PRODUCTION

How Surfactants Work no. 0.564

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Herbicides provide growers and land managers with a way to chemically manage weeds. They generally inhibit some biochemical process, work with one or several crops, and affect one or several weed species. **Adjuvants** (additives) are an effective way to improve their performance.

Quick Facts...

Adjuvants are any product added to a spray solution to enhance or modify its performance.

Surfactants are specialized additives, formulated to improve the emulsifying, spreading, sticking and absorbing properties of liquids.

The five surfactant classes are: nonionic surfactants, crop oil concentrates, nitrogen-surfactant blends, esterified seed oils and organo-silicone surfactants.

Herbicide, weed species and environmental conditions affect surfactant performance.

Why Surfactants?

Plants put up many barriers to the retention, entry and transport of herbicides. These barriers typically are greater for foliar-applied than for soil-applied herbicides. In addition, environmental conditions and plant factors (age, architecture, leaf morphology and leaf arrangement) may decrease herbicidal activity. Adjuvants are commonly used to improve herbicide performance.

Spray solution adjuvants are available for a variety of purposes. Some of the more common uses include:

- antifoam or defoaming materials,
- compatibility agents to aid mixing herbicides in spray solutions,
- buffer solutions to change spray solution pH,
- foam markers and dyes,
- suspension aids to improve herbicide suspension in spray solutions,
- tank cleaners and neutralizers, and
- surfactants.

Surfactants are a specialized additive formulated to improve the performance of herbicides in spray solution. They are, by far, the most commonly used adjuvant for postemergence herbicides.

Surfactants improve herbicide performance as a result of modifying one or more of the following spray solution characteristics:

- **mixing,** or emulsifying and dispersing oil-soluble and water-soluble molecules;
- **coverage,** or spreading and wetting on leaf surfaces;
- **spray retention,** or sticking on leaf surfaces; and
- **absorption,** or penetrating properties.

How Surfactants Work

Figure 1 illustrates how herbicide spray solution droplets containing surfactant provide greater leaf surface **coverage** and a greater potential for herbicide **absorption** into the plant.

The main barrier to herbicide movement into the plant is a waxy layer, called the **cuticle,** that covers the entire plant surface. Its purpose is to prevent water loss. It also inhibits herbicide movement into the plant.

Herbicides formulated or applied with surfactants reduce the **surface tension** of water and allow for more effective movement of the herbicide through

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the cuticle. Chemical properties of the herbicide, such as water solubility, also can influence how much herbicide enters the plant.

The performance of most surfactants results from three important factors: the herbicide, the weed species and environmental conditions.

Herbicide. Not all herbicides behave similarly in or on the plant. Differences in the herbicide's oil or water solubility influence absorption. Some surfactants work best with a certain type of herbicide and not others. Surfactant solubility should complement the solubility characteristics of the herbicide selected. That is, both should be oil-soluble or both water-soluble.

Weed species. In most situations, the weed species will be the factor which determines the herbicide and formulation selected. However, just as herbicides should be carefully evaluated for a particular use, surfactants perform differently based on the type of plant to be controlled. These differences are based largely on differences in wax content and composition, leaf arrangement and architecture, and plant hairs.

Environmental conditions. Also consider the environmental conditions when selecting a surfactant. Thin, relatively permeable cuticles are favored by high humidity and high moisture conditions. Under low humidity conditions, plant cuticles are generally thicker and harder to penetrate. During such conditions, crop oil concentrates and esterified seed oils can pass through the waxy cuticles better than can nonionic surfactants.

Surfactant Classes

Surfactants can be divided into five major classes with respect to their chemical composition: nonionic surfactants, crop oil concentrates, nitrogen-surfactant blends, esterified seed oils and organo silicone surfactants. Surfactants belonging to a given class behave similarly and have characteristics common with other surfactants in that class.

Nonionic surfactants are illustrated in Figure 1. Although ionic surfactants exist, the most prevalent form of surfactant used with herbicides is the nonionic form. Most nonionic surfactants are composed of linear or nonyl-phenol alcohols or fatty acids.

The function of surfactants in this class is to reduce surface tension, improve leaf surface spreading and sticking, and improve herbicide absorption. Some examples of nonionic surfactants include X-77 (UAP), Induce (Helena), Activator 90 (UAP), Triton Ag 98 (Rhone-Poulenc) and R-11 (Wilfarm).

Crop oil concentrates are a blend of petroleum-based oils (paraffin) and surfactants. The function of surfactants in this class is to reduce surface tension and improve leaf surface spreading and sticking. Some examples of crop oil concentrates include Agri-Dex (Helena), Prime Oil (Terra), Herbimax (UAP) and Crop Oil Plus (Wilfarm).

Nitrogen-surfactant blends typically consist of a premix of various forms of nitrogen and nonionic surfactants. They are commonly used with herbicides recommending the addition of ammonium sulfate or 28 percent nitrogen.

The activity of several herbicides (Accent, Banvel, Blazer, Poast, Pursuit and Roundup) is enhanced by the addition of ammonium as the source of nitrogen in nitrogen-surfactant blends. In addition, weed species such as green and giant foxtail, velvetleaf, quackgrass

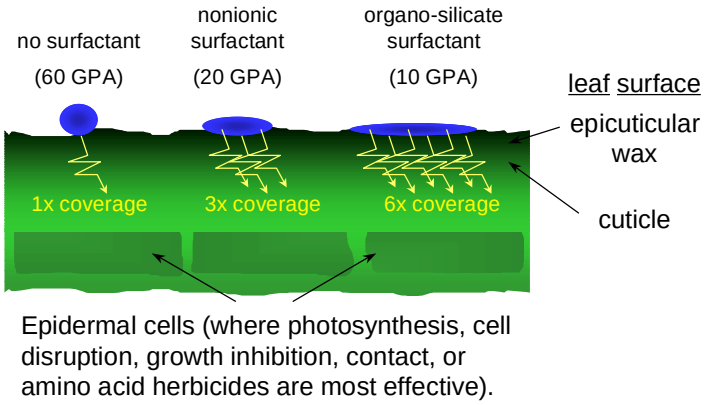

Figure 1: Surfactant effect on spreading and surface wetting.

For More Information

Weed Science, Principles and Practices. *1991. Ashton and Monaco, eds. John Wiley & Sons, Inc., New York.*

Surfactant and Adjuvant Technical Guide. *1996. Wilfarm L.L.C., Gladstone, Mo.*

Crop Protection Chemicals Reference. *1996. Chemical and Pharmaceutical Press, Inc., New York.*

Also see these Colorado State University Cooperative Extension fact sheets:

- *0.558,* Herbicide Formulations.
- *0.559,* Herbicide Surfactants and Adjuvants.
- *0.562,* Herbicide Behavior in Soils.
- *0.563,* Herbicide Selecticity and Performance.

and johnsongrass show increased susceptibility to herbicides containing ammonium.

However, other weeds (lambsquarters, pigweed, giant ragweed, nutsedge and smartweed) show no increased susceptibility to herbicides containing ammonium. Also, certain herbicides show no enhancement with the addition of ammonium.

The function of surfactants in this class is to reduce surface tension, improve leaf surface spreading and sticking, and improve herbicide absorption. Some examples of nitrogen-surfactant blends include Prefer 28 (Cenex), Surf-N (US), Inhance (Brandt), P-28 (Wilfarm) and Patrol (Helena).

Esterified seed oils are produced by reacting fatty acids from seed oils (corn, soybean, sunflower and canola) with an alcohol to form esters. Methyl or ethyl esters produced in this reaction are combined with surfactants or emulsifiers to form an esterified seed oil.

The function of surfactants in this class is to reduce surface tension, improve leaf surface spreading and sticking, and improve herbicide absorption. Some examples of esterified seed oils include Sun-It II (AmCy), MSO (UAP), Scoil (Agsco), Hasten (Wilfarm) and Mes-100 (Drexel).

Organo-silicone surfactants are typically blends of silicone with nonionic or other surfactants. Few are composed entirely of silicone. Surfactants in this class provide a tremendous reduction in surface tension and greatly improve herbicide absorption as compared with conventional surfactants. Some examples of organo-silicone surfactants include Silwet L77 (UAP), Silikin (Terra), Dyne-Amic (Helena), Kinetic (Helena), Sylgard 309 (Wilbur-Ellis) and Century (Precision).

Herbicide-Surfactant Combinations

Figure 2 gives examples of a few commonly used herbicides and an appropriate surfactant for use with each based on oil or water solubility. Because herbicides and surfactants differ in solubility, it is important to match the solubility of each in order to maximize their performance as a combination.

Herbicides in the hydrophilic-lipophilic balance (HLB) range of 1 to 10 are more soluble in oil than water. Those in the HLB range of 10 to 20 are more soluble in water than oil. Likewise, surfactants in the HLB range of 1 to 10 generally work best with an oil-soluble herbicide, and those in the HLB range of 10 to 20 generally work best with a water-soluble one.

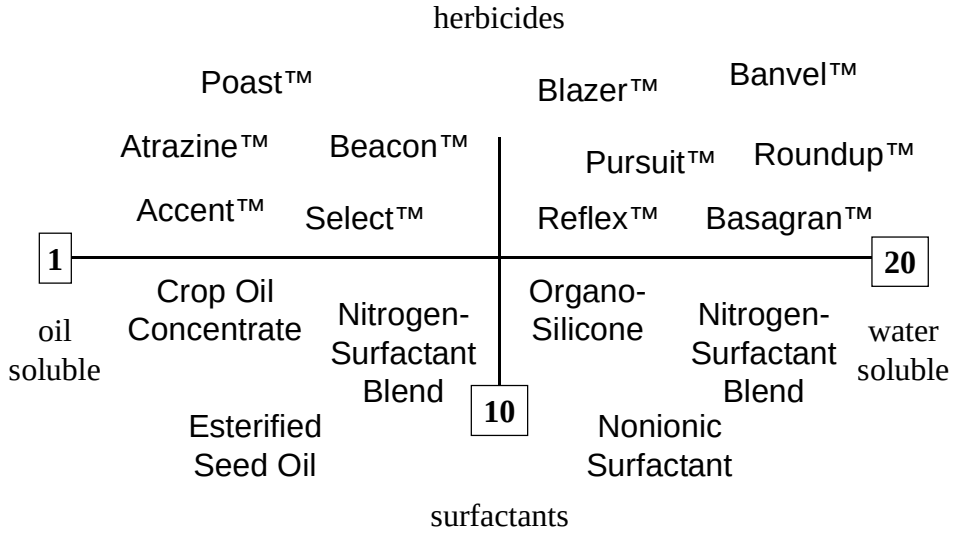

Figure 2: Hydrophilic-lipophilic balance (HLB) range of herbicides and surfactants.

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