AN INDUSTRY PERSPECTIVE ON ADJUVANT DEVELOPMENT AND TESTING PRACTICES

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Functions of Adjuvants

Wetting/Spreading
Reduces surface tension and allows droplet to spread on leaf surface.

Absorption/Penetration
Ability to penetrate or cross leaf surface layers.

Deposition
Aids droplets in reaching target and remaining there.

Water Quality
Buffer pH or reduce ions that bind and inactivate a.i.

Compatibility
Enhance solubility and interactions with formulation or tank-mix partners.

Drift Reduction
Reduce driftable fines in spray solution by enlarging or increasing weight of droplets.
ADJUVANT EFFECT ON A.I. PERFORMANCE

MATERIAL QUALITY + CONCENTRATION

EFFICIENCY TO TARGET
Speed and efficiency to target: Retention of a.i. vs. degradation

DELIVERY THROUGH EQUIPMENT
Does it clog nozzles, have uniformity, or easily drift, volatilize, etc.?

IN-CAN & TANK MIX
How material reacts to formulation or tank partners, water pH/hardness, temperature, etc.

COMPATIBILITY IN TANK

SPRAYABILITY & DEPOSITION

SPEED TO TARGET SITE VS. ENVIRONMENTAL FATE

SPRAY MIXTURE PERFORMANCE OVER TIME
LIFE CYCLE OF A SPRAY DROPLET

Formulation

Spray Solution

Application/Transport

Impact/Deposit

Droplet Fate

Biological Action
“In-can Formulation”

What is the formulation? How soluble in water, oil, solvents, etc. is it? What are the physical and chemical properties of the active molecule? How compatible with other formulations, fertilizers, pesticides, etc. is it?

Physicochemical properties of molecule; SL, SC, EC, WP, WDG, ME, OD, etc.
How compatible is it with other tank-mix partners? How much agitation is required to keep in homogenous solution? Is pH buffering or water-conditioning required?

Tank-mixed with water and/or other products

Water solubility, agitation requirements, water pH, ion ppm, etc.
“Application”

What nozzle/orifice is required for application? How much water is applied per unit area with product? What is the temperature, humidity, wind speed and direction, etc.?
SPRAYABILITY

Polymer (deposition aid)

Modified oil (deposition aid)

FF 8002

FF 8002
DROPLET PERFORMANCE

“What happens to the droplet?”

Does the spray droplet bounce off surface, roll off, stick, spread, break into particulates and scatter, etc.?

Droplet:surface interface

What happens at impact of droplet on pest or soil surface? Sticks, spreads, bounces, rolls off, etc.
ADJUVANT EFFECT

Marestail/horseweed leaf

TIME ELAPSED: 1 MIN. 30 SEC.
PLANT DEFENSE MECHANISMS - TRICHOMES

Trichomes on common mullein

Trichomes on velvetleaf

MCPA (Na salt) deposits on turkey mullein (*Eremocarpus setigerus*) leaves. Red arrows indicate herbicide droplets that have penetrated through the leaf hairs and reached the epidermal surface. Scale bar = 200 μm.
PLANT DEFENSE MECHANISMS - WAXY CUTICLE

Chenopodium album

SEM image at 350X of leaf surface

SEM image at 3500X showing epicuticular wax

Droplet Fate

Post-spray impact
Penetration, absorption, evaporation, photolysis, etc. Largely determined by architecture of plant, wax layers, pubescence, cuticular lining, surface tension, etc.

“Metabolism or Degradation”
After settling at destination from application, does the active ingredient-containing droplet degrade by hydrolysis, photolysis, or microbes, evaporate, volatilize, absorb or diffuse into plant, adsorb to soil, etc.?
Contact pesticides are directly dependent upon coverage, so spreading is key. Systemics are dependent upon absorption and translocation, thus it is imperative to keep the a.i. in a plant-available form as long as possible for maximum absorption and translocation to the site of action.
CONTACT VS. SYSTEMIC CONTROL

glufosinate on Palmer amaranth

gramicide on johnsongrass
Absorbed and translocated Glyphosate particles

With absorption additive  No absorption additive

EFFECT ON ABSORPTION = ↑ EFFICACY
FIELD TESTING

How do you test for adjuvant efficacy or determine proper use rate?

2 options...

1. Manipulate the pesticide dose/spray mixture.
   OR

2. Manipulate the pest stage of growth/maturity.
Points to keep in mind...

- Determining efficacy of adjuvant, not herbicide
- Weed growth stage and maturity
- Herbicide rate vs. expected weed mortality
- Reduce degree of weed control for comparing adjuvant differences
GROWTH STAGE AFFECTS CONTROL

Control of musk thistle at different growth stages.

<table>
<thead>
<tr>
<th>Herbicide</th>
<th>Rate</th>
<th>Growth stage at treatment</th>
<th>% of control</th>
</tr>
</thead>
<tbody>
<tr>
<td>2,4-D amine</td>
<td>2 qt/A</td>
<td>rosette</td>
<td>96</td>
</tr>
<tr>
<td></td>
<td></td>
<td>bolting</td>
<td>92</td>
</tr>
<tr>
<td></td>
<td></td>
<td>bud</td>
<td>73</td>
</tr>
<tr>
<td></td>
<td></td>
<td>early flower</td>
<td>75</td>
</tr>
</tbody>
</table>

*Wilson et al. NebGuide G92-1109, University of Nebraska, Cooperative Extension.

Control decreases as plant matures.
SCENARIO 1—YOUNG WEEDS, REDUCED HERBICIDE RATE

Pros

- Agrees with labeled weed size at application timing
- Weed physiology optimal for herbicide/adjuvant performance
- Higher surface area : mass ratio = more herbicide absorbed per unit mass of plant
- Promotes herbicide stewardship and lower field dose with aid of adjuvant

Cons

- Reduced loading of herbicide—possibly sublethal or unlabeled dose
- Reduced loading of in-can adjuvant system in herbicide formulation
SCENARIO 2—LARGE MATURE WEEDS, FULL HERBICIDE RATE

**Pros**

- Full loading of herbicide and in-can adjuvant system
- Cuticular wax more developed, stressing adjuvant performance

**Cons**

- Off-label weed size—mimics “rescue” treatment and lack of stewardship
- Weed physiology not conducive or favorable for herbicide/adjuvant performance
- Lower surface area : mass ratio = less herbicide absorbed per unit mass of plant
- Plant may translocate herbicide to sink instead of source
WHICH METHOD IS BEST AND WHY?

SCENARIO 1 – YOUNG WEEDS, REDUCED HERBICIDE RATE

- Test product to fit label spray application recommendations
- Reduces false negative or misleading results
- Doesn’t promote “rescue” or overly late spray applications
- Follows herbicide stewardship and resistance mgt. principles
- May allow for less environmental footprint with herbicide dose if adjuvant increases herbicide efficacy
Notice % control values. If 1X herbicide rate, control would have been almost 100%.

Looking for very small differences across similar formulations!!!
OTHER PRODUCT CHARACTERISTICS TO COMPARE OR CONSIDER

- SIGNAL WORD
- USE RATE
- COST OF INGREDIENTS
- LABEL REQUIREMENTS (I.E. NON-AMMONIACAL)
- SHELF-LIFE/STORAGE STABILITY PROPERTIES
- ALL PESTICIDE FORMULATIONS ARE NOT EQUAL (I.E. LOADED VS. UNLOADED)
THANK YOU!

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