# Consideration of Surfactants in Noxious Weed Control:

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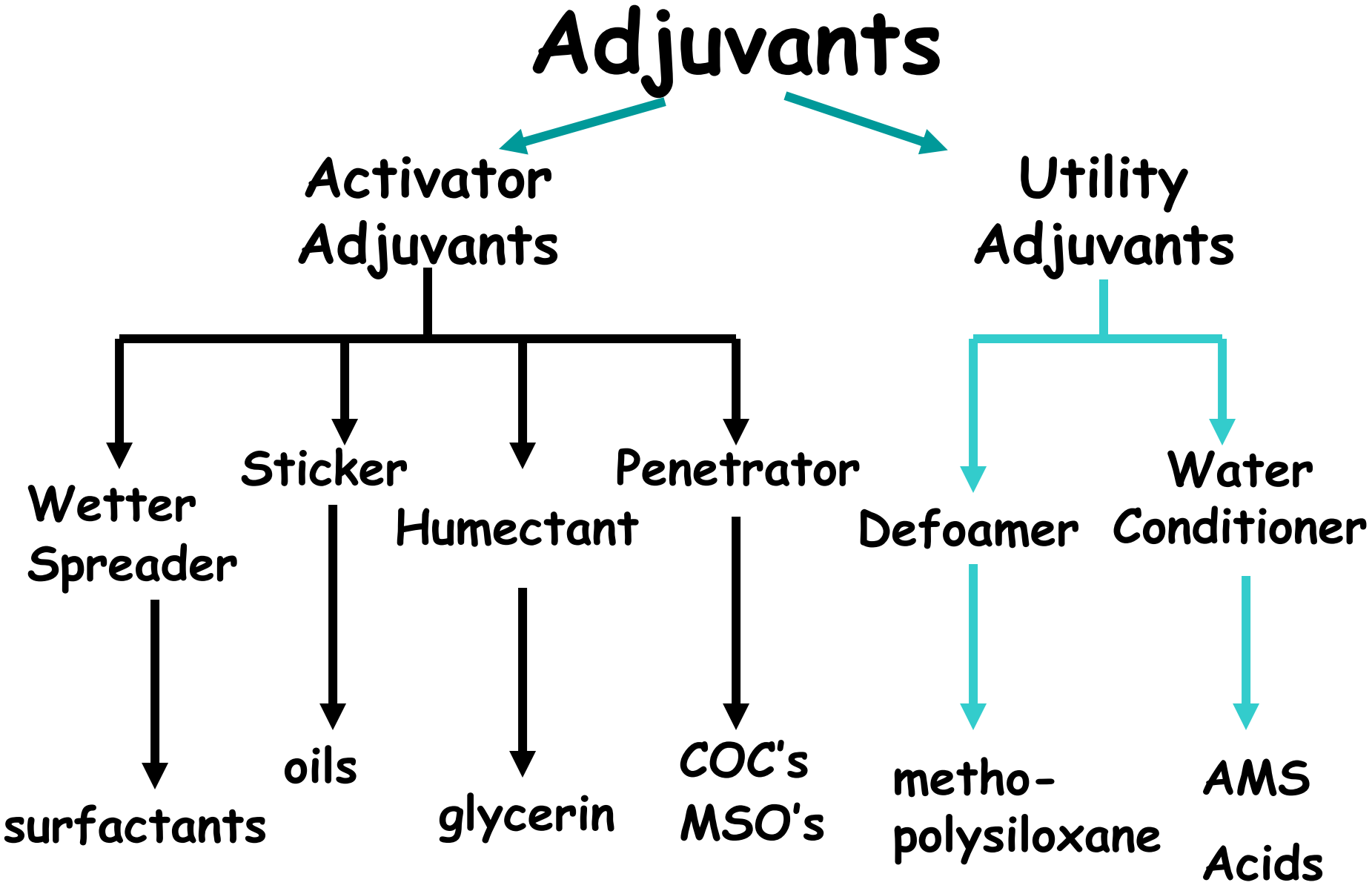


Slide courtesy of S. Nissen

# WSU's Pesticide Information Center On-Line (PICOL)

- 13,515 Pesticides
- 2,765 Herbicides
- 168 Special Local Need
- 632 Adjuvants
- 44 (43) Aquatic Adjuvants

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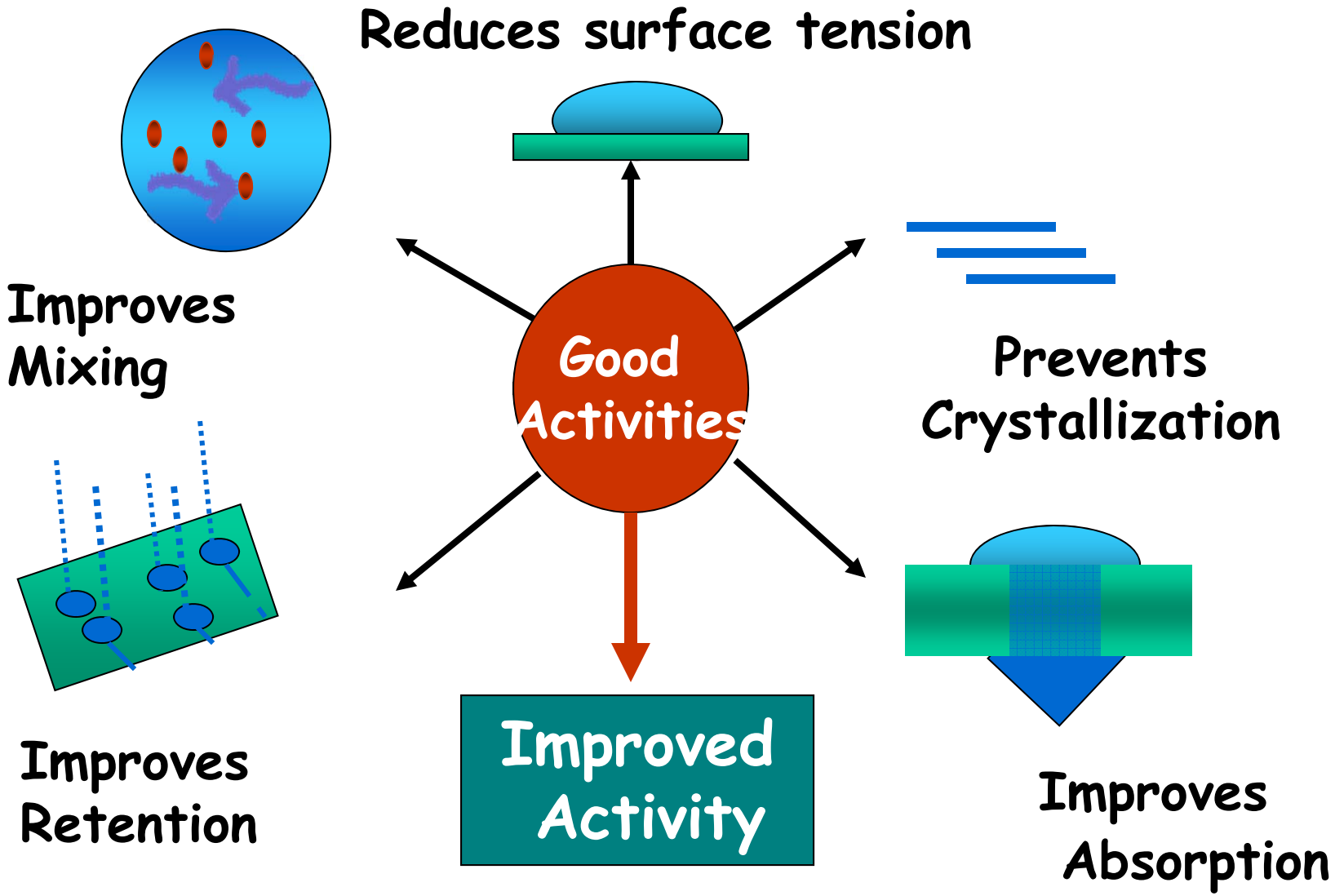
# COMPENDIUM OF HERBICIDE ADJUVANTS

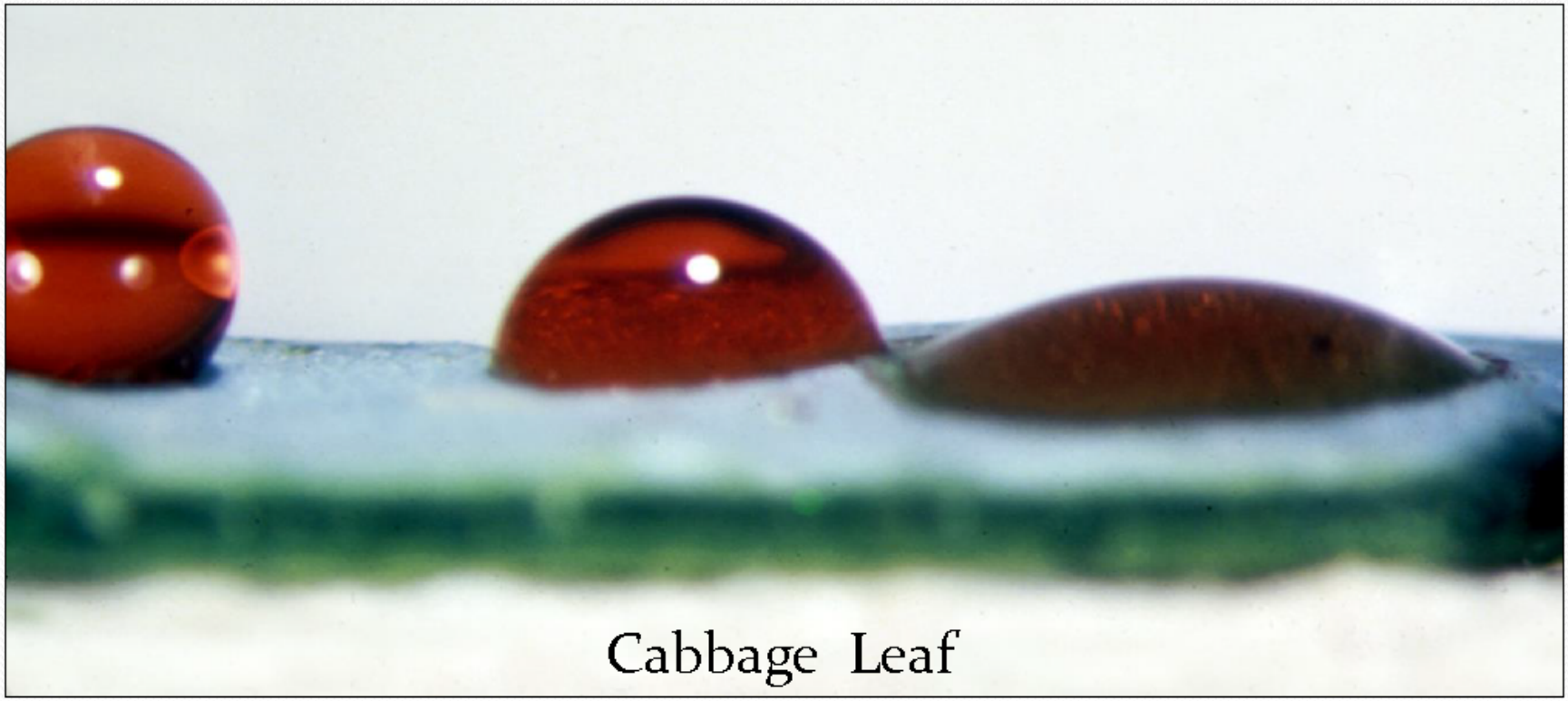
2016 • 13th Edition

# Activities of a Good Adjuvant




Slide courtesy of S. Nissen

## Left to Right: 0, 0.01, 0.1% Non-Ionic Surfactant




*Courtesy: Bukovac - Michigan State University*

# A little information on different surfactant types more commonly used

- **NIS**
- **Silicone surfactants**
- **Oils**
- **High surfactant oil concentrates**

## Nonionic surfactants (NIS)

- NIS mainly increase spray retention, and may help with herbicide absorption.
- Use at 0.25 to 0.5% v/v (1 to 4 pt/100 gal of spray solution) regardless of spray volume.
- NIS rate depends on the amount of active ingredient in the formulation, plant species and herbicides used. (see label)
- High rate is for use with low herbicide rates, drought stress and tolerant weeds, or when the surfactant contains less than 90% active ingredient.

## Silicone surfactants

- Reduce spray droplet surface tension, which allow the liquid to run into leaf stomata (“stomatal flooding”).
- Too high concentration – runoff
- May or may not increase efficacy
- Silicone surfactants are weed and herbicide specific just like other adjuvants.

## **Oils** - two types

Oil adjuvants enhance post-emergent activity of most herbicides more than NIS

- **Petroleum oils (Crop oil concentrates COC)**
  - COC is usually a petroleum, not a crop vegetable oil

- **Methylated vegetable or seed oils (MSO)**
  - Effective with all post-emergent herbicides, except Liberty and Cobra, and will antagonize Roundup
  - MSO enhances post-emergent herbicides > COC >NIS
  - MSO adjuvants are more aggressive in dissolving leaf wax and cuticle, resulting in faster and greater herbicide absorption
  - The greater herbicide enhancement from MSO adjuvants may occur more in low humidity/low rainfall environments where weeds develop a thicker cuticle
  - MSO adjuvants are more $ than NIS and COC

**Most herbicides give greater weed control when used with MSO-type adjuvants.**

- Especially when there are:
  - Low humidity, hot weather, lack of rain, and drought-stressed weeds
  - Weeds not actively growing due to some stress condition
  - Weeds larger than recommended on the label
  - Herbicides used at reduced rates
  - Target weeds that are somewhat tolerant to the herbicide (buckwheat, lambsquarters, ragweed to Pursuit or Raptor, or yellow foxtail to Accent)

## Oil adjuvant applied on a volume or area basis

- The optimum rate of a COC/MSO is 2 pt/A
- Many labels  recommend oil adjuvants at 1% v/v
- But this spray volume dependent:

1%  @ 17 GPA = 1.4 pt/A – barely ok
1%  @ 8.5 gpa = 0.68 pt/A – too low

Some herbicide labels contain information on adjuvant rates for different spray volumes. To ensure sufficient adjuvant concentration, add oil adjuvant at 1% v/v but no less than 1.25 pt/A at all spray volumes

This is in contrast to NIS Surfactant at 0.25 to 0.5% v/v water is sufficient across all water volumes

- **What do you do when you have lipophilic and hydrophilic herbicides in a tank mix?**
  - Lipophilic herbicides (Select, Banvel, Laudis, others)
  - Hydrophilic herbicides (Glyphosate )

**Do I even need an adjuvant?**

- POST-emergent herbicide effectiveness depends on spray droplet retention, deposition, and herbicide absorption by weed foliage. Adjuvants and spray water quality influence POST herbicide efficacy.
- Adjuvants are not needed with PRE-emergent herbicides unless weeds have emerged and labels include POST emergent application.

## What to use with what – follow the label!

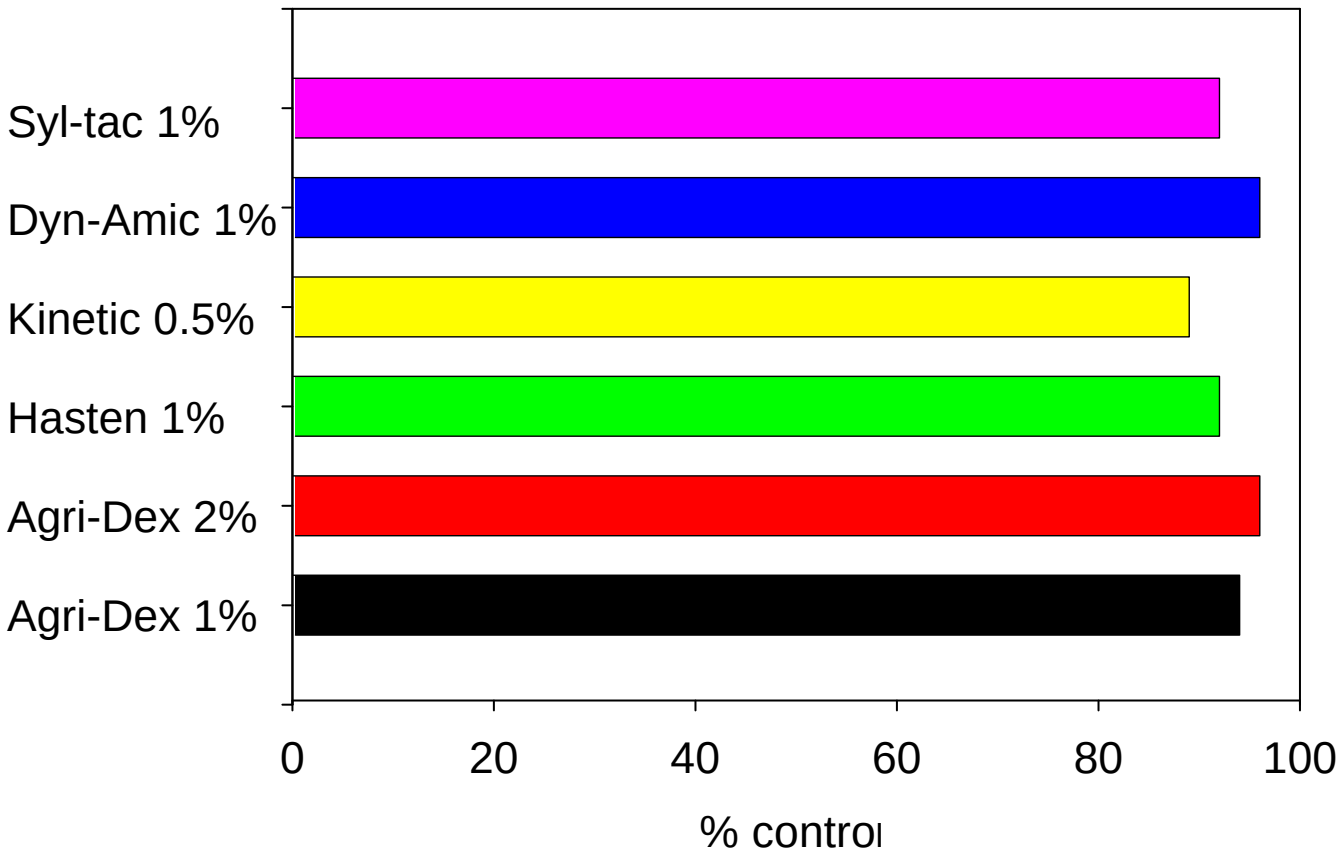
| *Herbicide* | *Adjuvants allowed* | *Comments* |
|---|---|---|
| 2,4-D amine | None | |
| 2,4-D ester | None | |
| Accent | COC or NIS[a] + $NH_4$ | NIS when tank mixed, except with atrazine |
| Accent Gold | COC + $NH_4$ | |
| Aim | NIS or COC | COC allowed if droughty |
| Atrazine | COC | |
| Banvel | NIS or $NH_4$ | Only if droughty |
| Basagran | COC + $NH_4$ | |
| Basis | NIS or COC + $NH_4$ | |
| Basis Gold | COC + $NH_4$ | |
| Beacon | COC or NIS + $NH_4$ | NIS when tank-mixed, except with atrazine |
| Buctril | COC or NIS | Adjuvants allowed if injury is acceptable |
| Buctril + atrazine | COC or NIS | Adjuvants allowed if injury is acceptable |
| Celebrity Plus | NIS + $NH_4$ | |
| Clarity | $NH_4$ +COC or NIS | Allowed if droughty; oils may cause injury if corn > 5 inches tall |
| Distinct | NIS + $NH_4$ | |
| Exceed | COC or NIS + $NH_4$ | |
| Hornet | NIS or COC + $NH_4$ | COC + $NH_4$ if dry |
| Laddok S-12 | COC + $NH_4$ | |
| Marksman | COC or NIS or $NH_4$ | Allowed if droughty |
| Northstar | COC or NIS + $NH_4$ | COC allowed only up to 12-inch-tall corn |
| Permit | COC or NIS + $NH_4$ | |
| Resource | COC + $NH_4$ | |
| Scorpion III | NIS + $NH_4$ | Allowed if droughty |
| Sencor | NIS or $NH_4$ | |
| Shotgun | None | |
| Spirit | COC or NIS + $NH_4$ | |
| Stinger | None | |
| Tough | None | |

**Is there that much difference in efficacy between surfactants**?

Depends on lot of variables

## Aquatic weed control - Spartina control

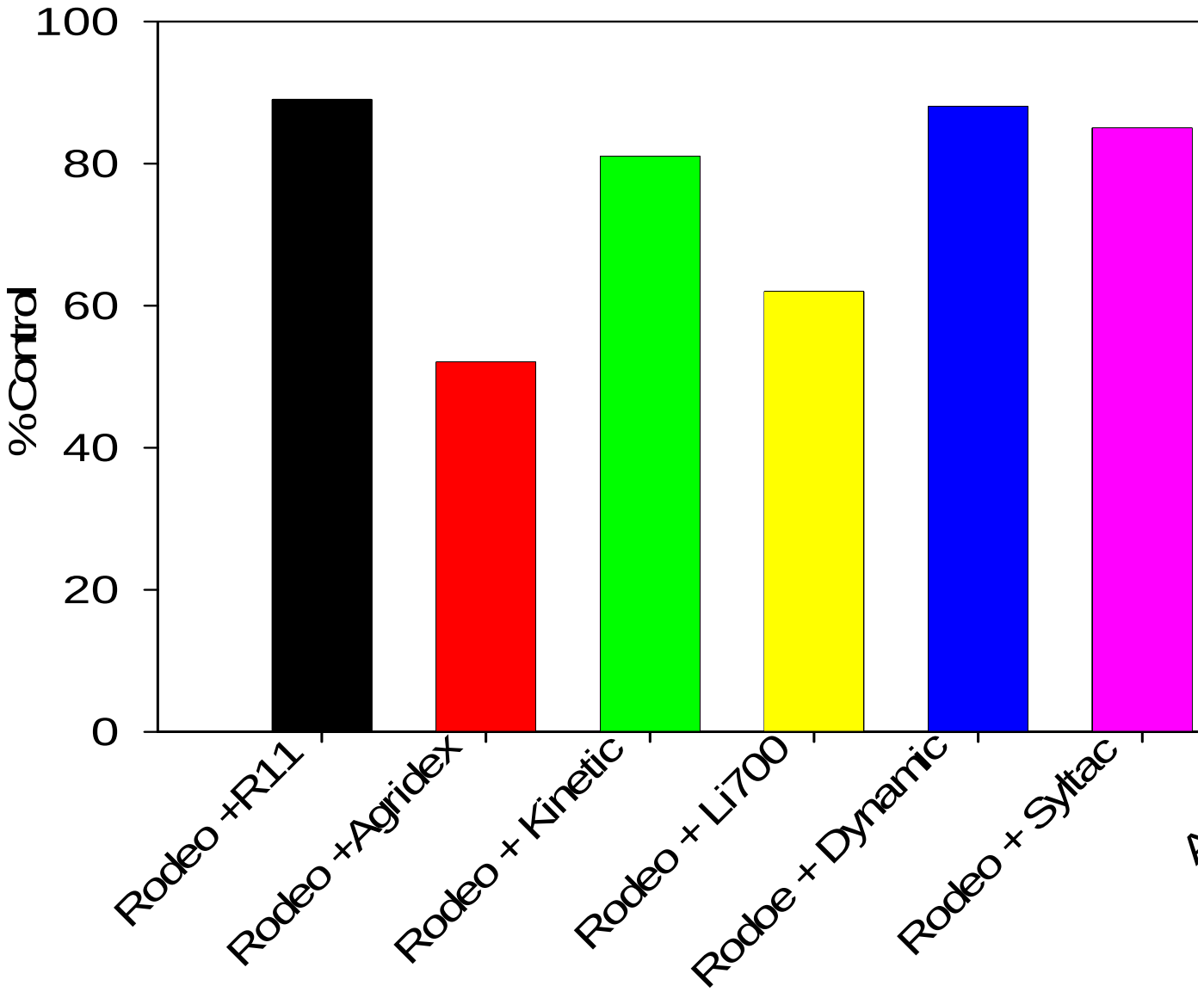
Effect of surfactant on the efficacy of imazapyr*




No significant difference between treatments

* 6 pt/ac, 10 gpa, >6 hrs dry time

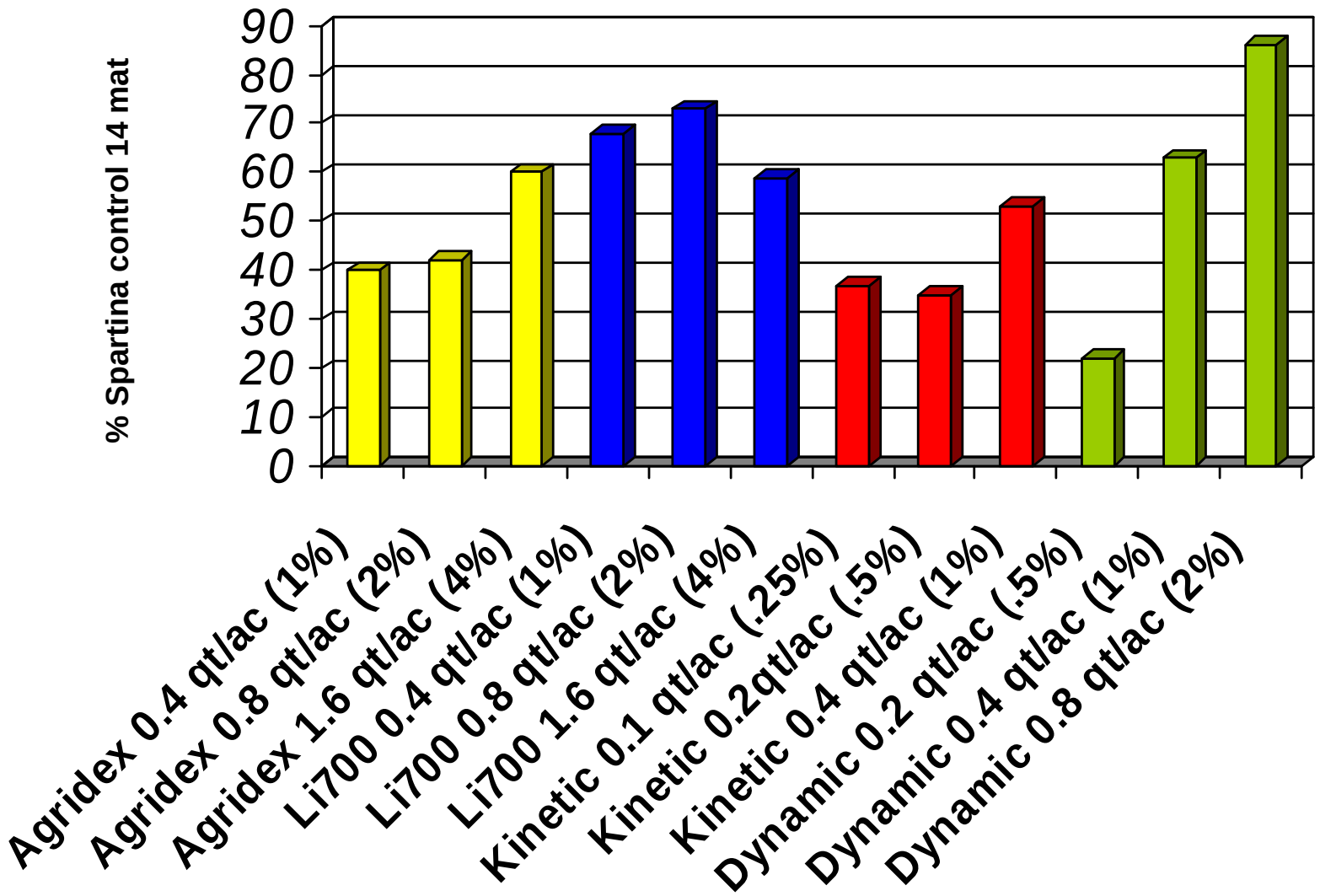
Long dry time – no surfactant effect




**Rodeo applied @ 7.5 qt/ac using 1% v/v surfactant @ 10 gpa, 8 hrs dry time**

Low herbicide rate, short dry time

## Efficacy as a function of surfactant & rate




**Rodeo @ 2 gallons/ac applied at 10 gpa spray volume**

**Anti-drift agents**

- Reduced driftable fines (<105 microns)
- Invert emulsion or polymers (polyacrylamide) which increase shear strength of water – (makes them large)
- Can change GPA (calibrate again if using)
- Can make a spray ‘goop’ – be careful on rate
- Common to have more tip clogging
- Follow mixing instructions

**Also reduced drift by**

- Spraying closer to target
- Lower pressure
- AI nozzles

**Water condition – i.e. spray carrier water quality**

- Minerals, clay, and organic matter
- Hard water cations or micronutrients such as calcium, magnesium, manganese, sodium, and iron
    - Glyphosate, ACCase inhibitors, ALS inhibitors, HPPD inhibitors, and Ignite all affected by water quality

.

Glyphosate, ACCase inhibitors, ALS inhibitors, HPPD inhibitors, and Ignite all affected by water quality

.

**AMS may contain contaminants and plugged nozzles – use spray grade AMS**

**The amount of AMS needed to overcome antagonistic ions can be determined as follows: Lbs AMS/100 gal = (0.002 X ppm K) + (0.005 X ppm Na) + (0.009 X ppm Ca) + (0.014 X ppm Mg) + (0.042 X ppm Fe).**

**Options to AMS for water conditioning:**

- **28% UAN fertilizer**
- **Water conditioner adjuvants w/o AMS**
- **Acidic AMS replacement (AAR) adjuvants**

**Ammonium sulfate**

- Add before herbicide – why?
- Very corrosive to sprayer parts

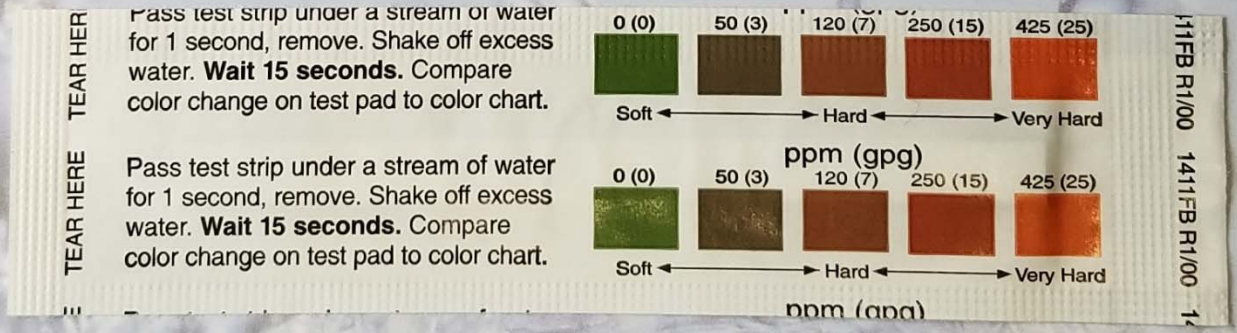
# TEST YOUR WATER

Water typically makes up about 90% of a grower or custom applicator's spray solution, but is rarely thought about. Poor water quality can reduce herbicide ***PERFORMANCE*** by as much as 20%.

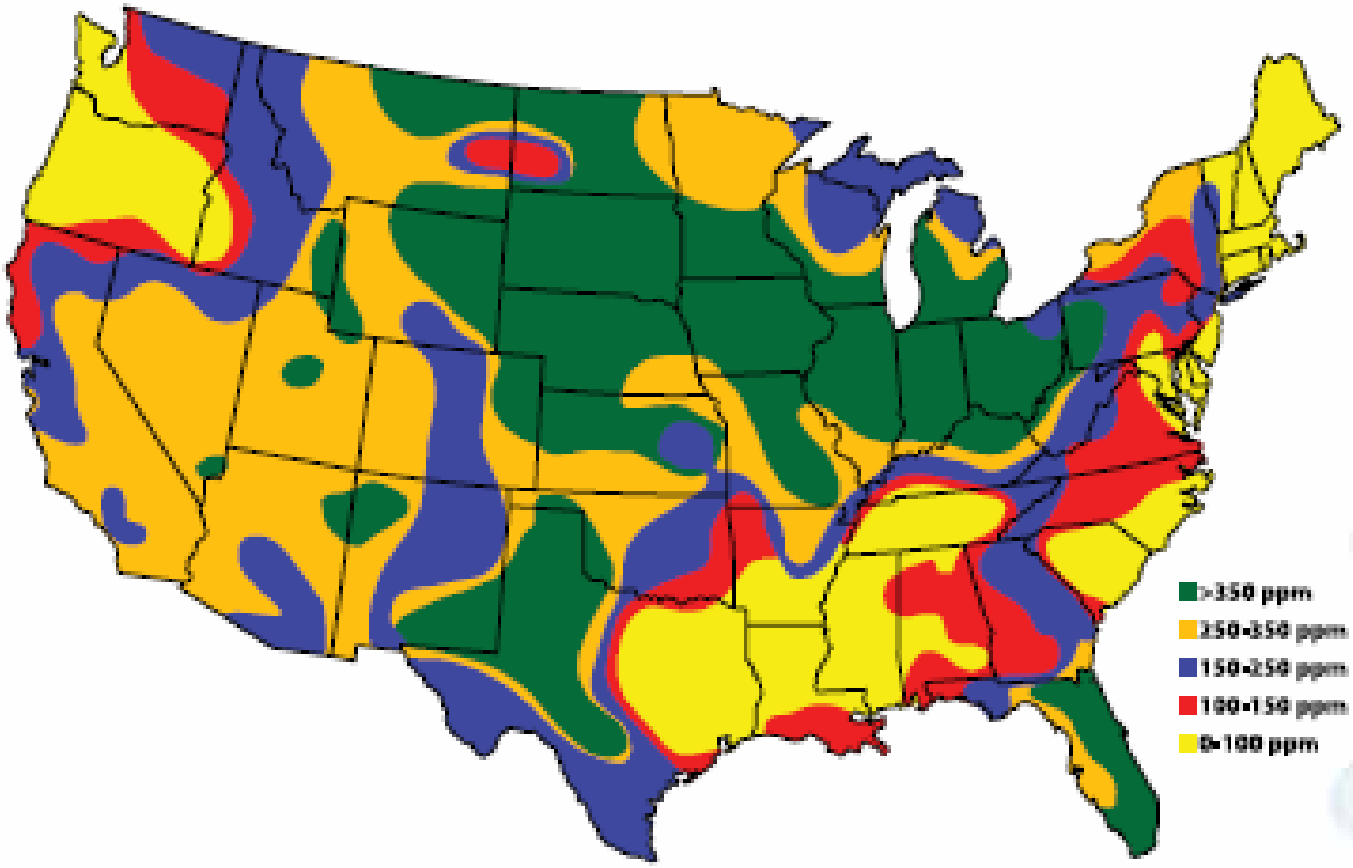
Water hardness is the biggest potential issue affecting herbicide ***PERFORMANCE***.

A simple water test is the first step to reducing these ***PERFORMANCE*** issues.

**Use the test strip provided to check your water!**




*See the other side for information on product selection to correct your potential water issues....*




This map represents **average** hardness of an area. Please test your water, as your water quality may differ.

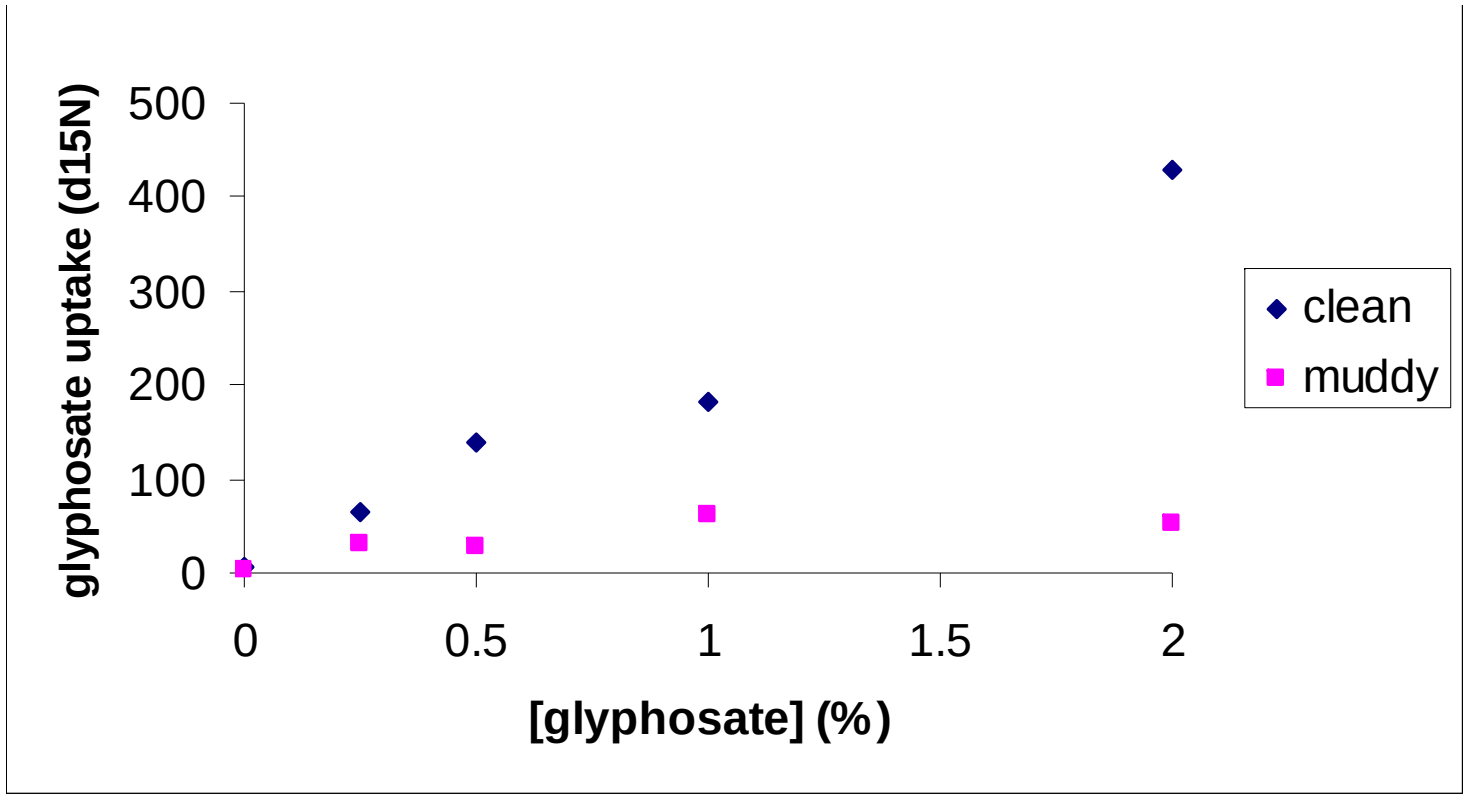
# Turbid water effects (dirty water)

**Sorption coefficients of several commonly used herbicides, and their responsiveness to water turbidity.**

| Herbicide | Koc (mg/L) | Turbidity effect |
|---|---|---|
| Glyphosate | 24,000 | Yes |
| Sethoxydim | 100 | No |
| Clethodim | - | No |
| Bentazon | 34 | No |
| 2,4-D amine | 100 | No |
| 2,4-D ester | 24 | No |
| Dicamba | 2 | No |
| Paraquat | 1,000,000 | Yes |

# Dirty leaf effects

**Effect of leaf sediment on glyphosate uptake**




**What can you do about turbid water?**

- AMS?
- Acidify?
- Deformer?
- Detergent?
- Buffering agent?

**What can you do about turbid water if you are using glyphosate or diquat or paraquat?**

- ~~AMS?~~
- ~~Acidify?~~
- ~~Deformer?~~
- ~~Detergent?~~
- ~~Buffering agent?~~

This type of antagonism cannot be corrected by adding AMS or buffering solutions.

**Instead**

- Choose a water source that is free of soil, grit, and organic matter.

or

- Switch herbicides to ones that are not affect by turbidity (low Koc)

## Spray tank pH

- May effect herbicide activity
- May effect herbicide longevity in spray tank

- Weak acid herbicides such as glyphosate, 2,4-D, dicamba, and many other herbicides remain neutral at acidic pH (< 7.0) and become negatively charged at alkaline pH (> 7.0)
  - The leaf cuticle and cell membrane can create barriers to the absorption of negatively charged herbicide
  - At pH>7 the negative charge on the herbicide can attract positively charged ions in the water that can form complexes with the herbicide, ultimately reducing its absorption into the plant
- Basic herbicides such as some ALS herbicides (Accent) remain neutral at alkaline pH levels
  - Less effective as the spray solution pH becomes acidic

**Extreme pH values (< 5.0 and > 8.0) also affect herbicide stability (half life)**

## Important to know your carrier water pH

Want to target the mid-range for everything

| Avoid using with high alkaline water (consider using water acidifier) | |
|---|---|
| Atrazine | Atrazine, Aatrex |
| Bromoxynil | Badge, Bromotril, |
| Clodinafop | Horizon |
| Diclofop | Hoegrass |
| Difenzoquat | Avenge |
| Diquat | Reglone, Reward |
| Glyphosate | Glyfos,Roundup, |
| Imazapyr | Arsenal |
| Naptalam | Alanap |
| Paraquat | Gramoxone |
| Trifluralin | Bonanza, Treflan. Rival |
| Phenmedipham | Prowl |
| Simazine | Princep |
| Diphenyether | Cobra |
| Resource | |
| Valor | N_phenylphthalimid |

| Fairly stable ( best mid pH range) | |
|---|---|
| Clopyralid + MCPA | Curtail M |
| Dicamba | Oracle, Banvel , |
| Metribuzin | Sencor |
| Oxyfluorfen | Goal |
| Pendimethalin | Prowl |
| Sethoxydim | Poast |
| Clomazone | Command |
| Diuron | Diurex, Karmex |

| Not stable at very low pH (<pH4) | |
|---|---|
| Nicosulfuron | Accent |
| Primisulfuron | Beacon |
| Metasulfuron Methyl | Ally |
| | Harmony |

**Take home on pH**

**pH 3.5-6.0** – Satisfactory for most spraying and short-term (12 to 24 hours) storage of most pesticide mixtures in the spray tank. However, the sulfonylurea herbicides (Accent, Harmony, etc.) degrade in low pH solutions

**pH 6.1-7.0** – Adequate for immediate spraying of most pesticides

**pH 7.0 and higher** – May need to add a buffer or acidifier depending on the pesticide

At high pH some herbicides have short longevity in spray tank; use immediately

**Acidifying surfactant – some examples**

TRI-FOL: propanetricarboxlic acid ½ to 2 pt/100 gal – an organic acid buffering agent

LI700: aykyl polyoxyethylene ether, phosphatidylcholine, methylacetic acid – a surfactant that  aids in acidifying, penetrating, and drift control

# Special considerations for common herbicides

# Glyphosate

- High KOC- won’t work with dirty water
- Hard water –Ca, Mg, Fe , Na inactivates – use AMS
- Plants with high intracellular Ca (velvetleaf and quackgrass)- add AMS
- Hard water
  - Use higher rates
  - Use tank mix immediately after mixing
  - Reduce carrier volume

# Clethodim and sethoxydim (grass herbicides)

- Turbid and hard water – no problem
- Water pH>7 reduces activity (weak acids are dissociates and poorly absorbed) – add water acidifier

# 2,4-D Amine

- Sensitive to hard water – reduces efficacy (test water and replace if >500 ppm alkalinity and/or hardness >600 ppm))

How toxic are adjuvants?

How careful do we have to be?

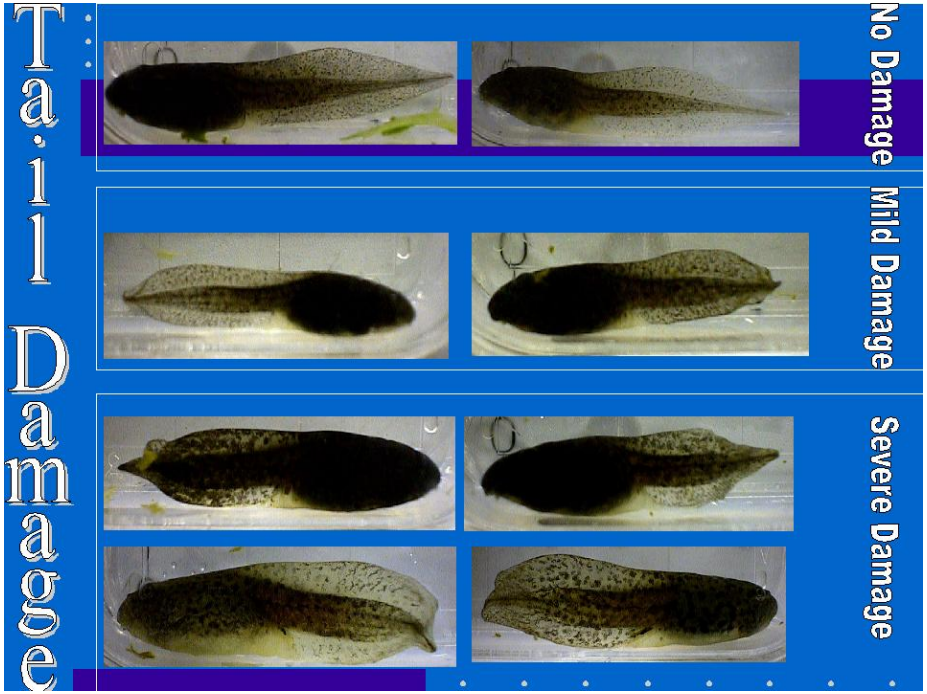
**>3000 journal articles in past 3 years related to subject**

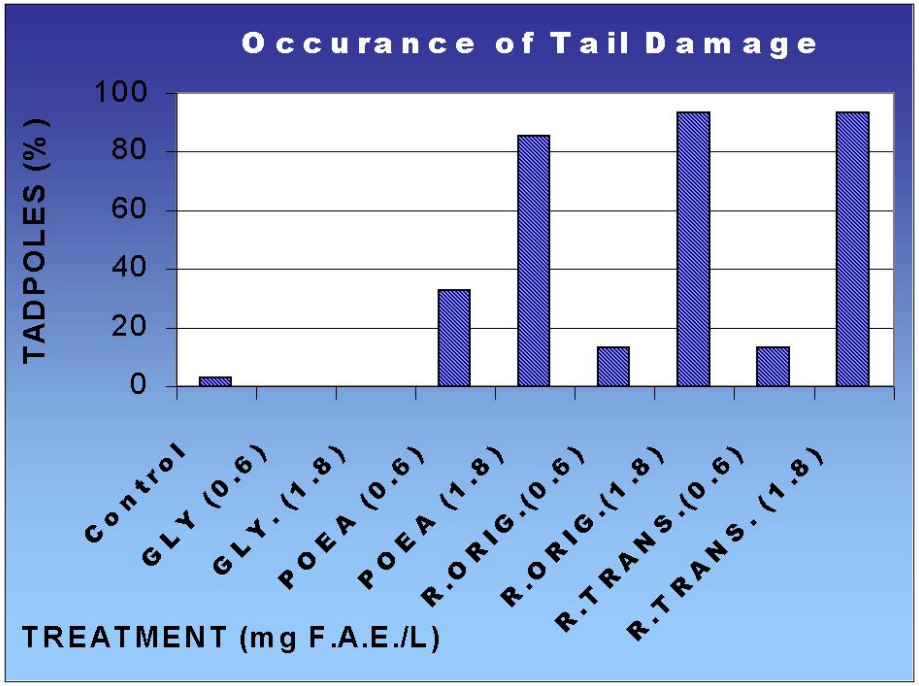
One of the major issues on surfactants toxicity during aquatic uses

(frogs, fish, aquatic insects)

- Estrogenic and acute toxicity effects
  - “glyphosate formulations containing the POEA surfactant have the same potential to cause substantial amphibian mortality at environmentally expected concentrations.”

**Estrogenic effects on tails in Frogs**



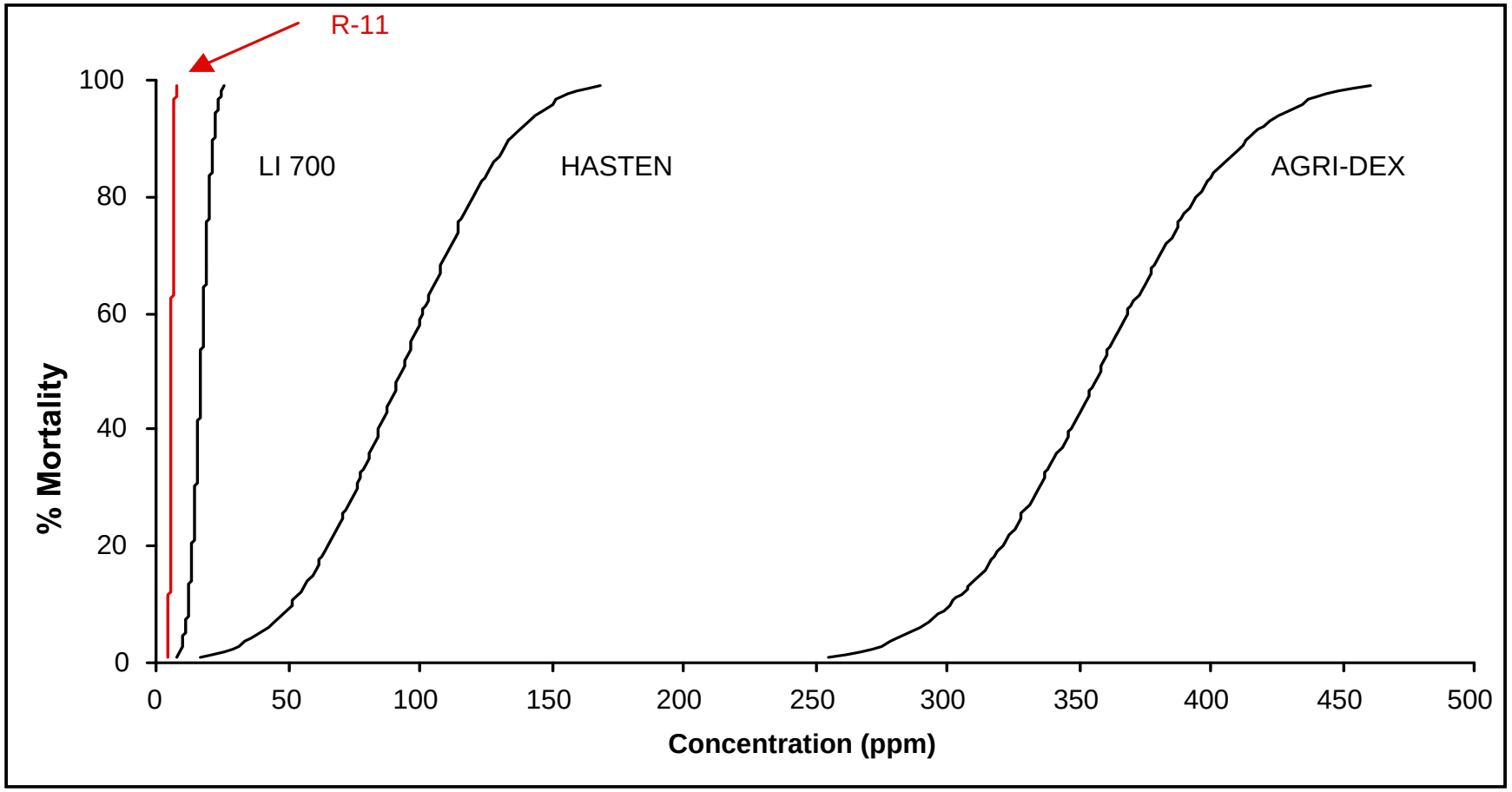



| Name | LC50 96 hour mg/l RAINBOW TROUT |
|---|---|
| Mon 0818 | 2 |
| X77 | 2 |
| R11 | 6 |
| Li700 | 17 |
| Hasten | 74 |
| Agridex | 271 |

NPE's

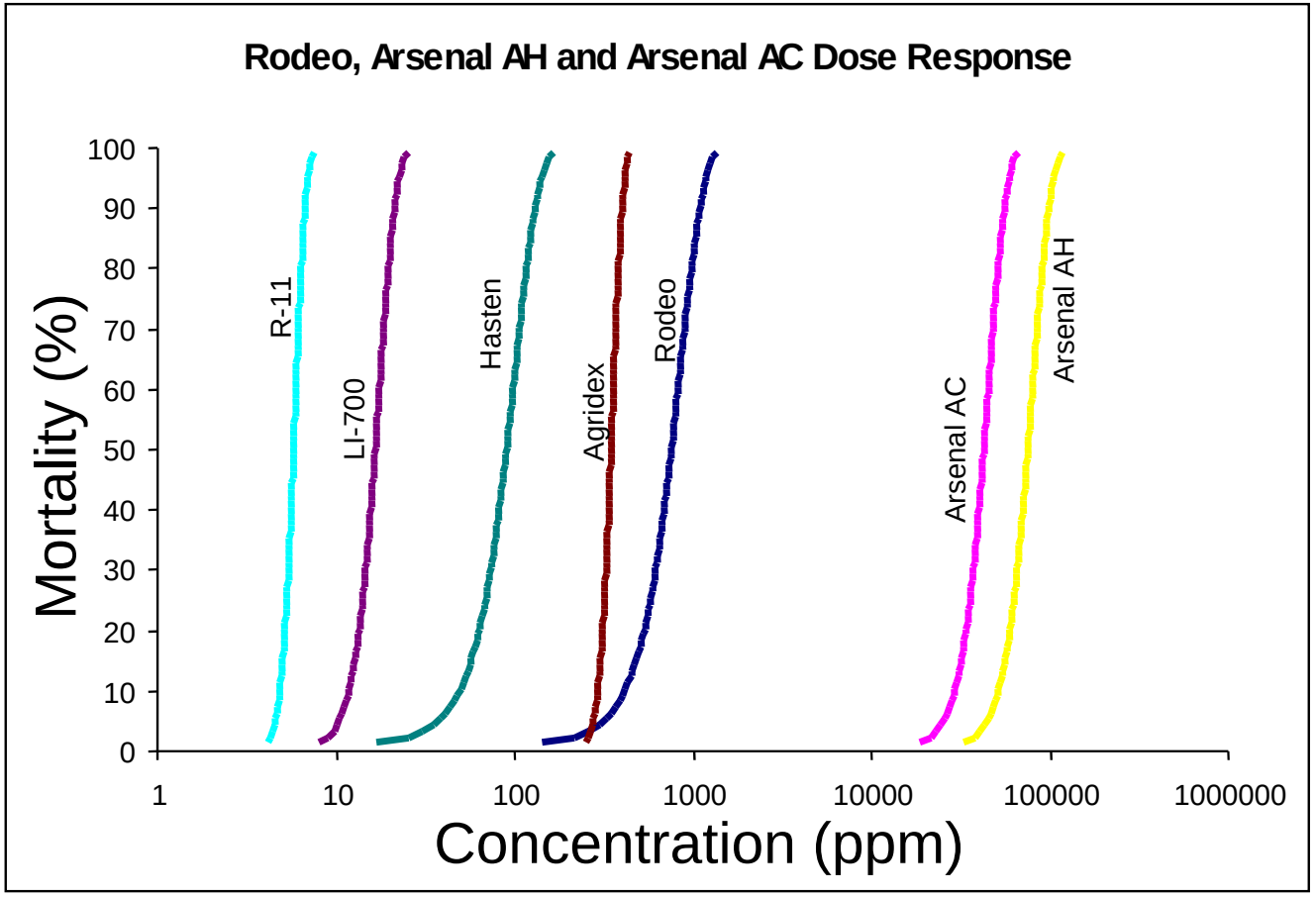
Data from – C Grue, UW, & others

# DOSE RESPONSE CURVES FOR TROUT




Slide courtesy of C Grue, UW

# DOSE RESPONSE CURVES FOR TROUT




Slide courtesy of C Grue, UW (Arsenal = Habitat / imazapyr)

**What about synergy or additive effects - we spray a tank mix, not single ingredients.**

| Name | LC50 96 hour mg/l RAINBOW TROUT |
|---|---|
| Mon 0818 | 2 |
| X77 | 2 |
| R11 | 6 |
| Li700 | 17 |
| Hasten | 74 |
| Agridex | 271 |
| Roundup | 8 |
| Rodeo | 786 |
| Habitat | 77716 |
| Rodeo + R11 | 5 |
| Rodeo + Li700 | 22 |
| Hatitat + Hasten | 113 |
| Habitat + Agridex | 479 |

NPE's

Data from – C Grue, UW, & others

Conclusion: Surfactant – makes the poison!

# Should you use an ‘Aquatic Approved Surfactant’ for all your spraying?

Washington State Department of Agriculture

*Washington State Department of Agriculture*
*Pesticide Management Division*
*Registration and Licensing Services Program*
*PO Box 42560 • Olympia WA 98504-2560*
*Telephone (360) 902-2030 • FAX (360) 902-2093*

**Spray Adjuvants Registered for Use on Aquatic Sites in Washington**
**(Revised November 23, 2016)**

These spray adjuvants are registered for use on aquatic sites in Washington, as of November 23, 2016. Before distributing or using an adjuvant, please verify that it is currently registered in Washington.

Spray adjuvants are listed in alphabetical order. No discrimination or endorsement is intended. The aquatic acute toxicity data are from studies that were submitted by the registrants.

| Product Name / State Registration Number | Registrant | Principal Functioning Agents | Acute Toxicity - Rainbow Trout | Acute Toxicity - Daphnids |
|---|---|---|---|---|
| Agri-Dex / 5905-50094 | Helena Chemical Company | Petroleum oil, polyoxyethylene sorbitan fatty acid ester, sorbitan fatty acid ester | LC50 (96 hour) >1000 mg/l, Practically non-toxic | LC50 (48 hour) >1000 mg/l, Practically non-toxic |
| AgriSolutions Inergy / 1381-13001 | Winfield Solutions | Modified vegetable (seed) oil, polysiloxane polyether copolymer, alkyl phenol ethoxylate | LC50 (96 hour) 37.5 mg/l, Slightly toxic | EC50 (48 hour) 127.27 mg/l, Practically non-toxic |
| Atmos / 1381-13006 | Winfield Solutions | Modified vegetable (seed) oil, saccharides, sorbitan fatty acid ester | LC50 (96 hour) 21.71 mg/L, Slightly toxic | EC50 (48 hour) 28.63 mg/L, Slightly toxic |
| Avor / 9349-16011 | Precision Laboratories Inc | Polyoxyethylene sorbitan fatty acid ester, mono- and diglycerides of C8-C18 fatty acids | LC50 (96 hour) >100 mg/l, Practically non-toxic | EC50 (48 hour) 121 mg/l, Practically non-toxic |
| Bond / 34704-04003 | Loveland Products | Synthetic latex, alcohol ethoxylate | LC50 (96 hour) 190 mg/l, Practically non-toxic | LC50 (48 hour) 614 mg/l, Practically non-toxic |

**6 page list of approved surfactants**

# WSDA list of approved aquatic surfactants

| Product Name | Acute Toxicity - Rainbow Trout | Acute Toxicity - Daphnids |
|---|---|---|
| Agri-Dex | 1000 | 1000 |
| Chempro | 1000 | 100 |
| Fast Break | 1000 | 100 |
| Cut-Rate | 782 | 223 |
| Fraction | 782 | 225 |
| Spray-Rite | 782 | 223 |
| Sinker | 750 | 1000 |
| Class Act NG | 447 | 377 |
| Bronc Plus Dry | 382 | 223 |
| Bronc Plus Dry-EDT | 382 | 223 |
| One-AP XL | 382 | 223 |
| Hasten-EA | 375 | 84 |
| Trail Blazer | 200 | 29 |
| Tronic | 200 | 28 |
| Bond | 190 | 614 |
| LI 700 | 130 | 190 |
| Avor | 100 | 121 |
| Brandt Magnify | 100 | 7 |
| Breeze | 100 | 100 |
| Bronc Max | 100 | 100 |
| Droplex | 100 | 100 |
| InterLock | 100 | 100 |
| Level 7 | 100 | 100 |
| Pro AMS Plus | 100 | 7 |
| Tactic | 100 | 310 |

| Product Name | Acute Toxicity - Rainbow Trout | Acute Toxicity - Daphnids |
|---|---|---|
| Competitor | 95 | 100 |
| NIS-EA | 82 | 218 |
| Rainier-EA | 82 | 218 |
| Cide-Kick II M | 45 | 6 |
| Cygnet Plus | 45 | 6 |
| Superb HC | 45 | 100 |
| Syl-Tac-EA | 45 | 137 |
| Renegade-EA | 42 | 25 |
| AgriSolutions Inergy | 37 | 127 |
| Turbulence | 37 | 127 |
| Winfield Solutions Inergy | 37 | 127 |
| MSO Concentrate | 35 | 18 |
| MSO Concentrate with Leci-Tech | 35 | 17 |
| Forge | 34 | 14 |
| Sphere 7 | 34 | 14 |
| Dyne-Amic | 23 | 60 |
| Destiny HC | 22 | 28 |
| Atmos | 21 | 28 |
| Spreader 90 | 18 | 9 |
| Liberate | 17 | 9 |
| Kinetic | 14 | 61 |
| Denali-EA | 11 | 9 |

# Alkylphenol ethoxylate vs. nonyl phenol ethoxylate

| | AE | NPE or POEA |
|---|---|---|
| Bio-degradability | Readily | Not readily |
| Concern about acute toxicity to fish | No | Yes |
| Breakdown products more toxic than parent compounds | No | Yes |
| Predicted chronic no effect concentration | 110 Ug/L | 0.33 Ug/L |
| Endocrine disruptor | No | Yes |

Some companies have gone NPE-free with their surfactants