

Title: Growth and Physiological Responses of Creeping Bentgrass to Saturated Soil

Authors: Yiwei Jiang and Kehua Wang

Objective: To identify growth and physiological traits of creeping bentgrass cultivars associated with tolerance to full and partial soil saturation

Rationale: Transient flooding or heavy irrigation followed by slow drainage can lead to low oxygen in the soil. Oxygen deficiency is one of the primary root stresses in saturated soil, and turf quality is negatively affected. Creeping bentgrass is a widely used cool-season turfgrass on golf greens and fairways in northern regions and transitional zones. Little is known about effects of soil saturation on growth of creeping bentgrass and potential variations in low oxygen tolerance among cultivars.

In the field, saturation may not always appear at or above the soil surface. Survival of grass plants may depend on depths of water level and duration of stress. Depths of water can also provide a useful indication as to whether the soil is aerobic or anaerobic, and how these conditions affect plant growth. Limited research in turfgrass indicates that root growth is negatively affected by poor soil aeration. Growth and physiological responses of turfgrasses to fully and partially saturated soils are not understood. Mechanisms of plant tolerance to low oxygen in the saturated soil may be diversified; however, data to support on these observations are limited in turfgrass species.

Knowledge of how soil saturation influences growth of creeping bentgrass and cultivar variations in low oxygen tolerance could provide valuable information for breeding program and for effective management of creeping bentgrass under excessive water and low soil oxygen conditions.

How it was done: Mature, healthy creeping bentgrass ('A-4', 'G-6', 'L-93', 'Pennlinks', and 'Penncross') sod plugs were collected from USGA sand mix at the William H. Daniel Research and Diagnostic Center at Purdue University in West Lafayette, IN. Grasses were grown in a greenhouse for 60 d in polyvinylchloride (PVC) tubes (10 cm diameter x 40 cm deep) filled with medium sand (0.25-0.5 mm diameter). Grasses were irrigated daily, mowed daily at 0.4 cm with an electric hand-held clippers, and fertilized weekly with full-strength Hoagland's solution to supply 290 kg N ha⁻¹. Grasses were moved to growth chambers for 15 d under temperature of 20°C/15°C (day/night), a 14 h photoperiod, and a photosynthetically active radiation of 600 μmol m⁻² s⁻¹ prior to stress treatments.

Saturation treatments were imposed by plugging the drainage holes of PVC tubes. A 1-cm diameter hole was drilled in the side, 2.5 cm above the bottom, and connected to an open-end transparent tubing with height of other end adjusted to 15-, 5- and 1-cm below the soil surface. This transparent tubing was not installed for the control PVC tubes. Water was added from canopy to maintain different water levels in the soil. The treatments included: Control, drained to field capacity (40 cm deep); 2) Water level at 1 cm below the soil surface (WL-1); 3) Water level at 5 cm below the soil surface (WL-5), and 4) Water level at 15 cm below the soil surface (WL-15). An additional 1.0 cm-diameter hole was drilled in the side of each PVC tube 15 cm below the soil surface to allow a probe inserted to measure soil redox potential (Eh). This hole was plugged at all time except during sampling.

Turf quality (TQ) was visually rated as an integral of color, uniformity, and density on the scale of 1 (brown leaves) to 9 (turgid, green leaves) at 7, 14, and 21 days of WL treatment. At the end of experiment (21d), soil redox potential, chlorophyll content (Chl), root dry weight, shoot water soluble carbohydrate content (SWSC) and root soluble carbohydrate content (RWSC), and root total soluble protein content were determined.

Results to date: Saturation significantly reduced TQ. Turf quality decreased with increasing water level from 15- to 1-cm below the soil surface (Table 1). At 21 d of treatment, TQ was acceptable (value of 6.2) under WL-15 but not under WL-5 and WL-1. Soil Eh measured at 15-cm deep decreased with increasing water level from 15- to 1 cm below the soil surface (Table1). Soil Eh decreased 37 %, 47 %, and 53 % under WL-15, WL-5, and WL-1, respectively. Root WSC decreased 32 %, 35 %, 44 %, RDW decreased 28 %, 21 %, 20 %, and RPRO decreased 16 %, 18 %, and 22 % under WL-15, WL-5, and WL-1, respectively.

Overall, G-6 and L-93 exhibited acceptable turf quality (>6), while A-4, Penncross and Pennlinks had unacceptable quality under WL conditions (Table 2). Significant differences in RDW were observed among five cultivars with A-4 showing the highest RDW and Pennlinks having the lowest (Table 2). Pennlinks had the highest RPRO and Penncross exhibited the lowest RPRO among five cultivars.

The results suggest that even partial saturation could substantially affect turfgrass growth and physiological activities, and cultivar variations in low oxygen tolerance could potentially be used for enhancing breeding programs.

Table 1. Effects of water level (WL) on soil redox potential (Eh), turf quality (TQ), chlorophyll content (Chl), shoot soluble water carbohydrate content (SWSC), root water soluble carbohydrate content (RWSC), root dry weight (RDW), and root total soluble protein content (RPRO) for five creeping bentgrass cultivars

| Treatment | Aboveground | | | Belowground | | | |
|--------------------|--------------------|---------|---------|-------------|---------|--------|---------|
| | TQ | Chl | SWSC | Eh | RWSC | RDW | RPRO |
| | | mg/g FW | mg/g DW | mV | mg/g DW | g | mg/g FW |
| Control | 7.6 a [†] | 1.58 a | 36.7 b | 364.2 a | 84.0 a | 0.85 a | 1.81 a |
| WL-15 [‡] | 6.2 b | 1.35 b | 43.8 ab | 230.9 b | 57.5 b | 0.61 b | 1.52 b |
| WL-5 | 5.7 c | 1.25 c | 43.8 ab | 192.7 bc | 54.3 b | 0.67 b | 1.48 b |
| WL-1 | 4.8 d | 1.16 d | 50.7 a | 171.3 c | 47.3 b | 0.68 b | 1.41 b |

[†] Means followed by the same letter within a column are not significantly different at $p < 0.05$.

[‡] Water level at 15-, 5-, and 1 cm below the soil surface, respectively.

Table 2. Cultivar differences in soil redox potential (Eh), turf quality (TQ), chlorophyll content (Chl), shoot soluble water carbohydrate content (SWSC), root water soluble carbohydrate content (RWSC), root dry weight (RDW), and root total soluble protein content (RPRO) under full and partial saturation treatments.

| Cultivar | Aboveground | | | Belowground | | | |
|-----------|--------------------|---------|---------|-------------|---------|---------|---------|
| | TQ | Chl | SWSC | Eh | RWSC | RDW | RPRO |
| | | mg/g FW | mg/g DW | mV | mg/g DW | g | mg/g FW |
| G-6 | 6.5 a [†] | 1.43 a | 34.4 b | 264.6 | 65.2 | 0.73 bc | 1.31 d |
| L-93 | 6.3 ab | 1.31 b | 40.1 ab | 215.1 | 54.9 | 0.78 ab | 1.62 b |
| A-4 | 5.9 bc | 1.30 b | 49.6 a | 233.3 | 58.6 | 0.92 a | 1.51 bc |
| Penncross | 5.9 c | 1.32 b | 46.8 a | 225.9 | 57.0 | 0.56 cd | 1.29 d |
| Pennlinks | 5.7 c | 1.32 b | 49.0 a | 264.4 | 63.9 | 0.51 d | 2.07 a |

[†] Means followed by the same letter within a column are not significantly different at $p < 0.05$.