LUNAR

TECHNICAL INFORMATION BULLETIN

LUNAR Soil Surfactant is a non-ionic surfactant designed to be used as a preventative treatment to prevent water repellent conditions in greens, tees, surrounds and other important areas on the golf course. LUNAR amends soil profiles and successfully addresses problems with water movement, water distribution, hydration and drainage in root zones caused by water repellency on mineral surfaces in soil profiles. LUNAR's blend of leading edge surfactants also provides the professional turfgrass manager with a highly effective tool to improve rootzone quality and productivity during stress conditions. LUNAR promotes the uniform and stable movement, retention and distribution of water and dissolved nutrients to plant roots and ecological communities that reside in this critical portion of the soil profile.

The rootzone defines the area where turfgrass draws moisture and also defines the rich reservoir of life-essential physical, chemical and biological processes for the turf plant. The rootzone is the target for applied fertilizers, pesticides and other plant health products that need to be directed to the plant via the root system. Therefore, it is essential that water movement into and through the rootzone proceeds in a uniform fashion and that distribution of air and water remain reliably consistent.

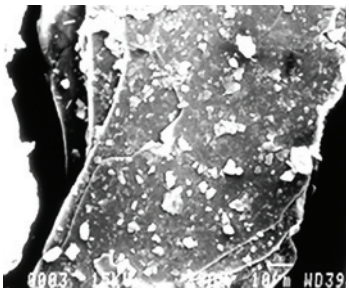
SOIL WATER REPELLENCY

Sand is the primary mineral fraction of the rootzone mixture for greens, tees, surrounds and other high value areas of the golf course. Sand provides a coarser soil texture than native soils, which maximizes water infiltration, air-filled porosity and percolation potentials. However, because of its very small surface area (as compared to clay soils), greens with high sand content are highly susceptible to becoming coated with waxy/non-polar compounds (associated with decomposition of plant litter and through exudates produced by microorganisms present in the soil).

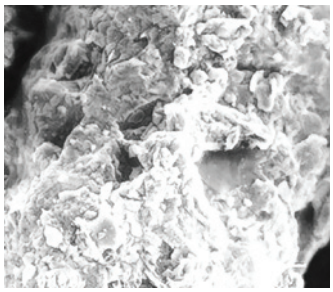
Non-polar Organic Coatings

The build-up of water repellent, non-polar organic coatings on mineral surfaces in the upper root zone has been identified by the general scientific community as the primary cause of soil hydrophobicity.

Many scientists point to humic substances as an example of organic polymer materials that will adopt conformational changes in order to facilitate their adsorption to the soil particle interface and ultimately form non-polar (water repellent) films or "coats." As a result, the surface of the soil particle surface can quickly be covered with adjoining sequences of these adsorbed, non-polar polymer chains. These "coatings," when subject to wetting and drying cycles, can rapidly become water repellent (hydrophobic).

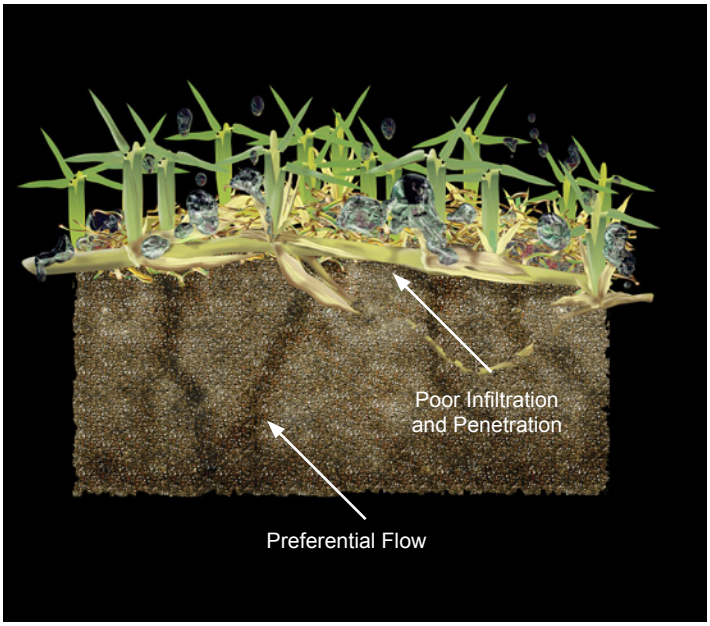


Electron micrograph of wettable (hydrophilic) soil particle. Little humic substance is visible.



Electron micrograph of non-wettable (hydrophobic) soil particle. Layer-on-layer deposition of humic substances is very visible.

When water molecules encounter hydrophobic areas as they move through the soil profile, they cannot adhere to the surfaces of the soil particles, resulting in the disruption their uniform movement through the rootzone. Oftentimes, this disruption of water's uniform wetting front can create areas of preferential flow (sometimes referred to as "fingered flow") that rapidly move water away from the rootzone -- leaving sections of the green without an adequate supply of water and nutrients. Understandably, hydrophobic conditions in the rootzone have been found to exacerbate the problems associated with heat and water deficit stresses.



Cross section of soil profile showing poor infiltration, poor penetration and a non-uniform wetting front – resulting in preferential flow of water.

The standard practice for addressing water-repellent sand root zones is the routine application of non-ionic soil surfactants. Block copolymers have now become the preferred surfactant chemistries because of their effectiveness and plant safety. However, not all surfactants (even block copolymer constructions) are the same as each chemistry produces it's unique pattern of attachment and hydration on the mineral particle surface. Therefore, the use of "blends" of surfactants has now become an important consideration in the development of newer, more effective turfgrass surfactant formulations.

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Surfactants attach to the soil particle surfaces and reduce surface tension that enhances water penetration, infiltration and uniform flow of water in the soil – even within highly water repellent rootzone profiles. Once attached to the non-polar surfaces, negative sites on the surfactant molecules serve as sites for water molecules attachment (adhesion). Attachment of water molecules to the surfactant molecules contribute to a uniform and consistent pattern of hydration.

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LUNAR soil surfactant deploys the use of different but complementary triblock surfactant chemistries to prevent problems associated with localized dry spots, poor infiltration of applied water and non-uniform water movement into the root zone (the symptoms of water repellency). LUNAR surfactant chemistries have different molecular constructions, attach differently to non-polar areas on soil particles and form different hydration patters. But when placed in a surfactant formulation together, they perform much better than singular surfactant chemistries when treating a soil profile with varying degrees of hydrophobiciy.

Both surfactants in the LUNAR formulation contain non-polar sites within their molecular architecture that the surfactants use to bond to the water repellent areas on soil particles within the soil profile. Once attached to the non-polar surfaces, negative sites on the surfactants' molecular structure serve as locations for water molecule attachment (adhesion).

Attachment of water molecules to the surfactants in LUNAR promote hydration to meet the turfgrass plant's demand for water. This also results in an unobstructed downward flow of water into the unsaturated soil matrix. Infiltration is enhanced as water molecules are attracted to negative sites on soil particle surfaces as well as negative sites on LUNAR surfactants that have attached to nonpolar areas on water repellent areas of the soil matrix. **The LUNAR surfactant blend reduces surface tension that enhances penetration, infiltration and contributes to uniform movement of water within the soil profile**.

Once water moves into the soil profile, the larger, more complex difunctional copolymer surfactant in the LUNAR formulation also promotes uniform vertical and lateral movement of water and solutes into and through the soil profile (matrix flow).

When incorporated within a comprehensive root zone management program, use of LUNAR's unique surfactant chemistries will result in:

- Increased water use efficiency
- Uniform movement and availability of water, fertilizers and other water soluble materials into and throughout the rootzone
- Root zones with vastly improved air-to-water ratios
- Reduced moisture stress to turfgrass
- Prevention and treatment applications for localized dry spot and water repellent soils
- Improved drainage
- Improved turf resilience and stress tolerance

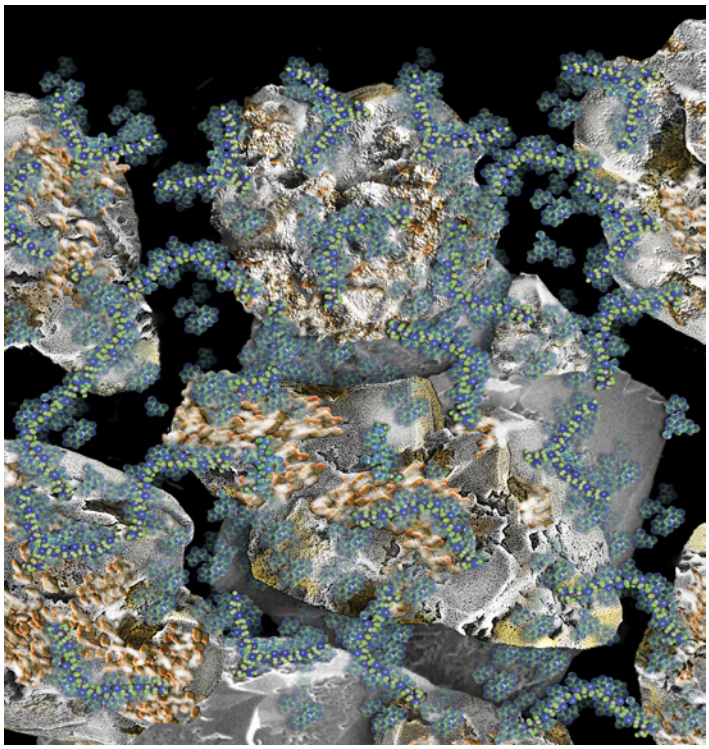

Illustration showing hydration matrix formed from the surfactant blend found in LUNAR. Not only is hydration enhanced, but air-to-water ratios are improved and movement of water from irrigation or rainfall events moves uniformly throughout soil profile.

DIRECTIONS FOR GENERAL TURF USE

GREENS, TEES, SURROUNDS AND SPORTS TURF

Localized Dry Spot and Water Repellency Conditions:

Apply LUNAR as a preventive program. LUNAR should be applied at 4-6 ounces (125 - 180 ml) per 1,000 sq. ft. (100 m^2) in 2 gallons (8 L) of water. Reapply every 30 days throughout heat stress period.

It is highly recommended that LUNAR Soil Surfactant be applied at least 30 days prior to the development of environmental conditions that promote plant stress and water repellency on thatch and soil particle surfaces.

NUMERATOR
TECHNOLOGIES, INC.
P.O. Box 868
Sarasota, Florida 34230
941.807.5333