Differentiating the Physiological Responses of Creeping Bentgrass to Carbonate, Chloride, and Sulfate Salinity

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Objectives:

1. Understand the physiology of leaf firing in creeping bentgrass which is one of the symptoms of salinity stress.
2. Differentiate physiological responses of creeping bentgrass to different types of salinity problems, i.e. carbonate, chloride, and sulfate.

Start Date: 2011
Project Duration: 2 years
Total Funding: $6,000

Creeping bentgrass "Penncross' sod was harvested from an established putting green, washed free of soil, and planted to plastic pots 12.7 × 12.7 × 12.7 cm. The growth medium was sand that conformed to the USGA recommendations of particle sizes and had a pH of 7.09, EC (electrical conductivity) of 0.2 dS m^{-1}, and OM (organic matter) of 0.1%. The grass was mowed at 3 cm height and fertilized every two weeks at 12.2 kg ha^{-1} of N using Nusion 29-2-3 (The Andersons, Mauree, OH). At each fertilization, micronutrients also were applied using Minors Pakage 0-1-1 (The Andersons, Mauree, OH) at a rate of 4.8 L ha^{-1} of product that contains 1% P_2O_5 from phosphoric acid, 1% K_2O from potassium hydroxide, 1% Mg, 0.02% B, 2.45% Fe, 0.25% Mn, and 0.05% Zn.

Four salts (NaCl, Na_2CO_3, Na_2SO_4, and $CaCl_2$) were used in the study with NaCl at 0, 25, 75, 125, 175, 225 mM, while other salts at 0, 25, 50, 75, 100, 125 mM. The different concentration range for NaCl was used in order to achieve either a similar range of electric conductivity (EC) or osmotic potential among the four salts. The salt solutions were applied once every other day. The study was terminated when some of the treatments resulted in complete dead grass. The experiment was arranged in a randomized complete block design with three replicates.

At the same molar concentration, NaCl had the lowest EC or highest osmotic potential compared to other three salts because NaCl is a 1:1 salt with mono charge, while the others are of 1:2 or 2:1 charge ratios. The EC of NaCl at 225 mM is equivalent to $CaCl_2$ at 125 mM. The osmotic potential of NaCl at 175 mM was equivalent to other salts at 125 mM. The four salts have significant different pH.

Creeping bentgrass responded to four salts differently, including growth (clipping yield), visual quality, leaf firing (green density and green color), and evapotranspiration (ET). The plant ET decreased with the increasing salt concentration, and the greatest reduction occurred in Na_2CO_3. The decrease in ET was detected first, and as time proceed, clipping yield also decreased with increasing salt concentration. Leaf firing, as a symptom of salinity stress, resulted in decline in green leaf density, which showed increasing severity with increasing salt concentrations. Toward the end of this experiment, significant reduction of turf visual quality was observed.

Comparing the above responses at the same salt concentration, it was apparent that alkalinity mainly was responsible for the injury caused by Na_2CO_3. However, $CaCl_2$ and Na_2SO_4 injuries were contributed from high EC and alkalinity. Creeping bentgrass was sensitive to both salinity and alkalinity, because NaCl, which had lowest pH, lowest EC, and highest osmotic potential, caused least injury compared to other salts at the same concentrations.

Leaf firing increased with increasing levels of salts. However, different salts showed different symptoms. Leaf firing caused by NaCl started from young leaf tips and developed toward the base as time went on. Chlorosis caused by Na_2CO_3 started with yellowing of the whole young leaf blade and then died as time proceeded. The Na_2SO_4 injury started from the young leaves with discoloration between veins and then bleached out the leaf blade and sheath, as the process went on. Finally, $CaCl_2$ caused leaf injuries from the tips of the leaf blades and turned into straw color as died back toward the base of leaf blades.

Future work on this project will be focused on growth and physiological responses of creeping bentgrass to different salts and different concentrations.

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Summary Points

- At the same molar concentrations, NaCl, Na_2CO_3, Na_2SO_4, and $CaCl_2$ caused different responses in 'Penncross' creeping bentgrass. All salts are not same in physiological and growth responses.
- At the same molar concentration, NaCl has the lowest pH and EC, and highest osmotic potential compared to other three. Na_2CO_3 had the highest pH among the four salts.
- Alkalinity combined with salinity caused the most leaf injury to 'Penncross' creeping bentgrass.
- The stress caused by four salts were ranked in order of Na_2CO_3, $CaCl_2$ and Na_2SO_4, and NaCl at the same molar concentration.
- Leaf firing symptoms were different on 'Penncross' bentgrass caused by NaCl, Na_2CO_3, Na_2SO_4, and $CaCl_2$.