Spray Adjuvants

An adjuvant is broadly defined as any nonpesticide material added to a pesticide product or pesticide spray mixture to improve the pesticide's performance and/or alter the physical properties of the spray mixture. Examples of adjuvants include surfactants, oils, compatibility agents, buffering and conditioning agents, defoaming agents, deposition agents, drift control agents, and thickeners.

The proper adjuvant may reduce or even eliminate spray application problems, thereby improving overall pesticide effectiveness. Because adjuvants themselves have no pesticidal properties, they are not required to be registered by the U.S. Environmental Protection Agency (EPA). Also, most states, including Pennsylvania, do not regulate the distribution of adjuvants.

The agricultural and horticultural industries are being overwhelmed by adjuvant choices. With so many products to choose from, how do you make an informed decision about which adjuvant to use for a particular situation? A good place to start is to understand the characteristics of this diverse group of chemicals.

Before using any adjuvant, you should check the pesticide's label. Many EPA-registered pesticide products have very specific recommendations on their labels about using one or more adjuvants. Not following these instructions is a violation of the product label and considered an illegal use of the pesticide.

If applicators have questions about the specific properties of an adjuvant or pesticide product, they should contact the manufacturer or the dealer where they bought the product before attempting to use it. Manufacturers and pesticide dealers can provide labels, technical data sheets, material safety data sheets (MSDS), supplemental labeling, and promotional literature about their products.

The two types of adjuvants are different in how they are combined with the pesticide. A *formulation adjuvant* is already included in the pesticide product by the manufacturer. A *spray adjuvant* is a separate product that is added to the spray tank by the applicator. Since applicators have no control over formulation adjuvants, this publication focuses on spray adjuvants.

Adjuvants and Spray Application

Some research indicates that up to 70 percent of the effectiveness of a pesticide depends on a proper spray application. However, the weakest link in the pesticide development process is the actual spray application. Therefore, using adjuvants to minimize or eliminate many spray application problems will help boost the pesticide's effectiveness.

Adjuvants are designed to perform specific functions, including buffering, dispersing, emulsifying, spreading, sticking, and wetting. Adjuvants also can reduce evaporation, foaming, spray drift, and volatilization. No

single adjuvant can perform all these functions, but different compatible adjuvants often can be combined to perform multiple functions at the same time.

The spray adjuvants can be categorized into two groups: activator adjuvants and special-purpose or utility adjuvants.

Activator adjuvants

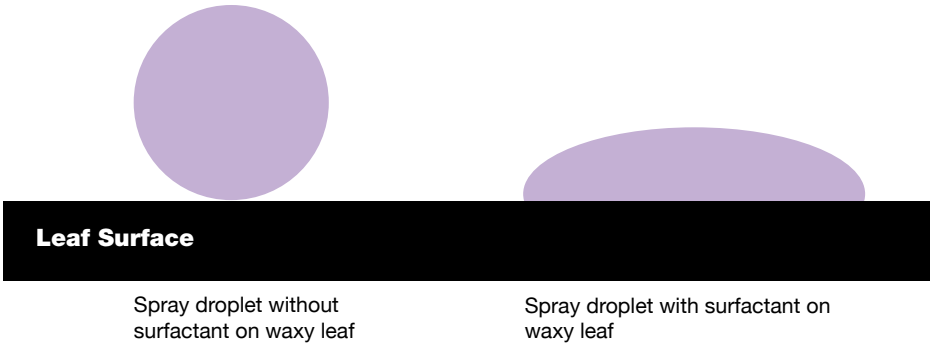
The main purpose of activator adjuvants is to improve the "activity" of the pesticide product. These improvements—both physical and chemical—generally lead to better absorption and, as a result, a more efficient use of the pesticide. Activator adjuvants include surfactants, oils, and nitrogen-based fertilizers.

Surfactants

Surfactants *(surf*ace *act*ing *a*g*ents*), also called wetting agents and spreaders, physically change the surface tension of a spray droplet. For a pesticide to perform its function properly on a plant, the spray droplet must be able to wet the foliage and spread out evenly. Surfactants make the area of pesticide coverage larger, which increases the pest's exposure to the chemical (see Figure 1). Surfactants are particularly useful when applying a pesticide to a plant with waxy or hairy leaves. Without proper wetting and spreading, spray droplets often run off or fail to provide good coverage to the surfaces. Too much surfactant, however, can cause excessive runoff, which may make the pesticide less effective.

Surfactants are classified by the way they ionize, or split apart, into electrically charged atoms or molecules called ions. Anionic surfactants have a negative charge and are most effective when used with contact pesticides. Cationic surfactants have a positive charge and should never be used as stand-alone surfactants because they are usually phytotoxic (poisonous to plants). Nonionic surfactants have no electrical charge. Pesticidal activity in the presence of a nonionic surfactant can be quite different from activity in the presence of a cationic or anionic surfactant. Nonionic surfactants are often used with systemic pesticides and help pesticide sprays penetrate plant cuticles. Also, nonionic surfactants are compatible with most pesticides and most EPA-registered pesticides that require a surfactant recommend a nonionic type. Keep in mind that selecting the wrong surfactant can reduce the effectiveness of a pesticide product and increase the risk of plant injury.

Figure 1. Droplet spread on waxy leaf surface due to surfactant.



Organo-silicone surfactants are a newer group of surfactants that are taking the place of the more traditional nonionic surfactants. They reduce surface tension, increase spreading ability, and improve rainfastness (the amount of time between a pesticide application and rainfall). Rainfastness can be improved when more pesticide is absorbed into the plant.

Oils

Oils are being used to control grassy weeds. The three types of oil-based adjuvants include crop oils, crop oil concentrates, and vegetable oil concentrates.

Crop oil is generally 95 to 98 percent paraffin or naptha-based petroleum oil with 1 to 2 percent surfactant/emulsifier. Crop oils promote the penetration of a pesticide spray either through a plant's waxy cuticle or through an insect's tough, chitinous shell. Traditional crop oils are more commonly used for insect and disease control and rarely with herbicides.

Crop oil concentrates (COCs) are made up of 80 to 85 percent emulsifiable petroleum-based oil and 15 to 20 percent nonionic surfactant. Crop oil concentrates have the penetration properties of oil and the spreading properties of a surfactant. COCs are often used with postemergence herbicides.

Vegetable oil concentrates (VOCs) are made up of 80 to 85 percent cropderived seed oil (usually cotton, linseed, soybean, or sunflower oil) and 15 to 20 percent nonionic surfactant. To improve their performance, many VOCs have undergone a process called esterification, which increases the oil-loving characteristics of the

seed oil and results in a methylated seed oil (MSO). MSOs work the same as traditional crop oil concentrates to increase penetration of the pesticide into the target pest.

Nitrogen-based fertilizers

Improved herbicide activity has been shown by adding ammonium sulfate or urea-ammonium nitrate to the spray mixture. Nitrogen fertilizers may replace some adjuvants but are usually included in addition to a surfactant and a crop oil concentrate for use with systemic pesticide products. Many fertilizer-based adjuvants are available in liquid forms, which are easier to mix and provide more consistent results. Fertilizers should only be used with herbicides when recommended by the label.

Special purpose/utility adjuvants

Special purpose adjuvants fix specific conditions that can affect the spray solution or the actual application of the pesticide in a negative way. By controlling these factors, you can maximize the efficient use of the pesticide. Compatibility agents, buffering and conditioning agents, defoaming agents, deposition agents, and drift control agents and thickeners modify the physical characteristics of the spray solution. Carefully follow product label directions before adding any adjuvant to a spray mix.

Compatibility agents

Pesticides are commonly mixed with liquid fertilizers or other pesticides. However, some combinations can be physically or chemically incompatible, causing clumps and uneven distribution in the spray tank. Occasionally, the incompatible mixture will clog the pump and hoses, resulting in

Jar Test for Compatibility of Pesticide Mixtures

Always wear personal protective equipment (PPE) when pouring or mixing pesticides, even for this simple test.

To conduct a jar test, add proportionate amounts of all the products you intend to mix in the spray tank to a clear quart jar. When using a liquid fertilizer carrier, many herbicide labels recommend using two jars for this test—one with and one without a compatibility agent.

Step 1.
Measure 1 pint of water (or carrier solution) into a clear quart jar. Use the same water source that will be used in the tank mix.

Step 2.
Add proportionate amounts of each product, one at a time, in the order suggested on the label, or add ingredients in the following order. Stir each time a formulation has been added.

1. Compatibility, buffering, or defoaming agents (if needed)
2. Wettable powders, dry flowables, water-dispersible granule products
3. Flowables, liquids, microencapsulated products
4. Solutions, soluble powder products
5. Remaining adjuvants, such as surfactants or crop oils (if needed)
6. Emulsifiable concentrates

Step 3.
Shake the jar vigorously and allow it to stand for at least 15 minutes. The mixture is probably not compatible if scum forms on the surface, the mixture clumps, or any solids settle to the bottom (except for wettable powders). Do not use a mixture that gives off heat (determined by feeling the jar) as that indicates a chemical reaction has occurred and changed the chemical properties of the products.

If a compatibility problem occurs, dispose of the mixture according to the pesticide product label. Finally, if no signs of incompatibility appear, put the pesticide test mixture into the spray tank. In addition, rinse all utensils and pour the rinse water (rinsate) into the spray tank and apply to a labeled site. Do not use utensils or jars for any other purpose after they have contacted pesticides.

expensive cleanup and repairs. Using a compatibility agent may eliminate these problems. A "jar test" can help determine the stability of the mixture (see panel).

Buffering and conditioning agents

Most pesticide solutions or suspensions are stable between pH 5.5 and pH 7.0 (slightly acidic to neutral). Pesticide solutions above pH 7.0 are at greater risk of degrading or breaking down. Acidifiers are adjuvants that lower the pH of the water in the spray tank, although they do not necessarily maintain a constant pH level. Buffers tend to stabilize the pH at a relatively constant level. Conditioning or water-softening agents reduce problems caused by hard water. Hard water minerals, especially calcium and magnesium ions, bind with active ingredients of some pesticides, which may decrease pesticide performance. Before using a buffer or conditioning agent, consider the specific pesticide requirements and test the water for pH and hardness.

Defoaming agents

Some pesticide formulations create foam or a frothy head in some spray tanks. This is often the result of the type of surfactant used in the formulation and the type of spray tank agitation system. The foam usually can be reduced or eliminated by adding a small amount of a defoaming agent.

Deposition agents

These adjuvants, which are often referred to as "stickers," increase the ability of solid particles to stick to the target surface. These adjuvants can decrease the amount of pesticide that washes off during irrigation or rain. Deposition agents can also reduce evaporation of the pesticide and some can slow degradation of pesticides by ultraviolet rays. Many deposition agents also include a wetting agent to make a general purpose product that both spreads and sticks to the target surface.

Drift control agents and thickeners

Drift is a function of droplet size, wind speed, and height of the spray boom. Small droplets (with diameters of 100 microns or less) tend to drift away from targeted areas. Drift retardants or deposition aids improve on-target placement of the pesticide spray by increasing the average droplet size. Drift reduction is a priority near sensitive sites, and using a spray drift agent may be well worth the small reduction in the effectiveness of the application that can result from the change in droplet size.

Thickeners, as the name suggests, increase the viscosity of spray mixtures. These adjuvants are used to control drift or slow evaporation after the spray has been deposited on the target area. Slowing evaporation is important when using systemic pesticides because they can penetrate the plant cuticle only as long as they remain in solution. Once the water has evaporated, any unabsorbed pesticide will remain on the leaf surface and can only be taken up by the plant if it returns to solution by rewetting.

How to Choose the Right Adjuvant

Many factors must be considered when choosing an adjuvant for use in a pest management program. The following are some guidelines:

- First and foremost, ***read the pesticide label.***
- Use only adjuvants manufactured and marketed for agricultural or horticultural uses. Do not use industrial products or household detergents with pesticides because they may interfere with or reduce pesticide performance.
- Pesticide labels seldom mention specific brands of adjuvants, but rather the general type of adjuvant, such as nonionic surfactant, crop oil, or defoaming agent. However, if the pesticide label lists a specific brand of adjuvant, that brand must be used. Any substitution would be a violation of the label.
- Miracle adjuvants do not exist. Ignore claims such as "keeps spray equipment clean," or "causes better root penetration." Always buy recognizable, name-brand products from a reputable dealer.
- Adjuvant recommendations may change due to changes in pesticide formulations, newly labeled tank mixes and premixes, and changes in application technology and procedures. **Always read the label *every time* a pesticide product is used.**
- Using an adjuvant is not always necessary. Knowing when *not* to use an adjuvant is just as important as knowing when to use one. If the pesticide label does not mention an adjuvant, the manufacturer's research probably has shown no benefits—or even adverse effects—from adjuvant use.

Spray adjuvants can play a major role in safe and effective pest control when used as recommended on the label. Although a single adjuvant may perform more than one function, no single product can solve every problem. As a result, many spray adjuvants are available, each formulated to solve problems associated with a particular type of application. **Read the pesticide label.**

The correct use of adjuvants does require knowledge of the site you plan to spray, the target pest, your equipment, and, of course, the pesticide you plan to use. By knowing the particular needs and limitations of the products you intend to use, adjuvants can prove to be a positive addition to the spray tank.

References

Petroff, Reeves. "Pesticide Adjuvants and Surfactants" and "Pesticide Interactions and Compatibility," Montana State University.

York, Alan C. "Section 6: Spray Adjuvants," CS 414–Weed Science, North Carolina State University.

Poison Control Centers
1-800-222-1222

Calling the toll-free National Poison Center hotline above will connect you to the nearest poison center. Pennsylvania residents are served by the Pittsburgh Poison Center and the Poison Control Center in Philadelphia.

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