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Rooting in a Creeping Bentgrass Putting Green in Response to Spring and Summer Coring

Jinmin Fu and Peter H. Dernoeden*

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ABSTRACT

Understanding root growth response of creeping bentgrass (*Agrostis stolonifera* L.) to coring will help golf course superintendents maintain high quality putting green turf. The objective of this field study was to examine the effects of coring on summer rooting in young creeping bentgrass grown on a sand-based root zone and maintained as a putting green. The study was initiated on 7-mo-old 'Providence' creeping bentgrass in 2006 and compared spring (SP) only coring, spring plus three summer (SU) corings (SP + SU) and a noncored control through 2007. The minirhizotron imagining technique was used to measure total root count (TRC) and total root length (TRL) from late spring to late summer. The percentage of the TRC in the surface 0- to 6-cm root zone depth averaged over measurement dates was 48 to 53% and 33 to 44% among all treatments in 2006 and 2007, respectively. Greater TRC were observed in 2006 with 28, 51, and 50% lower TRC's found in SP + SU, SP only, and noncored plots in 2007, respectively. Spring + SU coring generally reduced TRC and TRL at various root zone depths and dates during the first year of establishment. In 2007, greater TRC and TRL were observed throughout the 0- to 24-cm root zone in SP + SU cored compared to SP only and noncored plots. Thus, SP + SU coring in the second study year promoted creeping bentgrass root growth and/or longevity, but coring during the first summer of establishment reduced rooting.

Creeping bentgrass is the most widely used cool-season turfgrass on golf greens. Creeping bentgrass is aggressively stoloniferous and produces a well-defined surface organic layer, which hereafter will be referred to as the thatch-mat layer (McCarty et al., 2007). Excessive thatch-mat layers commonly are associated with negative effects on biological and soil properties as summarized by McCarty et al. (2005). Managing thatch-mat layers on putting greens is difficult and involves numerous cultural practices, including core cultivation (McCarty et al., 2007). In turfgrass management the term cultivation refers to working the soil and/or thatch-mat layer without destroying the turf (Turgeon, 2008). Coring (i.e., hollow or solid tines are used) is a cultivation technique (Beard, 1973) and the term coring will be used hereafter. Coring is used to manage thatch-mat layers and improve turf quality by promoting water infiltration, reducing soil surface wetness, and improving aeration and rooting (Beard, 1973; Fry and Huang, 2004).

Some research efforts involving coring have examined rooting by destructive sampling methods (Harper, 1953; Murphy et al., 1993; Wiecko et al., 1993). Reports on turf rooting in response to coring, however, have not been consistent. In a fairway coring study, Harper (1953) reported that a single spring coring did not affect bentgrass root mass compared to noncored bentgrass. In a Georgia study, Tifway bermudagrass [*Cynodon transvaalensis* Burtt-Davy × *C. dactylon* (L.) Pers] was cored to a 7.6-cm soil depth using hollow tines between late April and early August (Wiecko et al., 1993). Data from 1 yr of that study indicated that coring resulted in an increase in root length, but had no effect on root length in the second year (Wiecko et al., 1993). Murphy et al. (1993) sampled roots in a Penneagle creeping bentgrass green grown on a modified loamy sand. In compacted and noncompacted soil, coring reduced both total root weight and root density (Murphy et al., 1993). Furthermore, summer coring did not enhance surface root development of creeping bentgrass.

Root production, growth, longevity, and mortality are critical components contributing to plant adaptation to environmental stresses. Most turfgrass root studies were conducted using destructive soil sampling techniques, which typically quantify living and dead root biomass at a singular time of the growing season. Destructive sampling techniques are not able to detect root initiation or root death. The minirhizotron imaging technique, however, allows for nondestructive monitoring of root production and growth (Murphy et al., 1994; Liu and Huang 2002). The minirhizotron allows for the quantification of various living root parameters throughout a 0 to 24-cm deep root zone. Its greatest advantage is that it provides information on seasonal changes of the same roots, which eliminates confounding spatial variation and permits a high frequency of visual root observations (Murphy et al., 1994).

Coring generally is performed in the spring and autumn. Little information is available on summer coring effects on seasonal and vertical changes in a creeping bentgrass root system grown on a sand-based root zone. Previous studies were conducted on modified or native soil research putting greens. Most putting greens today are constructed with a high sand content to reduce

J. Fu, Key Laboratory of Plant Germplasm Enhancement and Specialty Agriculture, Wuhan Botanical Garden, The Chinese Academy of Science, Wuhan City, Hubei, 430074, P.R. China; P.H. Dernoeden, Dep. Plant Science and Landscape Architecture, Univ. of Maryland, College Park, MD 20742. Received 18 Mar. 2012. *Corresponding author (pd@umd.edu).

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Abbreviations: SP, spring only coring; SP + SU, spring plus summer coring; TRC, total root count; TRL, total root length.

problems associated with compaction; that is, to maintain air-filled porosity and drainage. Furthermore, we are not aware of any studies in which coring was assessed in the first and second summer following establishment. It was our hypothesis that summer coring would be more injurious to creeping bentgrass grown in the first summer following establishment than in the second summer after establishment. Thus, the objective of this study was to quantify summer rooting in response to spring and summer coring in putting green height creeping bentgrass grown on a sand-based root zone during the first two summers following establishment.

MATERIALS AND METHODS

This field study was conducted on a sand-based root zone built using USGA recommendations (Green Section Staff, 1993) at the University of Maryland Turfgrass Research Facility in College Park. The research green was built in 1999 and the root zone mixture consisted of 80:20 (v/v) sand and sphagnum peat. The modified sand mix (97% sand, 1% silt, and 2% clay) had an initial pH of 6.5 and 10 g kg^{-1} of organic matter. The site was an existing stand of creeping bentgrass, which was treated with glyphosate [N-(phosphonomethyl) glycine] in September 2005 and the existing sod was removed. The site was seeded (50 kg ha^{-1} seed) with Providence creeping bentgrass. A total of 250 kg ha^{-1} N was applied between 20 Sept. and 11 Nov. 2005 with a 20–9–16 (N–P–K) fertilizer. Urea was applied biweekly at 4.9 kg ha^{-1} N from 1 May through 7 June and then weekly through 24 August for a total of 78.4 kg ha^{-1} N during the 2006 experimental period. A total of 71 kg ha^{-1} N was applied as urea between September and November 2006. In 2007, the bentgrass was fertilized weekly (4.9 kg ha^{-1} N) with urea between 30 April and 27 August to provide a total of 88.2 kg ha^{-1} N during the experimental period. Iprodione [3-(3,5-dichlorophenyl)-N-(1-methylethyl)-2,4-dioxo-1-imidazolidinecarboxamide; 14.7 kg ai ha^{-1}] was applied to control dollar spot (*Sclerotinia homoeocarpa* F.T. Bennett) and brown patch (*Rhizoctonia solani* Kuhn) on a 10 to 14 d interval beginning mid-May and continuing through mid-August in 2006 and 2007. Iprodione was chosen since it has no known plant growth regulator effects. Turf was mowed three times weekly with a triplex mower to a height of 6 mm in the spring of 2006 and gradually reduced to 4 mm by 3 July 2006. The green was mowed to a height of 4 mm thereafter about five times weekly with a triplex mower and clippings were removed. The site was irrigated as needed to prevent wilt in all years. When irrigated, water was applied to wet the entire root zone and the site was syringed occasionally during sunny, rain-free periods. The green was not subjected to additional traffic stress beyond routine mowing and other management practices.

Three treatments were assessed in 2006 and 2007 as follows: SP only coring, SP + SU, and a noncored control. Spring coring involved larger diameter tines than summer coring since smaller tines would be expected to cause less injury to putting greens during summer stress periods. The SP treatment was performed using a Miltona Handi Aerifer (Miltona Turf Products, Miltona, MN). This hand-held, manual device had seven, 1.27 cm diam. hollow tines, which penetrated to a depth of 9 cm. Cores were removed on a 5-cm spacing, producing about 400 holes m^{-2}. Manual coring was performed to prevent damaging the minirhizontron tubes, which could not have been avoided by using a machine. Care was taken not to damage tubes by slowly inserting and removing the device once a tube was contacted. The SU corings were performed using one leg taken from a CoreMaster *12 Aerator (GreenCare, Sydney, Australia) equipped with a quadra-tine holder. The four, 0.64-cm diam. hollow tines penetrated to a depth of 5.5 cm on a right angle spacing of 3.8 cm and a diagonal spacing of 5.0 cm. The quadra-tine leg was manually forced into the turf and about 690 holes m^{-2} were made. Core spacing was performed visually without a template and overtime some holes would have been recored. Spring coring was performed on 27 Apr. 2006 and 29 Apr. 2007 using the 1.27-cm diam. tines described previously. Summer coring was performed using the previously described 0.64-cm diam. quadra-tines on 6 and 28 June and 25 July 2006 and 6 June and 3 and 31 July 2007. Topdressing using the previously described root zone mix was applied after all SP coring treatments to fill holes to the surface. Plots were brushed to re-incorporate sand brought to the surface with SU coring, but no additional topdressing sand was applied. Other than previously described, no topdressing program was imposed after summer coring.

Root measurements were obtained using the minirhizotron imaging technique as described by Murphy et al. (1994) and Liu and Huang (2002). Before treatments were imposed, two soil cores (5-cm in diam. by 60-cm long) were removed from each plot in April 2006 at a 30 degree angle from the soil surface. Two clear butyrate tubes of a size equivalent to the voids were plugged with a black rubber stopper at the bottom end, sealed with waterproof silicon sealant, and manually forced into holes in each plot for root observation. Each tube was positioned in the ground with the upper end oriented north and closed with a black rubber stopper that was flush with the soil surface such that tubes did not interfere with mowing. Tubes remained in ground over winter between April 2006 and September 2007. Images of roots visible against the surface of the tubes were recorded sequentially from the soil surface using a high-magnification minirhizotron camera (Bartz Technology Corp, Santa Barbara, CA). Image size was 1.4 by 1.8 cm and a total of 35 images were taken in each tube on each monitoring date. Root images were captured as bitmap (BMP) files on a personal computer. All visible roots were traced and analyzed using an image analysis program (RooTracker 2.0, Duke University, Durham, NC). This program determines root number, length, and diameter. Total root count was measured as the sum of all roots observed within a specified soil depth (hereafter root zone) range. Similarly, TRL was measured as the sum of all root lengths within a specified root zone range. Since the quadra-tines penetrated to a 5.5-cm depth, data were averaged at 6 cm increments for the 0- to 6- and 6- to 12-cm depths. Since there were few differences at the 12- to 18- or 18- to 24-cm root zone depths, data were averaged over the 12- to 24-cm root zone depth. Data also were summed over the entire 0- to 24-cm root zone. Rooting was assessed on 5 July, 3 and 28 Aug. 2006, and 30 May, 13 July and 4 Sept. 2007.

Air and soil temperatures were measured and reported in a companion study on the same research green (Fu and Dernoeden, 2009). Maximum and minimum air temperatures were determined in July and August in 2006 and 2007. Mean maximum and minimum air temperatures in July were 31.6 and 20.0°C in 2006 and 31.0 and 17.5°C in 2007, respectively. Mean maximum and minimum air temperatures in August were 31.6 and 18.2°C in 2006 and 31.5 and 20.2C in 2007, respectively. Soil