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PLATINUM TE™ NUTRITIONAL CHALLENGES

Seashore paspalum in general has superior nutrient absorption and utilization traits compared with other turfgrasses due to development of an extensive rhizome system. Since the turfgrass was exposed only to ocean water for nutrition during evolution in South Africa on sand dunes, the grass developed low requirements for some nutrients and no regulatory uptake mechanisms (luxury consumption) for other nutrients that are traditionally found in ocean water. The high root volume and root regeneration priorities of Platinum TE are primary contributors to these enhanced nutrient absorption, storage, and utilization characteristics.

NITROGEN

Seawater contains mainly soluble nitrates in low concentration (11.5% N) and as a result, Platinum TE has a low requirement for N, a very high efficiency for N uptake and utilization, and an enormous storage capability for N residuals. Platinum TE absorbs nitrate-N primarily and other nitrogen sources need to be converted to nitrates for uptake.

The general rule is to prescription-apply N and to not exceed 3.0% N accumulation in the leaves (general sufficiency range for all paspalum cultivars is 2.0-3.0% N). Concentrations above 3.0% N in the leaves can often result in storage of enough N internally in the Platinum TE to meet grass requirements for up to six weeks with no additional nitrogen fertilization.

N concentrations above 3.0% will make the shoots more succulent and puffy, and have in the past predisposed the grass to disease attack when environmental conditions favored pathogen population buildup. Monitor the N concentrations in the leaves with regular clippings 'wet chemistry' or ICP analysis.

Generally, Platinum TE primarily absorbs nitrates, and any other N fertilizer product compound must be converted to the nitrate form by *Nitrosomonas* in the soil for absorption. Expect a lag period of nitrate availability when soil and temperature conditions minimize the *Nitrosomonas* conversion process. Nitrogen is highly mobile internally in the plant.

Because of the low requirement for N and the tremendous capability for storing N residuals, application of nitrogen products seldom provides escalated growth responses in Platinum TE. Manganese is the kick-starter nutrient for promoting growth (activating over 35 enzymes for growth) while potassium activates over 80 enzymes for growth, especially when canopy density is not 100%.

Nitrogen functions: chlorophyll production in concert with sulfur, protein synthesis, photosynthesis, utilization of sunlight, activation of energy systems; uptake can be suppressed by chloride concentrations in irrigation water or that has accumulated in the soil >400 ppm.

Again, Platinum TE primarily absorbs nitrate-N. High salinity has a detrimental effect on microbial populations and subsequent conversions to nitrate-N as well as break-down of thatch or accumulated organic material.

Nitrogen is a component of all amino acids, amides, proteins, nucleic acids, nucleotides, and polyamines. Many glucoheptonate or gluconate carriers contain amino acids or other N residuals. The glucoheptonate or gluconate molecule is a long chain molecule and is generally not foliarly absorbed, but that molecule will move off the turf plants to the soil and provide carbons for microbial activity.

SODIUM

This toxic salt cation is very highly concentrated in ocean water (>10,560 ppm or >459 meq/L or about 77% of total cations), and as a result, paspalum developed a genetically-controlled regulatory exclusion mechanism for root absorption, but not for foliar absorption of sodium from topical applications of irrigation water or salt spray that are high in sodium concentration.

Platinum TE will absorb the quantity of Na via the roots that it needs as an internal cellular micronutrient up to its general salinity tolerance threshold, and then normally excludes any further root uptake. The root-absorbed Na is translocated rapidly to vacuoles in order to separate that toxic salt ion from the plasma membrane and from subsequent photosynthetic activity as well as potential growth rate activity. This root exclusion mechanism therefore leaves the excess sodium from irrigation water to accumulate in the soil profiles. Platinum TE has a thick wax load on leaves and stolons and this wax layer will sequester sprinkler irrigation or salt spray Na in that wax layer, thereby minimizing the Na from entering the interior cellular components. Elevated sodium concentrations are often recorded in plant tissue analysis data and reflect the high concentrations of Na from saline sprinkler irrigation that accumulates in the wax layer on the paspalum canopy.

The only counter ion to excess sodium accumulation either in the soil or internally in the grass plant is calcium on a meq/L to meq/L basis. Sodium is highly mobile internally in the plant and a regularly scheduled calcium therapy program (granular product application to the soil [gypsum, lime, calcium thiosulfate, calcium hydroxide or oxide, lime, phospho-gypsum, dolomite, calcium silicate, calcium sulfate anhydrite] plus liquid product [calcium nitrate, calcium chloride, calcium acetate, calcium gluconate/glucoheptonate, calcium complexed with sugar alcohols or amino acids] application topically for actual foliar absorption) is essential for minimizing the dual negative problems caused by this toxic salt ion.

The sodium ion by itself normally moves slowly in the soil due to its propensity for absorption of water films (balloon effect) and its strong adherence to cation exchange sites. This salt ion is a leachable compound when bound or complexed with sulfates or carbonates/bicarbonates as long as water infiltration and percolation rates through the soil profile are adequate for leaching salts down to functional drain lines. The unbound Na ion is difficult to leach out of the soil profile.

Sodium activates the enzymes catalyzing the conversion of pyruvate to phosphoenol-pyruvate in C_4 grasses. Sodium also substitutes for potassium in activating a number of enzymes, but too much internal concentration of sodium in Platinum TE or other turf grasses can negatively affect K-controlled turgor pressure osmotic adjustments, stomatal control, root regeneration, enzyme activation, and stress tolerance enhancement when the tolerance threshold is surpassed. Sodium also affects micro- and macronutrient availability for absorption.

MAGNESIUM

Magnesium concentrations are generally very high in ocean water (>1300 ppm or 107 meq/L or about 18% of cations). Paspalum did not develop efficiency uptake/utilization mechanisms for magnesium during evolutionary exposure to ocean water on sand dunes.

As a result, Platinum TE is a luxury consumer of magnesium and sufficiency ranges of 0.25-0.60% (wet chemistry/spectrophotometric analysis) should be maintained internally in the plant at all times.

For proper color expression, magnesium should always be lower (meq/L or %) in actual leaf concentration than calcium; otherwise, yellow chlorosis symptoms will occur. There is a delicate Ca:Mg balance that must be maintained with root absorbed and foliarly applied (including irrigation water concentrations) Mg fertilizer products, and the priority nutrient in that synergistic nutrient-balance partnership is calcium.

Magnesium is highly mobile internally in the plant. When magnesium reaches high concentrations in irrigation water or accumulates excessively in the soil, this salt ion eventually can start to mimic many of the negative internal- accumulation salt ion traits similar to sodium (excess water film absorption; domination of cation exchange sites; micro- and macro-nutrient imbalances).

Magnesium is the core molecule in chlorophyll, aids in phosphate metabolism, functions in plant respiration, and activates more enzyme systems than any other element. Mg is instrumental in activating enzymes involving phosphate transfers internally in the plant.

SULFATES

Sulfur is somewhat immobile internally in the plant. Generally, 2690 ppm (~56 meq/L) can be found in ocean water. Normal sufficiency levels in Platinum TE (wet chemistry/spectrophotometric analysis) leaves should range from 0.20 to 0.60%. Platinum TE is a luxury consumer of sulfur and sulfates since the plant did not develop genetic efficiency mechanisms for sulfates due to the exposure to high ocean levels of sulfates.

As long as infiltration and percolation rates are adequate through the soil profile, sulfates have good mobility and can move downward close to or in proximity to the leading edge of the wetting front. Sodium will bind with sulfates to form a leachable compound in the soil and this chemical complexation is the key objective when applying granular gypsum to soils with low S concentrations and high sodium levels.

When sulfur is high in soil profiles, application of lime (calcium carbonate) is recommended to minimize potential black layer problems. The resulting chemical reaction in conjunction with aeration is to actually form calcium sulfate or gypsum. The SO_4 compound is very stable in the soil as long as adequate oxygen flux continues throughout the profile; consequently, frequent aeration is required to minimize the chemical transition from SO_4 to H_2S, which leads to black layer problems.

Sulfur is a constituent of: amino acids (cysteine, cystine, methionine) and hence proteins (primarily in chloroplasts) and is involved in their synthesis; coenzymes such as thiamine, biotin and coenzyme A (with activation by manganese); and prosthetic groups (governing redox reactions such as those involving glutathione). Sulfolipid (in thylakoid membranes) concentrations in roots and salt tolerance in turfgrass plants are positively correlated.

CHLORIDES

Ocean water contains ~19,000 ppm chlorides or ~536 meq/L. Paspalum has an enormous tolerance to this toxic salt anion by rapidly translocating this highly mobile salt anion after absorption (either via the root system or foliarly) to growing leaf tips where it can be readily mowed off and removed from the plant.

The only negative component of high chloride exposure on paspalum occurs when soil accumulation levels exceed 500 ppm and *Nitrosomonas* conversion of ammonium-N and urea-N granular fertilizer products to nitrate-N is reduced or completely stopped.

The recommended management criterion for high chlorides in irrigation water is aeration and leaching—chlorides are highly mobile both in the soil profile (moving essentially with the front edge of the wetting front) and also internally in the turfgrass plant.

If infiltration and percolation rates are still adequately functioning in any soil profile, chlorides should move with the wetting front down to the functional drainage lines and not become a limiting salinity soil profile accumulation problem. If excess chlorides accumulate in the soil profile in combination with high total dissolved salts, an increase in localized dry spots can occur.

Excess chlorides will accumulate in landscape plants with the accumulation at the active growing points initially; and when Cl accumulation levels internally surpass the tolerance thresholds of the individual plant, those chlorides will gradually kill the plant. Direct sprinkler applications containing high chlorides (>355 ppm Cl) on any landscape plants can accumulate quickly at toxic levels and can eventually kill the plants. Such plants should be removed and only chloride tolerant landscape plants should be replanted.

Platinum TE will accumulate those excess chlorides in the growing points of the leaves and normal mowing practices will remove and recycle the chlorides in the soil.

Chlorides activate the enzyme system of photosystem II in which water is split and oxygen is released. Therefore, they are directly involved in the oxygen scavenging process for photosynthesis.

CALCIUM

Calcium is a critical MACRONUTRIENT for Platinum TE and works synergistically in conjunction with potassium. Regular applications of available calcium are an essential component of any Platinum TE fertility program.

Ocean water contains approximately 420 ppm (21 meq/L or about 3.5% of the cations) soluble calcium. Calcium foliarly absorbed should be applied to the grass on a regularly scheduled basis since movement within PlatinumTE from the roots upward is slow (3-4 weeks), and topical applications that are foliarly absorbed are not translocated downward from the shoots to the roots.

Calcium functions internally in the Platinum TE plant include: stabilization of nutrient balances, stimulation of root and shoot development, assisting in the reduction of nitrates for utilization by the plant, neutralizing organic acids, stabilizing internal water turgor pressure in concert with potassium, involvement directly in new cell formation, and active in stabilizing membranes (such as the plasma membrane) and cell walls.

Calcium also functions as an essential messenger (by binding to calmodulin, the protein important in signaling and regulating enzyme activity) for signaling abiotic and biotic stress responses internally in the turfgrass plant. Calcium is the key element for stabilizing overall salinity impacts internally in the grass plant, and for stabilizing water balances internally in conjunction with potassium. Calcium binds to polysaccharides in the cell wall to enhance cell structure. The nutrient assists in the movement of other fertilizer nutrients across the plasma membrane for subsequent use.

<u>Foliarly absorbed calcium products</u>: calcium nitrate, calcium chloride, calcium acetate, calcium gluconate or glucoheptonate, calcium complexed with sugar alcohols or amino acids. Application of these products once absorbed directly into the leaves will require 4-7 days before nutritional stabilization occurs and yellow discoloration disappears in the turfgrass canopy. These products have high solubility and fast release/availability to the turfgrass plant.

<u>Intermediate solubility and intermediate release traits</u>; normally in suspension; are not foliarly absorbed; only absorbed by the root cap; requires 3-4 weeks after absorption before nutritional stabilization occurs and yellow discoloration disappears in the turfgrass canopy: calcium sulfate (gypsum) and calcium thiosulfate.

<u>Slow release traits and low solubility</u>; not foliarly absorbed; only absorbed by the root cap; requires 3-5 weeks after soil application before nutritional stabilization occurs and yellow discoloration disappears in the turfgrass canopy: calcium oxide, calcium hydroxide, calcium carbonate (lime), calcium silicate, dolomite, phospho-gypsum, calcium silicate, calcium sulfate anhydrite.

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Most micronutrients have very low concentrations in ocean water and seashore paspalum did not develop any regulatory mechanisms for uptake, but generally has low requirements as well as a high utilization efficiency for these critical nutrients.

The primary consideration for the micronutrient fertilizer packages that are currently on the market include:

(1) most multi-micronutrient fertilizer package combinations include quite low concentrations (generally around 1% or less),

(2) salt ion interactions can be quite significant (example is molybdenum) and therefore, as salinity in the irrigation water and salt accumulation in the soil profile increases, availability of these key micronutrients can become limiting,

(3) foliar applications may be needed to supplement the fertilizer combination packages in order to meet sufficiency requirements for Platinum TE,

(4) internal plant mobility is a key consideration when determining type of product to apply plus frequency and volume of application.

MANGANESE

Manganese is generally found in low concentrations in most irrigation water sources and also in most soil types (the exception would be locations near manganese mines or when soil pHs range from 5.0 to 5.5 when Mn is highly available in the soil).

Manganese is a critical micronutrient for:

(1) activation of salt tolerance mechanisms in Platinum TE in conjunction with zinc especially in the root and crown region,

(2) suppression of root borne pathogens that cause take-all or decline or other root-borne pathogen problems,

(3) activation of over 35 enzymes for photosynthesis (that leads to growth rate and development plus color expression),

(4) functions in RNA synthesis + chloroplast/chlorophyll development + root lignin synthesis + root elongation and lateral root development. Sufficiency ranges for Platinum TE in leaves should be 50-300 ppm at all times,

(5) Mn is part of the water-splitting enzyme complex of photosystem II and the enzyme superoxide dismutase.

Manganese is immobile internally in the plant; therefore, both granular (applied to the soil for root absorption) and foliarly-absorbed liquid Mn products should be applied to the grass. Manganese is not translocated from the shoots to roots when foliarly absorbed, and liquid fertilizer applications may be needed as irrigation water increases in total salinity and specific salt ions.

Additional explanation of functions for manganese: RNA synthesis in chloroplasts (RNA polymerase activation of chlorophyll formation); synthesis of aromatic amino acids; activation of cell wall peroxidase that is involved in root lignin synthesis; activation of isoprenoid synthesis involved in gibberellin production and subsequent regulation of auxin levels; enhancement of root elongation and lateral root formation in conjunction with cytokinins. Therefore, soil-applied Mn amendments are essential in any paspalum fertility management program.

Manganese is an essential component of two critical enzymes for oxygen evolution during photosynthesis and in superoxide dismutase activation (which functions in activation of reactive oxygen species and eventual reduction of salt-induced cation shock damages intercellularly); an active cofactor in 35+ enzymes involved in respiration and metabolism of organic acids (especially the citric acid cycle).

ZINC

Zinc is absorbed predominately as a divalent cation (Zn_2+), except at higher soil pHs where the monovalent cation (ZnOH+) is absorbed by the roots.

Zinc is translocated mainly in the xylem and bound to organic acids, in tetrahedral complexes as the metal component in enzymes (alcohol dehydrogenase, Cu-Zn superoxide dismutase, carbonic anhydrase, RNA/DNA polymerase, other aldolases/isomerases/transphosphorylases), and involvement in carbohydrate metabolism, auxin metabolism, and protein synthesis.

Zinc is somewhat immobile internally and tissue concentration ranges of 20 to 250 ppm should be maintained in Platinum TE for best results. Excessive fertilization with calcium or phosphorus can at times cause zinc deficiency in plants.

Zn is the primary metal of a few metalloenzymes.

COPPER

Somewhat immobile internally in the turfgrass plant, Cu concentrations should be maintained at 5 to 50 ppm in Platinum TE. The divalent copper ion (Cu^{2+}) is strongly bound to humic and fulvic acids in soils, forming Cu-organic matter complexes and ligands with amino acids, phenolics, and synthetic chelators (such as EDTA or DTPA).

Copper functions include: bound to plastocyanin proteins in chloroplasts and synthesis of plastoquinones in the chloroplast membrane needed for electron transport between photosystems; respiration; photosynthesis (electron transport and oxygen affinity); secondary cell wall synthesis (lignin); activation in stress tolerances through Cu-Zn superoxide dismutase isoenzyme activity involved in salinity and cold tolerances; critical for maintaining vertical growth; component of many critical enzymes and proteins in the turfgrass plant.

Excess nitrogen can accentuate copper deficiency. Copper deficiency can also inhibit calcium transport to areas of new growth and negatively impair cell wall formation.

Cu is often a metal of several metalloenzymes similar to zinc. Excess Cu can be countered by applications of silicates.

IRON

Immobile in the plant, Fe concentrations in Platinum TE should be maintained at 50 to 500 ppm in the shoots utilizing both soil-applied and foliarly absorbed fertilizer sources. Both Fe (II) and Fe (III) chelates are absorbed by the roots of grasses.

High pH calcareous soils are detrimental for uptake of iron by turfgrass roots. High calcium will sequester Fe and render the nutrient insoluble and unavailable especially if high bicarbonates are present in the soil or water.

Iron is contained in proteins (heme-proteins such as cytochromes in chloroplasts and mitochondria and iron-sulfur proteins such as ferredoxin that functions in the electron transport chain of the nitrogenase complex) as well as other enzymes (catalase and its involvement with superoxide dismutase, photorespiration, and the glycolytic pathway; peroxidases that catalyze the polymerization of phenols to lignin).

BORON

Somewhat immobile internally in the plant, B mainly occurs in aqueous solution as boric acid (H_3BO_3). Postulated roles for B include sugar transport and carbohydrate metabolism, cell wall synthesis and structure, lignifications, RNA/ IAA/phenol metabolism, respiration, and membrane function in association with iron.

Sufficiency levels in shoot tissues of Platinum TE should be maintained at 5 to 60 ppm B. Platinum TE has a very high tolerance to boron, generally higher than 6.0-10.0 mg/kg (saturated paste extract concentration) that is documented for most grasses.

Boron, similar to calcium, will bind to pectic polysaccharides of the cell wall, contributing to cell wall structure.

POTASSIUM

Highly mobile internally in the turfgrass plant. Approximately 390 ppm (10 meq/L) concentration in ocean water.

Functions: stimulates development of fine-branched functional roots and root hairs; translocates sugars; involved in starch formation; key nutrient in osmo-regulation internally in the plant, especially as salinity increases in the plant and in the soil profile; regulates stomatal control and transpiration; regulatory in wear, cold, heat, drought and disease tolerances; indirectly functions in salinity tolerance through stabilization of turgor pressure, osmolyte balances, and osmo-regulation.

Normal tissue analysis (wet chemistry/spectrophotometric and ICP) sufficiency ranges are 2.00-4.00% for Platinum TE. In order to minimize scalping problems and to maintain expected greens speeds, tissue K should be maintained at 3%+.

Quite sensitive to increasing sodium in irrigation water and internally increasing concentrations of sodium in plasma membranes, resulting in cell leakage of K and loss of turgor pressure with increasing salinity. Sodium readily displaces K from cation exchange sites in the soil profile. Frequent, light prescription applications of potassium products are recommended weekly to bi-weekly.

Potassium activates over 80 enzymes and works in conjunction with calcium, sodium, nitrates, and chlorides involving cellular osmotica. Potassium works synergistically with phosphorus in root redevelopment and with calcium in moving critical nutrients across the plasma membrane for photosynthesis.

PHOSPHORUS

Highly mobile internally in the grass plant. Recommended leaf sufficiency ranges in Platinum TE are 0.30- 0.60%.

Primary functions: enzyme reactions, cell division, root formation, early growth in cool wet soils, promotion of manganese availability and subsequent activity.

Phosphorus is a component of nucleic acids (DNA and RNA); is directly involved in transfer and storage of ADP and ATP in cells; is directly involved in enhancement of full shiny dark green color expression in Platinum TE. Phosphorus is the one essential element that has a key role in all metabolites involving energy acquisition, storage, and utilization of sugar phosphates, adenosine phosphates (AMP, ADP, ATP), and in nucleotides and nucleic acids. Phytic acids or its calcium or magnesium salts (phytin) serve as phosphate storage compounds.

SILICON

Immobile internally in the plant, no sufficiency levels have been developed for silicon in Platinum TE. Monosilicic acid, $Si(OH)_4$, is the predominant compound in soil solutions. SiO_2 transport is only upward in the xylem after absorption by the roots; therefore, both granular and foliarly absorbed silicate fertilizer products should be applied.

Silicon is known to impart cell wall structural integrity that provides improved wear/traffic tolerance in turfgrasses; to suppress diseases and insects; to enhance salinity tolerance; to stabilize chlorophyll for transitioning into and out of cold temperature stresses; to remobilize soil phosphorus; to reduce water loss by cuticular transpiration, and to enhance nutrient uptake/utilization under salinity stress conditions.

Silicon confers strength and rigidity to the cell walls in the form of solid hydrated silica: $SiO_2 . nH_2O$.

Silicon is involved in enhancement of growth, promotion of upright or vertical growth, promotion of exposure of leaves to sunlight, and plant surface properties (roughness and appearance).

MOLYBDENUM

Somewhat immobile, but can be translocated via both the xylem and phloem, Mo occurs in aqueous solution mainly as the molybdate oxyanion ^{4}(MoO^{2+}).

Mo is found in several enzymes: xanthine oxidase/dehydrogenase, aldehyde oxidase, sulfite oxidase, nitrate reductase, and nitrogenase. Mo competes directly with divalent oxy-anions (SO^{4-}, HPO^{4-}) for exchange sites.

As soil acidity increases, Mo acquires hydrogen ions and becomes less ionic, or less readily absorbed by roots and occasionally forms Mo poly-anions that are completely unavailable for uptake. Excess applications of gypsum, single superphosphates or sulfur can negatively affect Mo availability.

Functions include enhancement of efficient N use and recycling N from nucleic acids via the nitrogenase enzyme; component of the enzyme involved in synthesis of ABA and IAA; and instrumental in signaling stress conditions between the root and the shoot.

Sufficiency ranges in Platinum TE should be maintained at 0.5 to 1.0 ppm Mo.

When growing a highly salt tolerant turfgrass, such as seashore paspalum, a significant number of known and unfortunately unknown nutrient interactions occur in the field. Frequent monitoring of soils, water, and tissue is required on a site-specific basis to fine-tune the fertility program in order to maximize grass performance. These nutritional x salinity interactions can be monitored with regularly scheduled testing of all components of the turf ecosystem.

Known Interactions

As salinity increases, K, Ca, Mg, P, and Cu concentrations decrease in leaf tissue; sodium concentration increases; iron and boron initially decrease, but then increase in concentration; chloride, manganese, and zinc initially increase, but then decrease in concentration.

Potassium is the most abundant nutrient in seashore paspalum tissues, contributing 24-40% to osmoticum. Internal plant K levels account for 76% of total shoot and 30% of total root variation. K, Ca, and Mg are key nutrients in shoots.

Positive correlations: shoots—K, Mg; roots—K, Mn, P, Cl

Negative sodium correlations: K, Ca, Mg

REASONS TO FERTILIZE WITH SALINITY CHALLENGES

****Basic nutrition**

****Correct imbalances**

****Correct for soil profile leaching losses**

****Activate plant stress tolerance mechanisms**

****Adjust for soil chemical problems**

****Regulate plant growth rates**

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