ADJUVANTS 101

Oregon Department of Agriculture
2019
Warren Gawlik – Wilbur-Ellis
My Background

- Agronomist and Sales Representative with Wilbur-Ellis
- B.S in Horticulture w/ a specific in Turfgrass Science – Oregon State University
- Managed golf courses for 13 years in Oregon, Washington and California
Adjuvant

• Definition

– An adjuvant is a material added to a mixture to aid or modify the action of an agrichemical, or alter the physical characteristics of the mixture.
Adjuvant

• What does this mean?
  – Adjuvants are products that can be added to a spray solution to improve performance.
Adjuvant is a Broad Term!

- Spreaders
- Spreaders + AMS
- Spreader-Activators
- Penetrator-Activator
- Spreader-Stickers
- Sticker-Extenders
- Silicones
- Crop Oil Concentrates
- High Surfactant Oil Concentrate
- Modified Seed Oils
- Modified Seed Oil + Organosilicone Blend
- Modified Seed Oil + Nitrogen
- Acidifier/Buffers
- Alkaline/Buffers
- Water Conditioners
- Deposition and Drift Management
- Etc!
State Adjuvant Registration

• In some states adjuvants are required to be registered; WA, CA, ID, UT and WY in the western states.

• In order to be registered these adjuvants must comply with the definitions established by ASTM.
Voluntary Adjuvant Certification Program

- Only organization representing adjuvants to the EPA. (EPA sets some of the requirements needed to be CPDA certified, along with U.S. Dept. of Transportation, U.S. OSHA)
- Certification program that sets viable minimum standards
  - Toxicology on all products required
  - Must meet ASTM definitions
  - Standards for active ingredients.
  - Certified formulation facilities
CPDA

CPDA Certified Products

- Started Certifying Products in 2001
- In excess of 2000 adjuvants in marketplace.
- Currently 102 adjuvants have received CPDA Certification
- Wilbur-Ellis – 11 products CPDA Certified
- Supporting companies are Wilbur-Ellis, Winfield Solutions, Helena, Loveland/CPS, United Suppliers, Intec and others.
Adjuvant Selection Factors

- Consider all factors and your experiences to make the proper adjuvant choice.

- Contact, translaminar, systemic
- Water Quality
- Target or Pest
- Target Leaf Structure
- Crop Leaf Structure
- Off-Target
- Drift
- Social/Political Concerns
- Equipment
- Weather
- Hot & Dry
- Cool & Humid
- Ground, aerial
- air blast, chemigation
- backpack
- Grass, Broadleaf
- Water hardness, pH & solubility
It all Starts with Proper Tank Mixing

W.A.L.E.S. & D.A.L.E.S.
Proper Tank Mixing

• Most mixing problems start when
  – the water temperature is **COLD**
  – incompatible products
  – when *adding spray material chemistry, fertilizers and additives in an incorrect order.*
Proper Tank Mixing

- ALWAYS WEAR THE PROPER PPE WHEN MIXING AND LOADING......
Proper Tank Mixing

• Water is always added to the spray tank first, usually ½ to ¾ of the total volume needed.

• If using water conditioners that lower the spray water pH (alkaline hydrolysis) or block against cation interference (hard water) they are ALWAYS added to the spray water before any spray materials.
Proper Tank Mixing

• Liquid fertilizers don’t replace the need for surfactants.
• They increase uptake
• They do not reduce surface tension or increase spreading.
Proper Tank Mixing

The proper sequence for adding spray materials to a spray tank can be easily remembered with the following phrases.

W.A.L.E.S. or D.A.L.E.S.
Proper Tank Mixing

• **W** refers to dry formulations wettable powders (W.P.) and water dispersible granules (W.D.G.).
• W.P. and W.D.G. are used interchangeably
Proper Tank Mixing

• **D** refers to dry flowables (D.F.). Some D.F. products are packaged in water soluble packets.

• These formulations should be added first to a tank that is ½ to ¾ full of water.
Proper Tank Mixing

- If liquids are added first, *the oils or emulsifiers they contain can coat dry products and prevent contact with the water.*
Proper Tank Mixing

- **A** means agitate to fully disperse the chemicals.
- Create a rolling surface action.
- Begin agitation before adding any chemicals.
- Excessive agitation can create foam and you may have to add some FTF DEFOAMER® to the spray tank.
Proper Tank Mixing

- L means liquids flowables.
Proper Tank Mixing

• **E** means emulsifiable concentrates (E.C.) and aqueous solutions (A.S.).
• These 2 formulations should be added to the spray tank after all dry and liquid flowables have been added.
Proper Tank Mixing

• **S** means surfactants and stickers
• These 2 products should be added to the spray tank after all other products are in the spray tank.
• Always add your spreader and stickers to the spray tank last unless you are using a combination product that also is a water conditioner.
INCREASING THE EFFECTIVENESS OF YOUR APPLICATIONS BY USING ADJUVANTS

• GET THE PRODUCT TO THE TARGET

• MAKE SURE THE PRODUCT IS STABLE IN THE TRANSPORT OF GETTING TO THE TARGET

• ONCE THE PRODUCT GETS TO THE TARGET, HOW DOES IT INTERFACE WITH THAT TARGET

DRIFT RETARDANT / DEPOSITION AID
WATER CONDITIONING TOOLS
SURFACTANTS / SPREADERS / OILS
Managing Spray Drift
Why Does Drift Matter?

- Reduced efficacy
- Wasted chemicals
- Off-target damage
- Proximity to high value crops

- Environmental impact
  - Water and Air Quality
- Public pesticide concerns!
  (Negative Perceptions)
- Result-higher costs-$$$

(Negative Perceptions)
Factors Affecting Drift

- **Spray Characteristics**
  - Chemical
  - Formulation
  - Droplet size
  - Evaporation

- **Equipment & Application**
  - Nozzle Type
  - Nozzle Size
  - Nozzle Pressure
  - Boom Height

- **Weather**
  - Wind Speed (direction and velocity)
  - Temperature and humidity
  - Air stability/inversions
  - Topography
Strategies to Reduce Drift

• Select nozzle to increase droplet size
• Increase flow rates - higher GPA
• Use lower pressures
• Use lower spray (boom) heights
• Avoid adverse weather conditions
• Consider using buffer zones
• Consider using new technologies:
  – Drift reduction nozzles
  – Shields, hoods
  – Drift reduction additives (DRT’s)
What Does A Good Drift Reduction Technology Product Do?

• The product must **INCREASE** the VMD (Volume Median Diameter) of the spray droplet.

• The product must **REDUCE** the % of fine spray droplets (driftable) <105 micron.
  —These droplets can only be seen and measured by a laser.

• *The most important thing a DRT product does is the reduction of the % of fine spray droplets (driftable) <105 micron.*
<table>
<thead>
<tr>
<th>Item</th>
<th>Micron Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pencil lead</td>
<td>2000 μm</td>
</tr>
<tr>
<td>Paper clip</td>
<td>850 μm</td>
</tr>
<tr>
<td>Staple</td>
<td>420 μm</td>
</tr>
<tr>
<td>Toothbrush bristle</td>
<td>300 μm</td>
</tr>
<tr>
<td>Sewing thread</td>
<td>150 μm</td>
</tr>
<tr>
<td>Human hair</td>
<td>100 μm</td>
</tr>
</tbody>
</table>
## The Effect of Droplet Size on Drift Potential

<table>
<thead>
<tr>
<th>Diameter, microns</th>
<th>Time to fall 10 feet in still air</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (Fog)</td>
<td>28 hours</td>
</tr>
<tr>
<td>10 (Fog)</td>
<td>17 minutes</td>
</tr>
<tr>
<td>100 (Mist)</td>
<td>11 seconds</td>
</tr>
<tr>
<td>200 (Fine Spray)</td>
<td>4 seconds</td>
</tr>
<tr>
<td>400 (Coarse Spray)</td>
<td>2 seconds</td>
</tr>
<tr>
<td>1,000 (Coarse Spray)</td>
<td>1 second</td>
</tr>
</tbody>
</table>
ACCUSTRIKE Chemistry

Example anatomy of a solution exiting a nozzle:

Figure adapted from “A comparison of initial spray characteristics produced by agricultural nozzles.”
https://doi.org/10.1016/j.cropro.2013.06.017
Nozzle Output: High Speed Photography

Nozzle: XR8008

Water

DILIGENCE-EA:
1 fl oz/A
(2 GPA)

1 3/8” Downstream Center of Nozzle
Alfalfa Application

With CROSSHAIR

Without CROSSHAIR

12 GPA  B. Wehri – Dillon, MT - 2011
Improved Herbicide Efficacy

- RoundUp Original MAX: 62.6%
- RT 3: 66.4%
- Touchdown Total: 66.8%
- Credit Xtra Mixed Salt: 64.8%

Without CROSSHAIR: 77%
With CROSSHAIR: 79.8%

NDSU 2007
WATER QUALITY
INCREASING THE **EFFECTIVENESS** OF YOUR APPLICATIONS BY USING ADJUVANTS

- GET THE PRODUCT TO THE TARGET
- **MAKE SURE THE PRODUCT IS STABLE IN THE TRANSPORT OF GETTING TO THE TARGET**
- ONCE THE PRODUCT GETS TO THE TARGET, HOW DOES IT INTERFACE WITH THAT TARGET

**DRIFT RETARDANT / DEPOSITION AID**

**WATER CONDITIONING TOOLS**

**SURFACTANTS / SPREADERS / OILS**
Water Conditioning Agent (ASTM Definition)

- A material that reduces or eliminates the antagonism between a pesticide formulation and ions present in the water that is utilized in a pesticide application.
What Does This Mean?

- Water conditioning agents are chemistries that treat hard water and/or adjust pH.
TRANSPORTATION TO THE TARGET

• Water Quality
  • Mineral Antagonism
  • pH
Mineral Antagonism

Water hardness (dissolved cations) levels interfere directly with a range of spray materials.

- Calcium [Ca++]
- Magnesium [Mg++]
- Iron [Fe++]
- Sodium [Na+]
Mineral Antagonism
How It Occurs

Glyphosate

Ca
Mg
Fe
Na
Ca
Mg
Fe
Na
Deactivated Herbicide
Addition of Ammonium Sulfate...Why?

The Sulfate ion “blocks” the mineral cation.

The Ammonium ions attach and “escort” the glyphosate into the plant.
WATER CONDITIONING PRODUCTS

- Mineral antagonism straight liquid AMS
  - Bronc Max
- Mineral antagonism COMBINATION products
  - Brimstone – Acid + Surfactant
  - Cayuse Plus – AMS + Surfactant
## AMS with Herbicides

Kochia control from herbicide formulations

Spray carrier salt

<table>
<thead>
<tr>
<th>Herbicide</th>
<th>None</th>
<th>+CaCl2</th>
<th>+CaCl+AMS</th>
</tr>
</thead>
<tbody>
<tr>
<td>2,4-D ester</td>
<td>45</td>
<td>0</td>
<td>45</td>
</tr>
<tr>
<td>2,4-D amine</td>
<td>38</td>
<td>0</td>
<td>38</td>
</tr>
<tr>
<td>Basagran-Na</td>
<td>55</td>
<td>7</td>
<td>61</td>
</tr>
<tr>
<td>Banvel-dma</td>
<td>67</td>
<td>17</td>
<td>70</td>
</tr>
<tr>
<td>Banvel-Na</td>
<td>34</td>
<td>9</td>
<td>69</td>
</tr>
<tr>
<td>Roundup-ipa</td>
<td>94</td>
<td>4</td>
<td>100</td>
</tr>
</tbody>
</table>

Nalewaja and Zollinger, NDSU
TRANSPORTATION TO THE TARGET

- Water Quality
  - Mineral Antagonism
  - pH
**Acidifier** *(ASTM Definition)*

- A material that can be added to spray mixtures to lower the pH.
**pH Scale**

**pH above 7** is considered **BASIC**

**pH below 7** is considered **ACIDIC**

**pH of 5 - 6.5 is generally the optimum for most spray solutions**
**Washington State pH Map 11/8/07**

**pH Levels**
- 5.5 - 5.99 – Yellow
- 6.0 - 6.49 – Red
- 6.50 - 6.99 – Turquoise
- 7.0 - 7.49 – Blue
- 7.5 - 7.99 – Green
- 8.0 - 8.49 – Purple
- 8.5 - 8.99 – Black
- 9.0+ – White
Spray Material Half-Life Chart
2015 | Turf & Ornamental | Vegetative Management

Adjusting the pH of the spray solution can reduce spray material decomposition and make the spray more effective. The following chart shows the Spray Material Half-Life or the time it takes for half the amount of chemical to be decomposed (made inactive at various pH levels).

<table>
<thead>
<tr>
<th>Spray Material Product</th>
<th>Buffering</th>
<th>Optimum pH</th>
<th>Half-Life at pH indicated (50% decomposition)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>9.0 Basic</td>
</tr>
<tr>
<td>KELTHANE®</td>
<td>X</td>
<td>5.5</td>
<td>1 hour</td>
</tr>
<tr>
<td>KOCIDE®</td>
<td></td>
<td>7.0</td>
<td></td>
</tr>
<tr>
<td>KERB®</td>
<td></td>
<td>6.5</td>
<td></td>
</tr>
<tr>
<td>MALATHION</td>
<td>X</td>
<td>5.0</td>
<td>5 hours</td>
</tr>
<tr>
<td>MANAGE®</td>
<td></td>
<td>7.0</td>
<td></td>
</tr>
<tr>
<td>MANEB® (Updated 5-03)</td>
<td>X</td>
<td>5.5</td>
<td>4 hours</td>
</tr>
</tbody>
</table>
SPRAY WATER ALKALINITY AGENT

- Raises and buffers pH of spray water
- Increases solubility and effectiveness of sulfonylurea herbicides
- Helps dissolve all DF formulations including Krovar and Diuron
- May aid in spray equipment clean out
- Use in a slurry mix prior to adding to tank
The clear solution to *Improved Performance*

**Oust® Extra**

**Oust® Extra**
with **CLIMB®** added
Measuring pH of Water

Assembled in Devine, TX
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- DRIFT RETARDANT / DEPOSITION AID
- WATER CONDITIONING TOOLS
- SURFACTANTS / SPREADERS / OILS
**SURFACTANTS**

Surfactant is a word derived from the term “surface-active agent.” Surfactants are adjuvants that reduce the surface tension of water or increases its wettability. They aid the emulsifying, spreading, wetting or other surface-modifying properties of liquids.

**ASTM Definition**
INTERFACE WITH TARGET

Leaf Cross Section

- stoma (opening for gas exchange)
- guard cells
- upper epidermis
- palisade mesophyll
- spongy mesophyll
- vein (vascular bundle)
- lower epidermis
- waxy cuticle

carbon dioxide → oxygen
FOLIAR ABSORPTION

- Systemic or herbicide pesticides must be absorbed into plants in order to be effective
- Pesticide absorption can occur through leaves, roots or both
- The primary barrier to foliar absorption of ANY pesticide is the CUTICLE
- The cuticle is a complex matrix of materials that vary in water solubility and include waxes, cutin and pectin
Spray Droplet Without Surfactant

• Surface tension of water is 72 dynes/cm
  – Droplets sit on leaf hairs or leaf surface
  – Very little leaf contact
  – Result equals reduced spray activity
Surfactant reduces surface tension to 20-40 dynes/cm.

- Droplets spread over leaf, penetrate hairy surface
- Increased leaf contact
- Increased spray activity
Proper Use of Wetting Agent

- Drastically increases plant surface area covered by spray.
- Reduces spray run-off from treated surfaces.
- Reduces spray droplet rebound

Time elapsed photography showing droplet compressing and rebounding from plant leaf. **Wetting agents reduce spray droplet surface tension and energy needed for this rebound to occur.**

Drops spread over surface rather bounce of surfaces.
Classes of Surfactants

- Non-Ionic Surfactant (NIS)
- Silicone-Based Surfactants
- Crop Oil Concentrates (COC)
- Methylated/Ethylated Seed Oils (MSO, ESO)
NON-IONIC SURFACTANTS (NIS)
NON-IONIC SURFACTANTS (NIS) are composed of alcohols and fatty acids, have no electrical charge, and are compatible with many herbicides.

- Advantages of non-ionic surfactants (NIS):
  - Reduced surface tension of the spray solution and increased coverage and wetting ability of the applied spray
  - Excellent compatibility many herbicides
  - Less costly than other types of surfactants
  - Stable in cold water
Surface tension and pesticide uptake vs surfactant rate of a typical NIS
NIS SURFACTANT Comparison of 90% Active Products
CPDA helps in descriptions

- **NIS 90/10**
  - 10% water
  - 40% Solvent Glycols
  - 50% TRUE Surfactant

- **R-11**
  - 10% water
  - 10% Solvent Glycols
  - 80% TRUE Surfactant

- **RAINIER-EA™**
  - 10% water
  - 2% Solvent Glycols
  - 88% TRUE Surfactant
OIL BASED SPRAY ADJUVANTS

VEGETABLE OILS, PETROLEUM BASED OILS, CROP OIL CONCENTRATES, MODIFIED SEED OILS, OIL BLENDS
PETROLEUM BASED OILS

Emulsifiable petroleum oil-based products

- DORMANT, SUMMER SPRAY OILS AND BASAL OILS- 415 SUPERIOR SPRAY OIL, 440 SUPERIOR SPRAY OIL, 470 SUPREME OIL, HORT OIL 98-2, W.E.B. OIL
  - Wil-Gro Hort Oil 98-2 — registered in ID/MT/OR/WA/WY and has organic registration through WSDA.
- CROP OIL CONCENTRATE (COC) – An emulsifiable petroleum oil-based product containing 15-20% w/w surfactant and a minimum of 80% w/w phytobland oil. MOR-ACT ADJUVANT, MOR-ACT CROP OIL CONCENTRATE, R.O.C.
VEGETABLE OILS

Oil extracted from seeds; typically those of corn, cotton, peanut, sunflower, canola or soybean.

- MODIFIED SEED OILS- fatty acids from the seed oils reacted with an alcohol to form esters. This chemical modification results in either a methylated or ethylated seed oil. **HASTEN EA** (ethylated), **SUPER SPREAD MSO** (methylated).

- OIL BLENDS – Typically blends with nitrogen or silicone adjuvants. **RENEGADE EA, SYL-TAC EA**

- HIGH SURFACTANT OIL CONCENTRATES – Contain 40-60% emulsifiers with MSO oil. **GLACIER EA**
Ethylated oils have less phyto' potential than other oils, are more biologically active (Canola is better than Soybean due to more fatty acid content and it is easier to process and remove impurities). Ethylated Oils have a translaminar effect with some actives.

MSO products tend to dissolve cuticle wax and work well with pubescent leaf surfaces. ESO’s have less solvency so they do not tend to dissolve wax (they utilize the lipophilic pathway) which can make them safer to the leaf surface. The COC products fall somewhere in between these two.

Petroleum and seed oil based products are dependent upon good spray coverage for optimum results since they are not as efficient spreaders as NIS and silicone based products.
Silicone Surfactants

- **SILICONE-BASED SURFACTANTS**, also known as organosilicones have superior spreading ability. Advantages of organosilicone-based spray adjuvants include:
  - Low application use rates of 4 to 6 ounces per 100 gallons of water
  - Reduced spray droplet “bounce” from foliage
  - Enhanced coverage of low spray application volumes
  - Increased rate and amount of herbicide solution absorbed by plants

Some disadvantages of silicone-based adjuvants include:
- Increased rate of spray droplet evaporation
- Eye exposure hazards
- High foaming potential
- Poor stability in low pH spray mixes
- Spray solution droplet coalescence and possible runoff from leaf surface
So what adjuvant should I use?

• **Consult the label** - Herbicide manufacturers conduct extensive research to determine how to achieve the most consistent performance with their products, so be sure to follow label recommendations. Some herbicides such as Milestone and Transline® specialty herbicides, have adjuvants in the formulated product.
  
  – For example, the label for Opensight® specialty herbicide states "applications of Opensight **must include** either a crop oil concentrate or a non-ionic surfactant. Apply non-ionic surfactant at 0.25% v/v (1 quart per 100 gallons spray solution) or 0.5% under arid conditions."

• **Contact the Manufacture Rep/Distributor Rep**
What other factors do I need from my adjuvant?

- Aquatically Labeled?
- Reduced Risk?
- NPE Free?
FOUR PILLARS FOR PREMIER PRODUCTS

ECO ADVANTAGE™

FOUR PILLARS FOR PREMIER PRODUCTS

PERFORMANCE

AQUATIC

NPE FREE

SAFETY
All ECO ADVANTAGE products meet or exceed competitors’ performance.

RAINIER-EA™ Compared with Other Nonionic Surfactants in Glyphosate

- RoundUp PowerMax® - Fully Loaded Glyphosate
- Buccaneer® - Partially Loaded Glyphosate
- TouchDown HiTech® - Unloaded Glyphosate
ECO ADVANTAGE products are approved to use in and around bodies of water.

Also Safe to Fish
Improved SAFETY handling means all ECO ADVANTAGE products have:

• Lower eye toxicity
• Reduced PPEs
• Undergone rigorous testing and are registered in every state
ENVIRONMENTAL CONCERNS

What are NPEs?
• NPE= Nonylphenol Ethoxylates
• Effective wetting agent, dispersant and emulsifier

Where are the issues?
• Trace amounts found in water and soil
• European ban
• Restrictions in Canada, Central and South America
• No restrictions in U.S. at this time
ECO ADVANTAGE

8 Products

GLACIER-EA™

HASTEN-EA®

RENEGADE-EA®

SYL-TAC-EA®

DENALI-EA™

RAINIER-EA®

ANTERO-EA™

DILIGENCE-EA™
SUMMARY

• Use a deposition aid of some type

• Consider using an adjuvant to increase a.i efficacy

• READ THE LABEL!

• Consult with your agronomist on your specific situation and specific tank mixes for the best adjuvant choice for improve your sprays
Questions?
*Not approved for aquatic use in Washington state.
IN-PLACE®

IN-PLACE Product Info:

• Encapsulates the active ingredient in larger than 105 microns size particles

• Rate depends on the formulation of pesticide that is used in the tank

• 4 : 2 : 1. 4 ounces per pint of EC/AC; 2 ounces per pound of DF/WP; 1 ounce per pint of Liquid Flowables
CROSSHAIR®

CROSSHAIR Product Info:
• Always use 4 fluid ounces of CROSSHAIR per acre
• CROSSHAIR must be added LAST in the tank
• Oil base product that attracts the active ingredient and forms droplets larger than 150 microns
MULTI-FUNCTIONAL ADJUVANT

DENALI-EA™

• Non-ionic surfactant – buffer – acidifier
• Principal Functioning Agents – 68.9%
• Surfactant content 60.9%
• Insecticides, Miticides, Herbicides, Fungicides, Aquatic
SYL-TAC-EA®

• Blend of ESO and Silicone Surfactant with 40% Surfactant Content.
• The technology feature of Syl-tac gives it the ability of get an active ingredient to diffuse throughout the leaf even if it isn’t a systemic product.
• Outdoor ornamental sprays vs. foliar herbicide applications use rates: For spray volumes of 30 gpa or less, use 4 fluid ounces per acre and for spray volumes greater than 30 gpa, use at a minimum 0.10% v/v or 12 fluid ounces per 100 gallons.
• Excellent choice for hard to control or noxious weeds, especially late in the season.
**Syl-tac EA’s translaminar effect has the ability to get a pesticide to diffuse throughout the leaf without the active ingredient having to be a systemic product.**

Lambda-cyhalothrin (Scimitar)
• Combination of a MSO EC + adjuvant + UAN nitrogen fertilizer solution with unique coupling, stability and surfactant agents.
• The UAN/Oil blend is required on many pesticide labels for increased efficacy of the active ingredient.
• 2.5% v/v delivers 1 quart (0.25% v/v) of a non-ionic surfactant. That 2.5% v/v rate also has 1% MSO EC (80% actual MSO) as well as 1.25% of UAN solution.
• Often used in late summer with herbicides to control hardened off weeds and getting some nitrogen drag into the plant.