Adjuvants –
The Rest of the Story

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Questions:

1. Are adjuvants regulated?
2. How many adjuvant classifications?
3. How many adjuvant modes of action?
4. Is it legal to apply herbicides at reduced rates?
5. Is it legal to apply herbicides at reduced gpa?
6. Does high water volume give good coverage?
7. Is good coverage necessary for optimum activity?
8. Does weed control increase as gpa increases?
9. Should adjuvants be applied at % vol/vol basis or on an area basis (pt/A)?
Questions:

10. What are basic pH blend adjuvants?
11. What is the difference between COC (petroleum oil) adjuvants and MSO (methylated seed oil) adjuvants?
12. Which salts in water antagonize herbicides?
13. Which herbicides are antagonized by salts?
14. What is the mode of action of AMS (ammonium sulfate)?
15. Do water conditioning/AMS replacement adjuvants work as well with glyphosate as AMS?
Questions:

1. Are adjuvants regulated?
Non-regulation of Adjuvants

Active Ingred. / Inerts / Formulants
- Not regulated
- Not standardized
- Those listed (claimed)
- Those not listed (proprietary)

Concentration – What is 90% a.i.???
Questions:

2. How many adjuvant classifications?
Adjuvant Classification

Components that increase efficacy

1. Surfactants
2. Oils
3. Fertilizer
Questions:

3. How many adjuvant modes of action?
Adjuvant Mode of Action

Surfactants / Oils / Fertilizer

1. Retain (Retention)
2. Deposit (Deposition)
3. Absorption
4. Translocation – to site of action

You Can Control
Adjuvant mode of action

1. Retention – NIS
2. Deposition – NIS and oils
3. Absorption – Oils and Fertilizer
4. Translocation – N fertilizer = Water quality
Questions:

4. Is it legal to apply herbicides at reduced rates?

NO!

EPA is concerned with impact of pesticides on the environment. A lower pesticide ai used would result in less impact. There is a provision in FIFRA that allows for legal use is reduced rates.

However – the manufacturer is removed from product liability. The user assumes the liability.
Questions:

6. Does high water volume give good coverage?
7. Is good coverage necessary for optimum activity?
8. Does weed control increase as gpa increases?
Spray Deposit Characteristics That Influence Herbicide Efficacy

“The Pile Effect”
Spray deposit remains partially moist

Herbicide and adjuvant evenly distributed

Herbicide remains dissolved in spray deposit

High herbicide absorption
Glyphosate absorption was greater with adjuvants that left a pile deposit.
High herbicide concentration vs. high plant coverage?

Which is better?

Glyphosate was more phytotoxic when applied in one concentrated drop (pile) than nine dilute drops of equal size.
Spray Volume: Quackgrass

Roundup UltraMAX®

LSD (0.05) = 10

% control

6 oz/A  3 oz/A  1.5 oz/A

5 gpa  10 gpa  20 gpa
Spray Volume: Roundup Ultra

2001 Fargo

LSD (0.05) = 11

% control

6 oz/A
3 oz/A
1.5 oz/A

2.5 gpa  5 gpa  10 gpa  20 gpa
Spray Volume: What we know

Many herbicides can be effectively applied in low spray volumes (2.5 to 5 gpa)

• Glyphosate
• Pursuit
• Raptor
• Assert
• Accent
• Everest
• Aim

• Select
• Poast
• Achieve
• Assure II
• Puma
• 2,4-D amine
Conundrum! –
How contain small droplets without sacrificing efficacy?
XR TeeJet
XR 11002
at 40 psi

Turbo TeeJet
TT 11002
at 20 psi

Al TeeJet
Al 11002
at 60 psi

TurboDrop XL
TDXL-110-02
at 60 psi
Herbicide efficacy at 5 gpa

Averaged over 3 grass species

% control

Roundup Ultra  | Assure II  | Pursuit  | Poast

XR 11001     | TD 11001  | LM 11002 | XR 11001

TT 11001     | TT 11002  | NS        | NS

NS
Glyphosate Summary

Glyphosate efficacy increased with AMS regardless of water hardness.

AMS at 0.5% w/v (4 lb / 100 gal) was generally sufficient to maximize glyphosate efficacy while AMS at 2% w/v occasionally was antagonistic.

Glyphosate rate could be reduced by half when applied in 2.5 or 5 gpa compared to 10 or 20 gpa.

Efficacy was generally similar for all glyphosate formulations that do not require additional surfactant.
Questions:

9. Should oil adjuvants be applied at:
   % vol/vol basis = 1% v/v or
   area basis (pt/A)?

   Which application type may not contain sufficient oil
   adjuvant concentration?
   % v/v or
   area (pt/A)
Question:
Should adjuvants be applied at % v/v or by area?
Poast and Select = 1 qt/A of oil adjuvant
Assure II, Fusidale DX, and Fusion = 1% v/v oil

At 17 gpa - 1% v/v PO = 0.17 gal = 1.4 pt/A
At 8.5 gpa - 1% v/v PO = 0.085 gal = 0.68 pt/A

Apply PO on area basis at 1 qt/A
Apply MSO on area basis at >1.2 pt/A
Spray Volume: What We Know

Efficacy generally increases as spray volume increases if adjuvant rate is \( \% \text{ v/v} \)
- oils and surfactants
- exception: basic blend (Quad 7)

Efficacy at low volume \( \geq \) high volume if adjuvants applied on an area basis
- oils and surfactants

Some herbicides are more effective in low volumes independent of adjuvant rate
- glyphosate and Raptor
Questions:

10. What are basic pH blend adjuvants?
\[ \text{pH of spray solution} = \text{solubility} \]

<table>
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<th></th>
<th>pKa</th>
<th>5</th>
<th>7</th>
<th>9</th>
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<td>18</td>
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Questions:

11. What is the difference between COC (petroleum oil) adjuvants and MSO (methylated seed oil) adjuvants?
### Dissolve green foxtail leaf wax

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<th>Adjuvant</th>
<th>0</th>
<th>5</th>
<th>10</th>
<th>20</th>
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<td>0</td>
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<td>3</td>
<td>5</td>
<td>7</td>
<td>9</td>
<td>10</td>
<td>10</td>
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Manthey, F.A. and J.D. Nalewaja

Evaluation scale: 0 = no solubility, 10 = total wax solubility
Questions:

12. Which salts in water antagonize herbicides?
What makes water hard?

Antagonistic minerals to herbicides:
- Calcium – Ca++
- Magnesium – Mg++
- Iron – Fe+++ (Hard water ions)
- Sodium – Na+ = Soft water
Questions:

13. Which herbicides are antagonized by salts in your spray water?
Questions:

Many herbicides are formulated as salts –
2,4-D – dma (dimethyl amine)
Curtail – mea (monethanolamine)
Dicamba – dma, dga, Na, K
Basagran – Na
Pursuit, Raptor, Liberty – NH4
Tordon – K
Milestone – triisopropylNH4
Questions:

What does “weak acid” mean?

Answer:

Herbicides dissociate from their salt in acid pH = <7

Herbicides can ionize in acid pH (lose or gain (+) or (−) charge)
Adjuvant quiz

Which herbicides are antagonized by salts in spray water?

A. 2,4-D, MCPA, Dicamba, Curtail
B. Glyphosate, Liberty (glufoninate)
C. Poast, Select, Fusilade, Assure II
D. Basagran, Reflex
## Adjuvant Rule #2

### Kochia control from herbicide formulations

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<tr>
<th>Herbicide</th>
<th>None</th>
<th>+CaCl₂</th>
<th>+CaCl₂+AMS</th>
<th>% control</th>
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<td>2,4-D - ester</td>
<td>45</td>
<td>0</td>
<td>45</td>
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<td>2,4-D - amine</td>
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<td>0</td>
<td>38</td>
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<td>55</td>
<td>7</td>
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<td>69</td>
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<tr>
<td>Roundup - ipa</td>
<td>94</td>
<td>4</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>
Questions:

14. What is the mode of action of AMS (ammonium sulfate)?
Glyphosate form in spray residue

\[
\begin{align*}
\text{Gly-IPA} & \xrightarrow{\text{Ca}^{++}} \text{Gly-Ca} \downarrow \\
\text{Gly-IPA} & \xrightarrow{\text{Na}^+} \text{Gly-NH}_4 \downarrow \\
\text{Gly-IPA} & \xrightarrow{\text{AMS} + \text{Ca}^{++}} \text{Gly-NH}_4 + \text{CaSO}_4 \downarrow \\
\end{align*}
\]

Glyt solubility: ipa + Na = 50%, NH$_4$ = 30%, Ca = 3%
Adjuvant Rule #2

Wheat control from Roundup

<table>
<thead>
<tr>
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<th>Roundup</th>
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<tr>
<td></td>
<td>Alone</td>
</tr>
<tr>
<td>Roundup alone +</td>
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<tr>
<td>Ammonium nitrate</td>
<td>62</td>
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<tr>
<td>Ammonium sulfate</td>
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</tbody>
</table>

Only use ammonium sulfate
Questions:

15. Do water conditioning/AMS replacement adjuvants work as well with glyphosate as AMS?
Alliance (Agriliance)
- AMS + water conditioning, coupling, and antifoam agents

Choice (Loveland)
- AMS and salts of organic acids + phosphate ester

Bronc Max (Wilbur-Ellis)
- AMS / ammonium alyl aryl sulfonates, polycarboxylic acid

Quest (Helena)
- hydroxycarboxylic acids, phosphoric acids, AMS, and polyacrylic acids

Citron (FarmDirect)
- 91% Citric acid, anhydrous

N-Tense (West Central/Van Diest)
- AMADS = >50% monocarbamidine dihydrogen sulfate or aminomethanamide dihydrogen tetraoxosulfate

Herbolyte (ProfitPro LLC)
- Hydroxytricarballylic acid >2%
- MSDS – ingredients not hazardous – none reported
# Materials and Methods

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<th>Water Cond.</th>
<th>Rate</th>
<th>Rate of AMS</th>
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<tr>
<td></td>
<td>½ label rate</td>
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<tr>
<td>Alliance</td>
<td>1.25% v/v = 4.25 lb/100</td>
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<tr>
<td>Bronc Max</td>
<td>0.5% v/v = ~ 8.5 lb/100</td>
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<tr>
<td>Choice</td>
<td>0.5% v/v = ?</td>
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<tr>
<td>Quest</td>
<td>0.5% v/v = ?</td>
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<tr>
<td>Citron</td>
<td>2.2 lb 100/gal = 0</td>
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<td>N-Tense</td>
<td>0.5% v/v = 0</td>
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<tr>
<td>Herbolyte</td>
<td>1% v/v = 0</td>
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<tr>
<td></td>
<td>Grass</td>
<td></td>
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<td>APSA 80</td>
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<td>AMS</td>
<td>--</td>
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<td>R-11 + AMS</td>
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<td>93</td>
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<tr>
<td>Class Act (NG)</td>
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<td>94</td>
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<td>Surfate</td>
<td>89</td>
<td>93</td>
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<td>Product Description</td>
<td>AMS (lb/100)</td>
<td>Grass</td>
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<td>-------------------------------------------</td>
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<td>Glyphosate +</td>
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<tr>
<td>R-11 + AMS</td>
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<td>93</td>
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<td>Class Act (NG) @ 2.5 %</td>
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<td>94</td>
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<td>Bronc Max + R-11</td>
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<td>Surfate @ 1%</td>
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<td>AMS</td>
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<td>Quest (0.5%) + Preference ?</td>
<td>87</td>
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<td>Choice (0.5%) + Liberate ?</td>
<td>81</td>
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<td>Citron (2.2 lb)+Preference 0</td>
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<td>84</td>
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<tr>
<td>N-Tense @ 0.5%</td>
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<td>90</td>
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<tr>
<td>Herbolyte @ 0.5%</td>
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<td>79</td>
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Data averaged over 68 means (272 observations).
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<th>Na</th>
<th>Bnvl</th>
<th>Rap</th>
<th>SF</th>
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<td>8</td>
<td>45</td>
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