Drought Resistance and Post-Drought Recovery of Three Warm Season Turf Grasses

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Abstract

Knowledge about the drought responses of different turf grasses would be of great importance in developing water-use-efficient landscapes. This study was designed to evaluate the drought resistant characteristics of three warm season turf grass species; Bermuda grass (*Cynodon dactylon -BMD*), Bahia grass (*Paspalum notatum* -BHI) and Centipede grass (*Eremochloa opiuroides -CPD*) by imposing 20 days of simulated drought followed by re-watering. Their relative drought resistance was compared by calculating ratios with those of control plants as well as the indices of drought survival and post drought recovery of each grass species. Plant dry weight, shoot and root dry weight, canopy height and number of leaves were measured as growth parameters while relative growth rate and relative cell membrane permeability were calculated to study the leaf cell stability. The study was arranged as a completely randomized design with four replicates allocating seven plants per replicate. Drought avoidance, drought tolerance and drought escape mechanisms were helped drought resistance grass species to survive under lengthy dry spells and all three warm season grass species studied showed one or more of them. BMD is a superior drought avoidance grass having a higher relative growth rate throughout, irrespective of time and treatment. Even though CPD has comparatively lower drought resistance, it had better resilience ability.

Key words: Drought resistance, Growth parameters, Relative cell membrane permeability

Introduction

Water limitation for agriculture and urban landscaping has become a common threat for plant growth and survival in many areas. Thus drought tolerant species play a vital role in such areas. Although the mechanisms of drought tolerance in terms of plant productivity under moderate drought have been investigated in many crops, Volaire and Lelievre (2001) have stated that mechanisms contributing to drought survival in perennial grasses have received limited attention, even though lawn plays a major role in landscaping. Drought survival of perennial grass species is extremely important in areas with prolonged periods of drought. Post-drought recovery and re-growth are also similarly important in perennial grass management to ensure rapid re-establishment. Based on the climatic adaptability of perennial grass species; there are warm season and cool season turf grasses and the warm season turf grass species use significantly less water than cool season species (Harivandi *et al.*, 2009). Plant response to drought stress involves changes in various morphological and physiological adaptations and drought tolerance and re-growth potential vary with grass species (Chai and Jan, 2010). It is generally believed that Bermuda grass has greater drought resistance as it contains both rhizomes and stolons while centipede grass bears only stolons and bahia grass has rhizome like stolons, which would serve as carbohydrate storage organs during stress. Carbohydrate accumulation in grass crown or rhizomes is important for the regeneration of new shoots and roots.

The objective of this study was to investigate the drought survival and post drought re-growth ability of BMD, BHI and CPD by comparing some mopho-physiological responses to drought stress and re-watering.

Materials and Methods

This experiment was set up on following warm season turf grass species, *Paspalum notatum* (Bahia grass-BHI), Cynodon *dactylon* (Bermuda grass-BMD) and

Eremochloa ophiuroides (Centipede grass-CPD). Seeds of these species were sown in 13 cm diameter plastic pots in growth chambers at 25±3°C day and night temperatures. Twenty days after germination (DAG) the pots were brought to the field capacity and imposed stimulated artificial drought for 20 days (40 DAG) and then re-watered on the following day and kept well-watered for another 20 days to observe the re-growth. Control pots were irrigated based on the moisture depletion. Treatments and species were arranged as a completely randomized design with two factors (watering treatments and species). Each treatment for each species was repeated in four replicates (four pots). The growth parameters were taken at 20, 40 and 60 DAG to compare the species responses to drought. The plant growth, in terms of dry weight, shoot dry weight, root dry weight, canopy height and number of leaves were recorded throughout the study period at 20 day intervals. Aesthetic appearance, leaf relative water content (RWC) and leaf relative cell membrane permeability (RCMP) were quantified 20 days of drought stress and 20 days of re-watering.

Leaf water status was determined by measuring RWC calculated as follows: RWC (%) = 100 × (FW – DW)/(TW – DW), where FW is the leaf fresh weight, DW is leaf dry weight for tissues dried at 85 °C for 3 d, and TW is turgid weight of leaves after being soaked in water for 4 h at ≈ 20 °C. Cell membrane permeability which can be readily measured by the efflux of electrolytes was estimated by calculating the ratio between osmotic solutions of leaves (water stressed: well-watered).

Aesthetic appearance was rated based on a leaf color and turgidity level. It was visually rated on a scale from 0 to 9, where the appearance of grass was rated as zero if leaves were completely brown and desiccated and rated as 9 if leaves were green and fully hydrated.

All the measurements of stressed plants were compared with those of control plants by calculating the ratios.

Results and Discussion

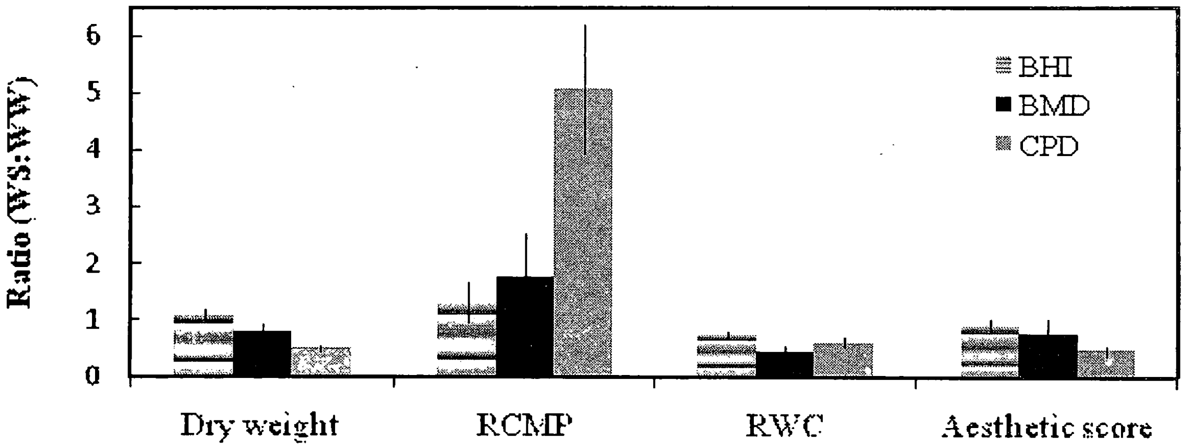
Drought resistant ability varies with grass species and falls into three categories; (1) °drought tolerance requires one or more physiological mechanisms that allow a plant to avoid tissue damaging water deficit even while growing in a drought stress environment, (2) drought avoidance occurs in plants that can endure internal water tissue deficits caused by drought and (3) drought escape for survival by the plant's completing its life cycle before serious plant water stress is developed (Sifers and Beard, 1999).

Significant ($P<0.05$) differences in dry matter production were observed among these three species. Within each species, the dry matter production differed between well-watered and water-stressed plants (data not shown). The inter-specific variation in relative growth rate (RGR) was calculated, and compared the species within each period irrespective of treatment, and hence the best performers can be identified. Mean RGR among species varied significantly ($P<0.05$) throughout the study period (data not shown). Bahia grass (BHI) did not show a significant RGR value under the water stress condition. However, during the re-growth after the drought stress, Centipede (CPD) grass showed significantly higher RGR value over the well-watered control plants. Nevertheless, Bermuda grass (BMD) showed a higher RGR throughout, irrespective of time and treatment. BMD is a superior drought avoidance grass having the key characteristics of the genetic potential for deep, dense rooting, bearing both above and below ground runners (rhizomes and stolons) and lower evaporation rate (Sifers and Beard, 1999).

Relative cell membrane permeability (RCMP) has been widely used as an indicator of leaf desiccation tolerance and the level of cell damage increases with the plasma membrane permeability (Martin *et al.*, 1987). A significantly higher RCMP ratio was found for CPD (5.082) at 20 days after drought stress and it was significantly lower in BHI (1.314) and in BMD (1.745). These RCMP ratios suggest that leaves of CPD experienced a cellular membrane damage but, the relative water content (RWC) ratio indicate that it would not severely declined or could not recover, after the re-watering. The ratio of RWC of BHI, CPD and BMD were 0.76, 0.61 and 0.45 respectively. However, BMD and BHI leaves were able to maintain better cell membrane stability than CPD under such severe drought stress. BHI falls into the drought avoidance category having deep fibrous root system with only rhizome like sotolon having drought tolerance mechanism rather than drought avoidance (Sifers and Beard, 1999).

Figure 1 shows the different plant attributes as a ratio of water-stressed to well-watered treatments, for the three species tested. Calculating the ratio of water stressed to well-watered plant attributes for each species reduces the inherent variation due to species differences, and allows for comparison of the relative response of each species to drought. For each attribute ratio, species were ranked giving scores. The highest rank was allocated to the best performer and *vice-versa*. The mean score for each species was obtained after pooling the ranks of all the plant attributes. It was evident that, Bahia grass (BHI) had the highest mean score while Centipede grass (CPD) exhibited a lower tolerance to drought (Table 1).

Figure 1. Interspecific variation in plant attributes in response to drought. RCMP: Relative cell membrane permeability, RWC: Relative water content.



(Sifers and Beard, 1999).

After 20 days of drought stress, the grass quality or the aesthetic appearance was visually estimated in these three species, where higher ratios were recorded from BHI (0.92) and BMD (0.76), whilst CPD had the lowest (0.48). Even though, CPD has a very limited root depth and density it is also a drought resistance grass variety

Table 1. Mean scores obtained by turf grass species in response to drought (during 20-40 days) and during the re-growth.

Species	Mean score value	
	During drought	During re-growth
BMD	5.92	9.7
BHI	7.83	5.3
CPD	2.33	9.7

Recovering ability of these turf grass species after the drought was observed by the re-growth (Table 1; during the re-growth). The shoot, root and total plant dry weights of droughted plants were compared with those of control plants. Both Bermuda grass (BMD) and Centipede grass (CPD) exhibited highest re-growth potential while Bahia grass (BHI) had the poorest re-growth capacity (Table 1). These results are in accordance with the RGR values discussed earlier. Bearing both rhizomes and stolons in BMD is a critical characteristic for having higher drought tolerance ability to store the carbohydrates during the drought and reuse them during the re-growth.

All these three grass species were able to withstand drought having one or more drought resistant abilities. Among these three grass species Burmuda grass (*Cynadon dactylon*) had the highest drought resistance and post-drought recovering ability. Post-drought recovery and physiological regulatory mechanisms could be associated with the accumulation of carbohydrates in leaves and rhizomes during drought stress and new root production after re-watering.

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