Use of Surfactants to Alleviate Dry Zones in Potato Hills and Decrease Nitrate Leaching

Eric Cooley and Birl Lowery

Department of Soil Science
University of Wisconsin-Madison

Introduction

From previous research, we found that overhead sprinkler irrigation and related recommended scheduling techniques result in an extremely dry soil zone in the portion of potato hills that contains the highest root density (Cooley et al., 199_). This dry zone is located at a 1-foot depth, directly below the top of the potato hill. This zone continues to desiccate over the course of the growing season, inhibiting proper water and fertilizer distribution to this region. We think that this dry zone results in decreased productivity and increased nitrate (NO₃) leaching. Thus, it could potentially contribute to groundwater contamination.

It is hypothesized that a combination of four factors causes this dry zone in the potato hill. The first is the high root density in this region causes a large uptake and removal rate of soil moisture from this zone. Second, hill geometry reduces infiltration of precipitation and irrigation water into the center of the hill and promotes water drainage to the furrow. Third, that the potato canopy which captures water and produces stem flow to the center portion of a potato hill, lays down as the growing season progresses and channels less water to the dry zone portion of the potato hill (Saffigna et al., 1976). Fourth, the sandy soils in these regions become hydrophobic as water content decreases in the soil, which reduces water infiltrating capacity in the dry zone (Hart et al., 1994).

It has been shown that surfactants can be used to increase water infiltration into hydrophobic soils (Pelishek et al., 1962; DeBano, 1971). Surfactant decreases the contact angle of soil water and soil particles by decreasing surface tension of soil water, thus increasing infiltration rate of unsaturated soils (Lowery, 1981). While surfactants increase water infiltration into hydrophobic or non-wetting soils, it may decrease water flux and aggregate stability in wettable soils (Pelishek et al., 1962; Mustafa and Letey, 1969; Miller et al., 1975).

The objective of this research was to determine the effect of surfactant on increasing soil water content in potato hills. A second objective was to determine if surfactant could be used to reduce NO₃ leaching.
Materials and Methods

We initiated a study in the spring of 1998 to apply surfactant to potato hills to induce greater water infiltration into the dry zone. The study was conducted at two sites. One site consisted of a small plot near Arena, Wisconsin, in the Lower Wisconsin River Valley on Sparta sand; the second was in a large field at the Wallendal family farm at Grand Marsh, Wisconsin, in the Central Sands Area of Wisconsin on Plainfield sand. Three plots at Grand Marsh were 48 ft x 100 ft consisted of 16 rows planted at a 36-inch spacing. Eight rows served as the control and the other eight rows had surfactant applied. The three plots at the Arena sites were 11.3 ft x 80 ft and consisted of four rows planted at a 34-inch spacing. One plot was a control while the other two were test plots with applied surfactant. Preference®, a non-ionic surfactant, was applied to all test potato plots at a rate 1 gallon/acre. A combination of three different application methods of surfactant to the potato hills was instituted (Figure 1). These were:

1. An 8-inch spray pattern of surfactant was made over seed pieces at planting to 9-inch depth at Grand Marsh site.

2. An 8-inch spray pattern of surfactant was made on sides of potato hill prior to second supplemental nitrogen application at Arena site.

3. A solid stream spray pattern of surfactant on the potato hilltop prior to second supplemental nitrogen application at Arena site.

Figure 1. Surfactant application placement.
To assess the impact of surfactants on NO₃ leaching, soil water sampling was conducted with porous-cup soil water samplers. Water content was measured with a dielectric capacitance technique called time domain reflectometry (TDR). The TDR system was used to monitor volumetric water contents at various depths and positions in the potato hill. Soil water content measurements were taken every 15 minutes during the growing season. Porous-cup samplers were installed at a 3-foot depth below the top of the potato hill. Soil water samples were collected from the porous-cup samplers weekly and analyzed for NO₃. It is thought that any contaminants that reach a 3-foot depth cannot be removed by potato roots and possibly cannot be denitrified by microbial activity. We anticipate that any NO₃ at this depth will leach to the groundwater.

Crop yields were measured on each plot to determine differences in yield between treated and untreated plots. Potatoes from each plot were cut, dried, and ground and are being analyzed for NO₃ content at the UW Soil and Plant Analysis Laboratory. The potatoes were also graded to determine relative quantities of different sizes.

**Results and Discussion**

Results from this first-year research project are encouraging. The concentration of NO₃ in water that leached below the potato hills was markedly decreased where surfactant was applied (Figures 2 and 3). Slightly higher yield and potato sizes were also observed (Tables 1 and 2).

Data from the TDR system showed an increase in water content in the dry zone of the hill in plots treated with surfactant. Soil water content in plots treated with surfactant averaged 5% higher than in non-treated plots. Soil water content in the furrow was much lower in surfactant treated plots; thus, there was a much higher infiltration rate into the potato hill and less runoff into the furrow in surfactant treated hills.

Graphs in Figures 2 and 3 show that NO₃ leaching below the potato hills with surfactant was much less than that under untreated potato hills. This is likely due to better utilization of nitrogen fertilizer because it moves with water and comes in contact with more roots in the center of the hill. Thus, it appears that with the surfactant more fertilizer/water solution penetrates the center of potato hills and less solution or water flows down the hillside into the furrow where there are few or no roots.

In all plots where surfactant was applied, NO₃ leaching was less than in plots where no surfactant was applied. With the center portion of the hill at a higher water content, higher calcium uptake and lower blistering of potato skins may also occur.

This study will be repeated in 1999 with variations in fertilizer and surfactant application rates and methods. Experiments with dyes and soil moisture monitoring techniques will also be implemented to gain a better understanding of the flow patterns and effects of surfactants on water infiltration in potato hills.
Table 1. Grand Marsh yield data.

<table>
<thead>
<tr>
<th>Plot</th>
<th>Average yield tons/acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>91.0</td>
</tr>
<tr>
<td>Surfactant w/seed piece</td>
<td>95.5</td>
</tr>
</tbody>
</table>

Table 2. Arena yield data.

<table>
<thead>
<tr>
<th>Plot</th>
<th>Average yield tons/acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>30.3</td>
</tr>
<tr>
<td>Surfactant; banded hillside</td>
<td>31.7</td>
</tr>
<tr>
<td>Surfactant; stream hilltop</td>
<td>31.2</td>
</tr>
</tbody>
</table>

References


This page intentionally left blank.