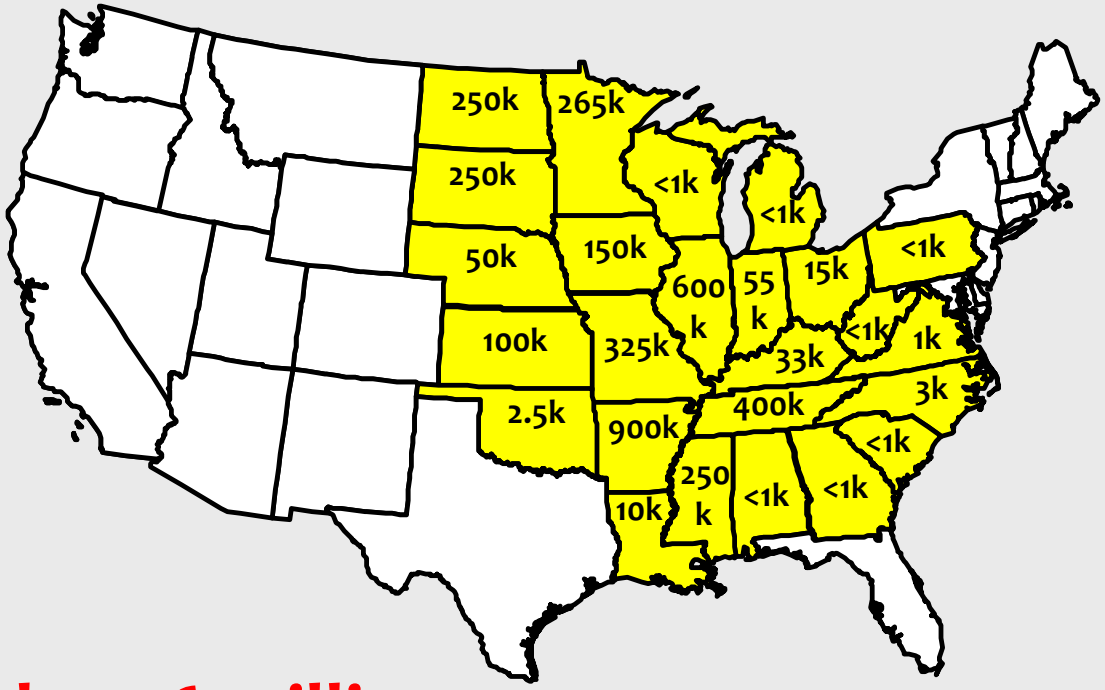
Dicamba:
Where it happened?
How it happened?
Why it happened?

Rich Zollinger
NDSU Extension Weed Specialist

Estimates of Dicamba-injured Soybean Acreage in the U.S. as Reported by State Extension Weed Scientists (*as of October 15, 2017)



*Total: ~3.6 million

What does this mean for dicamba? Soybean has 0 tolerance!

- Particle drift (including inversions)
- Volatilization

- Sprayer cleanout - contamination
- Misapplication

Application Education Summary

Summary of Application Requirements

The XtendiMax™ herbicide with VaporGrip™ Technology application requirements are intended to help maximize weed control with on-target applications and minimize the potential of off-target movement.

THIS SUMMARY IS NOT A SUBSTITUTE FOR READING AND FOLLOWING ALL PRODUCT LABELING.

NOW EPA APPROVED FOR IN-CROP USE	**HERBICIDE** Low volatility XtendiMax™ herbicide with VaporGrip™ Technology	<4"	**WEED HEIGHT** Spray weeds that are less than 4 inches tall
AMS	**AMMONIUM SULFATE** Ammonium sulfate and ammonium-based additives are prohibited in applications that include XtendiMax™ with VaporGrip™ Technology	3-10 mph	**WIND SPEED** Apply when wind speed is between 3 and 10 mph
XTENDIMAX 22 fl oz/A	**APPLICATION RATES** Apply 22 fluid ounces per acre for any single, in-crop application		**DOWNWIND BUFFER** Maintain the required label buffer to protect sensitive areas
min. 10 GPA	**SPRAY VOLUME** Apply in a minimum of 10 gallons of spray solution per acre		**SUSCEPTIBLE CROPS** Do not apply when wind is blowing toward adjacent susceptible crops
	NOZZLES To minimize drift, use nozzles approved on the herbicide product label and operating pressures to minimize driftable fines	15 mph	**GROUND SPEED** Do not exceed 15 mph ground speed
24	**SPRAY BOOM HEIGHT** Do not exceed a boom height of 24 inches above target pest or crop canopy. Excessive boom height will increase the potential for drift.	3X	**TRIPLE RINSE** Use triple-rinse cleanout procedure

Some things a grower can control.
Once the droplet leaves the nozzle then no control

Monsanto/BASF Academic Summit – Fall 2017

1. After water has evaporated:
   -What form is the dicamba deposit?
   -How much is absorbed/adsorbed?
   -Does dew solubilize dicamba deposits and cause volatility?

Physical Properties of dicamba:

2. Dissociation: Basic principle of chemistry
   -Is the BAPMA salt associated or disassociated with dicamba?
   -VaporGrip: a.i., MOA, how long associated with dicamba?
   -Under what conditions do dicamba anion and acid form?

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Physical Properties of dicamba:

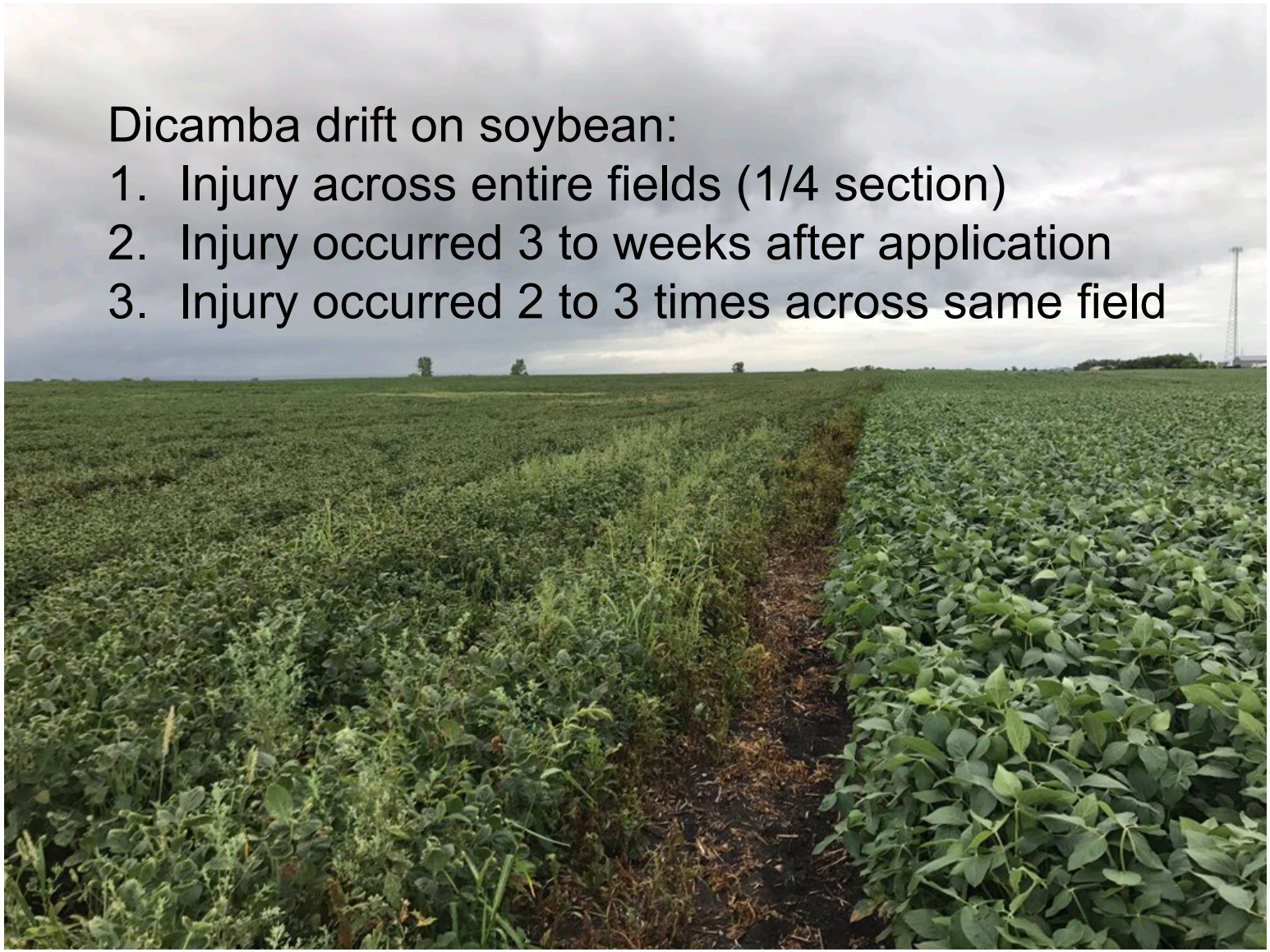
3. pKa, Kd, Koc, vapor pressure x temperature

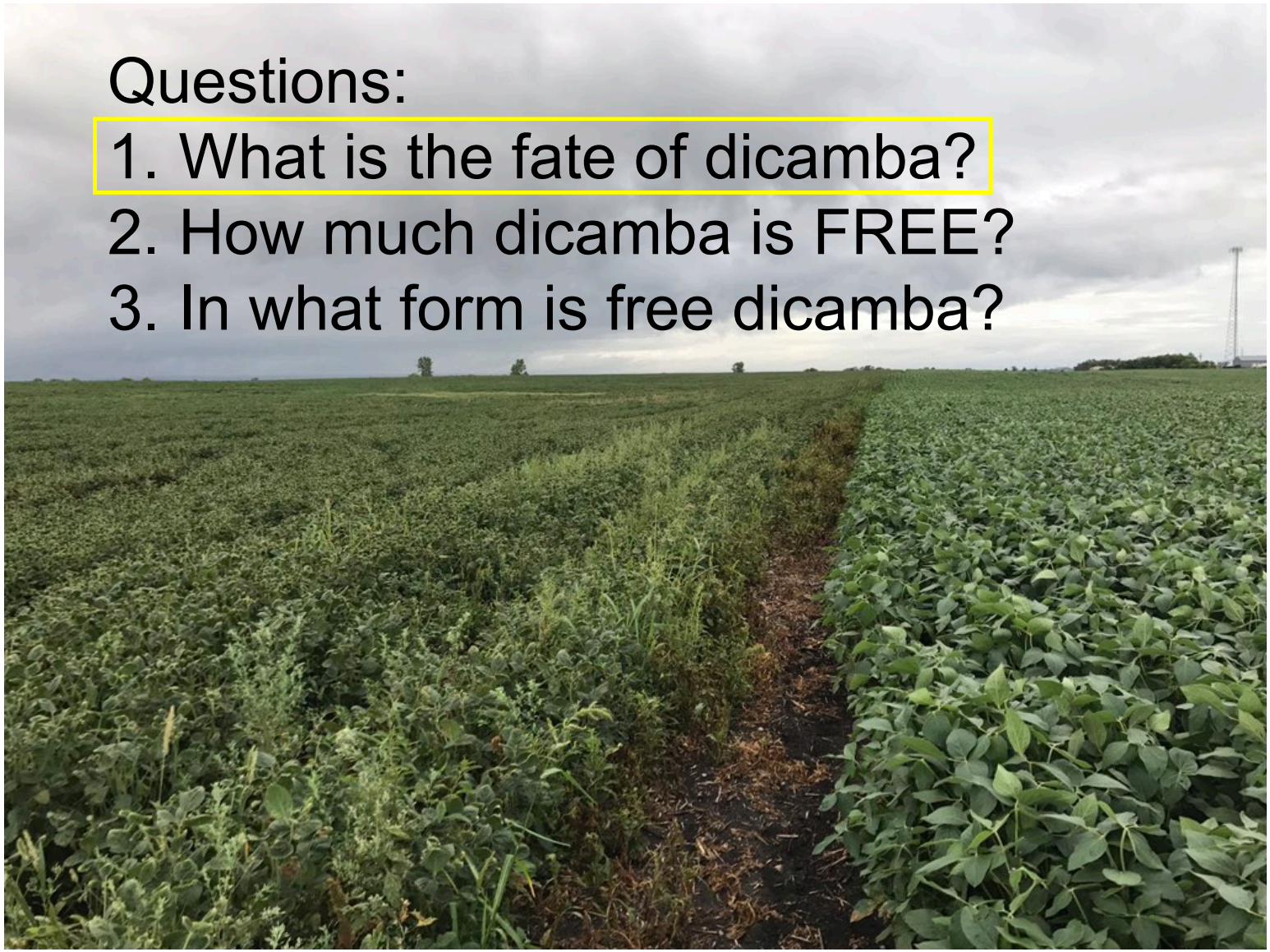
Environment:

4. Influence of rain/drought on fate of dicamba?

Observations:

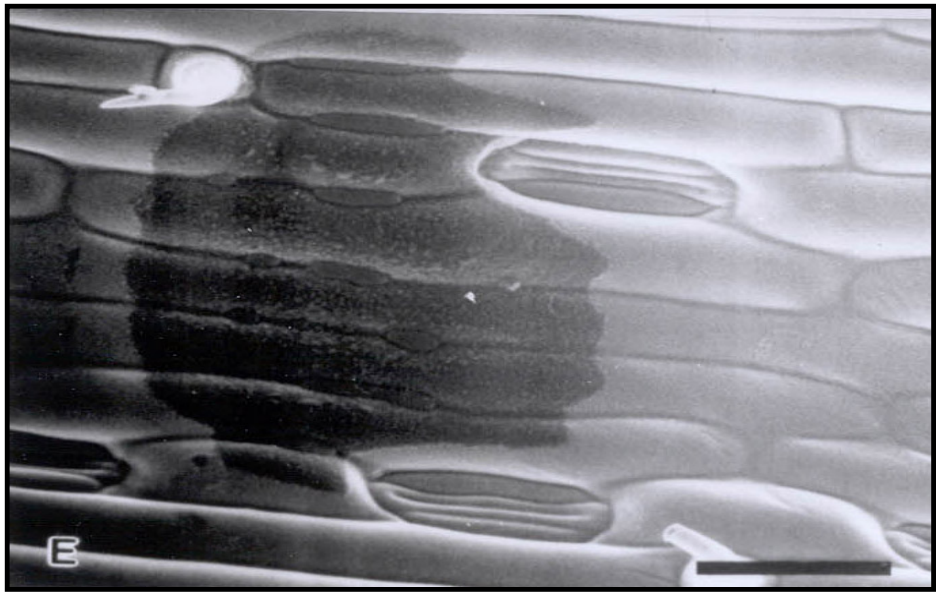
5.

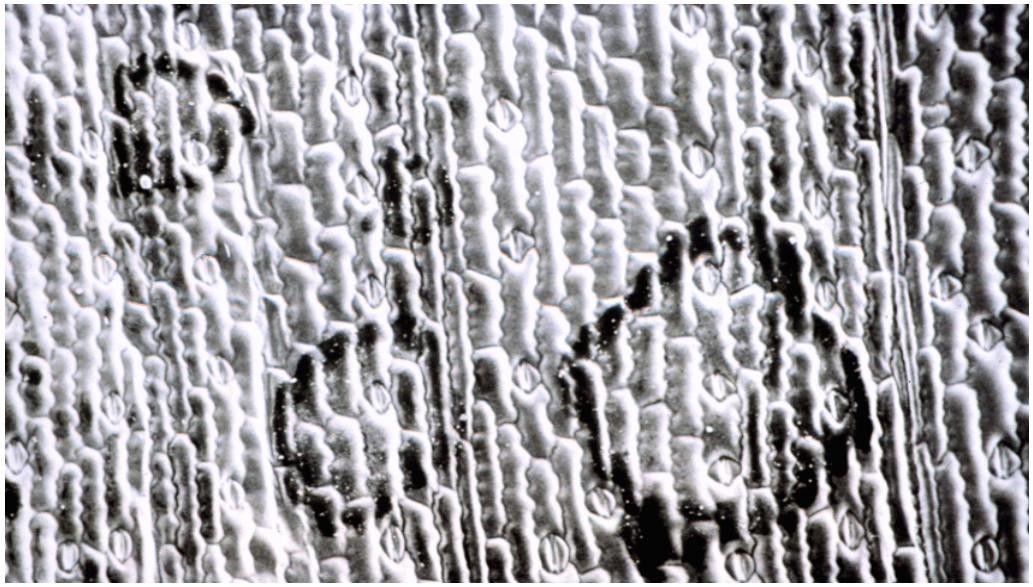

Dicamba drift on soybean:
1. Injury across entire fields (1/4 section)
2. Injury occurred 3 to weeks after application
3. Injury occurred 2 to 3 times across same field


Questions:
1. What is the fate of dicamba?
2. How much dicamba is FREE?
3. In what form is free dicamba?

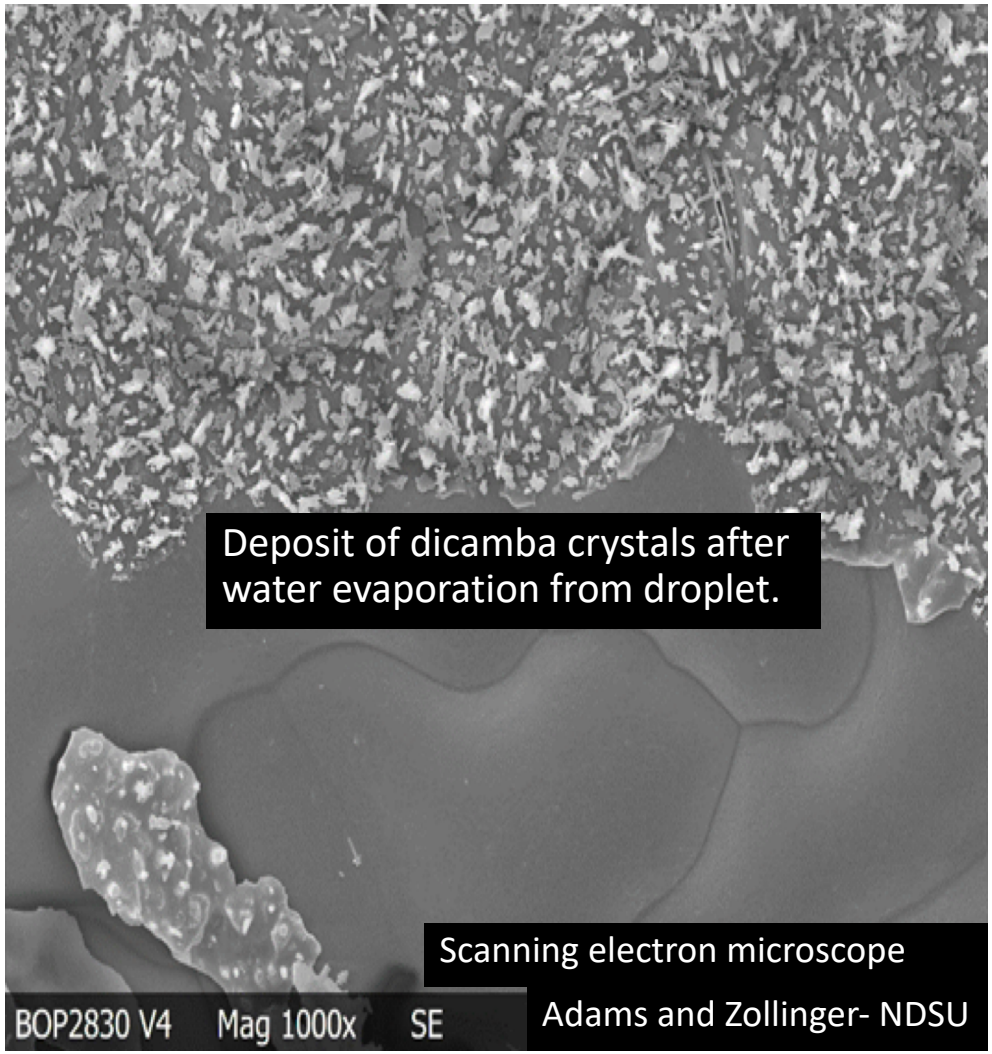
What does dicamba look like after water is gone?

Herbicide deposit on leaf surface



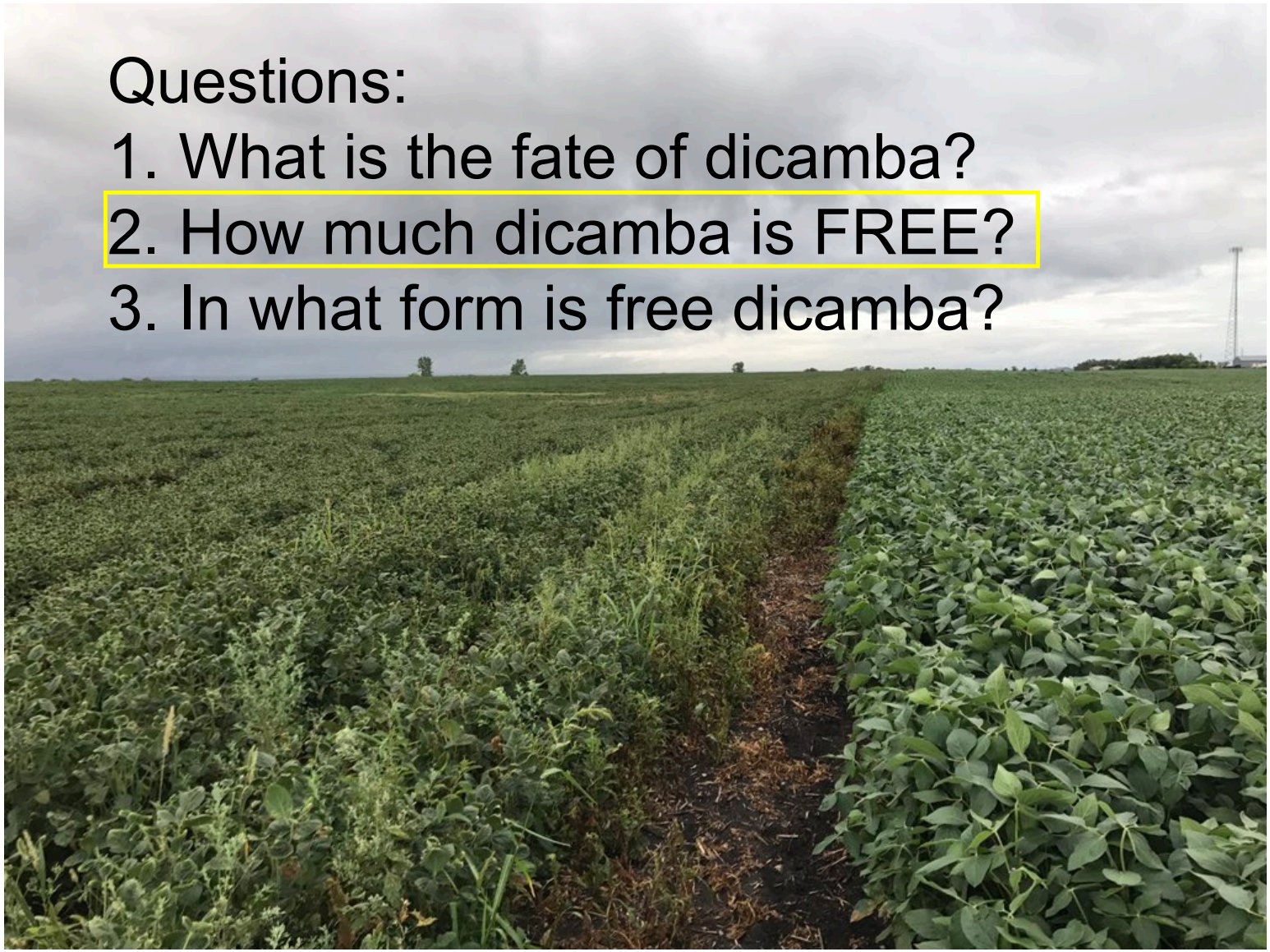


Dicamba crystallization on leaf surface



What is the fate of dicamba?

- Dissociated or acid?
- Wetting from dew?
- Wetting from light rain?
- Re-crystallized?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Dicamba Absorption Data

- Average absorption

Soybean =	38-75%
Leafy spurge =	60%
Kochia =	35%
Apple cuticles -	15% -30%
	~50% absorbed
	~50 unabsorbed!

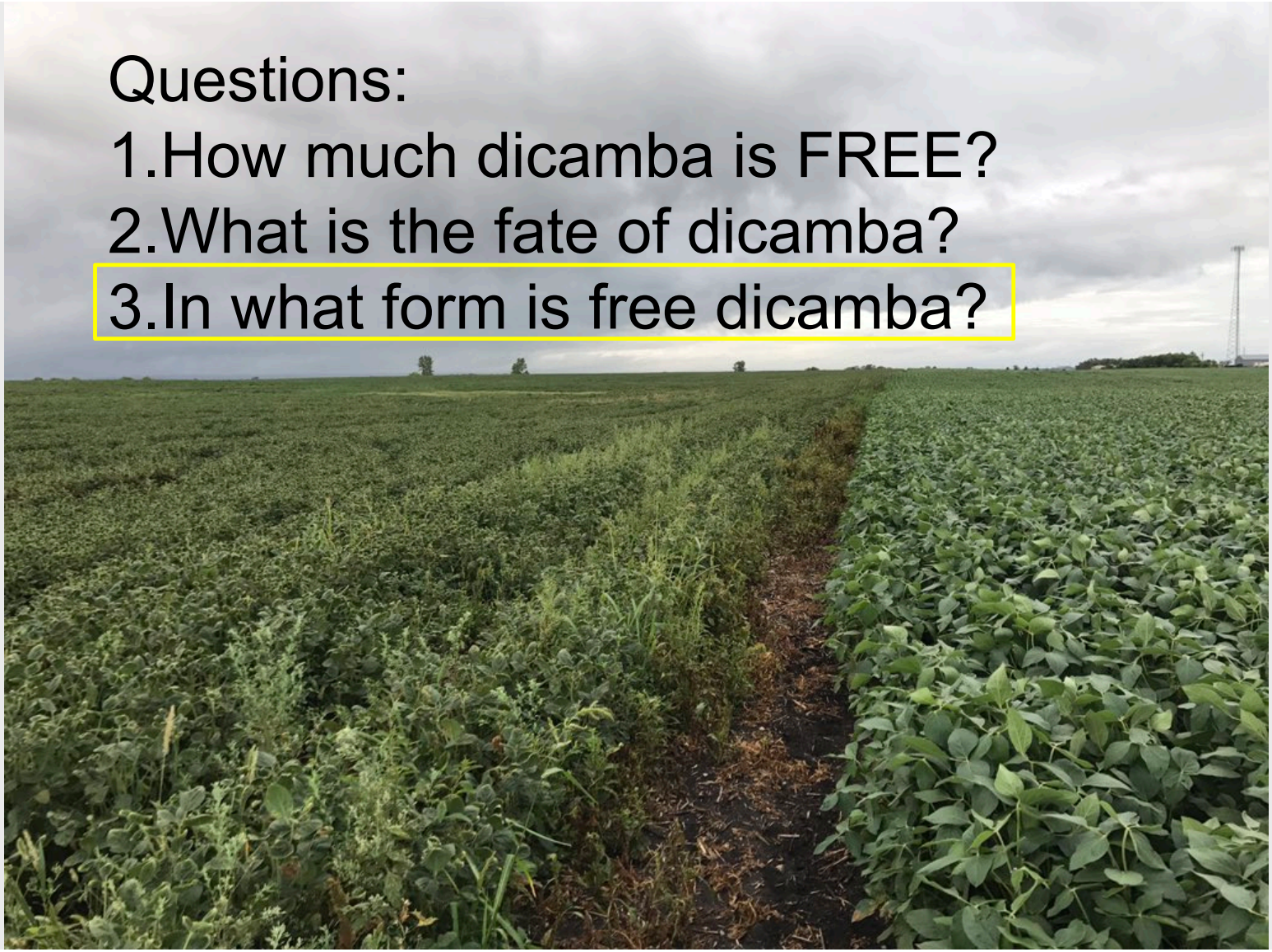
0.25 lb of dicamba on leaf + soil surface

7.5 m lbs of dicamba FREE!

How much dicamba is adsorbed to soil?

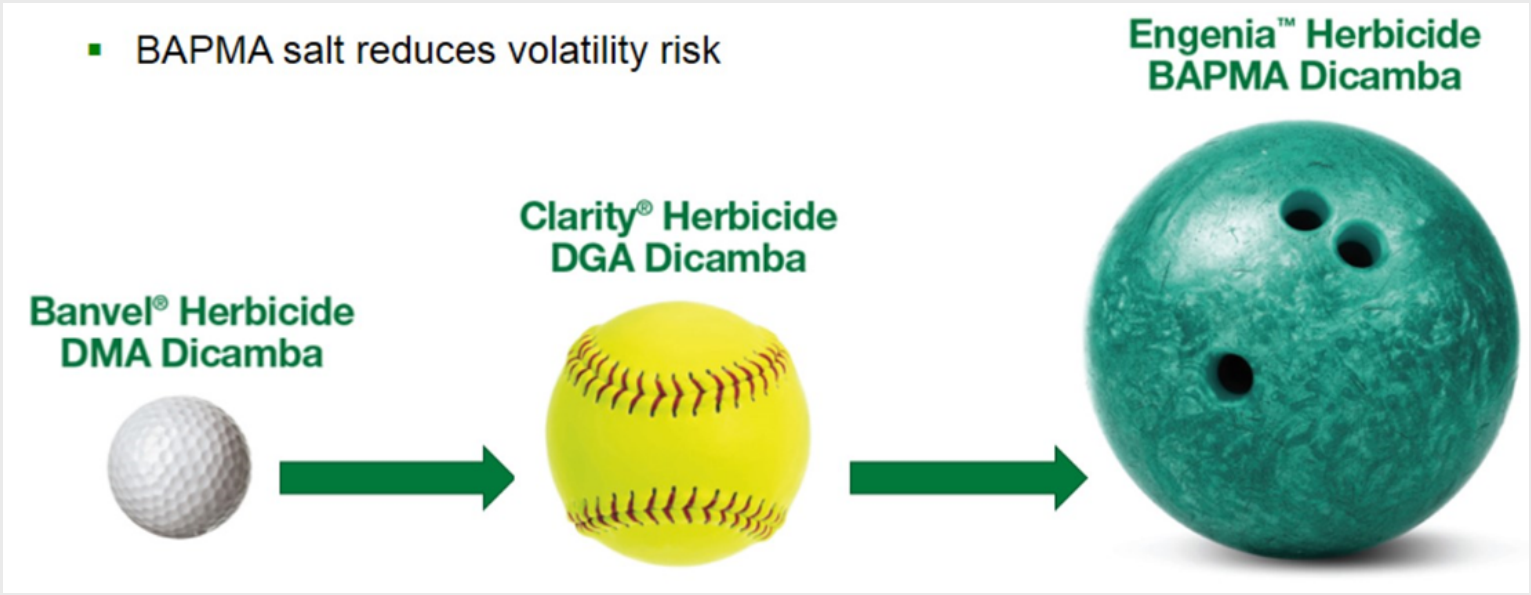
Dicamba Physical Properties

	Koc (mg/L)	Kd (mg/L)
Acetamides	100-600	1.1-2.7
DNAs	3000-9000	-
EPTC	136-264	0.77-3
Sulfentrazone	43	1
Glyphosate	24,000	324-600
2,4-D	20-136	0.17-1.27
Clopyralid	~60	-
Fluroxypyr	40-71	0.78-1.34
Picloram	17-160	0.5
Dicamba	2	0.05-0.13


Questions:
1.How much dicamba is FREE?
2.What is the fate of dicamba?
3.In what form is free dicamba?

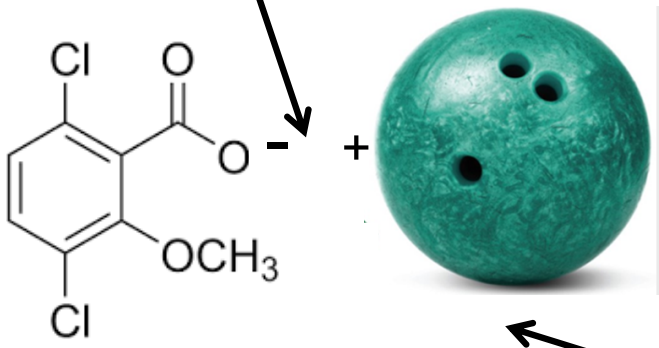
Engenia – Molecular Weight Theory

What is wrong with this picture?



Dissociation

Dicamba-acid = Volatile



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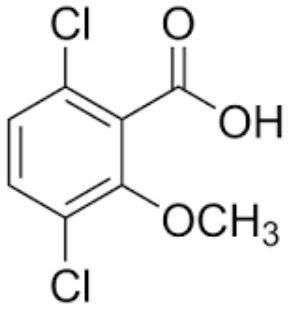
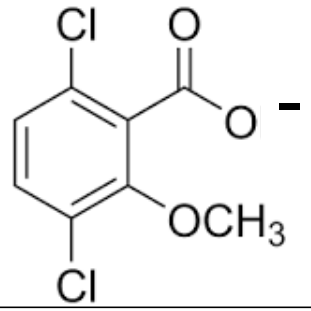


+H+



Dicamba-bapma or
-dga or
-dma

Dicamba-anion =
Not volatile

Vapor Grip – The Great Inigma

XtendiMax with “Vapor Grip”?

- 90% lower volatility than Clarity

What is Vapor Grip?

Monsanto Academic Summit – Sept 27, 2018

“Polymerized carboxylic acids”???

What is the mode of action of Vapor Grip?

- “Do not add acidifiers”
- “Do not add AMS”

Dicamba Physical Properties

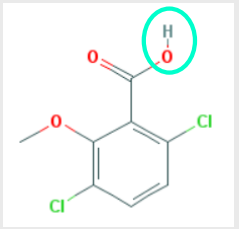
Herbicide Handbook

	pKa
Paraquat	--
Glyphosate	2.6, 5.6, 10.3
2,4-D	2.73
Aminopyralid	2.56 - dissociated and (-) charge
Clopyralid	2.3 - dissociated and (-) charge
Fluroxypyr	3
Picloram	2.3
Dicamba	1.87

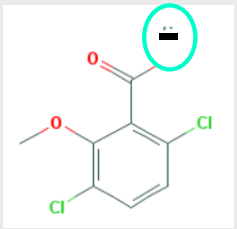
Dicamba Physical Properties

4. XtendiMax with “Vapor Grip”?

pH < 5.5 = dicamba-dga $\xrightarrow{H^+}$ dicamba-acid



pH > 5.5 = dicamba-dga $\longrightarrow$ dicamba-anion



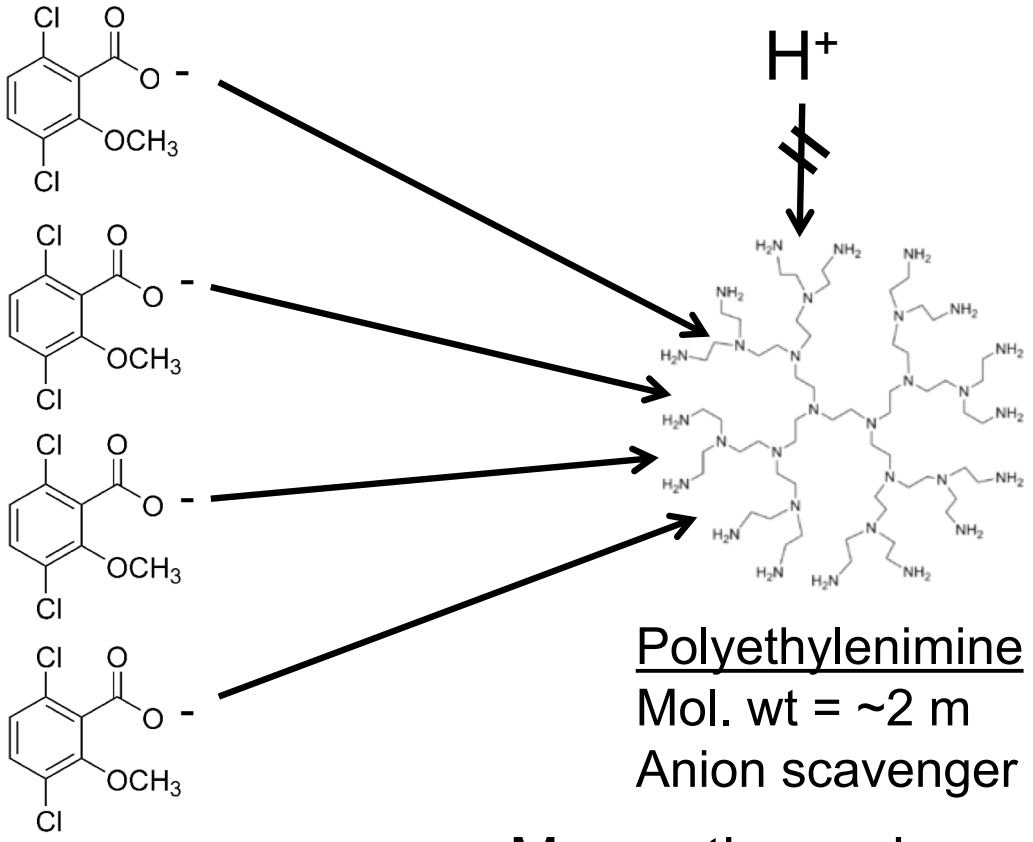
Dicamba pKa = ~2 dissociation constant

Low H+

pH 6 =	99.99 : 0.01	ratio of anionic : acid molecules
pH 5 =	99.9 : 0.1	“
pH 4 =	99:1	“
pH 3 =	90:10	“
pH 2 =	50:50	“

High H+

What is Vapor Grip



Dicamba-anion

Polyethylenimine
Mol. wt = ~2 m
Anion scavenger

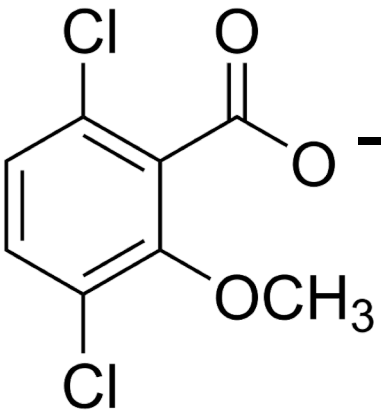
BAPMA: H_2N CH_3 N NH_2

DGA: H_2N O OH

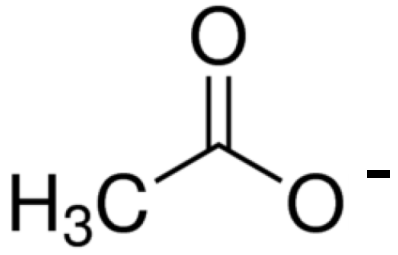
DMA: H_3C N CH_3 H

Many other anions can compete with binding sites

What is Vapor Grip



Dicamba-anion



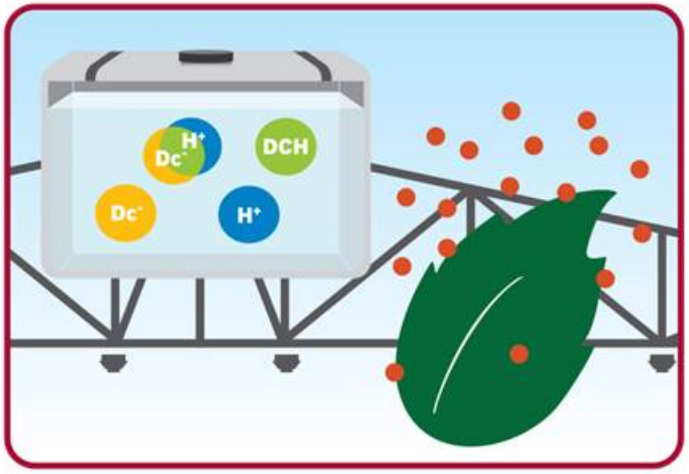
Acetic acid

Many other cations can compete with binding sites

VaporGrip™ Technology

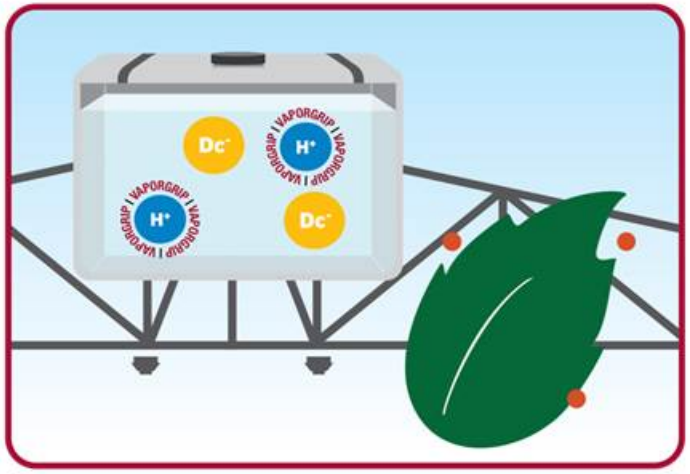
DMA Dicamba

(Not Approved for use in the Roundup Ready® Xtend Crop System)



In the tank there is the potential for dicamba acid (DCH) to form in solution and create off-target movement of dicamba through volatility after spraying

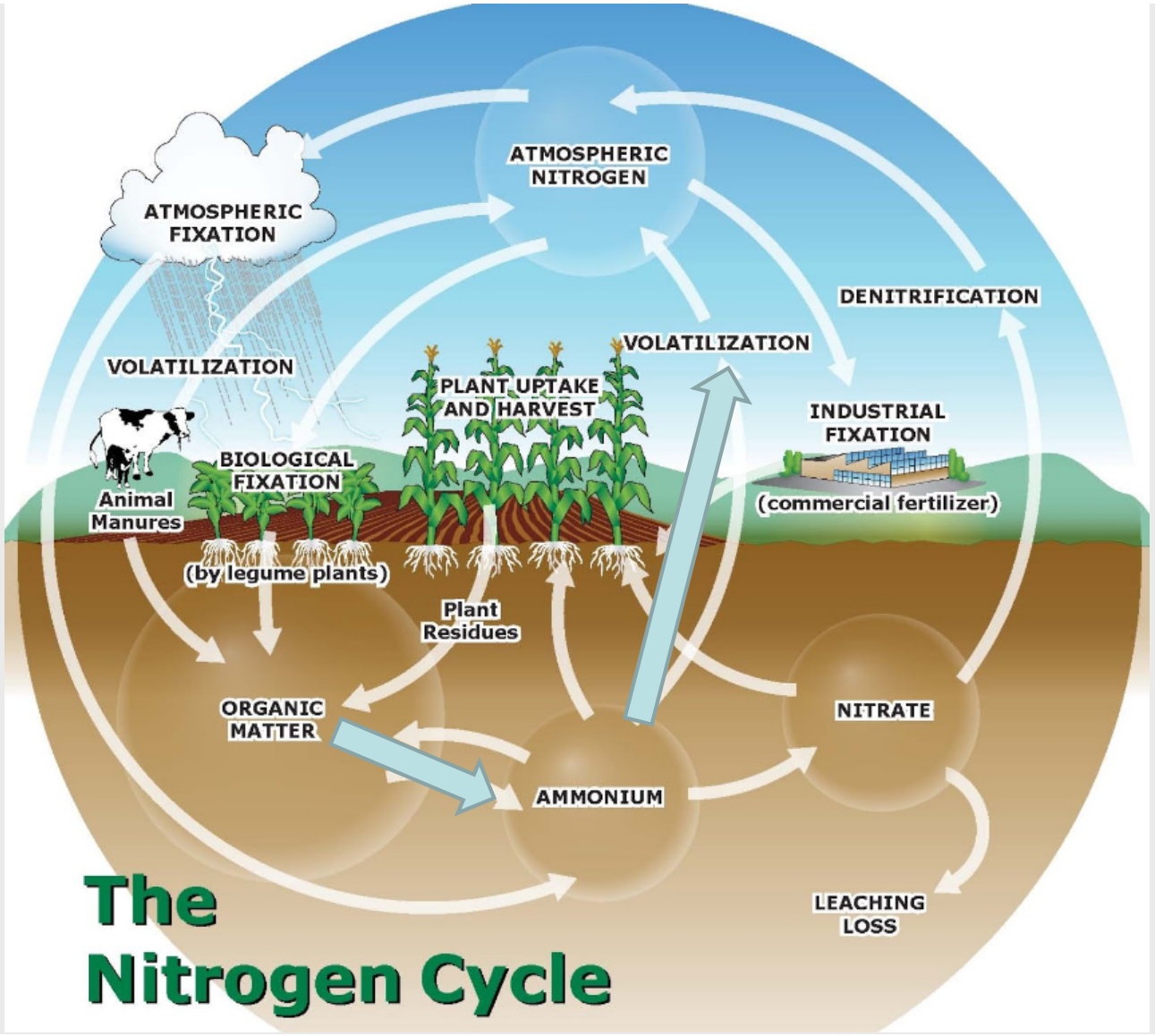
Low-Volatility Dicamba with VaporGrip™ Technology

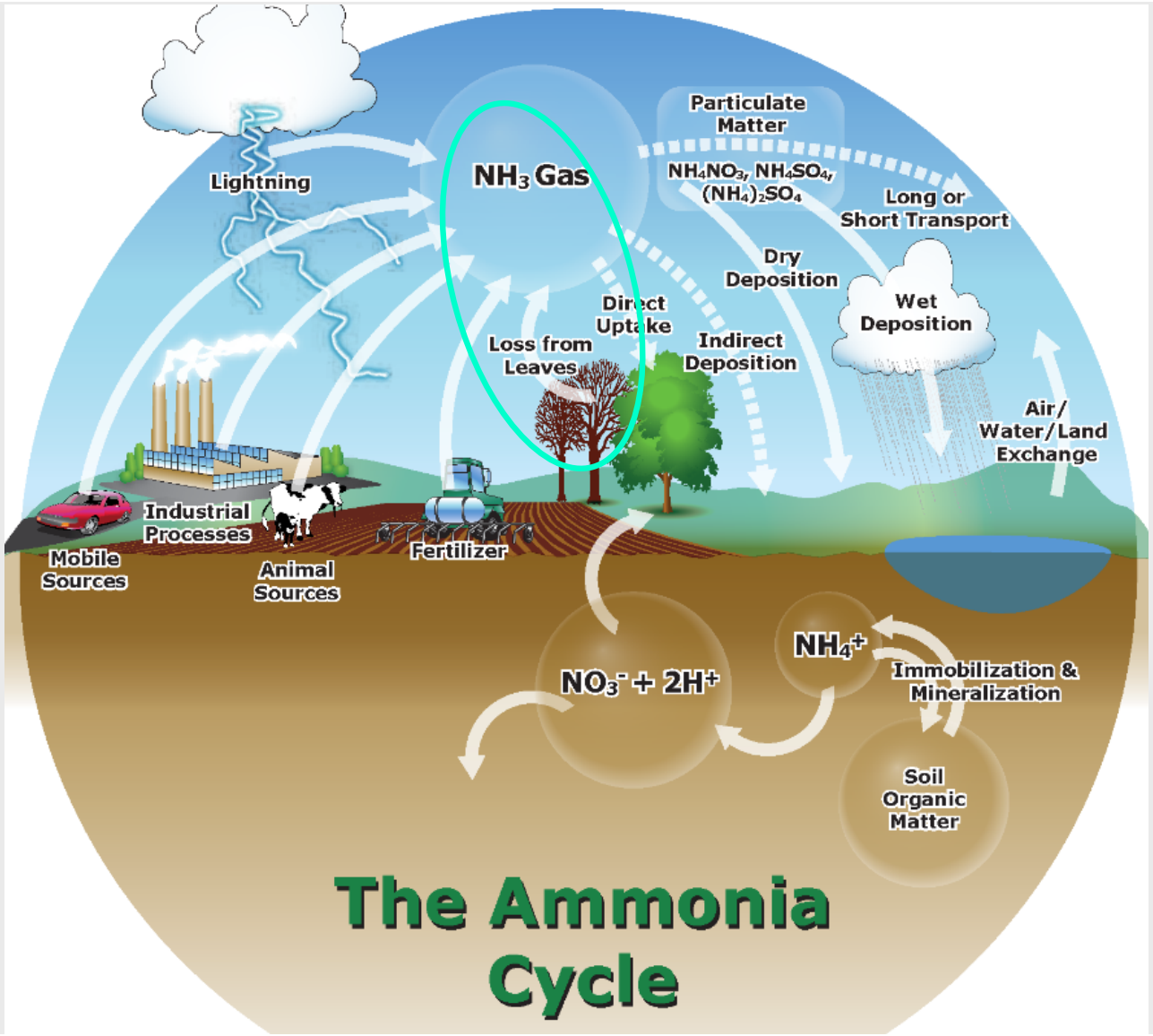


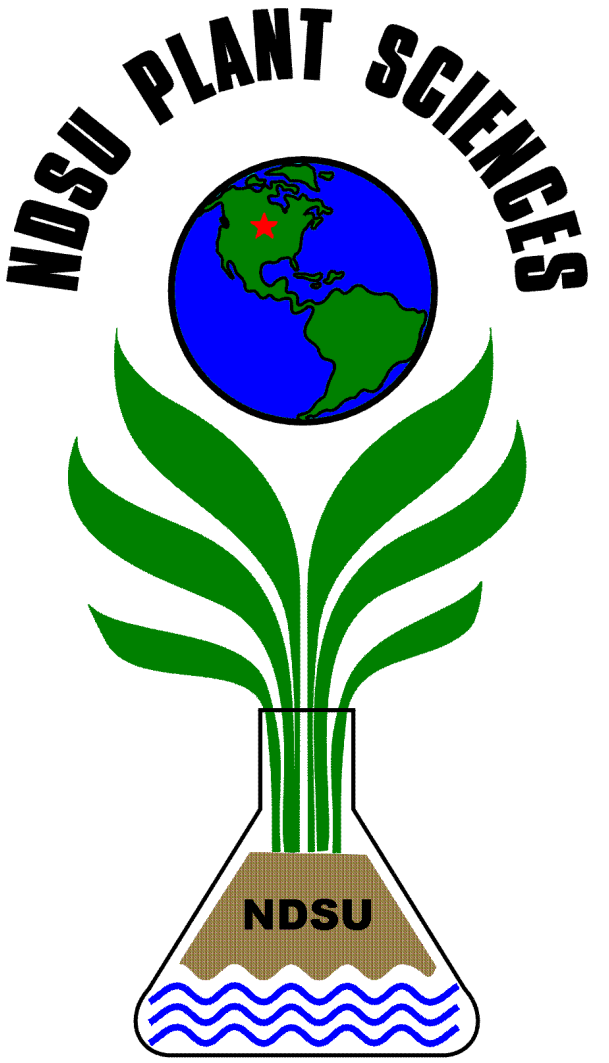
In the tank, VaporGrip™ Technology **prevents the formation of dicamba acid (DCH)** in solution, **minimizing potential off-target movement of dicamba** through volatility after spraying

THIS PRESENTATION ON APPLICATION REQUIREMENTS IS NOT A SUBSTITUTE FOR THE PRODUCT LABELING ALWAYS READ AND FOLLOW ALL PRODUCT LABELING.

V1 – 11/2016


ATMOSPHERIC NITROGEN
ATMOSPHERIC FIXATION
DENITRIFICATION
VOLATILIZATION
VOLATILIZATION
PLANT UPTAKE AND HARVEST
INDUSTRIAL FIXATION
BIOLOGICAL FIXATION
Animal Manures
(commercial fertilizer)
(by legume plants)
Plant Residues
ORGANIC MATTER
NITRATE
AMMONIUM
LEACHING LOSS
The Nitrogen Cycle


Lightning
NH_3 Gas
Particulate Matter
NH_4NO_3, NH_4SO_4, $(NH_4)_2SO_4$
Long or Short Transport
Dry Deposition
Wet Deposition
Direct Uptake
Loss from Leaves
Indirect Deposition
Air/ Water/Land Exchange
Industrial Processes
Mobile Sources
Animal Sources
Fertilizer
$NO_3^- + 2H^+$
NH_4^+
Immobilization & Mineralization
Soil Organic Matter
The Ammonia Cycle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Agriculture is in our roots