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AGRICULTURAL SPRAY ADJUVANTS

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A pesticide adjuvant is broadly defined as any substance added to the spray tank, separate from the pesticide formulation, that will improve the performance of the pesticide. This can include everything from wetter-spreaders to feeding stimulants. This is the range of functions covered by regulations in states that require registration of agricultural adjuvants. Washington and Idaho do require registration of adjuvants. Oregon does not. Oregon does require registration of agricultural amendments (sometimes called soil amendments, or substances that modify soil to promote plant growth). Sometimes adjuvants are more narrowly defined as a substance added to a pesticide mixture to improve its physical qualities and hence its effectiveness. This still includes wetter-spreaders, stickers, penetrants, compatibility agents, and so on.

Adjuvants have been used as long as pesticides have been used. In the early part of this century, animal proteins (calcium caseinate) were used as dispersants for lead arsenate. Animal bone glues were used as stickers. At that time, the pesticides that were available were not nearly so effective as now, they were difficult to formulate and disperse adequately, and only a few natural colloids and surfactants were available as aids or adjuvants. At that time, many of the university scientists in pest control research studied formulation aids as a means of squeezing every bit of effectiveness from the few pesticides available.

In the 1940's and 1950's, with the production of thousands of surfactants and the discovery of hundreds of pesticides, most of which were oil soluble, it became sufficiently easy to produce a pesticide formulation that was effective (the activity of the pesticide rather than the formulation became the limiting factor in effectivness).

Consequently, university pest control researchers all but abandoned study of formulation and adjuvants. The result is that when you are confronted with a bewildering array of choices for the purchase of an adjuvant and ask which is the best or which shall I buy, we do not have much test data and cannot give a specific answer. We can tell you what adjuvants are, how they work, or how to glean as much information as possible from the label, and this may help you to make a choice.

The adjuvants registered for use in the Pacific Northwest can be categorized according to the principal use on their label:

Categories of Agricultural Adjuvants

Activators	Special Purpose
Spreaders	Foliar nutrients
wetters	Compatability agents
Stickers	Drift retardants
builders	Foam retardants
extenders	Buffers
Emulsifiers	Inverting agents
dispersants	Soil penetrants
suspending agents	Stabilizing agents (UV filters)
Plant Penetrants	Feeding stimulants
translocators	Washing agents
Emulsifiable oils	Sinking agents
activators	Protectant binders

To the extent that one of the commonest questions about adjuvants is to simply identify what products are available and which are wetter-spreaders, stickers, and so on, it is possible to tabulate the products on the market according to their principal use. There are 155 agricultural spray adjuvants registered in the Pacific Northwest (WA, ID). Nearly half of these are either Wetter-Spreaders or Stickers. Emulsifiable Oils, Foliar Nutrients, and Compatibility agents account for another third of the registrations. Thus, even though there are 17 categories of adjuvants, 80 percent of the array of products available are in only five categories. Seven of the categories comprise trivial uses of minor purpose adjuvants. Of the major uses, all but foliar Nutrients, Buffers, Drift Retardants, and possibly Oils usually depend on surfactants to perform their major function. It is, therefore, of some value to understand the role of the surfactant chemical or principal active ingredients in performing the functions expected of an adjuvant and to be able to read the active ingredient statement on the label when comparing adjuvants and selecting the one right for your situation.

A surfactant is a "surface active agent" and is the active ingredient in most adjuvants. Surfactants are nonionic (do not ionize, but will have a slight electrostatic charge due to the polarity of dissimilar atoms in the molecule), anionic (ionized, have a strong negative charge), or cationic (ionized, have a strong positive charge).

Pesticide Emulsifiable Concentrates, Wettable Powders, and Flowables will contain 2 or 3 surfactants, usually nonionic and anionic. It is rare to encounter cationic surfactants in pesticide formulations.

Adjuvants will usually contain one or two surfactants, most often nonionics but occasionally including anionics. There are sometimes other chemicals included, depending on the purpose. In Wetter-Spreaders the most common principal active ingredient is an Alkyl-Aryl-Poly-Oxy-Ethylenate (one-half the products) or an Alcohol-Poly-Oxy-Ethylenate.

About ten percent of the Wetter-Spreaders contain an anionic surfactant, usually a fatty acid (FA) or a linear alkyl sulfonate (LAS). Stickers, or spreader-stickers, also most often contain an AAPOE surfactant as the principal ingredient but also contain fatty acids and LAS surfactants. Some stickers contain resin acids, menthene polymers, polyethylene plastic, or latex. It is reasonable to assume that products that contain similar surfactants will perform in a similar manner and in

proportion to the amount of active ingredient they contain. This assumption is held in spite of the fact that the molecular species of a surfactant will not be identical even though they carry the same "type" name. Two products may both contain an FA, but one may contain a 12-carbon fatty acid and the other an 18-carbon fatty acid, or an AAPOE may also have different numbers of carbon atoms in the hydrophobic tail and different numbers of ethylene oxide units in the hydrophilic head. These differences can affect how the surfactant acts but are not likely to affect efficiency within a "type" of surfactant when used for the same function within an adjuvant category.

The following brief descriptions of some of the categories of adjuvants may be helpful in clarifying the many functions adjuvants can perform.

WETTER-SPREADERS.

A spray drop must be able to wet the foliage and spread out or cover an area of the leaf for the pesticide to perform its pest control function. In some situations, (very waxy or hairy leaves or insufficient surfactant in the pesticide concentrate formulation), additional adjuvant is needed for good coverage. Too much surfactant may permit runoff or loss of deposit rather than increasing coverage. The surfactant acts here by reducing the surface tension of the water on the surface of the spray drop and by reducing the interfacial tension between the spray drop and surface of the leaf. This requires a surfactant that will preferentially aggregate at these surfaces. This may not be done effectively by the surfactants that form and stabilize the oil/water emulsion from the concentrate formulation.

STICKERS.

A sticker can perform three types of functions. It can increase the adhesion or "stickiness" of solid particles that otherwise might be easily dislodged from a leaf surface, sort of glue them on as it were. It can also reduce evaporation of the pesticide. If the dried residue from a spray drop consists of one-half pesticide and one-half of some other chemical (on a molar basis), the partial molal vapor pressure of the pesticide will be reduced by one-half and the evaporation rate will be accordingly diminished. The third function can be to provide a waterproof coating. If a pesticide is fairly water soluble, it may be washed off the leaf during heavy rainfalls that follow deposition. If the sticker is not water soluble, it can provide a degree of protection from this form of loss. Many of the stickers contain surfactants (AAPOE) as their principal functioning agent and are sold as spreader-stickers, which give both a sticker action and a wetter-spreader action. These will perform the first two functions quite well. But since the surfactants that provide wetter-spreader action must be somewhat water soluble, they may not provide good protection from rain. This will be provided by products that contain latex (rubber), polyethylene (plastic), resins (rosin), polymenthenes (rosin-like), or other waterproofing agents.

EMULSIFIABLE OIL ACTIVATORS.

Petroleum oils will enhance the penetration of some pesticides through the waxy layer of cuticle on a leaf surface and thus increase the rate of penetration. This is why brush is sometimes sprayed with a herbicide in diesel oil as a carrier or diluent, instead of water. The same effect can be gained in part with the addition of small amounts of a petroleum oil like a summer spray oil. Most herbicide activators are emulsifiable light oils containing variable amounts of surfactants to emulsify the oil.

Surfactants will also enhance penetration of some pesticides into plants, and for this reason one often finds the statement on the label of wetter-spreaders that they will increase plant penetration or activate pesticides and are also sometimes called Plant Penetrants or Translocators. This action by a surfactant is not related to its ability to reduce the surface tension of water as is its wetter-spreader action, but is a function of its specific molecular configuration. For this reason, a surfactant may increase penetration for a pesticide on one species of plant but not another, or for one pesticide but not another. It is best to consider specific data on each surfactant/pesticide/plant combination in drawing conclusions about a product's efficacy as a penetrant. Systemic insecticides, auxin herbicides and some other types, and translocatable fungicides can have their activity increased as a result of increased penetration. However, too much increase may result in loss of specificity between the weed and the crop from the action of herbicides.

FOLIAR NUTRIENTS.

These products may contain plant nutrients such as N,P,K, minor nutrients such as Sulfur and Zinc, and a variety of trace elements. They also contain a relatively small amount of surfactant. It is beyond the scope of a handbook on pest control to consider the relative effectiveness of foliar plant nutrients. The surfactant concentration is usually near 2%. Since this is one-tenth to one forty-fifth of the surfactant concentrations in wetter-spreaders, it is clear that these adjuvants will not be nearly as effective as wetter-spreaders in enhancing coverage by pesticides.

COMPATIBILITY AGENTS.

Pesticides can sometimes be combined with liquid fertilizers for application. The advantage is saving a trip through the field. The disadvantages are that there may be unequal distribution of the pesticide and that the pesticide formulation may break under the influence of the strong salt solutions in liquid fertilizers. There is a special class of emulsifiers known as Compatability Agents or Pesticide-Liquid Fertilizer Emulsification Adjuvants that are designed to prevent formulations from breaking when combined with liquid fertilizers. Unless the pesticide concentrate formulation specifically states that it is compatible with liquid fertilizers, it will probably be necessary to add a compatibility agent to ensure that the pesticide will not either cream or sink and thus leave a high treatment rate and a low treatment rate in opposite parts of the run. If you have not had prior experience with the mixture of pesticide/liquid fertilizer/compatibility agent in question, smallscale tests should be conducted in quart jars to determine stability prior to mixing in a spray tank .

DRIFT RETARDANTS.

Drift is a function of drop size. Drops with diameters of 100 microns (0.1 mm) or less contribute the bulk of the drift off site from the treated fields. Chemicals that increase the viscosity and the "tensile" strength of water will decrease the proportion of these smaller drops in a spray system. They will also increase the average drop size, or Mass Median Diameter. This will result in fewer drops per square inch of leaf surface, but it will still be the same rate of deposit of pesticide in pounds per acre. This may or may not affect the level of pest control and resulting crop yield. The need to reduce drift, particularly near sensitive sites, may very well take precedence over small reductions in efficacy. An increase in spray drop mass median diameter does not necessarily mean that the proportion of "fines" or small drops will be reduced with an accompanying reduction in

drift, but this is often the case. To ascertain performance with regard to drift reduction, data on downwind deposit rather than target crop deposit must be examined.

FOAM RETARDANTS.

Some formulations will create foam or a nice head, in some spray tanks. This is usually a result of both the surfactants used in the concentrate formulation and the type of spray tank agitation. This foam can be reduced or eliminated by a small amount of foam inhibitor. Foam is an emulsion of air in water and forms when the surfactant has a preferential air/water interface and good tensile strength. A variety of surfactants will destabilize these air/water emulsions but the most commonly used one is a silicone/carbon polymer known as Dimethylpolysiloxane (Sl). This is sometimes included in Wetter-Spreader adjuvant formulations or is available as a separate product which can be squirted directly into the foam on the top of the liquid in the spray tank.

BUFFERS.

Some water used for diluting pesticide formulations is alkaline (high pH). If the pH is sufficiently high and the pesticide is subject to degradation by alkaline hydrolysis, it may be necessary to lower the pH of the mix water. If the pesticide is alkaline labile but poorly water soluble, the formulation colloids will provide some protection from hydrolysis in the spray. However, to the extent that hydrolysis occurs from the dried salts in the residues on the leaf, the formulation will not provide protection. Buffers contain phosphoric acid or a salt of phosphoric acid, which will lower the pH or acidity of the water and tend to stabilize the pH at an acceptable value. The efficacy of any buffer product depends on its concentration of phosphoric acid and the degree of alkalinity or "hardness" of the mixing water that is being neutralized. The more alkaline the water, the greater the amount of buffer that will be required. Some products give directions indicating the amounts of buffering agent to be used with water of different alkalinity, but not all do. Some buffers have sufficient surfactant present to also perform as wetter-spreaders. The concentration of surfactant and phosphoric acid are usually lumped together and it is not possible to determine the concentration of either and thus predict their efficacy. It appears that for some buffers the surfactant concentration is 50% or more, though some do not contain surfactants, and that the phosphoric acid concentration ranges from about 2 to 10%. Some foliar nutrients that contain phosphorous are also labeled as buffers because the phosphorous nutrient is present as phosphoric acid or a salt and thus can also act as a buffering agent.

Buffers that acidify alkaline spray waters increase the effectiveness of a number of insecticides including Dylox, Phosdrin, Azodrin and Furadan. Some specific data from experiments in the Pacific Northwest are available. Since many organophosphorus and some carbamate materials are susceptible to breakdown in alkaline water and the cost of acidifying is minimal, many persons simply buffer all sprays with a pH of 7.5 or higher. When used at the recommended rate of 1-2 pints per 100 gallons, buffers do not increase the hazard of Dylox to pollinating bees or beneficial predators. All acidifiers tested (Sorba-Spray MG, Nutra Wet, Nu-Trex, Leaf Life, Nutra-Aid, WEX and TRI-fol) reduce pH values of about 8 down to 5.5 or 6 when used at 1-2 pints per 100 gallons. Buffers increase the residual life of trichlorfon about two-fold and can result in reducing the number of spray applications per season. Muriatic acid, Buffer-X or vinegar are not effective for this purpose.

Caution. If a grower chooses to use a Sorba-Spray formulation as an acidifier for Dylox, Sorba-Spray Mg should be used rather than other Sorba-Spray formulations that are incompatible or less effective. Do not apply these materials at nutrient-spray strength in mixtures with insecticides on crops pollinated by bees. Both the timing and dosage will be wrong and killing of bees may result. Reduced effect on lygus bugs may also occur. Do not mix nutrient spray powders with Dylox because they may cause a problem with plugging of sprayer equipment.

Spray additives.

Various other spray additives may increase the effectiveness of insecticides, but these have not been tested under Northwest conditions.

INVERTING AGENTS.

These are special emulsifiers that can invert an oil/water emulsion (the usual type in pesticide formulations) to a water/oil emulsion, or invert emulsion that is very viscous or "mayonnaise-like". This requires special application equipment and is effective in reducing drift.

MINOR PURPOSE ADJUVANTS.

A number of adjuvants for various special purposes exist for which there are only a few products available in each category. For some of these types, there is disagreement among researchers as to their effectiveness, circumstances under which they will be effective, and the concentrations that may be needed to be effective. If you have any questions about the uses or effectiveness of minor purpose adjuvants, it would be best to contact the manufacturer and request the data that supports their claims and make your own decision as to which to