Maximizing Product Performance of Aquatic Herbicides

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Learning Objectives

- Understand the importance of correct weed identification
- Describe the main types of adjuvants available and the proper selection for use with aquatic herbicides
- Be aware of water quality conditions that impact the effectiveness of herbicides
- Understand the influence of how product formulation affects its proper measurement for mixing
Why do herbicides fail?

• Improper weed identification (incorrect pesticide selection)
• Incorrect herbicide dosage
• Improper application timing
• Herbicide does not reach target weed
• Unfavorable environmental conditions
• State of poor herbicide condition
• Selecting the correct adjuvant, if needed
• Herbicide resistance
Why do herbicides fail?

Many of those reasons for failure share a commonality.

You’ve got to know what you’re doing!
Why do herbicides fail?

Many of those reasons for failure share a commonality

You’ve got to read the label!
Why do herbicides fail?

A man’s gotta know his herbicide’s limitations!
Herbicide Limitations

• Species-specific (there is no perfect herbicide for control of all species a manager faces)
• Require a long-term management commitment
• Can.....
  – be slow-acting
  – move off-site
  – injure desirable vegetation
  – be expensive
  – leave a negative public perception
## General Characteristics of Aquatic Herbicides

<table>
<thead>
<tr>
<th>Herbicide</th>
<th>Activity</th>
<th>MOA</th>
</tr>
</thead>
<tbody>
<tr>
<td>2,4-D</td>
<td></td>
<td>Growth regulator</td>
</tr>
<tr>
<td>Triclopyr</td>
<td></td>
<td>ALS enzyme</td>
</tr>
<tr>
<td>Bispyribac</td>
<td>Systemic</td>
<td>Photosynthesis (pigment inhibitor)</td>
</tr>
<tr>
<td>Imazamox</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Imazapyr</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Penoxsulam</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Glyphosate</td>
<td></td>
<td>Photosynthesis/enzyme</td>
</tr>
<tr>
<td>Topramezone</td>
<td></td>
<td>Photosynthesis</td>
</tr>
<tr>
<td>Fluridone</td>
<td></td>
<td>Contact</td>
</tr>
<tr>
<td>Carfentrazzone</td>
<td></td>
<td>PPO enzyme</td>
</tr>
<tr>
<td>Flumioxazin</td>
<td></td>
<td>Photosynthesis/enzyme</td>
</tr>
<tr>
<td>Copper</td>
<td></td>
<td>Photosynthesis</td>
</tr>
<tr>
<td>Diquat</td>
<td></td>
<td>Cell membrane disruptor</td>
</tr>
<tr>
<td>Endothall</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Weed Identification

Vascular Aquatic Plants Controlled by Sonar A.S.:

Submersed Plants:
- bladderwort (*Utricularia* spp.)
- common coontail (*Ceratophyllum demersum*)
- common elodea (*Elodea canadensis*)
- egeria, Brazilian elodea (*Egeria densa*)
- fanwort, cabomba (*Cabomba caroliniana*)
- hydrilla (*Hydrilla verticillata*)
- naiad (*Najas* spp.)
- pondweed (*Potamogeton* spp., except Illinois pondweed)
- watermilfoil (*Myriophyllum* spp., except variable-leaf milfoil)
Weed Identification

Fanwort (Cabomba)

Eurasian watermilfoil

Variable-leaf watermilfoil
Weed Identification

Illinois pondweed

Long leaf pondweed
Weed Identification

Para grass  Maidencane

Vascular Aquatic Plants Controlled by Sonar Q:

Submersed Plants:
- bladderwort (*Utricularia* spp.)
- common coontail (*Ceratophyllum demersum*) *
- common Elodea (*Elodea canadensis*) *
- egeria, Brazilian Elodea (*Egeria densa*)
- fanwort, Cabomba (*Cabomba caroliniana*)
- hydrilla (*Hydrilla verticillata*)
- naiad (*Najas* spp.) *
- pondweed (*Potamogeton* spp., except Illinois pondweed) *
- watermilfoil (*Myriophyllum* spp. except variable-leaf milfoil)

Shoreline Grasses:
- paragrass (*Urochloa mutica*)

Vascular Aquatic Plants Not Controlled by Sonar Q:

Emerged Plants:
- American frogbit (*Limnobium spongia*)
- arrowhead (*Sagittaria* spp.)
- bacopa (*Bacopa* spp.)
- big floatingheart, banana lily (*Nymphoides aquatica*)
- bulrush (*Scirpus* spp.)
- pickerelweed, lanceleaf (*Pontederia* spp.)
- rush (*Juncus* spp.)
- water pennywort (*Hydrocotyle* spp.)

Floating Plants:
- floating waterhyacinth (*Eichhornia crassipes*)
- waterlettuce (*Pistia stratiotes*)

Shoreline Grasses:
- maidencane (*Panicum hemitomon*)

NOTE: algae (chara, nitella, and filamentous species) are not controlled by Sonar Q
Weed Identification

Clearcast

Concentration rate range of 50 to 500 ppb

10X Difference!!!

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Scientific Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Curlyleaf pondweed</td>
<td>Potamogeton crispus</td>
</tr>
<tr>
<td>Eurasian watermilfoil</td>
<td>Myriophyllum spicatum</td>
</tr>
<tr>
<td>Hydrilla</td>
<td>Hydrilla verticillata</td>
</tr>
<tr>
<td>Water hyacinth</td>
<td>Eichhornia crassipes</td>
</tr>
<tr>
<td>Water stargrass</td>
<td>Heteranthera dubia</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Scientific Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>American pondweed</td>
<td>Potamogeton nodosus</td>
</tr>
<tr>
<td>Bladderwort</td>
<td>Utricularia spp.</td>
</tr>
<tr>
<td>Frog's bit</td>
<td>Lymnobium spongia</td>
</tr>
<tr>
<td>Illinois pondweed</td>
<td>Potamogeton illinoensis</td>
</tr>
<tr>
<td>Pickerelweed</td>
<td>Pontederia cordata</td>
</tr>
<tr>
<td>Salvinia</td>
<td>Salvinia spp.</td>
</tr>
<tr>
<td>Spikerush</td>
<td>Eleocharis baldwinii</td>
</tr>
<tr>
<td>Variable-leaf milfoil</td>
<td>Myriophyllum heterophyllum</td>
</tr>
<tr>
<td>Wigeon grass</td>
<td>Ruppii maritima</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Scientific Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bulrush</td>
<td>Schoenoplectus calificicus</td>
</tr>
<tr>
<td>Cattail</td>
<td>Typha spp.</td>
</tr>
<tr>
<td>Contain</td>
<td>Ceratophyllum demersum</td>
</tr>
<tr>
<td>Egeria</td>
<td>Egeria densa</td>
</tr>
<tr>
<td>Flowering rush</td>
<td>Butomus umbellatus</td>
</tr>
<tr>
<td>Spatterdock</td>
<td>Nuphar lutea</td>
</tr>
<tr>
<td>Southern naiad</td>
<td>Najas guadalupensis</td>
</tr>
<tr>
<td>Water lily</td>
<td>Nymphaea odorata</td>
</tr>
<tr>
<td>Watershield</td>
<td>Brasenia schreberi</td>
</tr>
</tbody>
</table>
Adjuvants can be confusing.

Dozens of manufactures:
- Dozens of different products.

Dozens of types:
- What do I use when?

Make a large difference in effectiveness:
- Allows reduced rates, reduced regrowth, etc.

Many claim very lofty results:
- What do I use when?
What is an adjuvant?

**Adjuvant:** any substance that has no pesticidal activity applied alone but when added to the formulation or the spray tank can improve pesticidal activity or application characteristics

- 2 classes of adjuvants:
  - Activators - improve performance
  - Utility - improve ease of application
Adjuvants

**Activators**

- Wetter-spreader
  - Non-ionic surfactant
  - Silicone surfactant
- Penetrate
  - Crop oils
  - Basal oils
- Sticker

**Utility**

- Compatibility agent
- Defoamer
- Anti-drift
- Water conditioner
- pH modifiers
- Polymers
How do I know if an adjuvant is needed?

• Some product labels.....
  – Require
  – Suggest
  – Don’t specify
  – Recommend the use of an adjuvant certified by the Council of Producers and Distributors of Agrotechnology (CPDA)

ADDITIVES
When applying Tradewind Herbicide to the foliage of floating or emerged aquatic weeds, mix with an adjuvant approved for use in aquatic habitats. Valent recommends the use of a Chemical Producers and Distributors Association certified adjuvant. Mix Tradewind Herbicide with a non-ionic surfactant containing at least 80% active ingredient. Follow adjuvant manufacturer’s label rates. Verify mixing compatibility with a jar test before using.
CPDA

- Adjuvant registrants submit packet to CPDA:
  - Product label
  - MSDS
  - 1 – 2 page summary of required toxicity studies

- Currently has a list of 70 certified adjuvants

- Users assured that the product will meet its performance claims and that all product labeling guidelines have been followed
**Adjuvants**

- **Surfactants**
  - Flattens out the spray drop
    - Leaves are covered with wax
    - Wax repels water
    - Surfactants overcome the repulsion
  - Reduces bounce
  - These are nonionic surfactants
Adjuvants

Pay attention to spray volume

Foliar Application to Floating and Emergent Weeds
Galleon SC can be applied as a foliar application to control weeds such as water hyacinth, water lettuce, water pennywort and other susceptible floating and emergent species. Applications should be conducted in a manner to maximize spray interception by target weeds while minimizing the amount of overspray that inadvertently enters the water.

100% spray retention
Spray retention – 1 squirt

30% spray retention
Spray retention – 3 squirts
Surfactants

- Which brand of surfactant is best?
- All of them are practically interchangeable
- Any nonionic type with >80% active ingredient will generally be fine
Adjuvants

• Beware of these!

• Adjuvants that claim:
  – Equal weed control at reduced herbicide rates
  – Products that “reduce regrowth of weeds”
  – Cocktails (spreader + sticker + compatibility + etc)
    These are usually more costly and give little benefit
  – *Anything that sounds too good to be true*

Stick with what you know!
State of Poor Pesticide Condition

Mix up a load and spray till it’s gone, right?
State of Poor Pesticide Condition

• Pesticides start to break down when they are in water
  – water
  – light
  – microbes
• These processes can be fast or slow. It depends…
State of Poor Pesticide Condition

 Glyphosate

 COOH--CH₂--NH--CH₂--P--OH
       |      |
       O    OH

 Glycosate

 Enzyme(s)

 Degrades rapidly in soil (Large number of microbes)
 Minimal degradation in water (Smaller number of microbes)

 (-O)₂-P--CH₂NH₃⁺
 Aminomethylphosphonic Acid (AMPA)

 NH₂--CH₃
 Methylamine

 OCPO₂H₂
 Formylphosphonate

 Transamination

 NH₄⁺

 N₂H₃⁺
 Methylamine dehydrogenase

 NH₄⁺
 Ammonium

 Phosphate

 CO₂

 Formaldehyde

 2CO₂

 Glyoxylate

 Glyoxylate & Citric Acid Cycles

 Amino Acids
 Carbohydrates
 Natural Acids
 CO₂

 Glyoxylate

 Citric Acid Cycles
State of Poor Pesticide Condition

Do you draw water from a pond?
State of Poor Pesticide Condition

Water Source

- Adsorption: process of accumulation at an interface
- Colloid – derived from the Greek term meaning glue-like – refers to the microscopic inorganic and organic matter in the soil
State of Poor Pesticide Condition

Water Source

- Pond water....
  - Often has organic matter floating in it
  - This can tie up and deactivate almost any herbicide
  - Differences in clarity can impact the efficacy of the herbicide
State of Poor Pesticide Condition

Water Source

**SPECIFIC USE DIRECTIONS**

**7.0 MIXING**

Roundup Ultra Label

Clean sprayer parts immediately after using this product by thoroughly flushing with water.

**NOTE:** REDUCED RESULTS MAY OCCUR IF WATER CONTAINING SOIL IS USED, SUCH AS VISIBLY MUDDY WATER OR WATER FROM PONDS AND DITCHES THAT IS NOT CLEAR.

Reward Landscape and Aquatic Herbicide dilution may result in reduced herbicidal activity. Avoid applying under conditions of high wind, water flow, or wave action.
State of Poor Pesticide Condition

Water Source

• Water hardness: a measurement of the total amount of calcium and magnesium ions in water

<table>
<thead>
<tr>
<th>Parts per million (ppm)</th>
<th>World Health Organization Water Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 114</td>
<td>Soft</td>
</tr>
<tr>
<td>114 – 342</td>
<td>Moderately hard</td>
</tr>
<tr>
<td>342 – 800</td>
<td>Hard</td>
</tr>
<tr>
<td>&gt; 800</td>
<td>Extremely hard</td>
</tr>
</tbody>
</table>
State of Poor Pesticide Condition

Water Source

- Several herbicides (including 2,4-D, dicamba, and glyphosate) have an overall negative charge.
- These herbicides can be influenced by hard water cations.
- Strong complexes can form when mixed with hard water.
- Negatively charged pesticide molecules attach to the positively charged cations Ca$^{++}$ and Mg$^{++}$.
State of Poor Pesticide Condition

- Studies have shown that increasing ion concentration decreases glyphosate activity
- Calcium will bind to the negatively charged glyphosate
- Glyphosate + calcium has no herbicidal activity

Water Source

\[
\text{HO-C-CH}_2\text{-NH-CH}_2\text{-PO(OH)}_2
\]

Glyphosate
State of Poor Pesticide Condition

Water Source

- The effects of hard water can be reversed with a water conditioner - commonly ammonium sulfate.

Add the water conditioner to the tank before you add the herbicide.

\[
\text{Water Source} (\text{NH}_4\text{SO}_4) = \text{NH}_4^+ + \text{SO}_4^{2-}
\]

\[
\text{Ca}^{2+} + \text{SO}_4^{2-} = \text{CaSO}_4
\]

7.4 Ammonium Sulfate

The addition of 1 to 2 percent dry ammonium sulfate to 100 gallons of water may increase the performance of herbicides, on annual and perennial crops. In hard water conditions, drought conditions, or applications of high volume, a liquid formulation may also be used. Dissolve 7.4 pounds in the spray tank before mixing with clean water after use to reduce foaming.

DIRECTIONS FOR USE

**Speedway** is intended for use with products registered for agricultural, horticultural, turf, ornamental and non-crop uses.

**ADD Speedway TO WATER BEFORE ADDING PESTICIDES**

**General use rate for water conditioning**
- Standard: 1 quart per 100 gallons of water
- Ground/Air range: 1-6 pints per 100 gallons of water

**For severe water conditions or to maximize pesticide activity**
- Ground/Air: 3-6 pints per 100 gallons of water
- Use a minimum of 1/2 pint per acre
State of Poor Pesticide Condition

Water Source

• pH
  – Indicator of alkalinity or acidity
  – Scale from 0 to 14
  – Logarithmic concentration scale of:
    • If $H^+ = OH^- :$ then pH is 7.0 or neutral
    • If $H^+ > OH^- :$ then pH is acidic
    • If $H^+ < OH^- :$ then pH is alkaline (basic)
State of Poor Pesticide Condition

- Scale is logarithmic; so:
  - pH 5.0 is 10x more acidic than pH 6.0
  - pH 4.0 is 100x more acidic than pH 6.0
State of Poor Pesticide Condition

Water Source

- Some pesticides lose effectiveness when mixed with alkaline water
  - pH of 8 to 9 can greatly diminish or cause complete loss of effectiveness
  - Most common with some insecticides:
    - Carbamates and organophosphates
  - Few fungicides and herbicides susceptible

PRODUCT INFORMATION

*Clipper* Herbicide is a fast acting contact herbicide that controls selected submersed, emergent and floating aquatic weeds. It is most effective when applied to young, actively growing weeds in water with a pH of less than 8.5.
State of Poor Pesticide Condition

Water Source

- Most water sources in FL derive from limestone aquifers
- Contain high levels of carbonates – removes $H^+$ from water, thus increases pH
## State of Poor Pesticide Condition

### Water Source

<table>
<thead>
<tr>
<th>Pesticide</th>
<th>pH 6</th>
<th>pH 7</th>
<th>pH 8</th>
<th>pH 9</th>
</tr>
</thead>
<tbody>
<tr>
<td>flumioxazin</td>
<td>---</td>
<td>24 h</td>
<td>---</td>
<td>15 min</td>
</tr>
<tr>
<td>captan</td>
<td>---</td>
<td>8 h</td>
<td>10 min</td>
<td>2 min</td>
</tr>
<tr>
<td>carbaryl</td>
<td>125 days</td>
<td>27 days</td>
<td>2-3 days</td>
<td>1-3 days</td>
</tr>
<tr>
<td>dimethoate</td>
<td>12 h</td>
<td>---</td>
<td>---</td>
<td>1 h</td>
</tr>
<tr>
<td>disulfoton</td>
<td>32 h</td>
<td>---</td>
<td>---</td>
<td>7 h</td>
</tr>
<tr>
<td>malathion</td>
<td>8 days</td>
<td>3 days</td>
<td>19 h</td>
<td>---</td>
</tr>
<tr>
<td>phosmet</td>
<td>---</td>
<td>1 day</td>
<td>4 h (pH 8.3)</td>
<td>1 min (pH 10)</td>
</tr>
<tr>
<td>trichlorfon</td>
<td>4 days</td>
<td>6 h</td>
<td>1 h</td>
<td>---</td>
</tr>
</tbody>
</table>
## Application and Sprayer Information

**IMPORTANT:** Read these entire Directions and Conditions of Sale, including the Warranty and Limitation of Damages provision, before using.

For use with products registered for: Agricultural, Aquatic, Forestry, Industrial, Municipal, Non-Cropland, Ornamental, Rights-of-Way, Turf and other uses.

Use 4 oz. to 2 pints of BUFFER XTRA STRENGTH per 100 gallons of water to lower and stabilize the pH of the spray solution. The rates of BUFFER XTRA STRENGTH may vary with water conditions and will depend upon the alkalinity of the water used or the presence of other products in the spray mix. The use of a pH measuring device is recommended for determining the optimum rate of BUFFER XTRA STRENGTH. Final spray solution pH for many pesticides should be in the 4-7 range.

- [ ] Agitation should continue until spray solution has been applied.
- [X] Mix only the amount of spray solution that can be applied the day of mixing. Apply *Clipper* Herbicide within 12 hours of mixing.
State of Poor Pesticide Condition

Water Source

http://soilslab.ifas.ufl.edu
Proper Measurement

What are you using to measure?

- Not all measuring devices are accurate
- There is a way to check
Proper Measurement

**8 fluid ounces = 1 cup = 236.5882 milliliters**

Collect 237 milliliters of water in the graduated cylinder, and pour that into the measuring device you want to evaluate. If the water level is at 8 ounces or the 1-cup line, then you know your container is accurate.
Proper Measurement

Is this any better?

How do you measure 14 ounces with this?
Proper Measurement

How would you measure less than 10 oz with this container?

Taller, narrower measuring containers typically have more graduation marks and more space between lines on the container compared to shorter, wider ones.

This one starts at 10 oz.
Proper Measurement

• Dry vs wet measure
  – An ounce is an ounce, right?

• Dry
  – Based on weight – 1/16 of a pound

• Wet
  – Based on volume – 1/128 of a gallon

These can be very different!
Proper Measurement

You can’t use a liquid measure for dry material!

1 liquid oz = 1/128 gal

1 dry oz = 1/16 lb
Proper Measurement

All these jars have 4 dry ounces, by weight, of material.

The volume occupied by dry material depends directly on the density and particle size.
Proper Measurement

- The specific volume of a dry wettable granule product depends on its density
- The volumes of WG products vary by their ingredients and the size and shape of their granules
The volume of 1 dry ounce of material varies greatly by device and product.
Proper Measurement

Same product, but different batches – notice slightly different amounts to make 1 ounce.
Proper Measurement

6 ounces of 4 different dry products compared to 6 fluid ounces of a liquid product.
Proper Measurement

Liquid product

Dry products
Proper Measurement

Some products’ caps are measuring devices – be careful!
Be sure to read the directions for how to use the markings on the cap!
Proper Measurement

• Things you need to know about retail-supplied measuring devices:
  – Make sure you know whether a measuring device is meant for fluid ounces or dry ounces
  – Be cautious of measuring devices for closely related products that are formulated differently
  – Many devices clearly state that they must be used for the products they came with, then discarded
  – Be cautious of containers that have different sets of graduation marks indicating both liquid and dry ounces
Proper Measurement

The most accurate and consistent way to measure dry formulations is to weigh them on a scale.
Review

What is the overall primary factor for why herbicides fail to control a weed?

A. It is some form of human error. √
B. Incorrect pest identification.
C. Improper application timing.
D. Pesticide resistance.
Review

Which type of measuring container for liquid pesticides would be expected to be most precise?

A. A measuring cup marked in ounces.
B. The cap from the product's container.
C. A tall, narrow cylinder marked in milliliters. ✓
D. A short cup marked in quarts and pints.
Review

Why can't liquid and dry measuring devices be used interchangeably?

A. An ounce of any liquid formulation always occupies the same amount of volume.

B. The volume of a dry formulation depends directly on its density and particle size.

C. An ounce of a liquid formulation and an ounce of a dry formulation would occupy the same volume.

D. Both A and B are correct. √
Review

Why do water sources containing silt and organic matter used for mixing with herbicides cause weed control failures?

A. They cause pesticides to bind with the calcium and magnesium ions which inactivates them.
B. They cause an alkaline hydrolysis reaction which quickly decomposes them.
C. They adsorb pesticides leaving them unavailable for uptake. ✓
D. They have been shown to enhance the development of pesticide resistance.
Review

What is a practical method for preventing antagonism of glyphosate mixed in hard water?

A. Add a buffering agent to lower the mix water's pH to a range of 4.5 to 6.0.
B. Add a nonionic surfactant of at least 80% active ingredient to the mix water at a volume of 1%.
C. Increase the application rate of glyphosate.
D. Add ammonium sulfate to the mix water prior to adding glyphosate. √
Thanks for your attention!