REBALANCE

SOIL CONDITIONER
SOIL SURFACTANT

TECHNICAL INFORMATION BULLETIN

Today, golf course superintendents must deal with turfgrass that has become less tolerant to heat and water deficit stress due to shortened root systems and lower carbohydrate (energy) reserves caused by today's use of lower mower heights, increased play (wear) and poor water quality. They are further challenged with soil profiles that are subject to non-uniform hydration and water movement caused by hydrophobic conditions on sand profiles.

Cool season turfgrasses often suffer from extended periods of heat stress, water deficit stress, or both during summer months. Heat and water deficit stresses manifest themselves as declines or reductions in turf quality, root growth, leaf water potential, cell membrane stability, photosynthetic rate, photochemical efficiency and carbohydrate accumulation.

Summer Bentgrass Decline

Thinning of cool season turfgrass on putting greens in the midsummer is commonly referred to as summer bentgrass decline (SBD). The cause of summer bentgrass decline is closely associated with high temperatures (both ambient and soil), high relative humidity, poor soil aeration and excessive or deficit soil moisture.

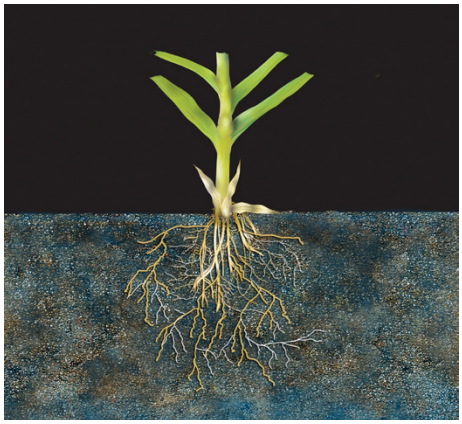
Soil temperature is considered to be the primary factor leading to SBD. Root dieback is frequently experienced as midsummer solar radiation elevates soil temperatures above 30º C - 35º C (85º F - 95º F).

Root mortality can be as much as 40% - 50% during the summer. Researchers report that reductions in root biomass and root death in response to high soil temperatures usually precede any decline in turf quality.

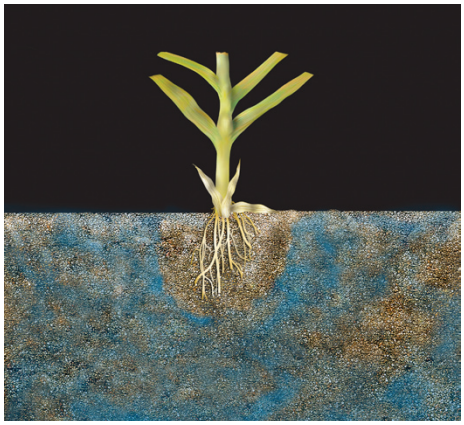
During these conditions, carbon allocation to roots decrease. While root production doesn't come to a complete stop, it is minimal. Researchers report that loss of root biomass and increased root mortality usually precede decline in shoot growth and turf quality.

As the root system declines, one can expect reductions in:

- the supply of water to the plant
- nutrient availability
- hormone synthesis that plays major roles in turf quality



Typical spring conditions showing healthy root mass and abundant water sources



Early to midsummer conditions showing root dieback and inability of root system to reach water sources

Water Deficit Stress

Even when grown in moist soil, turfgrass may experience daily periods of water deficit. Water deficit is a normal phenomenon that occurs in plants during the daytime when loss of water from the leaves exceeds water uptake in the roots. This deficit is normally made up at night and during periods of rain or dew formation.

Under high transpirational demand (such as occurs in midsummer), daytime wilting occurs when roots are incapable of drawing enough water from the soil to replace daytime water loss. This can occur as the result of the roots not being physically capable of reaching sources of water. It can also occur when water is diverted from roots due to non-uniform movement of water through the rootzone (preferential flow).

Water stress is characterized by the reduction of water content, turgor, total water potential, wilting and closure of stomata. Under extreme water deficit stress, **one can expect an inhibition of various physiological and biochemical processes such as**:

- **Photosynthesis**
- **Respiration**
- **Metabolic activities**
- **Carbohydrate production**
- **Chlorophyll production**
- **Hormonal activity**
- **Cell production and growth**

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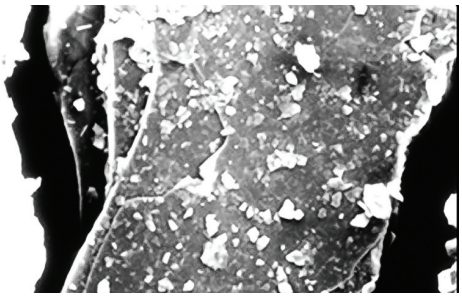
Water Availability

Water is essential for supporting plant life. It is the carrier in which dissolved minerals enter and move about in plants.

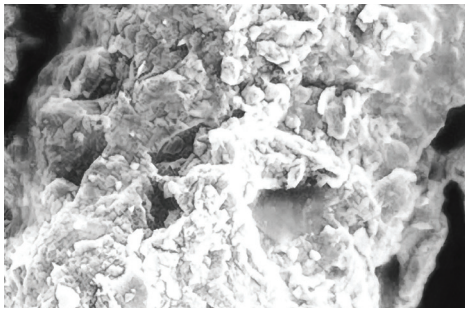
Water is also necessary for photosynthesis, the chemical conversion of sunlight into carbohydrates, to occur. Plant cooling and nutrient transport also occurs as a result of water movement through the plant and its release through leaves as vapor (evapotranspiration). Finally, water has a structural role in maintaining plant turgidity or rigidity.

Sand, as the primary mineral fraction of the rootzone mixture, provides a coarser soil texture than native soils, maximizing water infiltration, air-filled porosity and percolation. However, greens with high sand content tend to be more water repellent than native soils.



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

Because of its limited surface area, sand is 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).



Electron micrograph of non-wettable (hydrophobic) sand particle. Multiple layer deposition of humic substances is very visible.

It is well documented that natural organic matter in soils interacts with surfaces of inorganic materials, primarily aluminosilicates or clay minerals, to form a strongly associated organo-mineral composites that can form "coatings on soil particle surfaces.

These "coatings," when subject to wetting and drying cycles, can rapidly become water repellent (hydrophobicity) **and severely disrupt the uniform movement of water through the rootzone. Oftentimes, this disruption of the uniform wetting front can create areas of preferential flow (sometimes referred to as "fingered flow") that rapidly move water from the rootzone** -- leaving sections of the green without an adequate supply of water and nutrients. Hydrophobic conditions in the rootzone exacerbate the problems associated with heat and water deficit stresses.

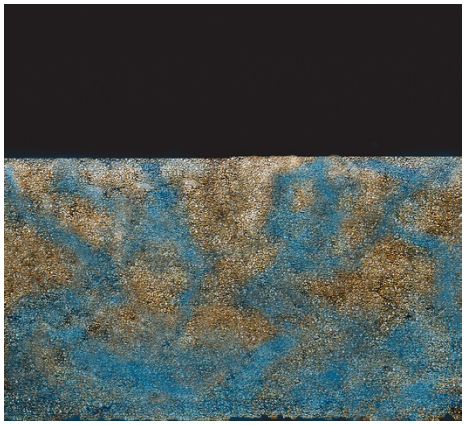


Illustration depicting preferential flow in sand-based rootzone.

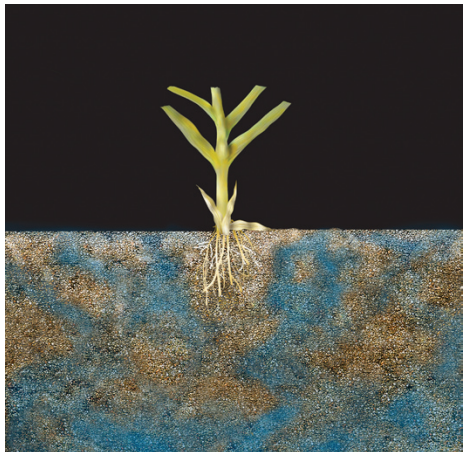
Mowing Heights

The impact of low mowing heights has been confirmed by the scientific community as having a profound negative impact on plant growth, development and stress tolerance.

At higher mowing heights, the turf plant, is able to efficiently make use of available energy, carbon dioxide and water to produce (via photosynthesis) both structural and non-structural carbohydrates (sugars) that the plant uses as raw materials for growth, repair and metabolic maintenance.

With lowered mowing heights, the amount of available leaf-blade surface for photosynthesis is significantly reduced. The turf plant must now reallocate its production of carbohydrates and may be required to use stored carbohydrate reserves for some of its regrowth, repair and metabolic requirements. **As stored carbohydrate reserves are depleted, plant growth, vigor and stress resistance decrease**.

Plant root mass and rooting depths are also reduced under lowered mowing heights. Shoot density increases at the expense of root density. **Shallow-rooted turf is more sensitive to heat and water stress than deep-rooted turf and cannot use soil water reserves adequately.**



Shallow rooted turfgrass plant showing signs of heat and/or water deficit stress in water-repellent soil

REBALANCE is an advanced rootzone soil surfactant and soil conditioner designed to enrich roozone profiles and enhance hydration, water movement, and promote uniform water distribution influenced by water repellent soil. The product contains a leading edge triblock surfactant and an auxin-enhanced seaweed extract (SWE). In addition to serving as a reservoir for major and minor nutrients, amino acids and vitamins, the amended seaweed extract also contains cytokinin and auxin -- important organic compounds that have been shown to enhance turfgrass tolerance to heat and water deficit stress.

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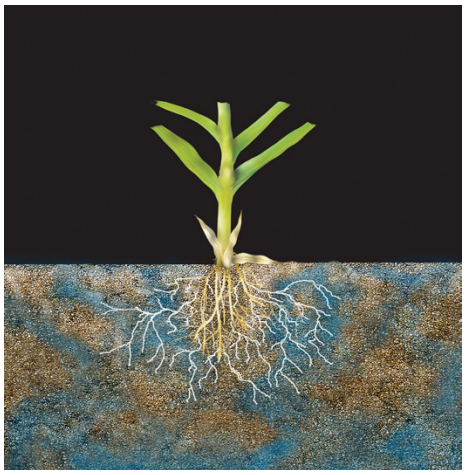
Seaweed Extract Component

Seaweed extracts (SWE) have been used as fertilizers and soil conditioners for centuries --serving as a reservoir for major and minor nutrients, amino acids and vitamins B1, B2, C, and E. More recently, seaweed and seaweed extract have been found to contain cytokinin and auxin -- important organic compounds that have been shown to enhance turfgrass tolerance to heat and water deficit stress.

Seaweed extracts may play an important role in restoring roots damaged from either high soil temperature alone or in combination with high air temperature. Auxins and cytokinins found in seaweed extracts induce the formation and growth of roots and shoots. A higher ratio of auxin to cytokinin ratio favors root production. Conversely, a high ratio of cytokinin to auxin favors shoot production.

Auxin is also important in the ratio because it is strongly associated with the elongation (growth) of cells. Additional auxins have been added to the REBALANCE formulation in order to provide an effective seaweed-based soil conditioner that consistently contributes to the plant's ability to increase the effective root area of absorption (root mass) during mid-summer stress conditions.



Re-establishment (regrowth) of viable root system with increased capability of reaching more sites of water

Roots are the primary sites of cytokinin synthesis and supply cytokinin for shoots. Root dieback under high soil temperatures can result in reduced cytokinin availability that may suppress the integrity of the photosynthetic apparatus and other key physiological processes and defense mechanisms influenced by cytokinin in turfgrass.

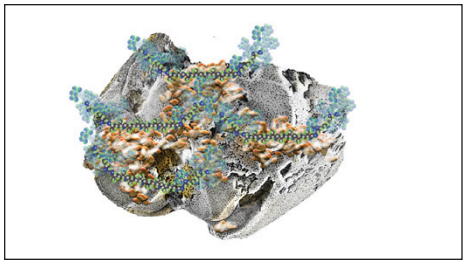
Researchers have found the when turfgrass roots are damaged or unhealthy from heat stress, cytokinin applications in the rootzone appear to reinstate cytokinin activity in the turfgrass plant and help mitigate heat stress injury.

Surfactant Component

In order to overcome environmental stresses caused by high temperatures and water deficit, it is imperative that water is available in the rootzone to satisfy traspirational demand by the plant.

The rootzone defines the area from which turfgrass can draw moisture as well as serves as a rich reservoir of life-essential physical, chemical and biological processes for the turf plant. The rootzone is also 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 is uniform and that distribution of air and water remain consistent.

Included in the REBALANCE formulation is a complex tri-block copolymer surfactant. It was chosen for its exceptional ability to establish or restore adhesion sites (negative sites) on thatch, surface litter and soil particle surfaces. The tri-block copolymer construction of the REBALANCE surfactant contains non-polar "anchors" that the surfactant uses to adhere to the water repellent surfaces on and within the soil profile.



Hydration of sand particle as water molecules attach to negative sites on REBALANCE surfactants

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 produce a very uniform and consistent pattern of hydration and of the surfaces and reduce surface tension that enhances penetration, infiltration and contributes to uniform flow in the soil – even within highly water repellent rootzone profiles.

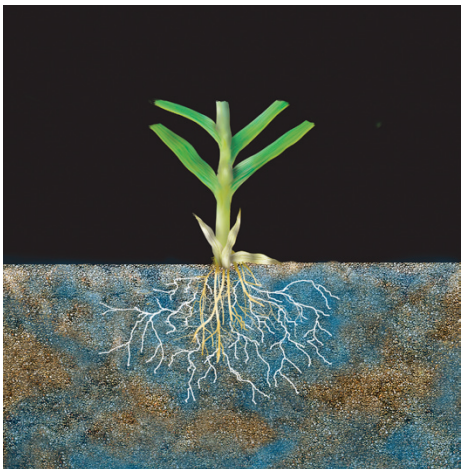


Illustration of increased hydration and uniformity of water movement created by REBALANCE surfactant

Benefits

Best results from use of REBALANCE can be expected when it is used to supplement well-planned and properly implemented cultural practices. Counters depletion of cytokinin and auxin synthesis during heat and water deficit stress conditions

- **Promotes the development of more extensive, healthier root systems that facilitate water and nutritional uptake by turfgrass**
- **Contributes to improved stress tolerance**
- **Increases transpirational cooling**
- **Improves air-to-water ratios in rootzone**
- **Corrects non-uniform movement of water into and through soil profile caused by water repellent conditions**

DIRECTIONS FOR USE

We highly recommend that REBALANCE be used in concert with a well-planned turfgrass management program that addresses heat and water deficit stress conditions.

Programs designed to address heat and water deficit stress

For best results, use of REBALANCE should start at least 30 – 60 days prior to anticipated onset of heat or water deficit stress conditions. Apply REBALANCE every 14 – 28 days during stress conditions. Tank mix REBALANCE at 2 – 4 oz. (60 - 120 ml) per 1000 ft.^{2} (100m^2) in 2 gallons (8 L) of water.

During periods of high temperature and water deficit stress, **REBALANCE is also available in a pellet formulation for supplemental hand syringing.** Each REBALANCE pellet will treat 6000 - to 8000 ft.^{2} (600 - 800 m^2)

Programs designed to address post stress recovery from heat and water deficit stress:

For best results, apply REBALANCE every 14 – 28 days to encourage root development and carbohydrate production. Tank mix REBALANCE at 2 – 4 oz. (60 - 120 ml) per 1000 ft.^{2} (100m^2) in 2 gallons (8 L) of water.

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