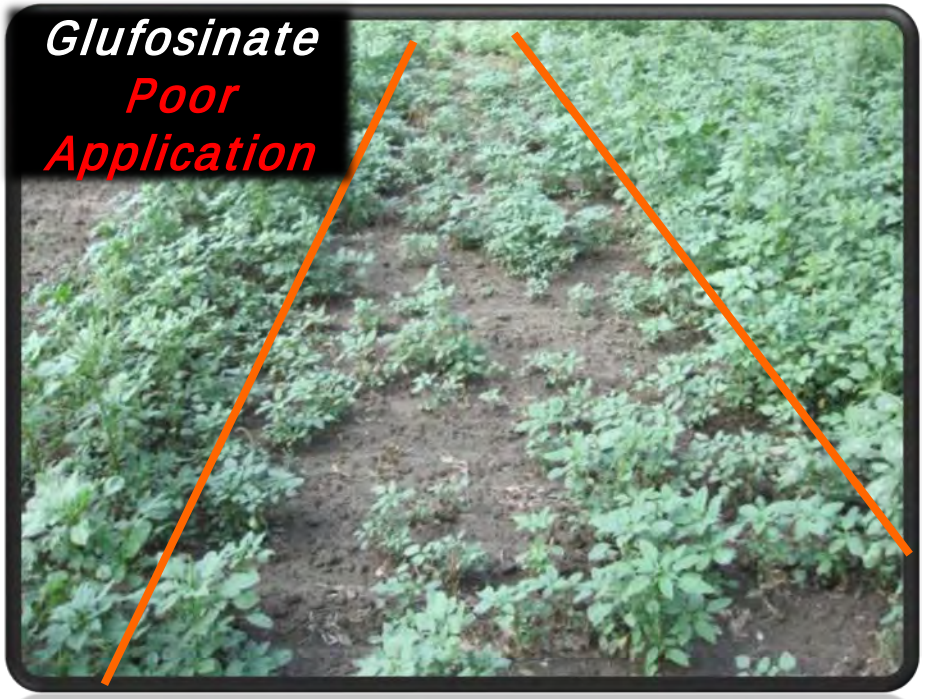
Glufosinate

Ammonium Sulfate and Droplet Size



Palmer amaranth Control

40% difference due to application method



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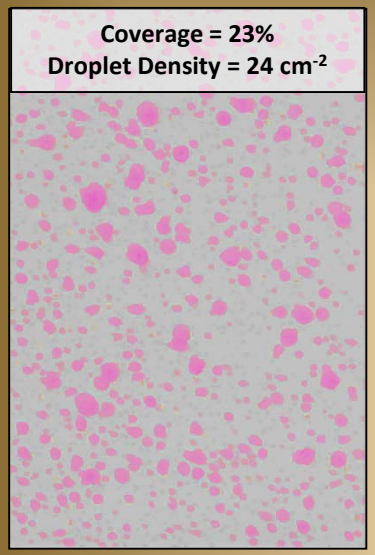
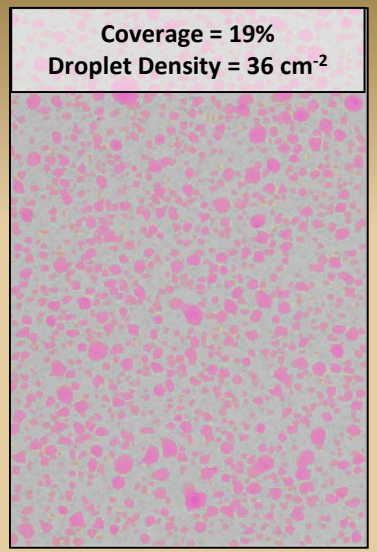
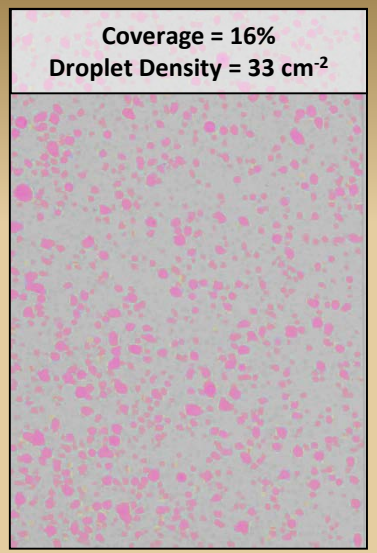
Liberty– Nozzle Type x Boom Height



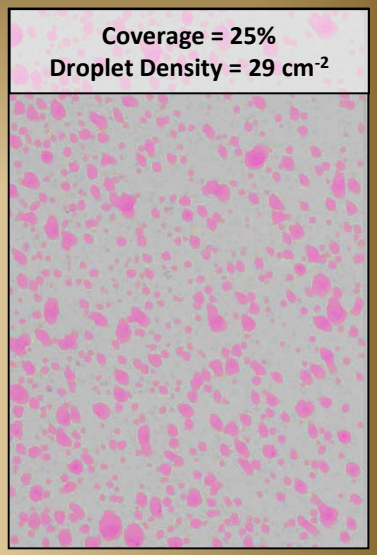
AIXR 11004 @ 24” Height



XR 11004 @ 24” Height



AIXR 11004 @ 48” Height



XR 11004 @ 48” Height

15 GPA

Source: AGCO SEPAC 2021

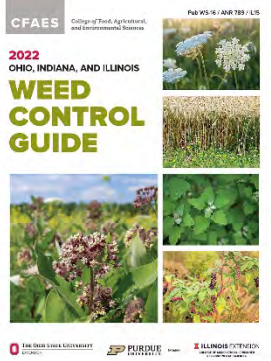
Corn POST HPPD Herbicides

- Mesotrione (Callisto, Acuron, Resicore, etc.)
- Tembotrione (Laudis, Capreno)
- Topramezone (Impact, Armezon Pro, etc.)
- Tolpyralate (Shieldex, Empyros brands, etc.)

- Crop Safety
  - All four actives have good crop safety
    - Some patchy bleaching on leaves expanding from the whorl
  - Mesotrione should not be applied with MSO or EC pesticide formulations
  - Tembotrione requires a safener

2022 Weed Control Guide

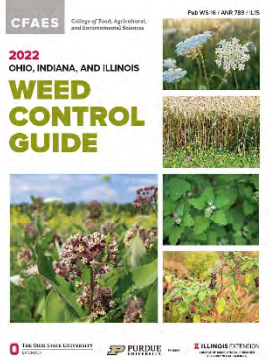
Ohio – Indiana - Illinois



Grass species	Mesotrione	Tembotrione	Tolpyralate	Topramezone
Barnyardgrass	-	8	7	7
Crabgrass	7*	8	7	7
Fall panicum	-	-	6	6
Field sandbur	-	6	-	-
Giant foxtail	-	7	7+	7+
Yellow foxtail	-	9	7	7
Shattercane	-	8	6	6
Seedling johnsongrass	-	8	7	7
Rhizome johnsongrass	-	7	-	-
Quackgrass	-	7	-	-
Woolly cupgrass	-	7+	6	6
Yellow nutsedge	-	-	-	-

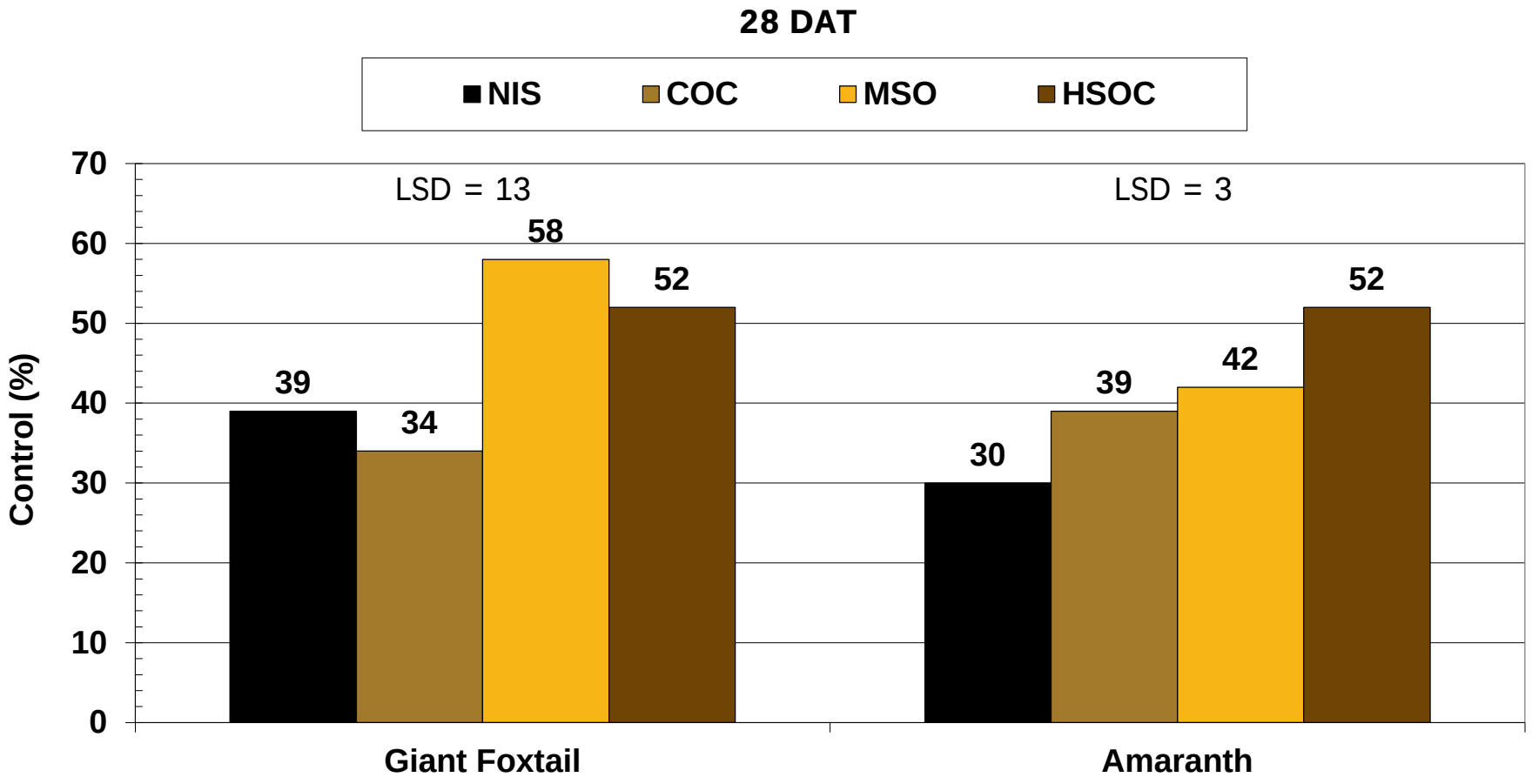
2022 Weed Control Guide

Ohio – Indiana - Illinois



Grass species	Mesotrione	Tembotrione	Tolpyralate	Topramezone
Annual morningglory	7	7	7	7
E. black nightshade	9	9	9	9
Burcucumber	8	7	7+	7+
Cocklebur	7+	8	8	8
Common ragweed	7	8	7	7
Giant ragweed	8	8	7	7
Jimsonweed	9	9	9	9
Kochia	8	8	8+	8+
C. lambsquarters	9	9	9	9
Palmer amaranth	8	8	8+	8
Pigweed (redroot/smooth)	8	9	9	9
P. smartweed	9	8	8	6
Velvetleaf	9	9	9	9
Waterhemp	8	8	8	8

Influence of Adjuvant on Laudis Efficacy



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Each adjuvant category is pooled over 5 commercial adjuvant products.

Application Factors Affecting the Efficacy of Foliar Active Herbicides

Can Be Managed

- **Herbicide**
  - Rate
  - Adjuvants
- **Sprayer**
  - Water quality
  - Carrier volume
  - Travel speed (nozzle size)
  - Nozzle type/design
  - Droplet size

Limited Ability to Manage

- **Weeds**
  - Inherent herbicide tolerance
  - Growth stage
  - Plant condition (stress?)
  - Vegetative canopy
- **Environment**
  - Temperature & relative humidity
  - Wind speed
  - Rainfall or dew
  - Time of day

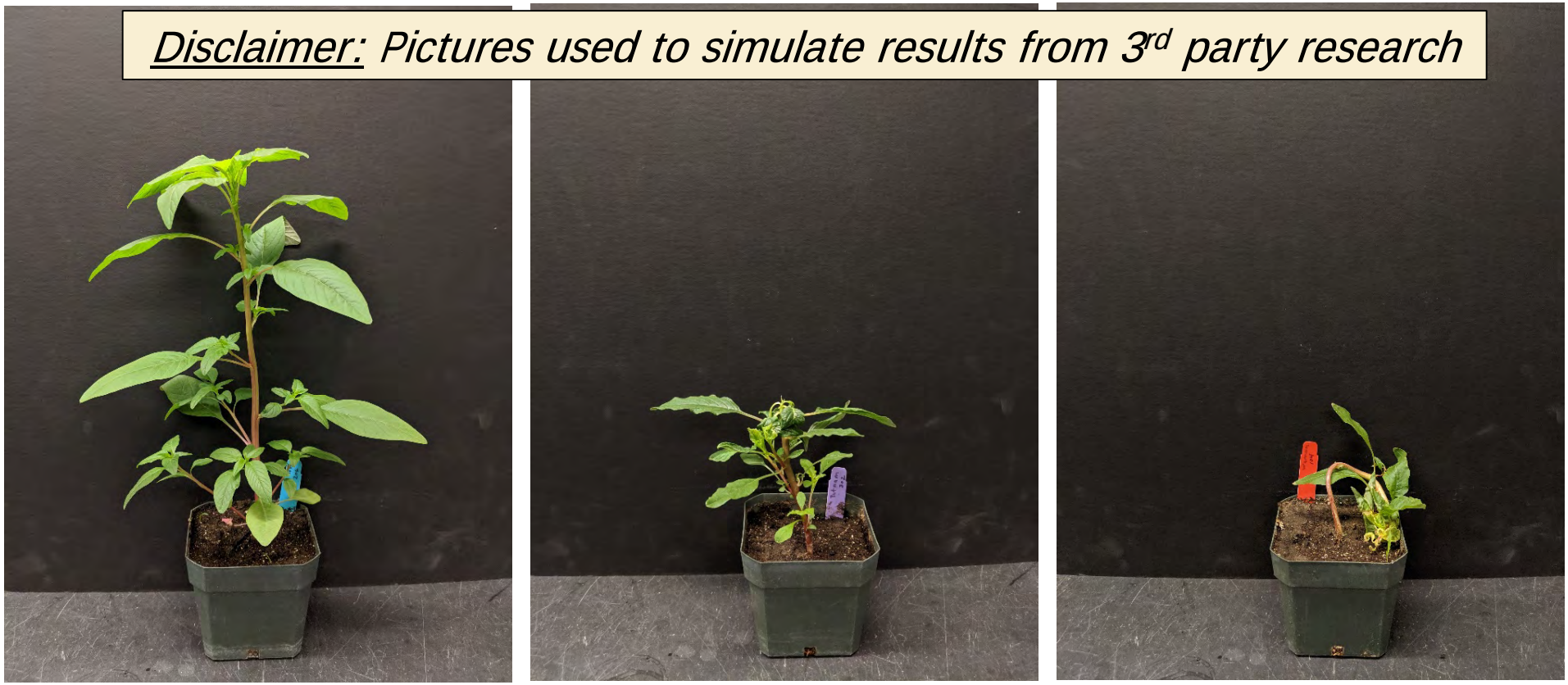
Impact of not using glyphosate with Group 4 and 27 herbicides

- Waterhemp activity for Group 4 and 27 herbicides is variable and best on weeds less than 3” tall
  - Effective tank mixtures have always improved the consistency of control for these herbicides

- Increase selection pressure for Group 4 and 27 resistance across the weed spectrum

Waterhemp Response to Dicamba *+ Glyphosate*

Disclaimer: Pictures used to simulate results from 3rd party research



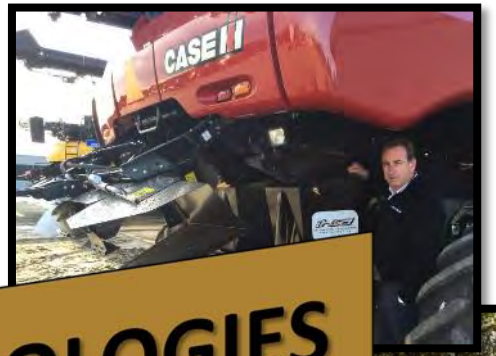
Nontreated

Dicamba 1X

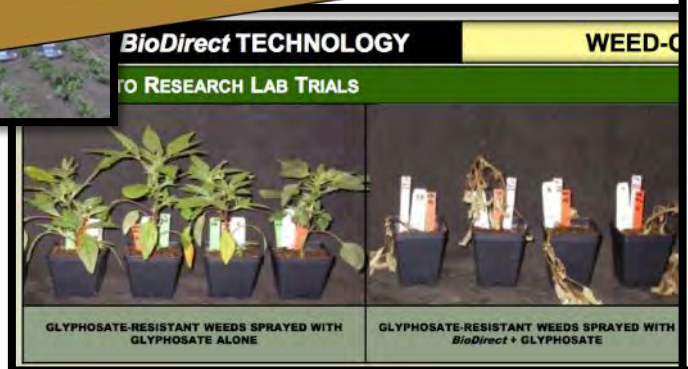
Dicamba 1X + Glyphosate (32oz RPM)

Less waterhemp survival with dicamba applied with glyphosate.

Technologies for Battling Weeds



LIBERTYLINK
GT27




One end of machine's power circuit is electrically in contact wtih soil through a coulter. Other end of circuit is connected to boom which comes in direct contact with weeds growing taller than crop.

ALL CURRENT/FUTURE TECHNOLOGIES WILL REQUIRE AN INTEGRATED PROGRAM APPROACH

Take ACTION
HERBICIDE-RESISTANCE MANAGEMENT

WEED OUT RESISTANCE
- Know Your Weeds
- Know Weed Growth
- Know Weed Seed Characteristics
- Know Herbicide Resistance

IN THE FIELD
- Rotate Crops
- Use Multiple Herbicide Sites of Action
- Incorporate Tillage Practices

SPRAY ATTENTION
- Know Herbicide Site of Action and Properties
- Manage Drift
- Know Environmental Conditions
- Know Your Neighbors

THE BOTTOM LINE
- Manage Risk
- Know Cost-Benefits of Practices
- Know the Cost of Poor Weed Control

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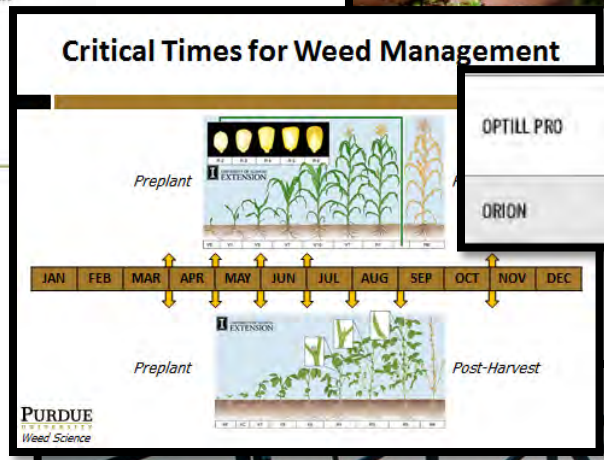
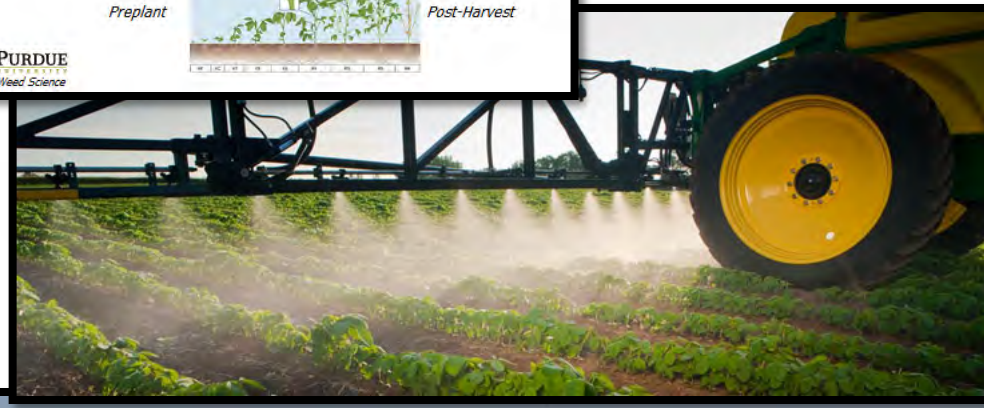


OPTILL PRO	saflufenacil	Sharpen	14
	imazethapyr	Pursuit	2
	dimethenamid-P	Outlook	15
ORION	flora sulam		2
	MCPA	MCPA	4




CROP-BE-GONE
FERTIZER
COMPANY
SUPPOSE WE REFUND YOUR MONEY, RE-SPRAY THE FIELD WITHOUT CHARGE, CLOSE THE STORE AND HAVE THE REP SHOT. WOULD THAT BE SATISFACTORY?
CAG Fert
To Tom - Mark -
From - Arlene J.

Weed Management:

Knowledge is Power!

Ignorance is a Rescue Treatment!

Thank You!

Questions?

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