Solving Spray Water Problems

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The Virginia Tech Spray Water Analysis Program (VT-SWAP) offers affordable water testing for Virginia's agriculture and horticulture producers, along with interpretation to help understand results and recommendations for improved pesticide mixing practices. For more information and additional resources, please visit the Spray Water Analysis Program web page (https://www.wellwater.bse.vt.edu/swap).

Introduction

Poor spray water quality can lead to problems with pesticide or herbicide effectiveness or application. Water quality is a measure of the physical, chemical, and biological characteristics of water for a particular use. Certain aspects of water quality can reduce the efficacy of a pesticide or affect how a pesticide interacts with plant surfaces or target pests. Problems that may occur include

- Water that is too acidic or alkaline can cause the chemical bonds holding the pesticide together to degrade, which may cause the pesticide to break down in the spray solution prior to application and render it ineffective. It can also prevent the pesticide from penetrating the target plant or pest.
- Hard water contains an excessive amount of positively charged molecules (cations) such as calcium, magnesium, and iron, and can cause some pesticide molecules to bind with the cations, resulting in reduced absorption of the product into the plant or pest. It can also cause the pesticide to precipitate (settle) out of solution.
- Turbid (cloudy or murky) water contains solid particles that can bind to pesticide molecules in the spray tank and deactivate them, plugging spray nozzles and leading to reduced or uneven applications.

Evaluating spray water chemistry with water testing can help identify water quality problems that might otherwise be overlooked. This publication examines possible solutions to spray water problems, including the use of adjuvants and other additives to enhance pesticide performance. For more information about how to test your spray water quality before using adjuvants or other additives, see Virginia Tech publication BSE-350P, "Spray Water Quality and Pesticide Characteristics."

Adjuvants

An adjuvant is a chemical added to the spray tank to improve mixing or application, or enhance pesticide activity or safety (Fishel 2020). The two basic types of adjuvants are **activator adjuvants** (e.g., surfactants, wetting agents, or penetrants) and **special-purpose adjuvants**, which are also called spray modifier agents and utility modifiers (Fishel 2020). Special-purpose adjuvants include compatibility, drift control, defoaming, buffering, and conditioning agents (Curran et al. 1999). This publication focuses on the most common types: surfactants, buffering agents, water conditioners, anti-foaming agents, and compatibility agents (table 1).

Table 1. Selected adjuvants and uses

Type of Adjuvant	Use
Surfactants	Help improve the pesticide's ability to emulsify, disperse, spread, and stick by reducing surface tension
Buffering Agents/ Acidifiers	Reduce problems associated with alkaline water by adjusting spray water pH levels
Water Conditioners	Reduce problems caused by hard water by preventing hard water cations from attaching to pesticide ions
Defoaming/ Antifoaming Agents	Prevent or eliminate foam caused by a surfactant or agitation
Compatibility Agents	Reduce incompatibility issues in the spray tank by keeping pesticides in suspension

Understanding the characteristics associated with different adjuvants is helpful. Choosing the best adjuvant for an application depends on the target pest, growth stage, water quality, application site and method, and environmental conditions during and up to 24 hours after application (Whitford et al. 2014). Applicators should read product labels to determine if an adjuvant is needed, and if so, what volume should be added to the tank. If adjuvants are premixed in the pesticide formulation, additional adjuvants may not be necessary. No adjuvant can improve all pesticide performance; environmental conditions, chemical and physical characteristics of the pesticide, and water quality must always be considered when selecting the most appropriate adjuvant to use (Tu, Hurd, and Randall 2001).

Activator Adjuvants

Activator adjuvants are designed to improve the biological activity of the pesticide after the spray has contacted the leaf or pest surface (Kuhns, Gover, and Johnson 2007). Examples of activator adjuvants include surfactants, wetting agents, oil concentrates, penetrants, and spreader-stickers. They increase pesticide absorption into plant or insect tissue by reducing surface tension on the leaf or insect and ultimately can lead to better weed, insect, or disease control.

Surfactants are one of the most common types of activator adjuvants. The primary role of a surfactant (which is short for SURFace ACTive AgeNT) is to increase pesticide spray droplet retention and absorption rate on the plant or pest surface (Curran et al. 1999). Surfactants reduce the surface tension of the spray solution, increasing the wetting, dispersing, sticking, and spreading properties of a pesticide mixture (Hock 2022). Reducing the surface tension of the pesticide mixture allows the pesticide to be absorbed by the plant or pest more completely, increasing efficacy and reducing the likelihood of the pesticide running off of the target surface (Curran et al. 1999). Surfactants allow the pesticide to break through hard-to-penetrate surfaces, like waxy or hairy surfaces of a leaf or the exoskeleton of an insect, to effectively eliminate the target plant or pest (Whitford et al. 2014) (fig. 1).

Figure 1. Surfactant successfully penetrating a hairy leaf surface.

Only use surfactants made for pesticide mixing, not cleaners, such as dish detergent. Selecting the wrong surfactant can damage the plant and may reduce pesticide effectiveness. Check the pesticide label to see what type of surfactant to use, if any. If unsure about which surfactant to use after reading the label, ask the manufacturer or dealer.

Special-purpose Adjuvants

Special-purpose adjuvants, which can alter properties that could negatively affect the spray solution or pesticide application, are also known as spray modifiers or utility adjuvants. Utility adjuvants can improve pesticide activity by altering the water pH, keeping cations in hard water from binding with pesticides, reducing tank mix incompatibilities, or improving the ability of the pesticide to remain on the plant surface. Utility adjuvants include buffering agents/ acidifiers, water conditioners, anti-foaming agents, and compatibility agents (table 2).

Table 2. Selected trade names and manufacturers of surfactants and special-purpose adjuvants.

Trade Name	Manufacturer
Surfactants	
LI-700	Loveland
Induce	Helena
Regulaid	KALO
Buffering Agents/Acidifiers	
LI-700	Loveland
pHase5	Loveland
BS-500	Drexel
Water Conditioners	
Choice Weather Master	Loveland
Deriva	Precision Laboratories
Foam Buster	Helena
Antifoaming Agents	
Breaker	Loveland
DeFoamer	Riverside/Terra
Foam Buster	Helena
Compatibility Agents	
E-Z Mix	Loveland
Combine	Riverside/Terra
Blendex VHC	Helena

Buffering Agents and Acidifiers

Buffering agents and acidifiers are used to adjust spray water pH. Most pesticides are weakly acidic or neutral and perform best in slightly acidic water (pH ranging from 4-6.5). Some pesticides added to water with a pH above 7.0 can break down quickly, reducing effectiveness (Tharp 2017). Sulfonylurea herbicides, such as chlorimuron, halosulfuron, nicosulfuron, rimsulfuron, thifensulfuron, and tribenuron are an exception, performing better in slightly alkaline environments (pH greater than 7). Buffering agents are used to stabilize pH longer term, while acidifiers reduce the pH of the water, but do not necessarily maintain it at a constant level (Tharp and Whitford 2015).

If the spray mix water's pH is alkaline, a buffering-acidifying agent can be added to prevent pesticide degradation. Buffering agents that are used to raise the pH of a water solution are usually only needed if using sulfonylurea herbicides (Tharp and Whitford 2015). Some buffering agents will change color to indicate that the correct pH has been achieved (Schilder 2008). Growers can continue to add the product until the color reached indicates the desired pH. Spray solutions containing fixed copper or lime fungicides, including Bordeaux, copper oxide, basic copper sulfate, copper hydroxide, etc., or lime sulfur should not be mixed with a buffering or acidifying agent since plant damage may occur (McKie and Johnson 2002). Before making buffering or acidifier adjustments, determine the pH of the water with pH strips, a pH meter, or laboratory testing, and read the labels carefully (table 3).

In general, the amount of adjuvant added will depend on the initial pH, the volume of water, the product type and effective concentration, and desired final results (Fishel and Ferrell 2019; McKie and Johnson 2002).

Table 3. Testing and adjusting the pH of alkaline water mixed with weakly acidic pesticides

Measure pH through Virginia Tech SWAP or a private lab or conduct your own field testing with a pH meter.
Onsite water pH testing procedure: 1. Collect a sample of water in a clean glass jar from the source used for pesticide applications. 2. Check the pH of the water using a pH meter, following manufacturer's directions. **pH 3.5-6.0:** Satisfactory for spraying most pesticides and for short-term storage (12-24 hours) of weakly acidic pesticides. **pH 6.1-7.0:** Satisfactory for spraying most pesticides within 2 hours. **pH > 7.0:** Add buffer or acidifier.
pH adjustment procedure: 1. Using an eyedropper, add 3 drops of buffering or acidifying agent to a pint of water. 2. Stir with a clean rod or spoon and recheck pH of the solution. 3. Repeat steps 1 and 2 until pH is within desired range. 4. For every 100 gallons of water in the spray tank, add 2 ounces for every 3 drops of buffer used in the jar test above. 5. Mix the tank and check to see if pH is satisfactory. 6. Add pesticides to the spray tank after achieving satisfactory pH.

(Adapted from Tharp 2017 and McKie and Johnson 2002)

Water Conditioners

Hard water contains higher amounts of positively charged ions (cations) such as calcium, magnesium, and iron that are attracted to negatively charged pesticide molecules. Once bound, these cations can limit pesticide efficacy by preventing the pesticide from entering the target plant or pest, or by deactivating certain pesticides. Products most affected by water hardness are weak-acid herbicides such as glyphosate, 2,4-D, and glufosinate. Water conditioners are a type of adjuvant added to the spray solutions to reduce problems associated with water hardness. Water conditioners chelate or bind hard water cations, preventing them from attaching to negatively charged pesticide ions; this allows the target plant to more readily absorb the pesticide, maximizing efficacy and lowering the risk of failure (Whitford et al. 2014).

Ammonium sulfate (AMS) is commonly used to alleviate hard water issues when using herbicides. AMS should be added to the spray tank and allowed to go into solution before adding the herbicide. The amount of AMS required varies based on the product used and should be added according to the product label. To calculate the rate of AMS based on a water test, see Virginia Tech publication BSE-350P, "Spray Water Quality and Pesticide Characteristics." It is important to note that AMS is not a "true" water conditioner but has been shown to improve hard water issues. To manage hard water, it is important to know whether or not the pesticide's efficacy is affected by hard water (e.g., weakly acidic or salt-based) and the level of water hardness. Water hardness may vary significantly depending on the water source (e.g., surface, groundwater) and is largely driven by the makeup of geology in groundwater. For example, groundwater tends to be very hard in the Valley and Ridge area of Virginia and not hard in the Piedmont area of Virginia.

Anti-foaming/Defoaming Agents

Anti-foaming agents are used with pesticide spray mixtures to prevent excessive foaming. Defoamers are used to control or remove foam once it has formed in the spray tank (Hock 2021). Often, the terms anti-foaming and defoaming are used interchangeably. Foam can result from air entrapment as a result of spray tank agitation (Curran et al. 1999; Kuhns, Gover, and Johnson 2007) and/or the presence of certain surfactants used to formulate the pesticide (Hock 2021). Air entrapment can lead to pump and spray problems such as active ingredients "de-mixing" from the water (Curran et al. 1999; Cush 2006). Foaming can negatively affect the mixing process by prolonging the mixing time and allowing the mixture to overflow or spill (Tu, Hurd, and Randal 2001). It is easier to prevent foam from forming than to minimize it after it forms (Whitford et al. 2014), so anti-foaming agents are sometimes recommended.

Compatibility Agents

Compatibility agents are added to spray mixtures consisting of two or more products to ensure the mixture stays homogeneous. Certain combinations of pesticide products and liquid carriers may cause incompatibilities, meaning the products fail to stay uniformly mixed. Incompatibilities can include products separating, falling out of the solution, gelling, or clumping together. Compatibility agents are used to keep pesticides in suspension and reduce these issues (Tu, Hurd, and Randall 2001).

Compatibility agents are usually added when using liquid fertilizer as a carrier, or when the water is relatively cold (lower than 42 F) (Whitford et al. 2018). Liquid fertilizers with high salt content can cause poor compatibility between two or more ingredients in the mixture. Colder water (lower than 42 F) can decrease the solubility of pesticide products. See Virginia Tech publication BSE-351P, "Understanding Spray Tank Mixing Practices," to read more about liquid fertilizers and the effect cold water has on tank mixing compatibility.

Filtration

Suspended solids such as sand, silt, clay, and organic matter cause water to be turbid or cloudy. These particles can bind to pesticides and reduce the amount of pesticide available to bind with the target site (Whitford et al. 2020). Filtration is a method used to prevent spray nozzles, pumps, and hoses from clogging up, enhancing the performance of pesticides by removing suspended solids and other particles from the water. See Virginia Tech publication BSE-350P, "Spray Water Quality and Pesticide Characteristics," for more information.

Conclusion

The efficacy of some pesticides can be impacted by the quality of the mixing water. Water quality and some pesticide compatibility issues can be addressed with adjuvants. An adjuvant is a chemical added to the spray tank to improve mixing, application, and/or enhance pesticide activity and safety. Consider several factors when selecting an adjuvant or additive, including the target pest, growth stage, water chemistry, application site, and environmental conditions. Having a basic understanding of adjuvants helps the user avoid mistakes in choosing, mixing, and applying the product. Further, it is important to always read the label and consult the manufacturer with any outstanding questions.

Disclaimer: Always read pesticide product labels thoroughly and consult a pesticide dealer, Extension agent, and/or manufacturer **before** adding an unfamiliar adjuvant to a spray mix. Using the wrong adjuvant can be harmful to crops and/or equipment. Products identified by proprietary or trade names in this publication are for clarity and do not imply endorsement or recommendation. Never mix pesticides that the product labels state not to. Sometimes products cannot be tank-mixed together and multiple, separate applications or choosing alternative products is necessary.

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