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GREENFLASH TECHNOLOGIES (GFT) SALT DETOXIFICATION TECHNOLOGY

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The environmental contamination of the greatest number of acres of farmland in the US is caused not by toxic chemicals or oil spills, but by salt. Over 23% of irrigable land in the US is now salt-impacted and the number grows every year. In the California San Joaquin Valley alone, over 2.8 million tons of salt enter the valley each year and only 350,000 tons leave it. Worldwide, the problem is estimated at over 20% of all arable land being salt-impacted to varying degrees.

Saline soils are indicative of inadequate drainage to leach salt from the soil or upward migration of salt from shallow ground water. Sodic (sodium dominated) soils have an abundance of sodium. Reclaimed water, fertilizers, soil amendments, manure and poor drainage may all contribute to salt and sodium buildup.

Salt concentration in soil is usually measure on terms of electrical conductivity (Ec) and sodium in terms of sodium absorption ratio (SAR). SAR measures the relative amount of sodium ions in the soil moderated by the amount of calcium and magnesium in the soil. Generally an Ec>4 is considered saline and SAR>12 is considered sodic. For most plants, soil conditions of Ec>5 and/or SAR>15 will lead to significant growth degradation and inability to absorb water.

Salts will build up in a soil due to geographical conditions, low rainfall, use of high-salt irrigation water, long-term use of some fertilizers, and alkaline soil conditions due to the parent soil materials. Salts aren’t just sodium chloride, but include carbonates, phosphates, sulfates and other compounds. However, the detrimental effect of sodium greatly exceeds those of the other salt forms. The salt build-up is due primarily to evaporation of saline water or the lack of sufficient fresh water to flush-out ground salts.

When soil is damaged by salt contamination, the harm extends immediately to native grasses, trees, shrubs and crops, preventing seed germination and plant growth. Saline conditions also destroy favorable microorganisms vital to productive, balanced soil. Salt contamination is most prevalent in two main areas of environmental concern: agricultural irrigation/fertilization and oil production.

In most cases, crop irrigation is pumped from underground aquifers that contain high amounts of soluble salts. When land is irrigated with this water, large amounts of salt accumulate on the surface. If salts are not leached adequately, there will be significant damage to plant roots.

Both chemical and natural animal fertilizers contain high amounts of salt. When farmers use fertilizers to increase production, they magnify the problem. The excessive "doses" of salt from these fertilizers cause salt content in the soil to continually increase. Farmers find they have to use more and more fertilizers to produce less and less crop yields and the salt levels steadily increase. Eventually the crops will be destroyed or production greatly reduced unless something is done to prevent, break down or "buffer" the existing salt buildup.

The salt "breakdown" process works like this: Salt is the result of reaction between an acid and a metal base. It is typically very reactive. Excessive salt amounts act as a toxin to aerobic soil microorganisms that require oxygen to establish their colonies and metabolize nutrients. Salt follows the water path and can be flushed from the soil. However, extensive flushing of salt deeper into the soil with water will normally only temporarily correct the problem. It does not correct the soil problems that have occurred due to the salt contamination.

Effects of salinity, sodicity and chloridity on soil and plant health

Excess salinity and sodicity can each have deleterious effects on both the soil physical properties and the health of plants in the soil. Salinity and sodicity are necessary for soil and plant health (at a low level), but they can both very quickly become toxic when they their levels exceed minimum thresholds. Chloridity is a micro-nutrient for plants at low levels, used by the plant to aid in photo-synthesis cell development and increased leaf area. However, at levels above 75 ppm, it starts becoming toxic to sensitive plants.

Salinity becomes a problem when enough salts accumulate in the root zone to negatively affect plant growth due to the increased osmotic pressure at the root boundary and the increased energy required by the plants to uptake the necessary amounts of water for their health. A positive effect of non-sodic salinity is increased flocculation of the soil due to the improved aggregation of the soil particles. Non-sodic salts, such as calcium and magnesium, are smaller and tend to bind better to the clay soil particles, causing fine particles to bind together into aggregates and leave larger spaces for water conductivity.

Increased levels of sodicity (beyond that needed to support plant cell life) causes a number of both soil and plant problems. Some of these are:

- Increased soil dispersion and swelling (plugging soil micro-pores)
- Decreased soil flocculation, infiltration and conductivity
- Increased surface crusting
- Increased osmotic pressure at root boundary
- Increased toxicity in the plant cells
- Decreased microbial biomass in the root zone
- Decreased ability to fix atmospheric nitrogen
- Reduction of plant ability to uptake potassium

The combination of non-sodic and sodic effects can be either helpful or more harmful. The presence of calcium or magnesium salts can counter some of the soil dispersion problems caused by the sodium (improving the flocculation), and can displace some of the sodium, making it easier to leach it out of the soil. However, the increased osmotic pressure associated with higher levels of any salinity quickly overcomes the benefits and causes increased stress in the plants lowering their ability to acquire the water they need to grow.

Nutrients enter plants via three routes: mass flow, root intercept and diffusion. In all cases the nutrients must be in the mineral form and dissolved in the soil water. While water can flow freely across the root boundary, nutrients require a channel (protein carrier) to cross the root boundary. These carriers control the amount of any nutrient being taken up and help maintain optimal levels of nutrients within the plant. pH within the plant is maintained by transfer of protons (mainly H^+) across the boundary to complement the transfer of nutrients.

Recent studies have shown that sodium (Na^+) competes with potassium (K^+), a key nutrient for plant cell life, for uptake into plants. This is due to the fact that the potassium and sodium ions both employ the same protein carriers to be uptaken by a plant. Specifically, the HKT protein has an important role in transporting both potassium and sodium ions across plant root membranes. When the soil water becomes highly sodic, this delicate transfer mechanism becomes upset and the plant often uptakes larger amounts of sodium leading to toxic conditions within the plant.

Increased sodium levels within the soil water also leads to a reduction of microbial activity within the root zone, upsetting the natural chelating factors within healthy soil and plant roots.

Increased chlorine levels in plants leads to excess accumulation in leaf cells, leading to yellowing, drying and burning of leaf tips and premature shedding. In general, the chlorine anion is not absorbed on soil particles in non-acidic soils. Therefore, if the chlorine ion in saline soils can be dissociated from the sodium ion, it is more easily leached from the soil. Also, various studies have shown that a competition exists between chloride and nitrate for uptake by plants, and that increased concentration of nitrates in the soil solution can lead to decreased concentration of chloride in the plants.

The **GreenFlash Technologies' Salt Detoxification Process and Technology** (GFT SDP) has been developed to overcome all of the conditions described above. With its combination of soil microbes, secondary metabolites, enzymes and organic acids it specifically addresses both the soil structure conditions and the plant nutrient and water uptake mechanisms. It includes several factors that work together to greatly enrich the soil environment and dramatically improve the quality of plants in the soil.

The factors include:

- Improvement in soil base saturation percentages
- Improved soil structure
- Salt buffering & complexing
- Increased microbial activity

- Humus creation
- Reduced soil compaction
- Increased plant nutrient uptake
- Enhanced water management in the soil

Improvement in base saturation percentages

Base saturation percentage is the relationship between concentrations of four key soil elements – magnesium, calcium, potassium and sodium. These elements are not created or destroyed, but they can be unevenly distributed within the soil in plant-available and unavailable (insoluble) forms. In the case of sodium, where lower water-soluble concentrations are desired, The GFT SDP shifts the concentrations into insoluble or immobilized compounds in the soil. This can significantly reduce the amount of sodium in the soil solution and thereby minimize the destruction of the soil structure and the toxicity in the root zone.

Soil Structure

Sodium (and other chemical salts) can break down soil structure by displacement of calcium - one of the important, molecular "building blocks" of healthy soil aggregates. As micro-aggregates and macro-aggregates break down, the soil structure can collapse - reducing pore spaces for air and water and reducing microbial activity. Broad spectrum fungicides can further reduce the level of microbiological activity.

The first line of defense is to rebalance the soil's chemistry. The GFT SDP reduces the soil's sodium and total salt content; in turn promoting the re-formation of micro-aggregates. This process helps to loosen up the soil permitting an improved movement of air and water. Micro-organisms are added and enhanced to respond to the air and water, which further contributes to the soil structure building process. Plant roots then gain better access to air, water and nutrients with a resultant improvement in growth and yield.

Salt Buffering & Complexing

The GFT SDP also increases the efficiency of applied fertilizers and results in improved crop response. Organically complexed nutrients are less subject to loss from leaching, volatilization, chemical fixation, and clay fixation. The complexing properties of organic carbon found in the GFT SDP serves another important function in many agricultural soils. The SaltDetox products buffer salts by dissociation and organic complexing (moving from mineral to organic form) and immobilization of the component elements. Dissociated salts are far less damaging to crops and soil and remain dispersed in the soil profile. Additionally, by dissociation of the sodium and chloride ions, excess chloride ions become more susceptible to leaching from the soil, particularly in neutral or alkaline soils.

Using GFT's bioremediation and soil "balancing" products to recondition soil will enhance microbial growth by producing and converting organic materials into agents that will combine with salts. These agents act as a "buffer" for the plants. This buffering effect allows soil microorganisms to proliferate, protecting them from harmful osmotic pressures. These conditioners inhibit salt uptake by the plant by a complexing effect, making them less susceptible to salt damage.

Increased microbial activity
In the GFT SDP, the colony forming units (CFUs) of indigenous beneficial microbial populations present in the rhizosphere (i.e. the near volume of the plant's root zone) are prodigiously increased (in geometric progression) with the application of the selected products. These enhanced microbial populations accomplish several functions that result in the ability of the GFT SDP treated soils to: 1) increase the uptake rate of beneficial soil nutrients, 2) restrict the uptake of sodium and 3) support plant life in a normally hostile high sodium environment.

Although plants require very low quantities of sodium, they do require cation balanced saturations of potassium, magnesium and calcium (Ca 60-75%, Mg 10-20%, K 2-8%), variations dependent upon soil type. A plant's roots absorb K^+, Mg^+ and Ca^{++} by releasing H^+ (acid) in exchange for these essential nutrients. These elements occur in soil as cations, (positively charged ions) which are adsorbed (held in plant-available form) on negatively charged clay or humus particles.

Healthy and active microbial populations in the soil convert organic K^+, Mg^+ and Ca^{++} to the mineral form which makes them more readily available to plants through osmotic action than any sodium present within the root zone. Therefore, the plant uptakes the K+, Mg+ and Ca++ and rejects the Na+.

There is yet another, less understood element in play. That is the inability of plants to distinguish between various elements in their root zone when the microbial population is low. When microbial soil populations are weak or non-existent, a plant's roots are exposed directly to whatever levels of potentially harmful nutrients, e.g. sodium, may be present in the soil. The roots in out-of-balance, sodic soils cannot readily distinguish sodium from potassium, magnesium and/or calcium (let alone micronutrients B, Zn, Mn, Cu, and Fe) which, in conditions of low microbial activity, remain mostly in the organic form and are thus more difficult for the plant to uptake.

Plants, in these conditions, will take up the sodium instead of the beneficial nutrients because sodium is more readily utilized in the environment of increased osmotic pressure that, in itself, results from elevated sodium levels. Whenever one of these elements is deficient, the root mistakenly takes up the sodium, which is harmful to the plant. The application of The GFT SDP to sodic soils effectively eliminates this characteristic in plants.

The GFT SDP directly adds beneficial microbes to the soil and enhances the soil conditions to enable microbial growth. Soil microorganisms proliferate when their "food of choice" is available and conditions are just right. The nutrient sources for soil organisms are as broad and diverse as the organism community itself. Pathways within soils are thin films of water on and between soil particles. The films both enable the microbes to get to their food source, but also carry food to the organisms. The microbes must also develop survival mechanisms (or perish) when food is scarce.

Soil microbes are able to survive by communication with their environment on a bio-chemical basis. For bacteria, nutrients are absorbed through their cell walls.

Some of these nutrients are readily available in water films; other nutrients must be obtained by the excretion of enzymes or other compounds in order to release the needed nutrients from organic or mineral particles. Nutrient availability signals the bacteria to multiply; but they are also receptive to biochemical signals indicating that the food reserves are limited or that conditions are developing which indicate the need for protective survival strategies. Through these mechanisms organisms work effectively and collectively to cycle nutrients within the soil.

Humus Creation

Creation of humus is a key factor obtained from the growth and proliferation of soil microbes. Humus is produced by the aerobic digestion of organic matter by these soil micro-organisms. Humus acts as the warehouse for many elements, such as phosphorus, potassium, etc. Nutrients are absorbed by humus, and are more available to growing plants than those precipitated as insoluble compounds. By-products of humus increase friability (crumbling or reducing to powdery form) of soils, improve tilth (soil looks as if it had been finely tilled), improve aeration and water penetration and change soil characteristics for heat absorption. Humus is the most important element in building and maintaining soil structure for a balanced soil. Humus is a by-product of living soil organisms. Polymers and polysaccharides bind soil particles together to reduce compaction, slow erosion, improve water retention and aeration.

Organic acids (such as humus/fulvic acids) are derived from decayed organic matter (humates). They help produce a high cation exchange capacity (CEC) in the soil which serves to collect and chelate plant food elements and release them as the plant requires. The chelation process holds the nutrients in the soil solution and prevents their leaching and runoff. GFT organic acids utilize a proprietary phenolic-acid based formulation with a smaller molecule size that creates nutrient and mineral complexes that are more easily taken up by the plants. These humic-like organic acids and the biological by-products in the GFT SDP improve humus content in the soil for better tilth, water and nutrient retention, and soil aeration. Seed germination and plant root and top growth are also enhanced.

Humus is an essential ingredient for maintaining the active and productive potential of the "rhizosphere," the dynamic world around the root zone of a plant. In the significance of plant life, the processes within the rhizosphere are second only to photosynthesis. Establishing and maintaining the optimum health of the rhizosphere is one of the most crucial choices a grower can make pertaining to crop productivity. Natural soil humus has the ability to put into solution and extract nutrients from the soil, and hold these nutrients in an absorbable form for plant absorption. Technically, humus compounds consist of acids, poly-saccharides, phenols, benzenes, aldehydes, ketones, amines, waxes, and resins that have a synergistic effect on soil microbes, plant nutrients, and plant roots.

Humus enhances soil structure, increases soil water-holding capacity, buffers the soil solution, stimulates soil microbes, and much more. It plays a vital role in plant nutrition in many ways:

- Humus delivers nutrients to roots in a readily absorbable form. Phosphorus, for example, can only be absorbed as a single, or

orthophosphate, molecule. When properly complexed with humus, phosphorus is held and protected in the ortho-form.
- Humus buffers the toxic effects that inorganic fertilizer and soil salts may cause. Inorganic foliar fertilizers have caused what growers recognize as "tissue burn." Less visible is the damage these salts have on tender root hairs when inorganic fertilizer is soil-applied.

Reduced Soil Compaction

Physical stress on the soil is caused by heavy equipment and tillage practices. Heavy farming equipment crushes soil particles into small, compacted layers. This can also occur below the soil surface at certain depths by tillage equipment. The results are very similar to chemical compaction with the destruction of soil structure and harm to plant growth.

Compacted soil can also become anaerobic and soggy, or dry and crusted. In either case, the conditions are harmful to plant growth. The first line of defense is to rebalance the soil's chemistry. The GFT SDP reduces the soil's sodium and total salt content, in turn promoting the re-formation of micro-aggregates. This process helps to loosen up the soil permitting an improved movement of air and water. Microorganisms respond to the air and water and are encouraged to function, which further contributes to the soil structure building process. Plant roots then gain better access to air, water and nutrients with a resultant improvement in growth and yield.

Improved Nutrient Uptake

Fertilizer applications are required to maintain crop productivity. Over time, however, well-fertilized areas can experience soil-related problems which affect efficient fertilizer utilization. These problems include the breakdown of the soil structure; loss of nutrients due to leaching or erosion; or chemical immobilization of stored nutrients within the soil.

The GFT SDP helps to reduce fertilizer loss. Higher amounts of nutrients are frequently seen in plants when soils are treated with the GFT SDP. In crops, this is also demonstrated by higher yields and higher crop quality. At least two mechanisms are presumed to be functioning. The first is that nutrient reserves stored in the soil (immobilized fertilizer) are made available to the plant. In addition, the GFT SDP may inhibit fertilizer from becoming immobilized, thus remaining available to the plant for a longer period of time.

Enhanced Water Management

Water management is the skill of efficiently applying water to the soil to meet plant growth requirements and stimulate aerobic microbiological functioning. Soil moisture content substantially below or above 50% of the soil's maximum water holding capacity is costly in terms of long term harm to the soil's productivity and wasted energy costs. Insufficient moisture promotes the build-up of salts, which destroys soil structure and further lessens the ability of roots to take up water.

Excessive moisture reduces soil aeration, wastes water and causes extra financial burdens relating to pumping and labor costs.

The GFT SDP helps to rebuild soil structure by balancing some of the soil's chemistry. Extractable sodium is reduced in the soil by leaching and/or precipitation, which, in turn, promotes the development of soil aggregation. The combination of small and large soil aggregates creates small and large pore spaces for improved drainage and aeration. Improved root growth increases the plant's access to water which, in turn, stimulates microbial functioning, further expanding the soil building processes. Water management is improved because the soil is better able to hold the plant's available moisture. Growers can then better judge irrigation requirements; and avoid over or under watering the crop.

Summary

In conclusion, the GreenFlash Technologies' unique approach to salt detoxification provides multiple mechanisms for reducing / eliminating the effects of salt in the soil, re-balances and re-structures the soil composition, improves water penetration and retention, builds a strong humus environment in the soil and increases the soil's ability to provide beneficial nutrients to the plants' root zone.

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