THE USE OF SURFACTANTS WITH SUBSTITUTED UREA AND URACIL HERBICIDES

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Summary

The use of surfactants for the enhancement of foliar action of pre-emergence herbicides has been a major advance in weed control in recent years. An assessment of the effect of various factors influencing the performance of herbicide-surfactant applications is made, with particular reference to diuron, linuron, and bromacil. Surfactant concentrations, absorption into leaf tissue, humidity, temperature, and the ionic nature of surfactants are among factors discussed.

A MAJOR ADVANCE in weed control in recent years has been the use of surfactants in enhancing foliar activity of pre-emergence type herbicides. Work has been conducted in this area of research in the laboratory, greenhouse and in the field by a great many investigators. The use of certain surfactants with diuron, linuron and bromacil have been registered for commercial use in the United States. These mixtures are also used widely throughout the world.

Despite this widespread use, there is still much to be learned about the use of these surfactant-herbicide mixtures in the field and their mode of action. It is not the purpose of this paper to define the mode of action of these surfactant-herbicide mixtures, but rather to point out some of the work that has been done, to facilitate the proper use of these mixtures under commercial use conditions.

A surfactant is simply another word for surface-active agent.

Historically, surfactants have been used with pesticide sprays to enhance wetting of the sprayed foliage, to increase pesticide deposit on the sprayed foliage, to enhance penetration of the pesticide as a binder agent or sticker to prevent removal of the spray deposit by washing. Ordinarily they have been used at rates of only a few ounces per 100 gallons. In the early 1960s U.S. Department of Agriculture workers in Mississippi reported that the foliar activity of diuron could be enhanced markedly by the additions of high rates of certain surfactants. Reference is now to rates of 0.5 to 1 gal per 100 gal, rather than the few ounces per 100 gal formerly used. This discovery opened a new field of research and development.

It has been discovered that there are many factors influencing the biological activity of herbicide-surfactant mixtures. These include spray volume, spray pressure, foliage coverage, relative humidity, air temperature, stage of growth, drought stress, the chemical structure of the surfactant and the solvent properties of the surfactant.

Heretofore, the so-called pre-emergence herbicides such as diuron, linuron and bromacil have not exhibited marked foliar activity when used alone. The addition of an effective surfactant

can increase the foliar activity of these herbicides to the extent that existing vegetation can be knocked-down rather quickly, and with subsequent rainfall or watering the residual effects of the herbicides prevail.

In general, a 0.5% concentration of an effective surfactant appears to be sufficient for use with diuron, linuron and bromacil to control small annual weeds. Rates as high as 1 or even 2% by volume of spray solution may be necessary to obtain desired post-emergence action on more mature or slower growing weeds or on perennial weeds. It is important to remember that the existing low levels of surfactant present in conventional wettable powder formulations are not sufficient to give the desired effects.

Spray volume, spray pressure and coverage of weed foliage are interrelated factors. A major objective in using herbicide-surfactant mixtures is to make sure that practically all the leaf surfaces of weeds are completely wet after spraying. To achieve this, a greater spray volume and spray pressure may be necessary to penetrate and wet dense masses of weed vegetation than is required with less dense weeds.

Relative humidity appears to play an important role in the movement of the herbicide into the foliage after foliar application of a herbicide-surfactant spray mixture. In greenhouse tests, increased activity with foliar treatments of herbicide-surfactant mixtures on weeds has been observed as the relative humidity increases. Maximum activity occurs at 100% relative humidity.

There is good evidence to indicate that temperature plays an important factor with the herbicide-surfactant mixtures. Greenhouse data show that post-emergence activity of Du Pont Surfactant WK (0.5%) in combination with 1 lb per acre of diuron on Johnson grass (*Sorghum halepense*) is influenced by temperature. With an increase of only 5 to 7°F, the injury to weeds was 20 to 50% greater. Similar trends have been noted with linuron and bromacil.

Field and greenhouse studies illustrate a close relationship between the stage of growth of weeds and their sensitivity to herbicide-surfactant mixtures. It has been found that, with annual weeds, the young tender succulent plant under favourable soil moisture conditions is much more sensitive to such herbicidal mixtures than is a more mature plant. With perennial weeds such as Johnson grass, good results have been obtained from applications which were made when the plants were approaching maturity.

Rates of herbicides which usually provide adequate weed control under normal moisture conditions are inadequate in times of drought stress. Greenhouse data show that the addition of surfactant does not materially improve foliar action of diuron under drought stress. The addition of humectants such as glycerol and ethylene glycol to the spray mixture at a 1% concentration did not reverse the drought stress effect.

The mode of penetration and action of herbicides in the presence of surfactant is still obscure. Theoretically, increased water solubility of the herbicide as affected by surfactant should result in increased foliar activity of the herbicide. No doubt, increased water solubility of the herbicide in the presence of a surfactant is a factor in potentiation of the herbicide. However, experimental results appear to indicate that the enhancement of herbicidal biological activity cannot be strongly correlated with increased solubility, or leaf wettability, or other physical indices.

The ionic nature of the surfactant does not appear to be an important factor in increasing the foliar activity of substituted

urea herbicides such as diuron. However, the specific surfactant and its concentration are important. As the rate of surfactant is increased or the concentrate of diuron is increased, differences between surfactants tend to disappear. It is quite common to hear of recommendations in which "any non-ionic" surfactant is recommended. It is only fair to say that, while most commercially available suitable surfactants for use with diuron, linuron and bromacil are non-ionic, it does not mean that all non-ionic surfactants are equally effective. There is evidence to support the idea that certain anionic and cationic surfactants may be equally as effective as certain of the effective non-ionic surfactants. Thus, a recommendation such as "suitable", "effective", or "satisfactory" surfactant is perhaps more accurate than specifying "any non-ionic" surfactant.

It has long been known that the substituted urea herbicides move upwards in the plant. There is no evidence to date that mixtures of diuron or linuron with surfactant cause the herbicide to move downward in the plant. Surfactants do, however, differ greatly in their ability to aid in depositing high concentrations of herbicide on the leaf tissue and in facilitating transport of the herbicide into leaf tissue, especially during the first 24 hours. For example, after 24 hours the amount of linuron absorbed with "Triton" X-100 treatment was 8 times that of the control (linuron without surfactant) while in combination with Surfactant WK the amount was 17 times greater than the control.

It is apparent that more research work will be required to provide a fuller understanding of the action of surfactant-herbicide mixtures. In the meantime, however, a great deal is known and this knowledge should be put to use.