Submersion Tolerance of Warm-season Turfgrasses

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Turfgrasses throughout the southeastern United States are often subjected to flooding following excessive rainfall. Little information is available on the submersion tolerance of turfgrasses. Buffalograss [*Buchloë dactyloides* (Nutt.) Engelm.] and bermudagrass [*Cynodon dactylon* (L.) Pers.] have exceptional inundation tolerance, the former resuming growth after 19 months under water (Gamble, 1958; Porterfield, 1945; Rhoades, 1967). This research was done to compare the submersion tolerance of five warm-season turfgrasses commonly grown in Louisiana.

Grasses evaluated were 'Meyer' zoysiagrass (*Zoysia japonica* Steud.), common centipedegrass [*Eremochloa ophiuroides* (Munro) Hack.], 'Raleigh' and 'Floritam' St. Augustinegrass [*Stenotaphrum secundatum* (Walt.) Kuntze], 'Pensacola' bahiagrass [*Paspalum notatum* Flüggé], and common bermudagrass. Grasses were established from sod in PVC columns (100 mm in diameter × 300 mm deep) containing a 3 sand : 1 sphagnum peat (v/v). Before submersion, grasses were fertilized with 50 kg N/ha and watered to prevent drought stress during establishment. Bermudagrass, St. Augustinegrass, centipedegrass, and zoysiagrass were clipped weekly to a 50-mm height using scissors; bahiagrass was maintained at a 75-mm height. Following a 6- to 8-week establishment period, columns were submerged in a large water tank (610 mm in diameter × 1220 mm deep) filled with tap water so that the tops of turf canopies were inundated ≈130 mm deep. In an initial 93-day study (Study I), the water tank was located in a fiberglass-covered greenhouse; in a 55-day study (Study II), the water tank was located outside in a

sunny location. Average water temperatures during Studies I and II were 21 and 26°C, respectively. 'Raleigh' was the St. Augustinegrass cultivar evaluated in Study I, while 'Floritam' was used in Study II. Submerged columns were arranged in a completely randomized design with four replications.

Submersion injury was determined by harvesting green shoots (leaf sheaths and blades) at the end of each study, drying for 48 h at 80°C, and weighing. Relative shoot weights were calculated by dividing the shoot weight from turf in a submerged column by the mean shoot weight from four nonsubmerged columns of the same species arranged randomly adjacent to the water tank. Mean highs for air in Studies I and II were 28 and 29°C, respectively, whereas mean lows were 18 and 19°C, respectively. Before the study began, clipping and fertilization of nonsubmerged grasses were the same as previously described for grasses to be submerged. Neither submerged nor nonsubmerged grasses were clipped after the studies began. Relative shoot weight data were subjected to analysis of variance, and means were separated using the Waller-Duncan Bayesian *k* ratio *t* test ($k = 100$, $P \approx 0.05$). Shoot elongation of grasses was determined by tying a short length of string around one randomly selected shoot per column and using a ruler to measure distance between the soil surface and shoot tip. Orthogonal contrasts were used to compare shoot elongation of submerged vs. nonsubmerged grasses within each species.

All grasses exhibited exceptional submersion tolerance, and only centipedegrass had no living shoots after 93 days of submersion in Study I (Table 1). Centipedegrass shoots appeared to have been killed after ≈60 days of submersion (data not presented). All grasses were living after 55 days of submersion when plants were harvested in Study II. Lower relative shoot weights of submerged grasses compared with nonsubmerged controls were due to little or no shoot growth under water,

and senescence of some tillers as the duration of submersion increased. Considering both tests, bermudagrass and bahiagrass had the best submersion tolerance, St. Augustinegrass and zoysiagrass exhibited intermediate tolerance, and centipedegrass had the poorest tolerance to submersion.

Shoot elongation of submerged bermudagrass (0.8 mm-day⁻¹, was significantly greater ($P < 0.001$) than of nonsubmerged bermudagrass (0.1 mm-day⁻¹; Study II). Enhanced shoot elongation during submersion has been observed in other submerged grasses, and is presumably a plant response to an increase in ethylene production in tissue that promotes cell extension (Jackson and Drew, 1984). Shoots that elongate beyond the surface of the water are able to resume photosynthesis.

It should be noted that the present study evaluated tolerance of deeply inundated grasses. It is generally believed that grasses subjected to flooding in a shallow water pool may be killed rapidly by scald resulting from lethal high water temperatures (unpublished). Furthermore, situations in which roots, but not shoots, are exposed to saturated conditions may result in different results than reported herein.

Literature Cited

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Table 1. Shoot survival of five warm-season turfgrasses following submersion.

Species	Shoot wt (% of nonflooded control)*,y	
	Study I	Study II
Bahiagrass	36.7 a	66.7 a
Bermudagrass	37.9 a	72.8 a
Centipedegrass	0.0 c	5.2 c
St. Augustinegrass	27.0 b	33.1 bc
Zoysiagrass	23.4 b	65.5 ab

*Shoots were harvested 93 and 55 days after submersion in Studies I and II, respectively.

yMean separation in columns by the Waller-Duncan Bayesian *k* ratio *t* test ($k = 100$, $P \approx 0.05$). Percentages are means of four replications.

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