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EFFICACY OF ETHYLENE FOR ENHANCING SHADE TOLERANCE IN SPORTS TURFGRASS

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ABSTRACT: Turfgrass management for provision of high quality sporting facilities is becoming increasingly important with recognition of the contribution of sports to tourism, which is a major driver for income security in the Caribbean Region. Bermuda grass [*Cynodon dactylon* (L.) Pers.] cultivars commonly cultivated on sports fields in the Region are adversely affected by shaded conditions likely to occur within enclosed stadia built to attract international sporting events. Poor surface stability and traction, and non-uniform appearance and performance are some of the adverse effects that can occur in turfgrass growing in the shadows of buildings and other structures. In this regard, pot studies were conducted at the University of the West Indies, Cave Hill Campus, Barbados, to investigate the effects of ethephon on the shade tolerance of Bermuda grass, cultivar Princess-77. Ethylene (released from applied ethephon), can potentially be used to enhance shade tolerance due to its frequently observed effects in reducing elongative growth while promoting lateral expansion in various plant species. This is an attractive option since ethephon is relatively cheap and non-toxic and it is already used for other purposes in the horticultural industry throughout the Region. In an initial investigation, turf quality and growth were monitored following the application of ethephon at three concentrations (0, 0.25 and 0.5%) to turfgrass exposed to full light or to 55% shade (provided by shade netting). Ethephon was applied (until leaf drip) to recently clipped (3 cm tall) turfgrass as an aqueous foliar spray, with and without added nutrients, using a handheld sprayer. A follow-up study investigated the effects of repeated application at the 0.25% concentration in shaded and non-shaded turf. Undesirable effects of shading on plant height were significantly reduced by increasing the concentration of ethephon or the frequency of its application. Reduction in the chlorophyll index with ethephon application was partially offset by the inclusion of nutrients in the spray solution. Dry mass of clippings was reduced by ethephon under shaded conditions with significant effects of the 0.25% solution applied at weekly intervals. Results suggest that ethephon use can be considered for counteracting adverse effects of shade on Bermuda grass.

Keywords: green cover, tissue moisture content, image analysis

INTRODUCTION

Bermuda grass, *Cynodon dactylon* (L.) Pers., generally has excellent turfgrass properties and many varieties show tolerance to drought and wear conditions with strong regenerative capacity (Wiecko, 2006). It is widely distributed in tropical regions and is frequently recommended as a warm-season turfgrass for sports fields, lawns and park areas. A major disadvantage of Bermuda grass as a sports turfgrass is that it does not respond well to shaded conditions, and it is ranked low in terms of shade tolerance amongst many of the popular tropical turfgrasses (Wiecko, 2006). Consequently, as the number of enclosed sports stadia increases and/or as stadium capacity increases, shade from surrounding structures can have adverse effects on playing field appearance and performance characteristics. Under shaded conditions, the tight-knit vegetated surface typical of this grass under non-shaded conditions does not form; instead there is increased elongative growth and reduced density of grass shoots with reduced lateral stem initiation (tillering) and growth (Dudeck and Peacock, 1992). Root growth is reduced due to the

fact that resources are diverted more towards upright shoot growth under shaded conditions. A weak (easily uprooted) low density turf with poor surface stability and traction results with consequent adverse effects on field uniformity in terms of appearance and performance characteristics. Shaded areas of sports turf grass often show increased disease problems (Beard, 1997) and require different management regimes in contrast to non-shaded areas, especially with regard to irrigation and fertilization.

Plant growth regulators (PGR's) are often used in the management of turfgrass (Watschke et al., 1992) and may provide cost effective alternatives for reducing the adverse effects of shade on the growth and quality of turfgrass. Trinexapac-ethyl is an anti-gibberellin PGR compound that is often used on golf courses to reduce excess vertical growth and improve turf quality (Tegg and Lane, 2004) and shade tolerance (Baldwin et al., 2009). Ethylene is a cheaper and possibly less toxic PGR that reduces elongative growth and promotes radial expansion and branching (Shatters et al., 1998), which are likely to be beneficial under shade conditions. The ethylene-releasing compound, Ethephon (2-chloroethylphosphonic acid), is commonly available in the Caribbean Region and is often used for promotion of fruit ripening. This compound breaks down to release ethylene gas within the plant's tissues upon application. Ethylene also induces senescence in plants, and can lead to discolorations and consequent poor turf quality (Shatters et al., 1998). Such discolorations can possibly be counteracted by the inclusion of low concentrations of nitrogen fertilizer in ethephon treatment solutions. The current study seeks to determine whether there are possible beneficial effects of Ethephon on the growth and turf quality of Bermuda grass "Princess 77" under shaded conditions. The inclusion of mineral nutrients in the application solution to counteract possible senescence-inducing effects of ethylene was also investigated.

MATERIALS AND METHODS

Two pot studies were conducted under field conditions on the grounds of the Cave Hill Campus of the University of the West Indies, Barbados, during the period November 2008 to March 2009. Seeds of Bermuda grass 'Princess-77' (Pennington Seed Inc., USA) were sown (50 000 seeds m^{-2}) in 2.5L plastic pots containing a 1:1 sand/soil mixture. Plants were watered daily and fertilizer (NPK 24:8:16, Scotts Miracle-Gro Products Inc., USA) was applied weekly. A split-plot experimental design was used for both studies with two main-plot light treatments: Full light, and 55% Shade (applied using shade netting), and four replications. In the first study, the sub-plot treatments consisted of six spray solutions (three Ethephon concentrations: 0, 0.25, 0.5% active ingredient; with and without added nutrients). Nutrients were added to the appropriate solutions using NPK 24:8:16 soluble fertilizer at 6 g/L. In the second study, Ethephon was applied at 0.25% concentration without added nutrients for all treatments and sub-plots consisted of 4 application frequencies: 0, 0.5, 1 and 2 times per week. Ethephon solutions were applied in late afternoon with a hand sprayer until leaf drip, and treatments were applied over a period of 3 to 4 weeks in each study.

Turf was clipped to the rim of each pot at weekly intervals and fresh and dry mass (after drying to constant mass in an over at 80° C) of clippings were determined. Observations were made at weekly intervals just prior to clipping and included turf height, greenness index and percentage green cover. Turf height (mm) was measured using a modification of the Rising Disk method (New Zealand Sports Turf Institute). The equipment consisted of a compact disc (diameter = 12 cm, mass = 15.052 g) with a 30 cm rod (with attached mm height scale at one end) threaded through the central aperture (diameter = 1.5 cm) of the compact disc. The graduated end of the rod was pushed vertically through the turfgrass to the soil surface, and the compact disc was allowed to fall along the rod from a fixed height of approximately 10 cm until it rested on the

surface of the turf being sampled. The height above the soil at which it rested was recorded and one measurement was made per pot. The soil surface was on average about 3 cm below the rim of the pots.

Greenness index was measured using a portable chlorophyll index meter (Field Scout CM-1000, Spectrum Technologies Inc., USA). The instrument was held approximately 30 cm above the turf and six readings were taken at random locations across the surface in each pot. Readings were taken between 10.00 am and 2.00 pm under bright sunlight conditions and average values were recorded. Greenness index is calculated by the instrument based on reflected red and infrared light wavelengths to give a dimensionless number between 0 and 999. Typically, greenness index for dense healthy turf can reach values of about 450. Digital image analysis was used to determine green cover percentage of individual pots. The digital camera was held approximately 30 centimeters above the pot with care not to cast any shadows on the sample area, and images were taken between 10 am and 2 pm. Images were uploaded to a computer and analyzed using image analysis software (Assess 2.0, American Phytopathology Society, USA) where percentage green cover was determined as the percentage of green pixels within the area of interest in each image.

RESULTS AND DISCUSSION

The height of shaded turfgrass decreased linearly as the Ethephon concentration was increased from 0 to 0.5% (Fig. 1) and the regression equation was as follows: $y = 55.8 - 28.6\ x$, $R^2 = 0.99$, where y is turf height and x is Ethephon concentration. No such trend was observed for the turfgrass in full light and shaded turf was marginally taller at 0% (and marginally shorter at 0.5%) Ethephon, compared to non-shaded turf. The dry mass of clippings followed a similar pattern to that of turf height but the decline with increased Ethephon concentration appeared to be much steeper (Fig. 2). The effect of shade in increasing vertical shoot growth and decreasing turf quality has been found for several turf species including Bermuda grass (Tegg and Lane, 2004). In glasshouse studies, 35 mM Ethephon (about 0.5% concentration) was effective in reducing plant height and increasing root production in Bermuda grass (Shatters et al., 1998). Effects of Ethephon on the dry mass of clippings were not significant for turfgrass under full light, and there was a significant decline in the mass of clippings obtained for shaded compared to non-shaded turf treated with 0.5% Ethephon. Adverse shade effects on turf height and clippings dry mass production were not significant following application of the 0.25% Ethephon treatment (Fig. 1 and 2).

Turf height was not significantly affected by the addition of nutrients to the spray solution and there were no significant interactions between nutrient level and other experimental factors with regard to any of the variables measured (data not shown). When data were pooled across Ethephon and light levels, there was a notable increase in the dry mass of clippings and a small but significant increase in greenness index with the inclusion of nutrients in the spray solution (Fig. 3). Although the responses were similar under varying Ethephon and light levels, the addition of nutrients to the Ethephon spray solutions may be beneficial for counteracting some of the senescence-inducing effects of ethylene. Further research is needed to optimize the type and amount of nutrients that should be included in the spray solution. Greenness index was significantly reduced by the 0.25% and 0.5% Ethephon treatments regardless of the light level or whether nutrients were included in the spray solution (Fig. 4). Terminal leaf necrosis and chlorosis of young developing leaves have been observed for Bermuda grass in response to Ethephon application (Shatters et al., 1998). Tissue moisture content of clippings increased with the application of 0.25% Ethephon, with no further increase at 0.5% Ethephon (Fig. 5). This

effect may be consistent with an earlier report of increased leaf/stem fresh mass ratio in Bermuda grass treated with Ethephon (Shatters et al., 1998).

In the second study, height of shaded turf was significantly reduced by increasing the application frequency of 0.25% Ethephon from 0 to 2 times per week (Fig. 6). The effect of shading on turf height was not significant at the Ethephon application frequency of 0.5 times per week (once every two weeks), and a once per week application of Ethephon was sufficient to reduce the height of shaded turf to a value similar to that of untreated non-shaded turf (Fig. 6). Highly significant effects of shading on percentage green cover were observed in the absence of Ethephon applications, and such effects became non-significant when Ethephon was applied at 0.5 or 1.0 time per week (Fig. 7). At 2.0 applications per week, percentage green cover was significantly reduced in non-shaded turfgrass. There does not appear to be any additional benefits of increasing the application frequency beyond 1.0 time per week.

CONCLUSIONS

Ethephon application may be beneficial to counteract some adverse effects of shade on turfgrass. Results suggest that 0.25% Ethephon applied once every 1 to 2 weeks may be effective. Senescence inducing effects of ethylene may be partially reduced by the inclusion of nutrients in the spray solution; further research is needed in this regard.

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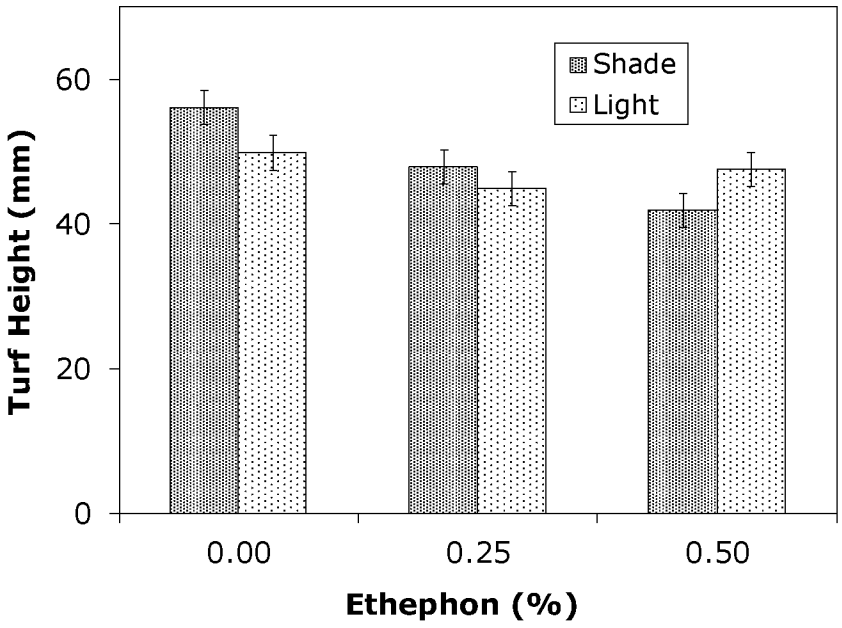

Figure 1. Turf height (mean ±SE) measured just prior to clipping of Bermuda grass subjected to weekly applications of Ethephon solutions under shaded (Shade) and full light (Light) conditions. Data were pooled for treatments with and without added nutrients in the spray solutions.

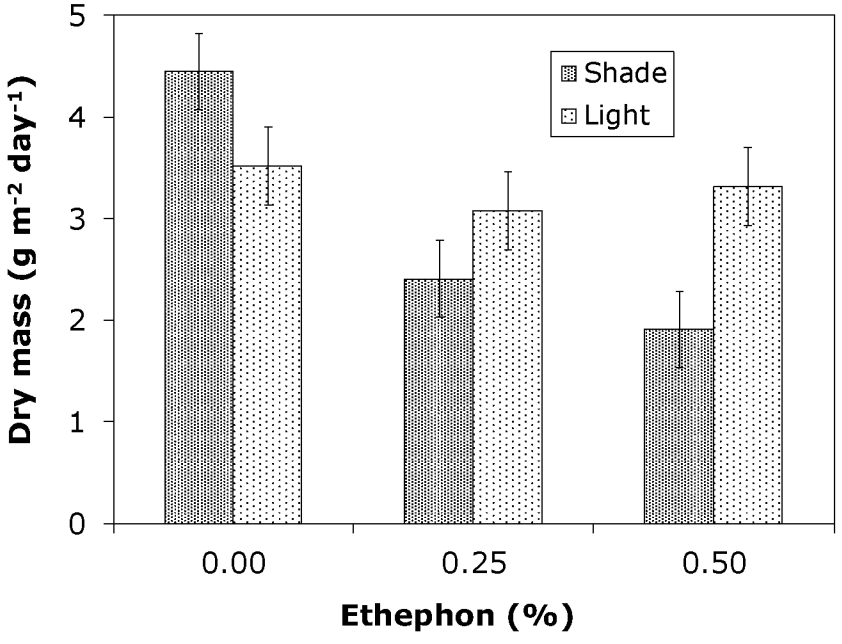

Figure 2. Clippings dry mass production (mean ±SE) for Bermuda grass subjected to weekly applications of Ethephon solutions under shaded (Shade) and full light (Light) conditions. Data were pooled for treatments with and without added nutrients in the spray solutions.

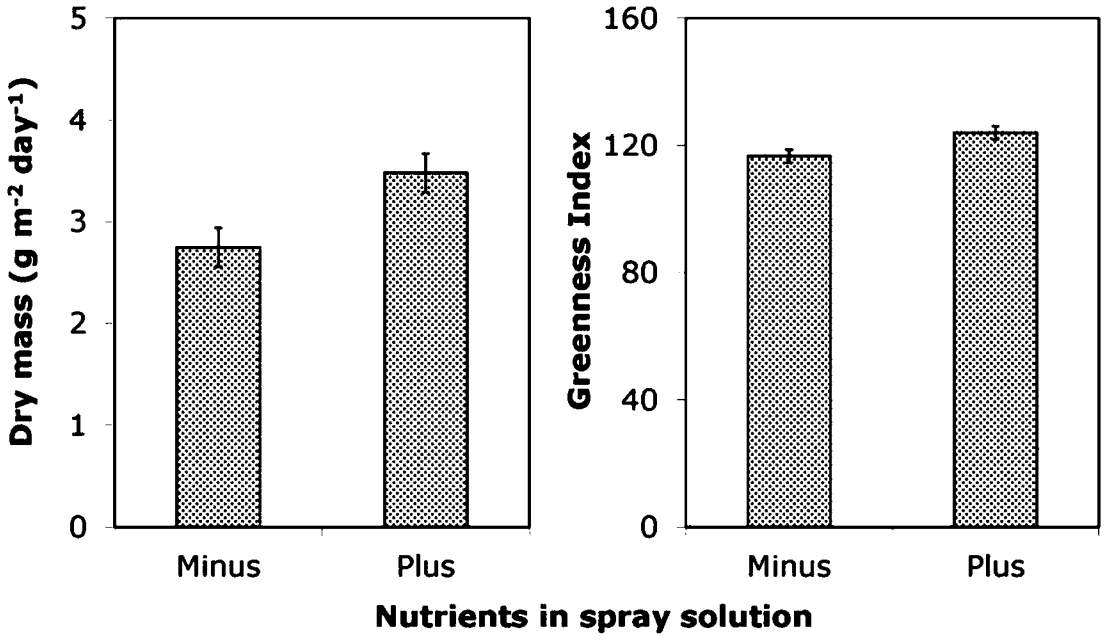

Figure 3. Clippings dry mass production and greenness index (mean ±SE) for Bermuda grass subjected to weekly applications of Ethephon with (Plus) or without (Minus) added nutrients in the spray solutions. Data were pooled for different Ethephon treatments under shaded and full light conditions.

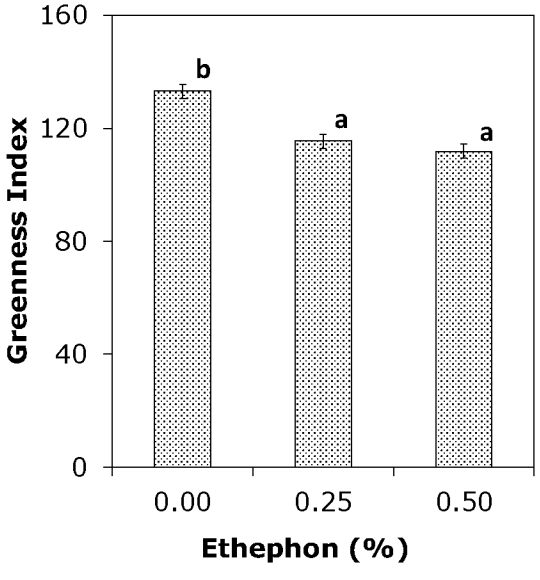

Figure 4. Greenness index (mean ±SE) for Bermuda grass subjected to weekly applications of Ethephon solutions. Data were pooled for treatments with and without added nutrients in the spray solutions under shaded and full light conditions. Means with a common attached letter are not significantly different from each other by the LSD test ($p > 0.05$).

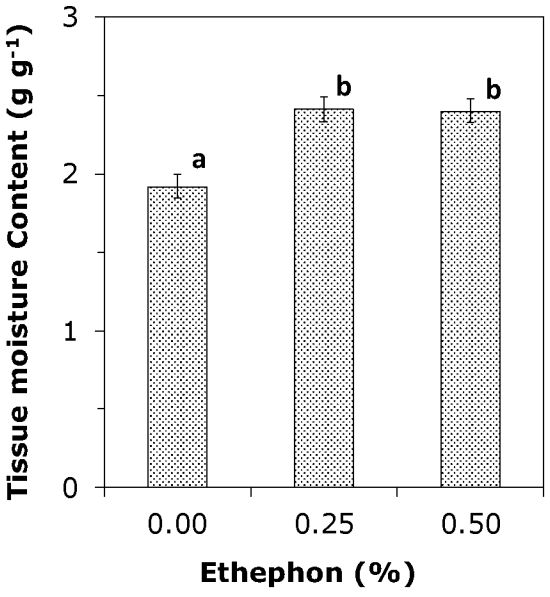

Figure 5. Tissue moisture content of clippings (per unit dry mass, mean ±SE) for Bermuda grass subjected to weekly applications of Ethephon solutions. Data were pooled for treatments with and without added nutrients in the spray solutions under shaded and full light conditions. Means with a common attached letter are not significantly different from each other by the LSD test ($p > 0.05$).

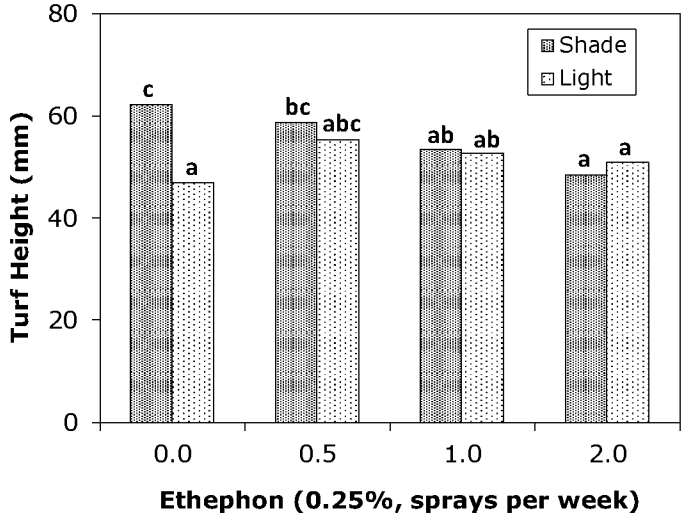

Figure 6. Turf height (mean ±SE) measured just prior to weekly clipping of Bermuda grass subjected to Ethephon (0.25%) applications under shaded (Shade) and full light (Light) conditions. Means with a common attached letter are not significantly different from each other by the LSD test ($p > 0.05$).

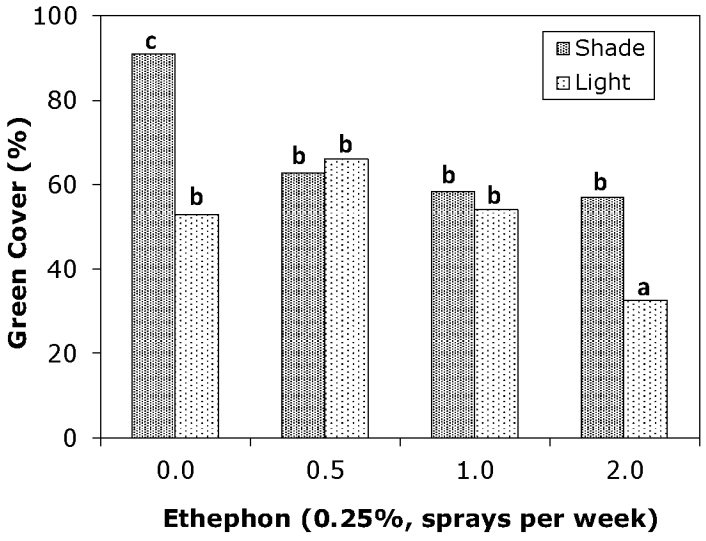

Figure 7. Percentage green cover measured just prior to weekly clipping of Bermuda grass subjected to Ethephon (0.25%) applications under shaded (Shade) and full light (Light) conditions. Means with a common attached letter are not significantly different from each other by the LSD test ($p > 0.05$).