Spray Adjuvants With Herbicides

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Spray adjuvants are substances added to pesticide spray mixtures to modify the physical properties of the spray solution and/or enhance pesticide performance. Adjuvants used alone generally have little or no pesticidal effect.

The need for an adjuvant and the best type to use depend on the pesticide, crop, pest, and environmental conditions. Adjuvants should be used as recommended on the pesticide label for optimum pesticide performance. Adjuvants should not be used indiscriminately, because misuse may lead to excessive crop injury, compatibility problems, or reduced pest control.

Choosing an adjuvant is difficult because of confusing terminology and the large number of adjuvants on the market. In addition, the adjuvant industry is not regulated, thus there are no set standards for adjuvant composition or quality. The ingredients of a particular adjuvant product may even change from year to year.

Adjuvants can be divided into two categories depending on their function—spray additives that improve pesticide efficacy, and spray additives that minimize handling and application problems. Adjuvants that enhance pesticide efficacy include surfactants, sticker-spreaders, oils, and salts or fertilizers. These materials increase spray coverage, spray droplet retention, and/or herbicide absorption into the plant. Examples of adjuvants that reduce application problems include compatibility agents, foam retardants, buffer agents, and drift control agents. Specific products may serve several functions to improve pesticide use and performance.

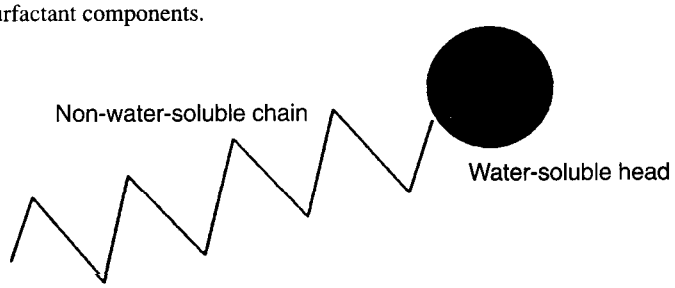
Types of Adjuvants

Adjuvants that Enhance Pesticide Efficacy

Surfactants are probably the most common type of spray adjuvants. Surfactants are surface active agents that influence mixing and interaction of different chemicals with surfaces. Many spray adjuvants have some surfactant properties. Surfactants may aid in mixing, dispersal, spreading and wetting properties of pesticide spray solutions. Wetting agents, sticker-spreaders, emulsifiers, and compatibility agents are all surfactants. The term surfactant is often used interchangeably with wetting agent, a substance that improves leaf wetting and surface coverage.

Surfactants are generally complex, long-chain molecules. One end of the molecule is attracted to water and water-soluble materials, while the other end is attracted to non-water-soluble materials such as oils and waxes (Figure 1). Thus, surfactant molecules orient themselves differently in water than in oil, based on the difference between the two ends of the molecule (Figure 2).

Figure 1. Surfactant components.



Addition of a surfactant to a spray solution reduces the surface tension of the solution, which facilitates mixing of nonsoluble materials because of the attraction of the surfactant to the different components of the spray mixture. A surfactant also will increase surface coverage of a spray droplet on a leaf by reducing the surface tension in the spray droplet and allowing it to spread more evenly over a waxy leaf surface (Figure 3).

Surfactants are classified according to three general types—nonionic, cationic, and anionic. Nonionic surfactants are the most common type and are compatible with most materials because they are not charged molecules and are not likely to react chemically with other chemicals. Cationic surfactants are positively (+) charged and anionic surfactants are negatively (-) charged molecules. Cationic and anionic surfactants are not readily available and are not commonly used because of possible reactions with pesticides and water impurities in the spray solution.

Emulsifiers are surfactants included in many pesticide and oil formulations to help disperse non-water-soluble materials in the spray solution as an emulsion. Many herbicides and oils are not very water soluble, thus would not mix uniformly in water without an emulsifier. Emulsifiers help suspend non-water-soluble materials in water as tiny droplets called micelles. Most pesticides and oil additives include emulsifiers in the formulation to facilitate mixing and handling the spray solution. Therefore, additional emulsifiers generally are not needed for pesticide application.

Sticker-spreaders improve surface coverage, as well as help retain the pesticide on the leaf surface, even if a rain follows application. Sticker-spreaders are usually a blend of surfactants and other chemicals such as latex. Stickers help retain the pesticide on the leaf surface because of a strong attraction to the chemical as well as the leaf surface, but also could reduce movement into the leaf because of the strong attraction to the wax on the leaf surface. Sticker-spreaders may be most useful to keep contact insecticides on the leaf surface where insects are moving and feeding.

Figure 2. Surfactant molecule orientation in water and oil.

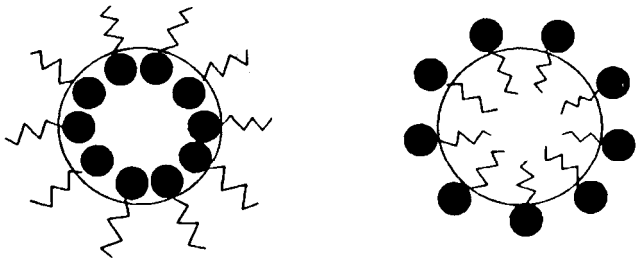
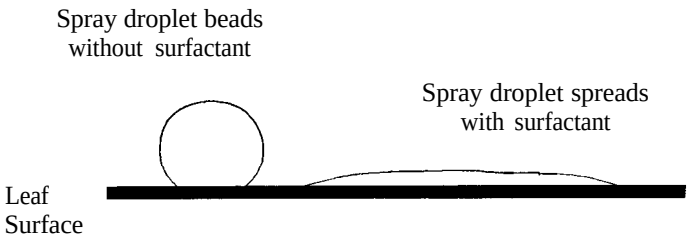


Figure 3. The effect of surfactant on spray droplet.



Oil adjuvants are petroleum- or vegetable-oil-based materials which are combined with emulsifiers and added to the spray solution to increase pesticide efficacy. Oil adjuvants generally enhance weed control by increasing the absorption of foliar-applied herbicides into the plant.

Crop oils are petroleum-based oils with 2-5 percent emulsifiers. Crop oils generally were used at 0.5–l gallon per acre, but are not commonly used anymore. **Crop oil concentrates** (COC) are petroleum-based oils containing 15–20 percent emulsifier and are commonly used at l–2 pints per acre. Crop oil concentrates essentially have replaced the use of crop oils with herbicides.

Oils derived from sunflowers, soybeans, flax, and other plants, and combined with 2–20 percent emulsifiers are called **vegetable oil** adjuvants, and usually are applied at l–2 pints per acre. Vegetable oils may be more, less, or as effective as petroleum-based oils depending on the herbicide, crop, and weed species.

Vegetable oils can be modified in various ways to alter their composition and effectiveness as adjuvants. For example, methylated vegetable oils such as *Scoil* and *Sun-It II* have proven more effective than unmodified vegetable oils or crop oil concentrates in enhancing weed control with certain herbicides including *Poast, Pursuit,* and *Scepter*. However, these products are more expensive than vegetable oils or crop oil concentrates and may increase the risk of crop injury.

Salts and fertilizers such as ammonium sulfate, 28 percent liquid UAN (urea ammonium nitrate), and 10–34–0 fertilizer have improved control of certain weed species with some

herbicides. The function of salts and fertilizers as spray adjuvants is unclear, but they seem to increase herbicide absorption or counteract the effect of impurities and other chemicals in the spray solution. Salts and fertilizers have been most effective at enhancing control of pubescent or hairy weed species such as velvetleaf and kochia.

Adjuvants that Minimize Handling and Application Problems

Compatibility agents are surfactants added to the spray solution to prevent physical or chemical reactions from occurring when pesticide or pesticide-fertilizer combinations are used. Compatibility agents may facilitate the mixing of certain pesticides or pesticide-fertilizer combinations, but will not solve all compatibility problems. A compatibility test with and without a compatibility agent should be conducted on a small scale before combining pesticides or fertilizers. Pesticide labels often provide information on the compatibility of tank mixtures and the suggested order of mixing.

Stability agents are substances such as **foam retardants,** or **buffer agents** which are added to the spray solution to stabilize the mixture. Foam retardants or anti-foaming agents suppress foam formation when certain chemicals are mixed and reduce mixing and application problems due to excess foam. Buffer agents alter the pH of spray solution. The pH of the spray mix may affect pesticide efficacy or rate of breakdown in solution. Several insecticides break down rapidly at a high pH, so a buffer agent that lowers pH may be beneficial. However, several herbicides, such as *Glean, Classic, Pinnacle,* and *Harmony Extra* are more stable at a high pH than a low pH, so lowering the spray pH too much may actually increase chemical breakdown. Little information is available on the need for buffer agents with herbicides.

Drift reduction agents are added to the spray solution to reduce the potential for physical movement of spray particles from the target area. A good polymer drift agent will reduce drift potential by reducing the amount of driftable fines (droplets less than 100 microns in size) through either increasing the viscosity of the spray solution, increasing the dynamic shear strength of the spray solution, or a combination of both.

Viscosity agents, such as *Nalcotrol,* make the solution thicker, thereby reducing the fine particles, as it takes more spray energy to atomize a thicker solution (honey compared with water). Viscosity agents will generally increase the average drop size of the spray and may alter the flow rate slightly. These compounds are often affected by the pH of the water supply or final solution.

Dynamic shear agents, such as *41-A DF,* increase the retentive strength between molecules, thereby reducing the fine particles, as it takes more energy to tear the liquid apart in the atomization process. Dynamic shear agents generally do not affect the viscosity of the solution and therefore will not change the flow rate. These compounds are less affected by solution pH and will produce a minor increase in average drop size.

Drift control agents vary greatly as to the percentage of active ingredient in the formulation. Therefore, it is important to use drift agents within the rates recommended on the label. Use of rates higher than those recommended may result in an excessive amount of spray "blobs," decreased effectiveness, and may actually increase the amount of driftable fines produced. It is important to recalibrate your sprayer when first adding a spray drift reduction agent, because some drift reduction agents may alter flow rate of the mixture.

Drift reduction agents vary in ease of mixing. However, cold water, poor agitation, and improper mixing sequence will increase initial mixing problems. Dry flowable drift agent formulations recently introduced are easy to measure and generally mix easily. Drift reduction techniques combined with the proper use of drift agents can substantially reduce the applicator's potential drift risk.

Adjuvant Use

The use of spray adjuvants can improve weed control, but may increase crop injury and reduce selectivity. Some herbicides require adjuvants all the time, others may need adjuvants only in specific situations, and adjuvants should not be used with certain herbicides. The best source of information for adjuvant use with a specific pesticide is the label (See Table). The pesticide label should indicate the percent active ingredient, if, when, what type, and at what rate an adjuvant should be used with that product. The label probably will not specify a brand of adjuvant, but rather a specific type.

Environmental conditions and stage of plant growth can influence pesticide efficacy and the need for an adjuvant. Postemergence herbicides must be absorbed through the cuticle and waxes that cover the plant foliage before exerting an effect on the weed. The cuticle and waxes on the leaf surface are defense mechanisms of the plant to avoid dessication and protect against insects and diseases. However, the cuticle and waxes, as well as leaf hairs, also are barriers to pesticide absorption into the plant. Plants develop thicker cuticles and wax layers as they mature or when exposed to long periods of environmental stress such as hot, dry conditions. Thick cuticle and wax layers inhibit herbicide absorption, thus older or drought stressed plants have greater tolerance to herbicides. Surfactant, fertilizer, and/or oil adjuvants often improve control of older or drought stressed weeds by increasing herbicide absorption. However, adjuvants which reduce the surface tension can increase the phytotoxicity of the solution because of increased leaf sur-

Table. Recommended adjuvant use with various herbicides

Herbicide	Surfactant	Surfactant +Fertilizer	Crop oil concentrate	Crop oil Concentrate +Fertilizer	Fertilizer	Other	Comments
Corn:							
Accent	*		**				COC preferred when used alone, but surfactant may be preferred in tank-mixes.
Beacon	*	*	**	*			COC preferred when used alone, but surfactant may be preferred in tank-mixes.
Atrazine			**				Foliar applications only.
Bladex	*					**	Vegetable oil may be used with the lower Bladex rates. **Do not use COC** where selective weed control is desired.
Basagran			**		*		Fertilizer preferred for velvetleaf control.
Laddock			**		*		Fertilizer preferred for velvetleaf control.
Buctril							None
Buctril+Atrazine							None
Marksman							Generally no adjuvant needed, but surfactant may be added to improve control of drought stressed weeds.
Banvel							None
2,4-D							None
Grain Sorghum:							
Atrazine			**				Foliar applications only.
Banvel							None
Marksman							None
Buctril							None
Buctril+Atrazine							None
Laddok			**		*		Fertilizer preferred for velvetleaf control.
2,4-D							None
Soybeans:							
Assure II	*		**				
Fusilade 2000	*	*	**	*			
Fusion	*		**				
Option II			**				
Poast Plus			**				
Select			**	*			
Basagran	**		*		*		
Blazer			*		*		Fertilizer preferred for velvetleaf control.
Basagran+Blazer			*		*		Fertilizer preferred for velvetleaf control.
Classic	*	**	*	*			
Classic+Pinnacle	*	**	*	*			
Cobra	*		**		*		
Pinnacle	*	**	*				
Pursuit		**				**	Methylated vegetable oil plus 28%N has provided the best weed control.
Scepter	**		*			**	Methylated vegetable oil may provide better weed control than surfactant.
Wheat:							
Ally+2,4-D/MCPA	**						Do not add surfactant if applied with liquid fertilizer as the carrier.
Amber	**						
Banvel							None
Buctril							None
Bronate							None
Finesse	**						Do not add surfactant if applied with liquid fertilizer as the carrier.

* = other labeled adjuvants
** = preferred adjuvant

Table. Recommended adjuvant use with various herbicides (continued)

Herbicide	Surfactant	Surfactant +Fertilizer	Crop oil concentrate	Crop oil Concentrate +Fertilizer	Fertilizer	Other	Comments
Wheat (continued):							
Glean+2,4-D/MCPA	**						Do not add surfactant if applied with liquid fertilizer as the carrier.
Harmony	**						
Tordon+2,4-D/MCPA							None
2,4-D							None
Burndown:							
Cyclone, Gramoxone	**		*				
Roundup	*					**	Surfactant+ammonium sulfate preferred at the lower application rates.
Landmaster BW						**	Ammonium sulfate
Fallow Master						**	Ammonium sulfate
Banvel							None
2,4-D							Surfactants may aid kochia and Russian thistle control.
Atrazine			**				
Bladex			**				Prior to crop emergence.

Refer to the specific herbicide label for recommendations on drift reduction agents.

* = other labeled adjuvants
** = preferred adjuvant

face coverage. This may increase the herbicide absorption by crops disproportionately and result in excessive crop injury.

Temperature and humidity at treatment time also can influence herbicide and adjuvant activity. Herbicide absorption generally is greater with high than with low humidity because the spray droplets do not dry as quickly. Also, because the leaf cuticle is hydrated, there are more pathways for herbicide movement into the leaf. Generally, most contact postemergence herbicides such as *Cyclone, Gramoxone Extra, Basagran, Cobra, Blazer,* and *Buctril* are more active with high temperatures than with low temperatures. An adjuvant may improve weed control if the herbicide is applied when conditions are not favorable for activity. However, an adjuvant could increase crop injury substantially if the herbicide is applied when conditions are favorable for activity, as with hot, humid weather. Most herbicide labels outline the temperature and conditions when adjuvants should and should not be used.

Combinations of multiple types of adjuvants may reduce the effectiveness of the individual adjuvants; for example, the combination of a wetting agent that reduces surface tension and viscosity and a drift agent that increases viscosity and modifies surface tension. Adjuvant combinations also may be incompatible, resulting in formation of suspended flocculant. Additionally, certain adjuvants may reduce the efficacy of a herbicide by bonding to the chemical, such as the addition of a clay-based adjuvant to *Roundup.*

Research indicates that adjuvants do not improve the effectiveness of soil-applied herbicides, although compatibility or stabilizing agents may help with mixing and handling these products, especially if applied with fertilizer.

Spray adjuvants should be used only if recommended on the herbicide label, or where experience or research has proven acceptability and effectiveness. Refer to the Table for labeled and preferred adjuvant recommendations with several commonly used postemergence herbicides. The addition of adjuvants to *Banvel,* 2,4-D, or *Buctril* for example, often causes increased crop injury. The nonlabeled use of an adjuvant could exempt the pesticide company from liability for nonperformance or crop injury caused by their product.

Adjuvant Rates

Adjuvants are added to the spray mixture and applied at either a volume per acre, or percent of spray volume basis. Oil and fertilizer adjuvants usually are added on a volume per acre basis; for example, 1 pint, quart, or gallon per acre, regardless of spray volume per acre. Therefore, the quantity to add to the spray tank depends on the number of acres to be treated.

Most surfactants and adjuvants that minimize mixing and handling problems are added on a percent spray volume (% v/v) basis, and the quantity to add depends on the total volume of spray solution. Surfactants often are

added at 0.12–l% v/v, which is equal to 1 pint to 1 gallon of adjuvant per 100 gallons of spray solution. Drift agent labels usually specify a quantity per volume, such as 3–5 ounces per 100 gallons of spray solution.

Surfactants are formulated and sold with various percentages of active ingredient. The percent active ingredient of surfactants probably will affect the rates to use and effectiveness. When a range of surfactant rates is recommended, the high rate generally is for use with low rates of the herbicide, drought stress, control of weeds with a waxy leaf surface, or when the surfactant contains a low percentage active ingredient (less than 50–80 percent). When comparing the economics of various products, be sure to calculate cost per acre, not just consider the initial cost per unit of product.

The rate of adjuvant to be applied should be stated on the pesticide or adjuvant label. The pesticide label is the best source of information for adjuvant use and rate. The adjuvant label provides information on use when the pesticide label does not include adjuvant recommendations.

No endorsement is intended or implied, nor is any criticism implied of similar products not mentioned. Products without label registration are presented for informational purposes only and not as recommendations

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