SURFACTANTS:

How They Increase Herbicide Action

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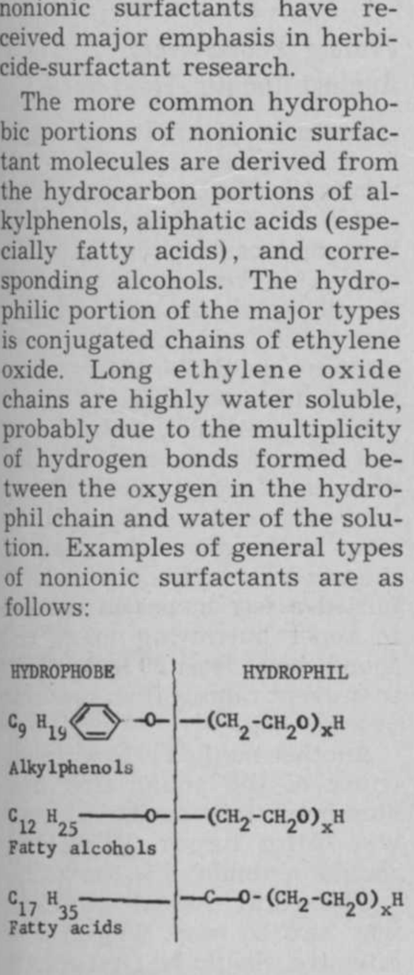
SURFACTANTS are widely used with agricultural pesticides to facilitate application and achieve better control of pests. The reasons for the increased efficiency resulting from surfactants remain obscure. The role of surfactants is often confusing and the terms used by farmers and other nontechnical personnel to discuss surfactants add to this confusion. Some of the terms most commonly encountered, and used interchangeably, are activator, additive, adjuvant, detergent, soap, spreader, surface-active agent, surfactant, and wetting agent. The common assumption that these terms are synonymous has contributed to the confusion that exists in surfactant terminology. Of these, additive, adjuvant, detergent, surfactant, and wetting agent are most commonly used.

The word "surfactant" is derived from the term "surface-active agent" and is defined by the Weed Society of America as "a material which facilitates and accentuates the emulsifying, dispersing, spreading, wetting, and other surface-modifying properties of herbicide formulations." A "wetting agent" is "any compound which when added to a spray solution causes it to contact plant surfaces more thoroughly." Thus a wetting agent is not necessarily a surfactant. An "additive" is "any material that is added to the spray solution and is not necessarily a wetting agent or a surfactant." An "adjuvant" is "that which assists, aids, or modifies" and thus might be as descriptive as any other term for reference to most surfactant-wetting agent materials. The term "detergent" is "any cleaning agent or solvent such as water or soap." Although water may be a detergent, it is not a satisfactory wetting agent because water usually does a very poor job of wetting. Lest this seem confusing, it should be remembered that *to wet* simply means "to cover or soak with a liquid." Spraying with water does not necessarily insure wetting.

Surfactants come in a wide variety of types. Several thousand trade name surfactants are already available. However, numerous hydrocarbon nuclei and polar functional groups are possible, so that there is no practical limit to the possible variety of surfactants. These materials are generally classified as anionic, cationic, and nonionic, depending on the electrocharge of the surface-active group. Anionic surfactants contain negatively charged atoms or groups; cationic surfactants contain positively charged atoms or groups; and nonionic surfactants are neutral. Compounds of the anionic and cationic class can be mixed with nonionics but not with one another. Anionic materials are generally used in detergents for home laundering and cleaning agents. Many emulsifying agents are mixtures of anionic and nonionic surfactants. Although cationic surfactants find many uses, their major outlet has been in various germicidal preparations such as hair shampoos and baby soaps. A few surfactants, also being marketed, are referred to as "formulated" materials. These products contain either an anionic, cationic, or nonionic surfactant plus other materials such as alcohol, fatty acids, etc., which are supposed to aid penetration and translocation. Nonionic surfactants have been the most widely used groups, for reasons discussed below, by Midsouth farmers.

Nonionic surfactant molecules consist of two major chemical groups. One group is fat soluble (lipophilic), water insoluble (hydrophobic), and nonpolar. The second group is water soluble (hydrophilic), fat insoluble, and polar. Because neither positive nor negative ions are produced in any quantity, these surfactants have advantages over anionic and cationic surfactants. Most nonionic surfactants are not subject to hydrolysis by acidic or alkaline aqueous solutions. They do not form salts with metal ions, which make them equally effective in hard and soft waters. Because of these advantages, nonionic surfactants have received major emphasis in herbicide-surfactant research.

The more common hydrophobic portions of nonionic surfactant molecules are derived from the hydrocarbon portions of alkylphenols, aliphatic acids (especially fatty acids), and corresponding alcohols. The hydrophilic portion of the major types is conjugated chains of ethylene oxide. Long ethylene oxide chains are highly water soluble, probably due to the multiplicity of hydrogen bonds formed between the oxygen in the hydrophil chain and water of the solution. Examples of general types of nonionic surfactants are as follows:



The letter x in the hydrophil portion of the molecule denotes the number of moles of ethylene oxide per mole of hydrophobe. Of the general types listed, only the alkylphenols have been retailed to farmers in quantity. The alkylphenols—including the the octyl-, nonyl-, and dodecylphenols—are important because of their ability to increase the activity of foliar-applied 3-(3,4-dichlorophenyl)-1,1-dimethylurea (diuron) to weeds in cotton, and because of economy. Continued research will probably demonstrate many equally effective surfactants.

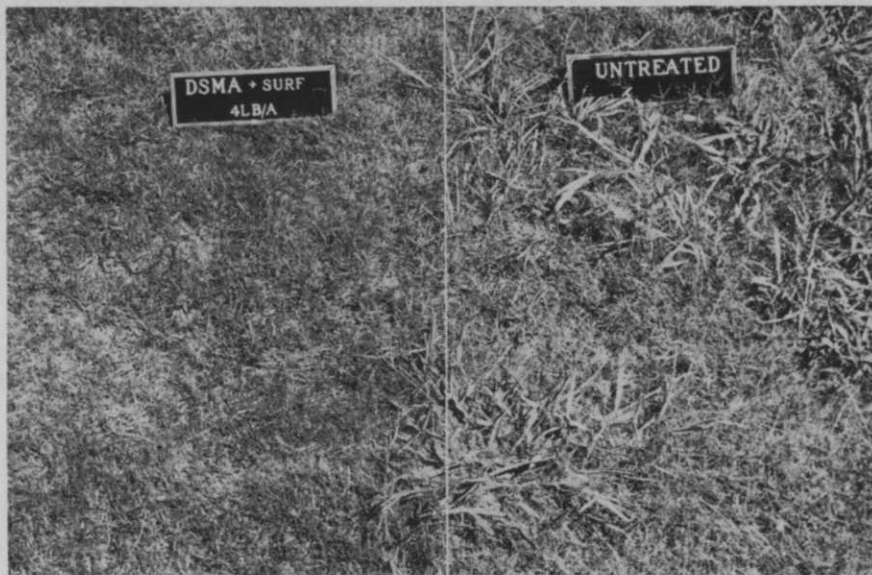


Figure 1. Typical control of dallisgrass in bermudagrass from the application of 4 lb/A of disodium monomethylarsenate (DSMA) plus 0.5% surfactant.

Effects of Surfactants on Herbicides

Aqueous foliage sprays of diuron without surfactant are relatively nonphytotoxic. If, however, a surfactant is included in the spray mixture, diuron is very phytotoxic at rates as low as 0.1 to 0.2 lb/A. Diuron-surfactant mixtures have been widely used in the Midsouth for weed control in cotton. The level of toxicity of these treatments is affected by the type of surfactant used. Ethoxylated nonylphenol surfactants containing 9-10 moles of

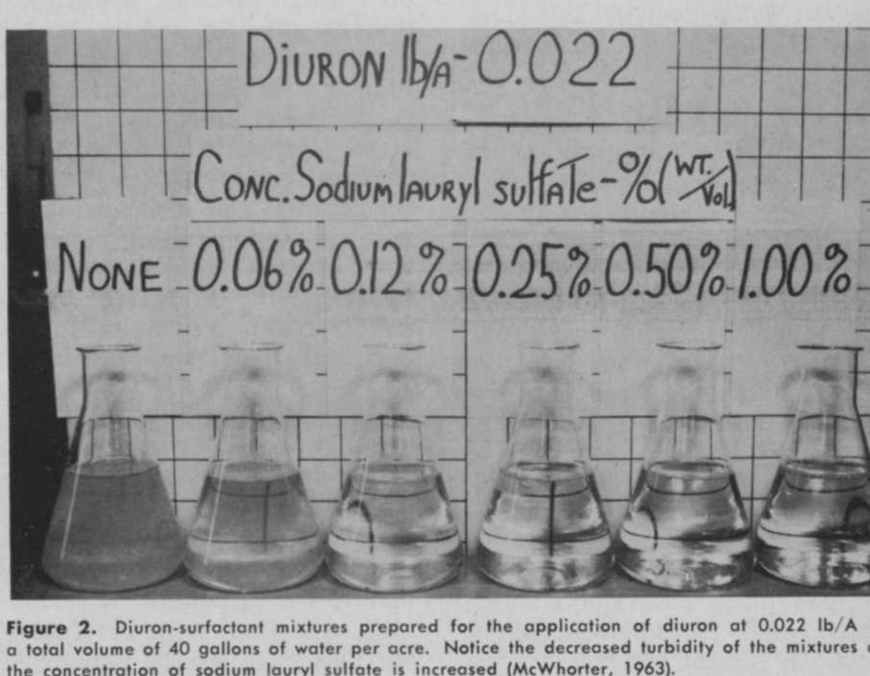


Figure 2. Diuron-surfactant mixtures prepared for the application of diuron at 0.022 lb/A in a total volume of 40 gallons of water per acre. Notice the decreased turbidity of the mixtures as the concentration of sodium lauryl sulfate is increased (McWhorter, 1963).

Table 1. The Effectiveness of DSMA at 4 lb/A in Controlling Dallisgrass in Bermudagrass as Affected by the Addition of a Surfactant.

	No. of plants per sq. feet	Percent Reduction
Untreated	5.29	0
DSMA	2.25	58
DSMA + 0.5% ethoxylated nonylphenol type	0.53	90

ethylene oxide have generally provided maximum crabgrass control when applied in mixtures containing diuron. In these and other greenhouse studies at the Delta Branch Experiment Station, Stoneville, Mississippi, ethoxylated nonylphenol surfactants containing 15-30 moles of ethylene oxide were also effective in increasing diuron toxicity, but they were comparatively poor in increasing spray-mixture wettability.

Surfactants also enhance the activity of herbicides other than diuron. For example, surfactants increase the activity of 3,4-dichloropropionanilide (DPA), used for the control of grasses in rice; 2,2-dichloropropionic acid (dalapon), used primarily for johnsongrass control; and disodium monomethylarsenate (DSMA), extensively used in the Midsouth for nutgrass and johnsongrass control. In addition, DSMA is very effective for controlling dallisgrass in bermudagrass (Fig. 1). The data in Table 1 shows that 0.5% (wt/v) of surfactant increased the control of dallisgrass by 32% over that of DSMA without surfactant.

Surfactants Can Increase Herbicidal Effectiveness

Surfactants can increase herbicidal effectiveness by: (a) improving plant coverage; (b) removing air films between spray and leaf surface; and (c) increasing foliar absorption and translocation. Surfactants improve plant coverage by reducing the surface tension and thereby increasing the total area of leaf surface that becomes wet. Increased wetting of a leaf surface results in the herbicide being spread over a larger area. Improved plant coverage and removal of air films between spray and leaf surface can increase the foliar absorption and translocation of herbicides.

Surfactants can also reduce the turbidity of herbicide spray solutions which may affect herbicide effectiveness (Fig. 2). It was originally believed that surfactants greatly reduced the turbidity of diuron suspensions by increasing the solubility of diuron in water. This is now known to be only partially true. Recent research with diuron-surfactant mixtures has suggested that reduced turbidity results from the formation of colloidal solutions and that diuron is incorporated into the colloid micelles by the process of "solubilization." Although additional research is needed to determine what role surfactants are performing in reducing turbidity, herbicidal activity has been greatly increased.

Even though phytotoxicity of many herbicides is increased by adding a low concentration of surfactant to the spray mixture, this may not always be beneficial inasmuch as a surfactant may eliminate species selectivity, thereby causing greater injury to a crop or turf. Therefore, judicious selection of surfactants is extremely important for the farmer, grower, or turf manager because the proper selection of surfactants and concentrations will aid in controlling resistant weed species. It will also lessen the possibility of damage to desirable plants and decrease the cost of herbicidal application.

Present, Future Surfactant Usage

The use of surfactants with herbicides to increase phytotoxicity has grown tremendously within the past four years in Mississippi. In 1960, approximately 64,000 pounds of surfactant were used with herbicides. By 1963 over 500,000 pounds of surfactant were used to control weeds in agronomic crops, pastures, and rights-of-way. This represents an increase of nearly 700%.

Although there has been a phenomenal increase in the use of surfactants to increase herbicidal action, it appears that this trend has only just begun. In the future a suitable surfactant will probably be chosen for herbicide application, just as a specific solvent is now selected for formulation of a pesticide. Indications are that such information will be available in the next few years. The problem will probably grow more complex. In the future not only will the surfactant be selected for the herbicide, but it will be selected for the particular crop and weed on which the material will be applied. Surfactants will greatly broaden the scope of herbicidal weed control, perhaps enough to surprise even those who are expecting the change.

Protect Young Trees Against Rabbits, Field Mice

Recently planted trees must be given protection during the winter months to prevent rabbits and field mice from eating the bark and causing death of the tree. This reminder is issued by the National Arborist Association, which adds that these precautions should be used to protect shrubs, too.

Ideal protection, which will last several years, is installation of a loose cylinder of ¼-inch hardware cloth, supported by stout stakes about the trunk of the tree. The cylinder should be buried a few inches in the soil to repel burrowing mice, and should be at least 30 inches high to prevent rabbits from reaching over the top.

Another method is to wrap the trunk of the young tree with aluminum foil, burlap, or tree-wrapping paper. Wrappings should be removed in the spring.

Chemical rodent repellents may also be used, which, to be effective, should be used according to manufacturers' directions on the container label.