

Introduction to TerraBella

In nature, particular species of beneficial bacteria and fungi promote healthy plant growth and soil fertility. These “good” microbes not only aid in nutrient uptake, but also displace harmful soil life that may be present. While common in natural settings, these microbe populations are often very low in urban and residential landscapes, including nursery potting soils and agricultural soils. TerraBella consists of a highly concentrated mixture of beneficial organisms capable of boosting the fertility of the soil, increasing crop yield and quality.

The most active area involved in nutrient uptake for a plant is the root, and the area of soil immediately surrounding the roots, called the **Rhizosphere** or root zone. The rhizosphere is quite small, including a few millimeters or at most centimeters of soil around the plant root area. The rhizosphere is of particular importance as it contains a microbial population whose actions differ significantly from bulk soil. This occurs because the plant roots release organic compounds, which can serve as a food source for the microbes. In return, the microbes assist the plant in nutrient uptake, using several different mechanisms including: (1) changing the chemical form of the nutrient to make it available for plant use; (2) mobilizing nutrients that are absorbed and adsorbed onto soil particles; and (3) using the first two mechanisms to provide the nutrients required for good plant root development. In particular, nutrients are required for root hairs development. These hairs have a large surface area relative to the rest of the root, and are responsible for most of the water and nutrient uptake into a plant.

Phylloxera

Phylloxera nymphs hatch from eggs and move to leaves or to the roots where they begin new infections in the **root form**. In this form they perforate the root to find nourishment, infecting the root with a poisonous secretion that prevents it from healing. It is this poison which eventually kills the vine.

Numerous studies have shown that the limitation on the amount of nutrients that plants can acquire in fertilized soil is the availability of these same nutrients (the amount of nutrients released from soil particles), and not the actual concentration of these same nutrients in soil. When TerraBella microbes colonize a plant's root zone (the soil immediately surrounding the roots), the TerraBella microbes release nutrients into this root zone and not directly into the actual plant root. Phylloxera nymphs can then obtain the nourishment they require from these TerraBella induced nutrients in the root zone without having to spend the energy necessary to infect the plant root, with plenty of available nutrients left over for the plant to use.

Fusarium and Verticillium Wilt

Different types of *Fusarium* fungi can infect a number of different crops. The crop of the most significant commercial interest is the banana. *Fusarium oxysporum* is the causative agent of Panama disease in bananas, and has caused the disappearance of the Gros Michael banana cultivar worldwide. The Cavendish banana cultivar is beginning to show susceptibility to *Fusarium* as well, which is of great concern to banana growers as there is currently no other banana cultivar available.

Soil-specific differences in susceptibility to *Fusarium* are seen in banana plants, and at least part of that difference is due to the soil microbiology. In particular, the presence of certain types of *Actinomyces* bacteria appears to be able to suppress *Fusarium* growth in soil. TerraBella contains *Actinomyces* bacteria, so therefore it does prevent *Fusarium* infection of banana and/or other types of plants.

Root knot, Ring and Dagger Nematodes

While TerraBella-treated grapevines had more nematodes than untreated grapevines, no harmful effects from nematodes were seen on the grapevines treated with TerraBella. We believe that TerraBella increases the amount of nutrients in the soil that nematodes require which accounts for the lack of harmful effects on the TerraBella treated grapevines. TerraBella appears to help prevent root infection by providing enough nutrients for the nematodes such that the nematodes did not need to obtain nutrients from the grapevine.

Western corn rootworm

One of the primary methods currently being studied to control Western corn rootworm is engineering susceptible crops (such as corn) to make 2 insecticidal toxins that are naturally produced by the bacteria *Bacillus thuringiensis*. *Bacillus thuringiensis* (or a closely related bacterial species) is included in the TerraBella product. There are other bacteria with insecticidal capabilities in TerraBella that may also be effective.

One note of caution is from the data on the nematode analysis of grapevine soil - where significantly more root knot and ring nematodes were found in TerraBella-treated plots. This was likely due to the increased amount of nutrients available in the treated soil, but a similar result may be seen with Western corn rootworm. Note that although there were more root knot and ring nematodes, there wasn't a correspondent negative effect on grapevine growth, suggesting that these nematodes weren't damaging the plant roots at the time of the study. Again, this is likely due to the nematodes being able to obtain nutrients they require from the TerraBella-treated soil rather than feeding off off the plant itself,

Southern Blight/crown rot/white mold

1. *Sclerotium rolfsii* is a fungal plant pathogen that is associated with disease in

approximately 200 different genera of plants, including ornamental plants and field crops including, though not limited to, tomatoes, peanuts, carrots, potatoes, sweet potatoes, etc, etc. It is commonly referred to as "Southern blight" because of the devastating effect it has on crops in the Southern US, especially peanuts. It flourishes in hot climates, but is also found in colder climates as well. It is also referred to as crown rot and white mold.

2. Infection is usually restricted to plant parts in contact with the soil, especially roots.

3. Control of Southern blight is a challenge, with prevention being the best management strategy.

Because Southern blight infects plants where they contact the soil, TerraBella treatment should be able to help prevent infection or mitigate the symptoms of the infection, since TerraBella works by creating a healthy rhizosphere (root zone), including the growth of healthy mycorrhizae in the root zone.

Bacterial speck

Bacterial speck is a disease that affects tomatoes and is of particular concern in young developing tomatoes in moist climates - so it is probably a big problem in California this year, with the huge amounts of off-season rainfall we've been getting. It is caused by *Pseudomonas syringae* pv. tomato, which is found in soil and plant roots, so TerraBella should be able to help with this disease. To be clear, no tests have been conducted specifically using our product against speck so definitive tests should be conducted to determine if we can alleviate the disease.

Fairy Ring

Generally caused by the basidiomycete or "mushroom" group of fungi. Fairy rings are usually first noticed as irregular rings or arcs of darker green grass on the turf surface. The darker color is caused by the release of nitrogen as the fairy ring fungus breaks down organic matter. The margins of the rings are often irregular or wavy. On putting surfaces especially, the entire area defined by the ring may be darker green than the surrounding uncolonized area. The rings can remain green or progress to the point where dead grass develops at the margin. Death of grass at the margin has been attributed to moisture stress due to hydrophobic soil conditions that develop as the fairy ring fungus grows. The death has also been linked to excess nitrogen release or the formation of hydrogen cyanide or other toxic metabolites.

* Fairy ring is more commonly observed under heavy thatch.

* Type 2 rings are more likely to progress to damaging Type 1 rings when moisture is limiting.

* Fairy ring symptoms are usually more noticeable in nitrogen-deficient turf

TerraBella can help prevent symptoms due to low nitrogen by making nitrogen already present in the soil available to plant roots. Additionally, TerraBella can help ensure the plants have a healthy root system, including growth of the "good" mycorrhizae that will result in better-aerated soil surrounding the root system. This will help to ensure that water can penetrate the soil and reach the plant roots.

Dollar spot

Most commonly caused by *Lanzia* spp. and *Moellerodiscus* spp. fungi, it produces 2-3 inch circular patches on creeping bentgrass turf and 4-6 inch circular to blotchy areas on bluegrass lawns (it can infect other grass types as well), resulting in straw colored patches. A faint cobwebby growth may be seen on the leaves of affected plants when the grass is covered with dew early in the morning. In the early stages of disease, leaves develop distinct tan-colored spots and bands; quite often a reddish-brown border can be seen on the leaf spots.

- * High level of thatches in the lawn which provides the perfect condition for fungus development, especially during the winter.
- * Low soil moisture is another cause of dollar spot condition.
- * Low nitrogen levels also results in disease symptoms.

Similar to how TerraBella can help alleviate the fairy ring problem (above), it can help prevent low nitrogen levels by making nitrogen already present in the soil available to plant roots. Additionally, TerraBella can help ensure the plants have a healthy root system, including growth of the "good" mycorrhizae that will result in better-aerated soil surrounding the root system, which will help to ensure that water can penetrate the soil and reach the plant roots.

Pink snow mold

Winter diseases of turfgrasses are often associated with melting snow or cold, wet periods. Bluegrasses (*Poa* sp.), fescues (*Festuca* sp.), and ryegrasses (*Lolium* sp.) may be attacked, but bentgrasses (*Agrostis palustris*) are most susceptible. *Microdochium nivale*, the fungus that causes Pink Snow Mold, produces roughly circular bleached patches up to 60 cm in diameter. Often the mycelium of the fungus is readily visible. This disease can become severe when turf is subjected to prolong periods of cool, wet weather from early autumn to late spring, and does not require snow cover to develop. A severe infection by *M. nivale* kills the turfgrass.

Causes:

- * High fertilizer levels during cold weather
- * High moisture conditions (such as occurs when snow melts, or if grass is covered by leaves, etc. with moisture trapped underneath).

TerraBella can help ensure the plants have a healthy root system that will result in better-aerated soil surrounding the root system and allowing moisture to drain from the turf surface. Additionally, TerraBella will not exacerbate (make worse) high nitrogen conditions, as it is not a nitrogen-containing fertilizer. While TerraBella will help plants to take up nitrogen already present in the soil, it will not increase the amount of nitrogen present.

Herbicides and TerraBella

Cerano (clomazone) is a "bleaching herbicide" - it is used to treat rice fields early in the growth cycle (seedlings), when the fields are submerged in water for the purpose of targeting watergrasses and weeds. While cerano may have a negative effect on the fungi in TerraBella, it should not effect the bacteria in TerraBella.

Shark (carfentrazone) is a "broadleaf herbicide" - it is used to treat rice fields later in the growth cycle (at the 2 to 3 leaf stage), and works well on flooded fields in conjunction with other herbicides. Shark is applied as a foliar spray, so it should not significantly effect TerraBella microbes, since TerraBella works in the soil.

Propanil herbicides (this is the chemical name, not the commercial name, one commercial example is Stam) is also applied as a foliar spray, needing sunlight and higher temperatures to be effective, as it works by blocking photosynthesis. Because of this, it also should not significantly effect TerraBella activity, since TerraBella works in the soil.

Maize treatment by TerraBella

Reasons why TerraBella treatment may benefit maize: Maize plants have a fairly shallow root system, making them somewhat intolerant to drought and nutrient-deficient soil conditions. TerraBella helps plants form a healthy rhizosphere, which can result in increasing the availability of nutrients in the soil for plant uptake. TerraBella treatment also helps arbuscular mycorrhizae colonize the root system, resulting in increased drought resistance and nutrient uptake.

One potential concern for TerraBella treatment of maize: Immature maize plants accumulate a fairly powerful antimicrobial substance (DIMBOA). While DIMBOA can be found in maize roots, whether it will interfere with TerraBella activity will depend on how much DIMBOA is exuded from the root into the surrounding soil. There are conflicting reports in the scientific literature on DIMBOA-producing grasses (mostly done on wheat, not corn) about the likelihood that the DIMBOA will be exuded into the surrounding soils, so it is not possible to predict how significant of a problem this may present.