Status of Research Related to the Use and Effect of Surfactants on Various Crops and Soils

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THE RESULTS of the research efforts of the Atlantic Refining Company and the United States Department of Agriculture (1, 2) related to the use of surfactants as soil additives have had a stimulating effect on others. This stimulation has resulted in a substantial amount of research (4, 5, 7, 8, 9, 10, 11, 13, 14).

Results from an Illinois Farm Supply Company experimental plot (during the summer of 1953), comparing the effect of various fertilizer treatments on both yield quantity and quality, led us to believe that we could discern both yield increase and positive animal taste preference on the portion of the plot treated with mixed fertilizers that contained a small amount of surfactant which had been used to facilitate processing and reduce product caking. Hypotheses related to the possible reasons for observed differentials were related to the members of the American Farm Research Association at a meeting that fall (3).

The first news release on the Atlantic Refining Company work (1) was carried in the Wall Street Journal, closely following the 1953 Dallas, Tex., meeting of the American Society of Agronomy.

Crop Response

Although Lemon's work (2) was confined to an investigation of the suppression of the evaporation of soil moisture with surfactants, the research report of the Atlantic Refining Company included theoretical aspects, effect with regard to permeability, and effect on plant growth.

An examination of Atlantic's results (1), dealing with plant growth, indicates that an application of 15 lbs. per acre of Ultrawet PR-51[2] to Philadelphia clay loam soil resulted in yield increases of 31% for bush beans, 177% for carrots, 84% for tomatoes, 9% for wax beans, and less than 1% for field corn; a decrease in yield of 6% for potatoes; an increase in content of reducing sugars, in some instances of vitamins, and the enhancement of absorption of applied phosphorus by bush beans under the imposed experimental conditions (the applied phosphatic fertilizer was ammonium phosphate).

A review of the University of Wisconsin's 1952–1953 experimental results (11) reveals that yields were significantly increased with broadcast applications of 25 to 100 lbs./A. of Ultrawet PR-51 on several soil types for Sudan grass, canning peas, alfalfa-brome-red clover, red clover-timothy, potatoes, alfafa, red clover, and spinach. No significant yield increases were established for sugar beets, red beets, field corn, and sweet corn.

The crop response results from experimental wheat plots at Southern Illinois University for 1954 (7) indicated no yield increase for any of the comparative, fertility-level, surfactant treatments. The limiting yield factor was lack of moisture inasmuch as this was a year of extreme drought in Southern Illinois. Soil moisture content at 6- and 18-in. levels was determined for each of the experimental plots. Although moisture determinations indicated that surfactant-treated plots contained up to 42% more moisture than the respective, non-surfactant-treated, control plots, significant differences in wheat yield did not exist.

Results of experimental greenhouse work conducted at the University of Illinois during 1954 (8) reveal that various surfactant treatments had no significant effect on rye grass with respect to the efficiency of nitrogen utilization by the plants, yield, and protein content. All test plots were supplied with an abundance of water. Results of experimental, blue grass, field plots revealed that surfactants did not significantly increase the yield; however surfactant treatment did appear to minimize crop "burn" on plots that had received a high rate of nitrogen applied in the fall.

Universal Detergents Inc. reports that the surfactant treatment of mixed pasture grass, experimental plots resulted in yield increases ranging from approximately 8% to 109% (9).

Experimental results obtained by Kansas State College (10) indicate that surfactant treatment ranging from 25 to 200 lbs./A. caused significant though small increases in barley yield. No significant yield differences occurred whenever winter wheat plots were treated with various levels of surfactant.

The Illinois Farm Supply Company experimental plot results (5) for 1954–1955 reveal no significant increase in yield for field corn, soybeans, wheat, red clover, rye grass, and oats. A report from a cooperative experimental plot in Idaho (12) however indicated that surfactant use on an irrigated slope enabled the operator to produce an alfalfa crop for the first time.

Surfactant Effect on Soils

The Atlantic Refining Company (1, 13) has reported that the treatment of soil with surfactant facilitates the soil water intake rate up to an increase of 380%.

Lemon (2) has proposed the hypothesis that soil application of surfactants can effect the economy of water utilization by increasing the infiltration rate and decreasing the evaporation rate. It is also pointed out that the soil application of surfactants accelerates the dry soil "mulching" by "decreasing the water-holding capacity of the surface layer of the soil and reducing the rate of capillary movement of water from lower soil depths." Reported data also show that the application of surfactants to soils in the experiments results in the suppression of the soil moisture evaporation rate, and in two specific instances, (one being particularly outstanding) increases the water-holding capacity of the soil. Lemon also pointed out that unidentified mechanisms affecting the various relationships were obviously in operation.

Vavra (7) shows that the moisture content of surfactant treated plots is higher than that of the non-surfactant treated controls at both the 6-in. and 18-in. levels.

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Spurrier's (8) work shows that differences in soil moisture evaporation rates of surfactant-treated and non-surfactant-treated soils are not significantly different whenever the soils are in an undisturbed environment (that is, where the ambient air above the soil remains static); however the soil moisture evaporation rate of the surfactant-treated soils was greatly reduced with respect to a disturbed environment.

Universal Detergents Inc. (9) reports significantly higher moisture content of surfactant treated soils at 3, 6, 9, 12, 15, 18, 21, 24, 27, 30, 33, and 36-in. depths than the non-surfactant-treated controls. The moisture content differentials appear to become increasingly larger with increase in depth. Universal Detergents also maintains that surfactant enhances soil tilth.

Our Idaho cooperator reported that irrigation of a slope results in high run-off when no surfactant was used. However whenever surfactant was employed as a soil additive, all of the applied water was absorbed by the soil.

Illinois Farm Supply Company research results (5, 6) indicate that surfactant application to certain Illinois soils can accelerate the infiltration rate by 300%. Our results also indicate that the treatment of certain Illinois soils with very small quantities of specific surfactants can significantly increase the water-holding capacity of the soil. The soil tilth on our experimental plots appeared to be improved in many instances.

Plant Emergence and Phytotoxicity

Spurrier (8) reports toxicity of surfactant (alkyl aryl sodium sulfonate) to soybeans and wheat at an aqueous concentration of 10,000 p.p.m. and to alfalfa at approximately 1,000 p.p.m. No significant increases in germination were apparent with all levels of surfactant treatment.

Copper (4) reports possible benefits with respect to time of emergence for corn. This effect becomes more apparent with decreased saturation of the planting medium (below 45% saturation).

Illinois Farm Supply Company results (6) indicate that surfactant applications possibly result in increased emergence rate and increased plant survival.

Conclusion

A perusal of the existing inconsistent and incompatible results of both field and laboratory experimentation with surfactants on various crops and soils stimulates our thinking and results in the inevitable questioning, formulation of hypotheses, and subsequent further experimentation that either validates or invalidates our basic understanding of the problems involved and our working hypothetical concepts.

At this point an examination of past experimental work brings a number of questions to our attention. Examples of questions demanding further experimentation for the elucidation of surfactant effect are as follows:

Are the surfactant functions resulting in plant-growth stimulation synonymous with the surfactant functions resulting in the alteration of soil properties?

Why does the selective addition of surfactant to specific soils increase the water-holding capacity of these soils?

Why does not the selective addition of surfactant increase the water-holding capacity of other specific soils?

Why does the selective addition of surfactant to various crops on a specific soil result in yield increases for some crops but not others?

If the addition of a surfactant to a soil results in a significant elevation of the moisture content of that soil, why is it that the crops produced on the surfactant-treated soils do not respond to the differential moisture during periods of moisture stress?

Is the surfactant effect purely physical in nature, or are we altering the physico-chemical system?

Does the use of surfactants affect only the process rate, or does it alter the system of the process itself?

Do connections exist between the functions of humates and soil organic matter and the functions of surfactants in the soil?

It appears logical to conclude that the primary responsibility for future research and development of this use for surfactants largely rests with the members of the American Oil Chemists' Society. The revelation of the mechanisms of the functions of surfactants with specific soils and crops could feasibly be translated into handsome profits. The potential is there as a challenge.

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