Reducing irrigation of turfgrass areas by detecting stress early and using wetting agents.

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ABSTRACT

In order to optimize irrigation reduction and conserve water resources, ways to increase water use efficiency and early plant responses to water stress need to be identified. This experiment was conducted to determine if frequent surfactant applications in couple with identifying water stress early can reduce the need for irrigation while maintaining turfgrass quality. Three consecutive trials were conducted in which bermudagrass was subjected to either (*i*) no irrigation, (*ii*) irrigated daily or, (*iii*) initially treated with a surfactant over a dry-down period. Turfgrass quality and localized dry spot (LDS) symptoms from surfactant-treated turfgrass was similar or better than irrigated turfgrass, with both showing greater quality and less LDS symptoms than observed from the non-irrigated, non-treated turfgrass. On some dates, the sensor determined water stress before stress was visually apparent. Applying a surfactant decreased irrigation requirements up to 71% while maintaining similar quality as bermudagrass that is not water stressed.

INTRODUCTION

Ensuring a high quality water supply for human consumption and for the preservation of natural resources is a priority within an increasing number of State legislatures. Thus regulations are either currently in place or are expected for non-essential uses of fresh water such as irrigation of large turfgrass landscapes (i.e. golf courses, sports fields, parks and residential lawns). Compliance of these restrictions while continuing to maintain quality turfgrass will require proper methods to be identified for altering management practices.

Turfgrass managers already utilize many water saving management options: scheduling irrigations during early morning hours to maximize distribution uniformity by reducing applied water to wind drift and evaporation; incorporate additions from rainfall into irrigation scheduling; promote uniform wetting fronts by applying surfactants; and irrigating infrequently but deeply to discourage growth of disease pathogens, but encourage deep rooting., Turfgrass managers are hesitant to further curtail irrigation since increasing the period time between irrigations can cause the soil to dry out. These wetting and drying cycles promote subcritical soil water repellency to develop causing the soil profile to be difficult to rehydrate and alleviate visual LDS symptoms (Wilkinson and Miller, 1978). As it is, these wetting and drying cycles already occur in South Florida during the transition of the dry season to the wet season (end of April to the end of May) when rainfall is infrequent and higher temperatures, longer day lengths and increased wind speeds result in greater evapotranspiration (ET) demand. During this time, soil water repellency symptoms can develop quickly. Subsequently, preferential flow patterns develop causing non-uniform soil wetting fronts decreasing infiltration and soil moisture, and increasing ponding and subsequent losses by evaporation and runoff (Dekker et al., 2001). Turfgrass quality declines and the occurrence of localized dry spot (LDS) increase (Snyder et al., 1984; Wallis et al., 1989; Snyder and Cisar, 2004).

Management of water repellent soils includes both non-favorable and favorable methods for water conservation. For example, increasing irrigation frequency and quantity to make sure the turfgrass does not dry out (Snyder et al., 1984; Cisar et al., 2000; McCarty and Miller, 2002) may increase the amount of water used for irrigation. In comparison, improving soil physical characteristics by frequent aerification and topdressing, and vertical mowing, will help to ameliorate water repellency (Karnock and Tucker, 1999) and increase water movement into and throughout the soil.

Since further irrigation curtailment is not conducive to maintaining quality turfgrass, managers must implement alternative management strategies that maximize the water they have available to them in order to meet future water restrictions without compromising turfgrass quality. This includes maximizing the delivery of applied water (timing and amount of water entering the root zone), and maintaining water within the rootzone for availability to the turfgrass (Carrow et al., 2005; Kostka et al., 2007).

Surfactants can promote a uniform moist soil profile and rewetting of the soil, less water stress and LDS, as well as continued turfgrass quality in bermudagrass maintained on sandy soils (Park et al., 2004, Karnok and Tucker, 2001; Cisar et al., 2000; Miller and Kostka, 1998; York and Baldwin, 1992; Wilkinson and Miller, 1978). If surfactants increase water infiltration (Letey et al., 1969), promote uniform soil wetting fronts (Kostka, 2000), and increase plant available water (Leinauer et al., 2001), perhaps they can also assist in increasing water use efficiency (WUE) for non water-repellent soils as well.

Another management strategy may be to detect water stress at early stages in order for quick intervention and potential reduction in management inputs (irrigation). While traditional methods for determining water stress have relied on visual observations of wilted turfgrass, monitoring the spectral reflectance has proven as way to document less obvious differences in turfgrass stands (Narra et al., 2004; Nutter et al., 1993; Shepard et al., 1990). Perhaps this is because spectral reflectance allows not only for monitoring the visible part of the spectrum, but also the near-infrared range, which is not perceivable by the human eye (Lemon, 1966).

In order to maintain quality bermudagrass and comply with water regulations, proper methods need to be identified for altering management practices to maximize water applications to the root zone. This experiment examines if turfgrass quality can be maintained when less irrigation is applied if (a) a surfactant is integrated into an irrigation schedule, and (b) early signs of stress are monitoring for.

METHODS AND MATERIALS

This experiment was conducted during April and May 2004, when high ET demand, and low precipitation was conducive to LDS symptom development. The experiment consisted of three trials, each consisting of a dry-down period (April 30-May02, May 05-06, and May 16-18 for trials 1, 2, and 3, respectively) and was conducted at the Fort Lauderdale Research and Education Center in Fort Lauderdale, Florida. Sixteen meter^2 *Cynodon dactylon* X *Cynodon transvaalensis* 'Tifdwarf' bermudagrass plots were grown in on a Margate fine sand [Siliceous, hyperthermic Mollic Psamnaquent]. For each trial, each plot was subjected to one of three treatments in a randomized complete block design: (*i*) irrigated daily to replace daily potential ET (IIRD); (*ii*) application of a surfactant (APG-EO/PO block copolymer surfactant blend, currently commercialized as patented Dispatch) at a rate of 89ml ha^{-1} upon initiation of each trial (SURF); or (*iii*) no irrigation and no surfactant (NINS). The surfactant was injected into an irrigation system and applied with irrigation equaling to the current days potential ET. No further irrigation was applied to the surfactant treated plots for the remainder of each trial. Treatments were replicated four times for a total of twelve test plots. Treatments were applied to the same plots for each of the three trials. Rainbird 1800 quarter circle pop up irrigation sprinklers were located at the four corners of each plot to evenly distributed irrigation water and/ or the surfactant over the bermudagrass. Each plot had an irrigation shut off valve to control irrigation for individual plots. Each trial was initiated when bermudagrass showed no visual water stress symptoms (acceptable visual quality and minimal LDS symptoms).

An experimental active turf quality sensor (LI-COR, Lincoln NE) measuring reflectance within two narrow wavebands within the red (400-700 nm) and near-infrared (715-950 nm) was used to monitor water stress. Due to proprietary reasons, specific wavelengths will be released at a later date. The sensor was mounted on a tripod looking down on a 0.6 meter diameter circular area (LI-COR, Lincoln NE). The sensor's circuitry was designed to reject all external light (natural and artificial), and only to detect reflected light originating from the instrument. Twice daily (at 0800 and 1500 hrs), reflectance at the two wavelengths was measured in each plot four times and averaged for each observation period. Turf quality was assessed by monitoring the wavelengths and calculating the near-IR/Red ratio. Visual turf quality (rated on a 1-10 scale with 1= dead turf, 6= minimally acceptable, and 10=dark green turf) and % LDS symptoms were rated at the same time as the 1500 hr sensor measurements were collected. Each trial ended when wilting was visually observed at which time clippings were removed from a 1m^2 area to determine growth. Clippings were dried at 60 ^{o}C and then weighed. Immediately after clippings were removed, the turfgrass was irrigated to replace daily potential ET and turfgrass was allowed to recover. Water use efficiency was determined by dividing the clipping yields by the total amount of water applied for each treatment.

Data from the three trials were pooled after the variances were determined similar by Levene's test for homogeneity, and thus results are discussed as pooled trial averages. Pooled treatment means were statistically tested using an ANOVA, with significant treatment differences identified by the Duncan's Multiple Range Test (SAS Institute, 1990). Rainfall, ET and air temperature were obtained from the Florida Automated Weather Network via a weather station located approximately 100 meters from the experimental site.

RESULTS AND DISCUSSION

Optimum drought conditions persisted during the experimental period, characterized by low rainfall (one rain event = 23 mm) with high ET demand (May ET=188mm) and high temperatures (average May daily temperature=26°C). Visual ratings and sensor assessment of quality document that SURF bermudagrass had similar quality as IRRD bermudagrass, with both treatments having greater quality than the NINS bermudagrass (Table 1). A similar trend was evident when comparing the percentage of LDS, with over three times as much LDS observed on NINS bermudagrass than the other treatments (Table 1).

The average irrigation applied to all turfgrass at trial initiation was 4.3mm. Although the IRRD bermudagrass was irrigated for the remainder of each trial, the fact that SURF bermudagrass and IRRD bermudagrass showed similar quality and physiological condition as measured by the reflectance ratio suggests that they had similar soil water available to them. Yet the SURF bermudagrass received a mean of 63 % less irrigation than the irrigated turfgrass. This is also indicated by the SURF bermudagrass having a greater WUE than the IRRD and NINS bermudagrass (Table 1).

Mean near-IR/Red reflectance ratios revealed diurnal patterns with higher AM ratios compared to PM ratios. Perhaps this is because these wavebands monitor for morphology differences due rehydration of the turfgrass from the surrounding available soil water overnight, and mid-day water stress due to high evaporative demands.

When slopes are determined from daily PM reflectance ratios, SURF bermudagrass and IRRD bermudagrass resulted in average slopes of 0.05 ($R^2 = 0.99$) and 0.06 ($R^2 = 0.95$), respectively compared to a slope much closer to a slope much closer to 0 for the NINS bermudagrass (0.005 and $R^2 = 0.45$). The PM positive slopes found in the SURF and IRRD bermudagrass document growth, suggesting that soil water was not a limiting factor. The NINS slope much closer to zero maybe due to the combination of reduced growth rate and intensified mid-day water stress as by not having sufficient plant available water.

CONCLUSIONS

This experiment demonstrated that WUE for minimally irrigated turf can be increased by integrating a surfactant within the irrigation schedule, to the point of better WUE than if the turf had been irrigated daily to replace ETp. While visual quality treatment differences were observed, this was only during the PM. Visual quality as a means to asses water stress is difficult during morning hours because of overnight plant rehydration from the surrounding soil, presence of dew, and the angle of the sun. Monitoring AM NIR/Red reflectance ratios compensated for the inability to visually monitor quality in the morning. Both utilizing a surfactant with irrigation and monitoring NIR/Red reflectance ratios can be used as best management practices for water conservation.

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Table 1. Significance (and LSD) of treatment effect on pooled trial mean visual quality ratings, %LDS, NIR/Red reflectance ratios, and WUE (g cm^{-2}).

	Quality	%LDS	AM NIR/Red reflectance ratios	PM NIR/Red reflectance ratios	WUE
NINS	6.3b∫	35a	0.915b	0.838b	12.5b
SURF	7.4a	11b	1.035a	0.978a	20.0a
IRRD	7.6a	8b	1.037a	0.983a	8.4b
Significance†	***	***	***	***	***
LSD‡	0.4	7.3	0.049	0.050	4.7

∫Means with the same letter within a column are not significantly different according to Duncan's Multiple Range Test at P=0.05.
†*** = P<0.001 respectively.
‡LSD: Least significant difference