Zoysiagrass in Shade

Influence of Trinexapac-ethyl

Y.L. Qian and M.C. Engelke

Shade, whether from trees or buildings, presents a problem in the management of turfgrasses. Few turfgrasses can survive long term when shading exceeds 75 percent (Warren, 1962). Diamond zoysiagrass has been noted for its good shade tolerance when compared to other zoysiagrass cultivars (Riffel et al., 1995). A preliminary study demonstrated that acceptable turf quality of Diamond was maintained for over five months under 73 percent shade, but not for 86 percent shade (Qian and Engelke, 1997).

Compared to full-sun conditions, a shade level of 86 percent resulted in a four-fold increase in shoot vertical growth and two-fold increase in clipping yields of Diamond zoysiagrass (Qian and Engelke, 1997). Increased shoot growth is also promoted by gibberellic acid (GA) in most plants (Endo et al., 1989). Though no research has been done on turfgrasses, Gawronska et al. (1995) found that increased biosynthesis of GA partially contributed to excessive shoot growth of *Pisum sativum* L. in response to low-light intensity. It is possible that a similar physiological process occurs in zoysiagrass under heavy shade. Increasing shoot growth is a shade avoidance mechanism of plants, but it is ineffective and undesirable in turfgrass because of regular mowing. Rapid vertical shoot growth leading to more clippings accelerates the energy depletion of turfgrass tissue. We have observed an 85 percent decrease in total nonstructural carbohydrate content (TNC) of Diamond zoysiagrass under 86 percent shade, which led to decreased density and stand persistence.

Therefore, we hypothesize that shade tolerance might be increased by using an anti-gibberellic acid type of plant growth regulator (PGR), such as Trinexapac-ethyl (TE) which exerts its effect by blocking the formation of 3 -OH late in the GA biosynthesis pathway, thus inhibiting plant elongation (Adams et al., 1992). Trinexapac-ethyl has been widely used to suppress turfgrass shoot growth and reduce mowing frequency to lower maintenance costs.

While much research has been done under natural sunlight conditions (Marcum and Jiang, 1997; Johnson, 1992; Johnson, 1993a; Johnson, 1993b; Johnson, 1994), no studies have been done under heavily shaded environments. Information is needed about the effects of TE on the rooting, carbohydrate status and photosynthesis characteristics of turfgrass subjected to heavy shade conditions.

The objective of this study was to evaluate the influence of TE at various rates on turfgrass shade tolerance by 1) determining the growth habit and turf performance; 2) measuring root production and root viability; and 3) determining the effects of TE on photosynthesis rate and non-structural carbohydrate status of Diamond zoysiagrass grown in a heavy shade condition.

Greenhouse Study — This study was conducted at the Texas A&M University's Dallas Research Center. Sod of mature Diamond zoysiagrass was harvested on Nov. 22, 1996 from a field of Houston black clay soil. Washed sod was transplanted to a heat bench filled with sterilized sand premixed with 17-2.6-8.3 N-P-K resin-coated fertilizer (Osmocote) to provide 24 Kg N/ha. A 20-8.8-16.6 N-P-K soluble fertilizer was applied monthly to provide 24 Kg N/ha. To stimulate an active growth of Diamond, root zone temperature was maintained between 23°C and 26°C from December 1996 to

March 1997. The heat bench was designed to circulate controlled-temperature water through a copper pipe grid system embedded under the soil surface. Turf was irrigated daily to prevent drought stress.

Shading was imposed on January 4 when turf was well established. A shade cloth with 75 percent light filtering property was mounted on a PVC frame and supported 50 cm above the turf canopy. The shade cloth was draped on all sides to prevent the effect of incline light.

Trinexapac-ethyl treatments were first applied on January 12, 1997. Treatments included:

1) monthly TE application at 0.048 kg ai ha-1 (MTE), the applications were made on January 12, Feburary 14, March 24, April 9, May 9, June 9, July 9 and August 4;

2) bimonthly application at 0.096 kg ai ha-1 (BTE), the applications were made on January 12, March 24, May 9 and July 9;

3) trimonthly TE application at 0.192 kg ai ha-1 (TTE), the applications were made on January 12, April 9 and July 9;

4) the untreated control.

Trinexapac-ethyl was applied with a pressurized sprayer that delivered 518 liters ha-1 at a pressure of 1.5 kg cm-2. Turf was clipped weekly at a 2.0-cm height.

Turf quality was visually assessed weekly on a 1 (poorest) to 9 (best) scale; ratings of less than 6 were considered unacceptable. The estimation of turf quality was based on primary components of color, density and uniformity. Turf canopy height was measured before the clipping event. Shoot growth rate was calculated as the difference between the canopy height and mowing height.

Tiller number, root mass and percentage of living roots were determined after using a core sampler to remove two cores per plot on 10, 15 and 20 weeks after initial TE treatment. Immediately after harvesting, cores were cut along the soil-thatch interface and the tiller number was counted. The underground sections were transferred to the laboratory, where roots were gently washed free of soil over two layers of fine screen, blotted dry and the root fresh weight was determined. Data on turf quality, tiller number, root mass and viability and TNC were analyzed.

Results and Discussion

Great seasonal and diurnal fluctuations of light intensity were observed. Despite these seasonal and diurnal fluctuations, the light level under shade cloth in the greenhouse was consistently at 14±2 percent natural sunlight, i.e., 86±2 percent shade.

Shoot Growth — As established in a previous study, shade at 86 percent highly stimulated the vertical shoot growth of Diamond compared to full sun condition (Qian and Engelke, 1997). The excessive vertical shoot growth induced by shade was markedly inhibited by TE at all applied rates 7 to 10 days after application, with the duration of suppression appearing to depend on treatments and environments (data not shown). Monthly TE (0.048 kg ai/ha) provided the most consistent growth suppression; the mean shoot growth rate over the study period was only 25 percent of the control.

Turf Quality — For the control, turf exhibited acceptable quality only in the first 6 weeks, thereafter, quality declined to a commercially unacceptable level. The slight recovery in turf quality of the control between June and August may have been due to the seasonal improvement of light conditions.

All TE treatments remarkably improved the quality of shaded Diamond. Enhanced vigor, color and density were consistently observed. TTE caused slight foliar injury 1 to 2 weeks after application, but subsequent turf quality was significantly enhanced compared to the control. Ten to 12 weeks after treatment, when the response of shoot growth suppression was diminished for TTE, turf quality declined slightly.

Tiller Number — Diamond in the control treatment exhibited a gradual decline in tiller number 5 to 15 weeks after shading in the greenhouse. Twenty weeks after the initial replication treatments, increased tiller number was observed, probably due to the seasonal improvement of solar irradiance. Fifteen weeks after the initial treatments, the MTE and BTE turf had higher tiller numbers than either the control or TTE treatment. MTE and BTE turf had 27 percent more tillers than that of the control 20 weeks after the initial treatment.

Increasing tiller number has been reported for other turfgrass when treated with anti-gibberellin PGRs (Dernoeden, 1984; Watschke et al., 1992). However, this response was magnified under our heavily shaded conditions. Another study with three light regimes and two PGR treatments indicated that the greatest suppression of vertical shoot growth and the most significant increase in tiller number and turf quality occurred at the highest shade level when environmental conditions favored rapid growth (Qian et al., 1998). Trinexapac-ethyl caused little reduction in vertical shoot growth and little or no increase in turf quality and tiller number when conditions favored slow growth.

Root Production and Root Viability — In the greenhouse, treated turf exhibited higher root mass than that of the untreated control 10 weeks after the TE treatments. Twenty weeks after the initial treatment, the turf had >70 percent greater root mass than the control. Though TE has been reported to decrease total root length of 'Kentucky-31' tall fescue under natural greenhouse light conditions (Marcum and Jiang, 1997), our results indicated that TE increased root mass of Diamond zoysiagrass under heavy shade.

Carbohydrate Reserve Status — Total non-structural carbohydrate content of Diamond zoysiagrass grown under 86 percent shade in the greenhouse was extremely low, especially between January and March when the natural light intensity was low. Despite the improved light conditions in mid-summer, TNC across all treatments declined over time. Trinexapac-ethyl treatments significantly improved TNC.

The TNC increase in TE treated turf was probably due in part to a higher rate of photosynthesis per unit of turf area. Decreased shoot growth may also partially account for the carbohydrate build-up in TE treated turf (Brown and Blaser, 1965).

Canopy Photosynthesis — The general light response pattern of apparent photosynthetic rate was similar to that reported for many other plant species. Light saturation points (the amount of light required to maximize the photosynthetic rate of turf community) were not significantly different among treatments.

Maximum photosynthetic rates among treatments were different. Diamond treated with TE had a significantly higher maximum Pn than that of the control. Though estimates of maximum photosynthesis rates under heavy shade were not as meaningful as compensation point (since the former is rarely achieved under heavy shade conditions), this result suggests that TE increased the photosynthesis capacity of Diamond grown under heavy shade.

Conclusions

Shade caused an excessive vertical shoot growth and resulted in a shoot canopy with fewer living tillers of Diamond zoysiagrass. We have documented with these experiments that monthly TE application at 0.048 kg ai/ha or bimonthly TE at 0.096 kg ai/ha could effectively suppress shoot elongation and increase the tiller density. Resulting benefits included 1) improved plant carbohydrate reserve status; 2) improved root system; 3) increased canopy photosynthesis; and 4) ultimately enhanced turf quality compared to the control under heavy shaded conditions.

Our work demonstrated that trinexapac-ethyl can be used as an effective management tool for turf managers to achieve dual benefits of reducing mowing requirements and increasing shade tolerance of Diamond zoysiagrass.

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Y.L. Qian, Dept. of Horticulture and Landscape Architecture, Colorado State Univ., Fort Collins, CO 80523-1173; M.C. Engelke, Texas A&M Res. and Ext. Ctr., Texas A&M Univ. System, 17360 Coit Road, Dallas, TX 75252-6599.