THE EFFECT OF NITROGEN FERTILITY ON GROWTH AND QUALITY OF VELVET BENTGRASS AND CREEPING BENTGRASS

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Introduction:

Creeping bentgrass (*Agrostis stolonifera* L.) is the most widely planted turfgrass on golf course putting greens in temperate North America (Beard, 2002). Establishment and management practices are well understood for this turfgrass, hence its widespread popularity (Beard, 1973; Christians, 1998; Beard, 2002). Unfortunately, newer generation creeping bentgrass cultivars require regular applications of both fertilizer and fungicide to maintain acceptable putting green quality. Therefore, creeping bentgrass can be considered to require significant inputs for maintenance (Dernoeden, 2002). Municipal restrictions on pesticides are becoming more prevalent (Burrows, 2002; Cousineau, 2002), and the potential to restrict use of chemical fertilizers in the future also exists. These management challenges have started a movement in the golf industry to reduce inputs. An approach to achieving this goal is adapting use of alternative, lower input turfgrasses for putting greens. Velvet bentgrass (*Agrostis canina* L.) is thought to be an excellent alternative to creeping bentgrass due to disease resistance (Brilman and Meyer, 2000) and reportedly superior putting surface quality (Moneith and Welton, 1932). However, establishment and management practices for this species of bentgrass have not been extensively studied.

Proper nitrogen fertility is essential to turfgrass growth and development. Nitrogen aids in turfgrass recovery from stresses such as wear, physical injury from maintenance practices, and damage from pests (Beard 1973; Beard, 2002). Nitrogen application rate is a significant contributor to turfgrass quality as it can affect not only the aesthetics of the turfgrass stand, but in the case of a putting green, functional characteristics such as ball roll speed (Johnson et al. 2003). However, it is known that applying nitrogen in amounts greater than the requirements of the turfgrasses in question can result in increased above-ground growth (Markland and Roberts, 1969; Christians et al. 1979). Increased growth is of special concern on putting greens as the logistics of maintenance become difficult and labor costs increase in part due to increased mowing frequency. Nitrogen application above the requirements of the turfgrass stand also reduces depth and density of root growth (Bowman et al. 1998; Schlossberg and Karnok, 2001). A decreased root mass reduces nutrient uptake (Bowman et al. 1998) and water uptake (DaCosta and Huang, 2006a). Therefore, identifying optimal nitrogen levels for turfgrasses at establishment (to maximize root and shoot development) and over the longer term (to stabilize root production and turfgrass quality) are very important to managing a turfgrass stand such as a putting green. Anecdotally SR7200 velvet bentgrass requires a substantial amount of nitrogen fertility to hasten establishment, but very little once established (Brilman, 2007, Pers. Comm.). When nitrogen is applied to established stands of SR7200 velvet bentgrass, both turfgrass color and quality increase (Boesch and Mitkowski, 2007). However, Paré (2004) noted that established Vesper, another cultivar of velvet bentgrass, showed decreased turfgrass quality at nitrogen application rates higher than 1.5kg/100m^2/year. Therefore, it is important to determine acceptable nitrogen rates, as little is known about turf color and quality responses of velvet bentgrass at establishment.

The purpose of this study was to determine the ideal establishment requirements and nitrogen requirements for maintenance in velvet bentgrass. Two greenhouse projects and one large-scale field project were conducted from 2006 through 2008. The results of the greenhouse projects suggested that of the treatments tested (nitrogen rate, phosphorus rate, rootzone material and seeding rate) only nitrogen rate and rootzone material had a significant effect on growth of velvet bentgrass. It was found that velvet bentgrass needed a relatively high level of nitrogen to become established, but for maintenance, the species fared well under more moderate leaves. Results also indicated that quality of velvet bentgrass was positively correlated with amount of organic material (i.e. peat) in the rootzone mixture. These results were used to design the field project which is presented below.

Methods:

Turfgrass establishment:

During the summer of 2006, three putting greens were established at the Guelph Turfgrass Institute and Environmental Research Centre (GTI), University of Guelph, Guelph, ON, Canada. The putting green areas used for this experiment included one USGA specification 80:20 (sand:peat) putting green and two push-up style 'native soil' putting greens formed from an onsite 30.5cm deep rootzone created in the construction phase of the GTI (1987-1993). Prior to plot establishment, soil samples were taken to confirm uniformity of the putting greens. Each green was divided into 9 quadrants and 15 soil cores to a depth of 15cm were taken from each quadrant at random. The 15 cores from each quadrant were then mixed thoroughly, air dried, and sent for testing at the Department of Plant and Soil Science, University of Massachusetts, Amherst, MA. The soil test results confirmed good uniformity within each site. Soil pH in the USGA green was 8.0 with available phosphorus (P_2O_5) and available potassium (K_2O) levels of 9.1 and 20.7 ppm, respectively; the organic matter content of this putting green was 1.3% (w/w). For the soil putting greens, the pH averaged 7.7 with available phosphorus (P_2O_5) and available potassium (K_2O) levels of 8 and 74 ppm; the organic matter content of these putting greens was 4.4% (w/w). Because phosphorus and potassium levels were relatively low in both rootzones, these nutrients were included with the starter fertility regime and pre-treatment nutrient applications. Both areas were seeded to three varieties of turfgrass – one section on each green were seeded to creeping bentgrass, cultivar

Penn A-4, one to creeping bentgrass, cultivar L-93 and one to velvet bentgrass, cultivar SR-7200. All bentgrasses were seeded at a rate of 0.6 kg/100m2.

Experimental conditions:
An 11-week project was conducted in 2007 from June 27 to September 4 (71 days). Throughout the experiment, ambient temperature, relative humidity, and precipitation were monitored by the on-site Environment Canada weather station. Prior to the experiment, soil testing was performed to confirm uniformity of the putting greens. Fifteen soil cores taken to a depth of 15 cm were sampled from each turf section on each putting green at random. The 15 cores from each turf section were then mixed thoroughly, air dried, and sent for testing at the Soil and Nutrient Laboratory division of Laboratory Services, University of Guelph, Guelph, ON. The soil test results confirmed good uniformity within each respective putting green. Soil pH in the USGA green was 7.5 with available phosphorus (P) and available potassium (K) levels of 11 and 20.3 ppm, respectively. The organic matter content of the USGA green was 1.3% (w/w). For the soil putting greens, the pH averaged 7.4 with available phosphorus (P) and available potassium (K) levels of 22 and 87ppm, respectively. The organic matter content of the soil putting greens averaged 4.1% (w/w). Clippings were also sampled from each turf main plot prior to beginning treatments by making one mower pass across each block and bulking these clippings to obtain a baseline nitrogen level. The baseline tissue nitrogen levels confirmed good uniformity across all turf types on both rootzones.

Plant Culture:
Each putting green was irrigated as required to prevent drought stress when rainfall was insufficient. Volumetric soil water content was checked occasionally using a Time Domain Reflectometer (TDR) 200 soil moisture probe (Spectrum Technologies Inc., Plainfield, IL) to confirm that each putting green was at a uniform moisture content across plot areas, and confirm proper irrigation system and sprinkler head function. Plots were mowed daily at a height of 3.4-4.4mm using a Toro Greensmaster 3050 Triplex greens mower (The Toro Company, Bloomington, MN). The reels on the triplex mower were 11-blade units equipped with a tournament bedknives.

Fertility Treatments:
Urea (46-0-0) was used as the nitrogen source for this study as it is a readily available nitrogen source for plants. Six nitrogen rates were investigated: 0.12, 0.24, 0.48, 0.96, 1.8, 2.8g N/m^2/week. These were the same weekly rates investigated in the second greenhouse study, and translate to approximate annual rates of 0.25, 0.5, 1.0, 2.0, 4.0, 6.0kg $N/100m^2$, based on a 21 to 22 week growing season. The timeframe of 21 to 22 weeks was selected as it is the period of the most intensive play on golf courses in Ontario, extending from May through to September. Nitrogen was applied either weekly or every other week (bi-weekly) to simulate light, frequent applications, which is a common practice for putting greens (Beard, 2002; Turgeon, 2005). The three highest rates, 0.96, 1.9, 2.8g N/m^2 (equates to 2.09, 4.13, 6.09g 46-0-0/m^2/week, or 4.18, 8.26, 12.18g 46-0-0/plot/week) were applied on a

weekly schedule as a small preliminary test prior to the experiment determined that these rates had the potential to burn the turfgrasses if put on at a bi-weekly interval at twice the concentration. The three lowest rates, 0.12, 0.24, 0.48g N/m^2 were applied on a bi-weekly schedule (equates to 0.52, 1.04, 2.09g 46-0-0/m^2 bi-weekly or 1.04, 2.08, 4.18g 46-0-0/plot bi-weekly) as the granular urea at the lowest two rates on a weekly basis would not have provided sufficient fertilizer material to deliver even coverage across the plots. Two methods for nitrogen application were also examined in this experiment: foliar and granular application of the urea. The granular urea treatment was applied to the plots using a small hand shaker then watered in promptly after application using a watering can. This process provided approximately 2-3mm of irrigation to dissolve the fertilizer prills into the soil, minimizing any transfer of urea into the turf leaf blades. All greens were irrigated the day prior to nitrogen application to reduce the variability introduced by watering in the granular treatment. The foliar treatments were applied to plots using a compressed air powered, 4-nozzle bicycle sprayer with an effective spray width of 1m. The spray output was 100mL/plot at 20 PSI, equivalent to a spray volume of 5L/100m^2.

Data Collection:

Clippings

Clippings were collected twice on July 31 and August 28 for both soil putting greens, and on August 1 and August 29 for the USGA putting green. The dry weights of these samples were used to gauge growth differences in response to the treatments. Clippings were collected from the plots using a Toro Flex-21 (0.53m width of cut) walk behind greens mower bench set to 4.06mm. To collect the clippings, one mower swath was cut at the end of each plot (in between blocks) to allow for an accurate start and end point. A visual representation of this process is shown in Plate 4.2. The total area clipped and collected in each plot was 0.78m^2 [0.53m x 1.47m or (width of cut) x (2m plot length - 2 half mower swaths)]. Mowing was restricted on the plots for two days prior to clipping collection to ensure an accurate sample size from each plot. Clippings from the plots were emptied from the mower's collection basket directly into standard paper lunch bags and dried for at least 96 hours at 70°C in a convection lab dryer (Fisher Scientific Company, Ottawa, ON). Following drying, samples were transferred to a lab bench and allowed to cool and equilibrate at room temperature for 30-60 minutes. Clipping samples were promptly weighed on an analytical balance and the weights recorded. Following weighing, the clippings were re-inserted into their respective bags and stored under ambient lab conditions for nitrogen analysis.

Thatch/Mat Layer

Thatch/mat layer was measured at the beginning (June 26) and end of the experiment (September 12-19). Thatch/mat depth on June 26 was determined by randomly taking 4 cores from each turf main plot on all greens; two measurements were taken on each core using a ruler. At the end of the experiment thatch/mat measurements were only taken from the USGA green and one soil green as the both soil greens had similar thatch/mat depths at the start of the season. Furthermore, only rates of 0.12, 0.96, and 2.8g N/m^2/week for both foliar and granular applications were evaluated due to time restrictions. At the final measurement, three random cores were taken from each of the experimental plots and measured twice using digital calipers to obtain an accurate thatch/mat measurement.

Turfgrass Color and Overall Quality Ratings
Visual turf quality ratings were recorded weekly for the duration of the experiment commencing on July 3 and terminating on September 4. Visual ratings were based on a scale of 1-9 as described in chapter 2.2.5. Overall turfgrass quality and turfgrass color ratings were evaluated. This rating system is based on the National Turfgrass Evaluation Program protocol (Morris, undated), and is a widely accepted gauge for visual turfgrass evaluation.

Weed Invasion
Weed invasion was recorded for all plots twice during 2007. This measure was recorded to determine if nitrogen rate and application method influenced weed invasion over the course of the experiment. The measurements were recorded prior to treatment application in June and after treatment application in September using the point quadrat method (25-point quadrat) thrown at random on each plot 4 times, for a total of 100 points. The number of points identified, i.e., where a weed touched a point on the grid, counts as a value of 1/100, or 1 percent weed cover. The primary weed identified was creeping bentgrass in the velvet bentgrass plots and was due to 'escapes' from the glyphosate application following initial washouts during establishment in 2006. This was primarily an issue on the USGA sand green.

Nitrogen Analysis
Nitrogen analysis was performed on clipping samples obtained at the second collection (end of August). Dried turfgrass tissue was ground in a Wiley mill 'Mini-mill' (Thomas Scientific, Swedesboro, NJ) equipped with a 20 mesh screen (~0.850mm) to homogenize samples. The mill was cleaned thoroughly between each sample using compressed air and a small vacuum cleaner. Ground tissue was stored under ambient lab conditions. A Total Kjeldahl Nitrogen (TKN) acid digestion was then performed on the plant. Quantitative determination of TKN of the digested samples was determined by the Soil and Nutrient Laboratory division of Laboratory Services, (University of Guelph, Guelph, ON).

Results and Discussion:

Due to issues with initial seeding of the USGA sand green (thunderstorms after seeding created movement of the seeds of the cultivars) there was a significant amount of creeping bentgrass in the velvet bentgrass plots. Therefore, it was very difficult to collect any accurate data and the sand green was excluded from the analysis.

In both years, there was a significant effect of nitrogen on clipping weight for all three cultivars. All cultivars increased in clipping weight as nitrogen rates increased but there was not a significant difference in yield between the cultivars (data shown for 2007 only (Fig. 1). There was no effect of fertilizer delivery, as both foliar and granular treatments showed the same trend. Analysis of tissue nitrogen showed the

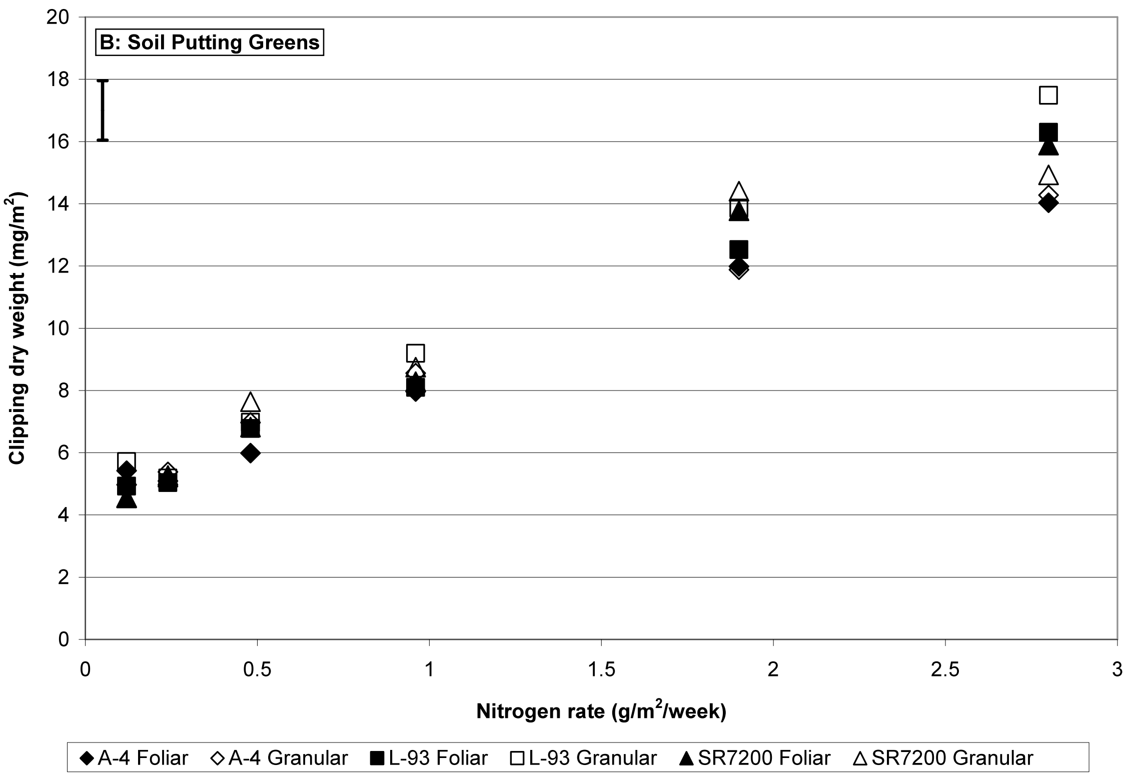


Fig. 1. Effect of nitrogen rate on clipping dry weight of velvet bentgrass SR7200 and creeping bentgrass cultivars L-93 and Penn A-4

same trend as clipping weight. There was a significant increase as nitrogen rates increased. These results were expected as previous research has shown that increasing nitrogen rates will lead to increased clippings (Christians et al., 1979; Markland and Roberts, 1969). It would stand to reason that nitrogen levels in the tissue would also increase as amount of nitrogen applied increases.

Thatch layers increased significantly with increasing nitrogen rates, although again, there were no differences between the cultivars (data not shown). Thatch levels did not increase significantly between the two years of the study, although the trend remained the same with thatch levels increasing with increasing with nitrogen rate.

Where the turfgrass species differed in their reaction to nitrogen rates was in turfgrass quality (Fig. 2). Turfgrass quality in 2007 in velvet bentgrass was significantly higher than the two creeping bentgrass cultivars at the lowest nitrogen levels, but as nitrogen rate increased, both of the creeping bentgrass cultivars increased in turfgrass quality while velvet bentgrass decreased significantly in quality to a final value of less than 4 (based on the NTEP scale of 1-9), well below acceptable quality for a putting green surface.

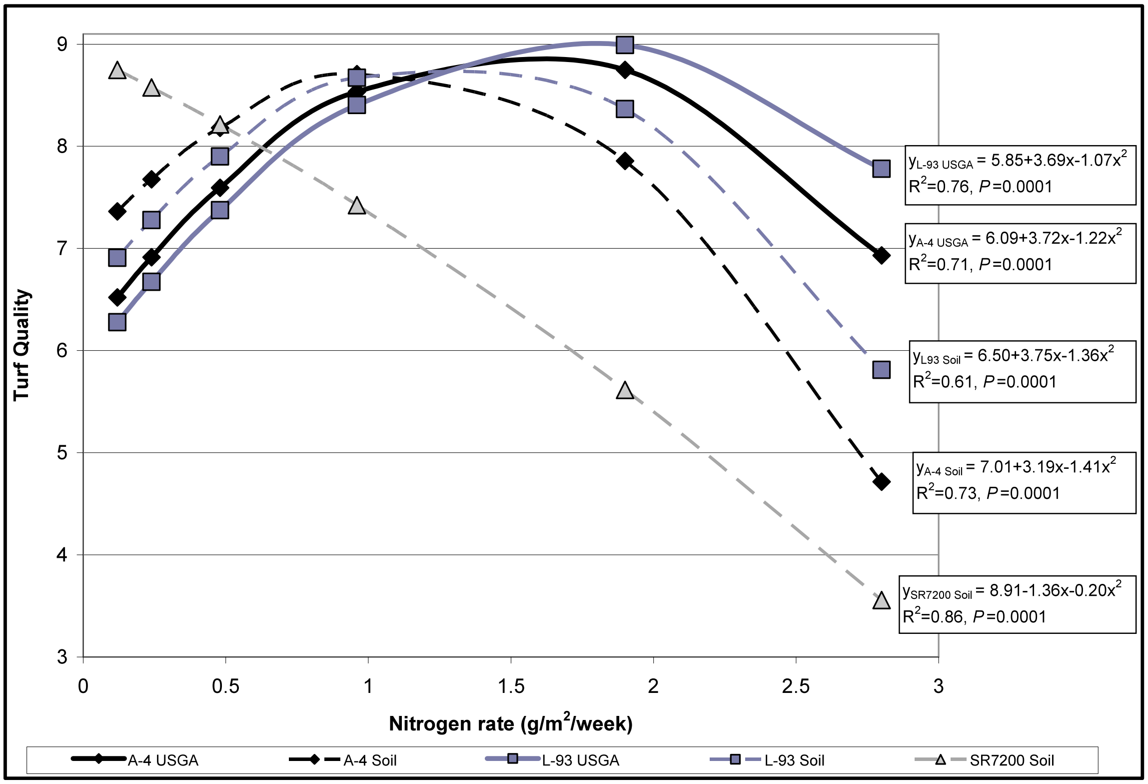
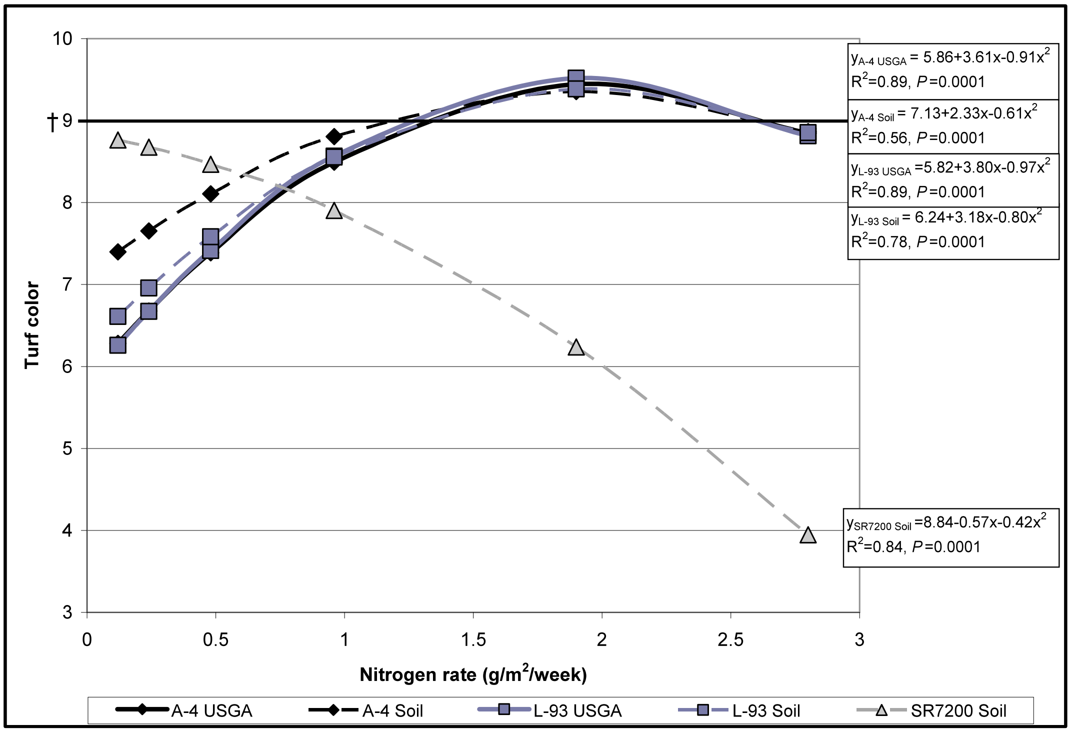


Fig. 2. Regression curves for the effect of urea nitrogen rate on quality of both velvet and creeping bentgrass cultivars. Values of turfgrass quality are based on NTEP ratings with 1 being low quality and 9 being highest quality. Acceptable putting turf quality is a rating of 6.

The primary component of turfgrass quality that led to the values observed was that of color (Fig. 3). Severe turfgrass chlorosis was observed in the velvet bentgrass plots as nitrogen levels increased, while color was significantly better in the velvet plots at the two lowest nitrogen rates than in the two creeping bentgrass cultivars.



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In the 2008 season, these differences were not as extreme. Turfgrass quality increased with increasing nitrogen rates up to the rate of 0.48g N/m2 and then decreased with the last two nitrogen rates. Both of the cultivars of creeping bentgrass showed the same trend as in the previous season – a stready increase in quality with increasing nitrogen rate.

The decrease in color and subsequently quality ratings for velvet bentgrass with increasing nitrogen rates suggests that velvet bentgrass has a sensitivity to high levels of nitrogen. However, the ability of velvet bentgrass to grow well under extremely low levels of nitrogen (yearly equivalents of 0.25 – 0.5 kg/100m2) might indicate that this species of turfgrass is extremely efficient at utilizing nitrogen. Current research being conducted at the University of Guelph is exploring the mechanisms behind both the species' ability to thrive under low nitrogen as well as its intolerance to high (>/= 2 kg/100m2) of nitrogen.

Conclusions:

This study evaluated the response of two cultivars of creeping bentgrass (*Agrostis stolonifera* L.) and a cultivar of velvet bentgrass (*Agrostis canina* L.) to increasing levels of nitrogen in the form of urea. The results indicated that although velvet bentgrass required relatively high levels of nitrogen (0.75 g N/m2) at establishment, in the field, the species was able to thrive and reach maximum quality (a rating of nearly 9) with as little as 0.12 g N/m2/week (equivalent to ~ 0.25 kg N/100m2 annually). Both creeping bentgrass cultivars, however, did not achieve maximum color and quality ratings until nitrogen levels of 0.96 g N/m2/week (equivalent to annual levels of ~ 2 kg N/100m2) were added. In addition, the velvet bentgrass responded negatively to increasing amounts of nitrogen, while both creeping bentgrass cultivars continued to show an increase in quality with increasing nitrogen levels.

We believe that the results of this study confirm that velvet bentgrass does indeed require fewer nitrogen inputs to achieve acceptable quality for a putting green. In addition, anectodal data on incidence of dollar spot infection suggested that velvet bentgrass was resistant to this disease as symptoms were only present on the creeping bentgrass cultivar Penn A-4. The data from this study suggest that velvet bentgrass could be an acceptable low-input alternative to creeping bentgrass for putting greens in Ontario. However, more research needs to be conducted to determine if these results would continue over a longer period of time and also how disease tolerance changes relative to nitrogen rate.

Literature Cited:

Beard, J.B. 1973. Turfgrass: Science and culture. Prentice-Hall Inc. Englewood Cliffs, New Jersey. 658p.

Beard, J.B., 2002. Turf Management for Golf Courses. Ann Arbor Press. Chelsea, Michigan. 793p.

Boesch, B.P and N.A. Mitkowski. 2007. Management of velvet bentgrass putting greens. Applied Turfgrass Science doi:10.1094/ATS-2007-0125-01-RS

Bowman, D.C., Devitt, D.A., Engelke, M.C., and T.W. Rufty, Jr. 1998. Root architecture affects nitrate leaching from bentgrass turf. Crop Science. 38:1633-1639.

Brilman, L.A., and W.A. Meyer. 2000. Velvet bentgrass: Rediscovering a misunderstood turfgrass. Golf Course Management. 68:70-75.

Burrows, B. 2002. Pesticide ban coming to a golf course near you? GreenMaster. 37:6,8-10.

Christians, N. 1998. Fundamentals of turfgrass management. John Wiley and Sons Inc. Hoboken, New Jersey. 359p.

Christians, N.E., Martin, D.P., and J.F. Wilkinson. 1979. Nitrogen, phosphorus, and potassium effects on quality and growth of Kentucky bluegrass and creeping bentgrass. Agronomy Journal. 71:564-567.

Cousineau, K. 2002. An update on pesticides. GreenMaster. 37:23.

DaCosta, M., and B. Huang. 2006b. Osmotic adjustment associated with variation in bentgrass tolerance to drought stress. Journal of the American Society for Horticultural Science. 131:338-344.

Dernoeden, P.H. 2002. Creeping Bentgrass Management – Summer Stresses, Weeds and Selected Maladies. John Wiley and Sons Inc. Hoboken, New Jersey: 133p.

Johnson, P.G., Koenig, R.T., and K.L. Kopp. 2003. Nitrogen, phosphorus, and potassium responses and requirements in calcareous sand greens. Agronomy Journal. 95:697-702.

Markland, F.E., and E.C. Roberts. 1969. Influence of nitrogen fertilizers on Washington creeping bentgrass, *Agrostis palustris* Huds. I. Growth and mineral composition. Agronomy Journal. 61:698-700.

Moneith, J., and K. Welton. 1932. Putting tests upon bentgrasses. The Bulletin of the USGA green section. 12:224-227.

Paré, K. 2004. Nitrogen requirements and leaching potential of putting green grasses (*Poa annua* L. ecotypes and *Agrostis* L. species). MSc Thesis, University of Guelph:117p.

Schlossberg, M.J., and K.J. Karnok. 2001. Root and shoot performance of three creeping bentgrass cultivars as affected by nitrogen fertility. Journal of Plant Nutrition. 24:535-548.