

Drought responses and survival of turfgrasses during quiescence in the Intermountain West of North America

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ABSTRACT

The Intermountain West of North America has a cool-arid climate with dry, warm to hot summers causing most grasses to enter a quiescent state if irrigation is not provided. However, their tolerance to this extended quiescence varies considerably. We conducted three experiments to determine tolerance to quiescence and investigate mechanisms involved in plant tolerance. Field research in Logan, UT has evaluated five turfgrasses for extended quiescence survival without irrigation and minimal irrigation; screened 150 Kentucky bluegrass varieties over 2 yrs for survival without irrigation; and studied stomatal conductance, water potential, canopy temperature, and soil water extraction in Kentucky bluegrass and tall fescue with and without irrigation over 2 summers. Tall fescue remains actively growing during extended drought because of a deep root system. Stomatal conductance in tall fescue decreases, but pre-dawn water potential is maintained. Kentucky bluegrass and perennial ryegrass enter quiescence, but recover in late summer. Prairie junegrass and fine fescues do not reliably survive extended quiescence, but the poor recovery may be due to effects of high temperatures rather than being solely water related. Minimal irrigation during quiescence may benefit survival but results are mixed. Significant varietal differences in tolerance of extended quiescence exist in Kentucky bluegrass, but if repeated a second year, few varieties survive.

INTRODUCTION

Management of turfgrass areas vary from highly maintained to essentially no maintenance. Likewise, the expectations of these areas range from green actively growing turf throughout the growing season (and sometimes beyond) to simply preventing erosion and enabling occasional use for recreational and utility activities. This wide range of expectations and management means that no one species of turfgrass will suit the needs of all areas, especially in a climate like the Intermountain West. Even in the moderately maintained areas, which are usually managed for active growth throughout the growing season, are sometimes required to go dry due to voluntary or required irrigation restrictions.

Native grasses, such as the wheatgrasses, are well adapted to our climate, some having summer dormancy traits. However these grasses have not yet proven effective in most medium to high maintenance areas. Hence we wanted to explore the ability of commonly used non-native grasses to survive extended quiescence, and explore the mechanisms involved in that tolerance. To address these questions we have conducted three experiments: (1) evaluate survival of several species during quiescence; (2) study of physiological responses and drought tolerance mechanisms of two turfgrass species, and; (3) assess bluegrass varieties for tolerance of extended quiescence.

MATERIALS AND METHODS

Experiment 1: Evaluation of species tolerance to extended quiescence -

In 2003, Kentucky bluegrass, tall fescue, perennial ryegrass, crested hairgrass, hard fescue, and creeping red fescue were given irrigation treatments of no supplemental irrigation, 0.6cm (¼”) of water every month, and 0.6cm (¼”) of water every two weeks. Each irrigation regime had three replications. The summer of 2003 was nearly rain-free with above normal temperatures for most of June, July, and August. Irrigation and rainfall ceased mid May and every two weeks, beginning on June 4th, plugs were removed, put in a greenhouse, and watered for re-growth (Fig 1 and 2). Recovery was rated using visual ratings and digital photograph analysis. To measure soil moisture extraction during the summer, a similar plot was used in 2004. Kentucky bluegrass and tall fescue plots were allowed to enter quiescence and each plot contained a access tube allowing twice weekly measurement of soil moisture to 100 cm using a Sentek Diviner 2000 probe.

Experiment 2: Physiological responses of Kentucky bluegrass and tall fescue to drought -

In 2007, (established in 2003) a plot of four Kentucky bluegrass varieties (Newport, Midnight, Rugby II, Baron), one tall fescue (Gazelle) and one perennial ryegrass (variety unknown) were exposed to three irrigation treatments: no irrigation, 1.2 cm (½”) of water every month, and well-watered (80% ETo) beginning June 15th. Each treatment was replicated three times. During the summer we recorded the following data: visual quality, surface temperature with infrared thermometer, stomatal conductance using a leaf porometer (Decagon Devices), and plant water potential using a pressure chamber.

Experiment 3: Assessment of extended quiescence tolerance among bluegrass varieties -

In 2006 and 2007, we allowed the 2000 National Turfgrass Evaluation Program Kentucky bluegrass trial located in Logan, Utah to enter quiescence and did not provide supplemental irrigation. This trial included 173 Kentucky bluegrass and hybrid bluegrass varieties planted in 5' x 5' plots with three replications. This trial was planted in September 2000 and managed under low to medium maintenance conditions through 2005. Not all the plots were available for study in 2007 due to encroachment by surrounding plots. In both years, periodic photographs were taken of each plot and the photographs were analyzed for green cover. Visual ratings were also made in 2006 on a scale of 1 to 9 with 1 being completely brown and a 9 being a fully green plot.

In all the experiments, the soil was a deep Millville silt loam with no rooting restrictions, which allowed deep rooting of the grasses.

RESULTS AND DISCUSSION

Experiment 1 - Grasses began to enter quiescence as early as June 4th and most were completely quiescent by the end of June. Tall fescue remained partially green to mid-August. The soil at the research site was deep, free of compaction layers or other rooting restrictions allowing tall fescue to root deeply and tap into subsoil moisture.

Early plant collection from the plots showed all species recovering (Fig. 1), however, the grasses were not completely quiescent at the time of this first collection. Species differences began to appear by mid-July (Fig. 1). Tall fescue, perennial ryegrass, and Kentucky bluegrass were equal in recovery, while crested hairgrass, hard fescue, and creeping red fescue showed significantly reduced recovery. By mid-September (Fig. 1), four months since the last irrigation,

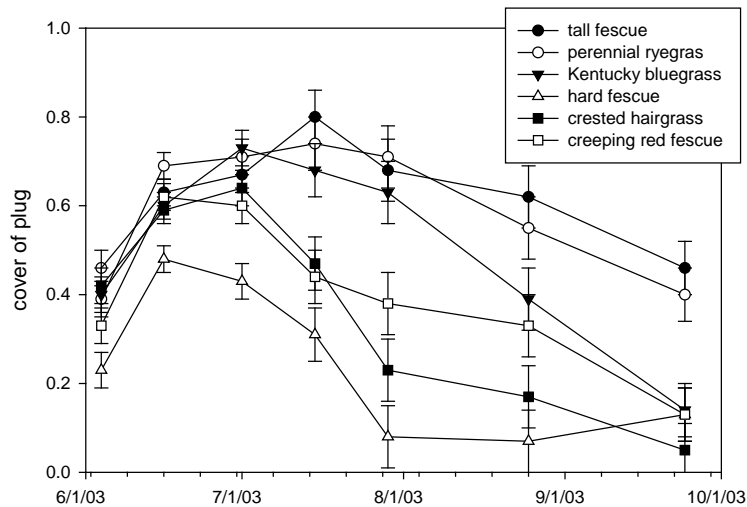


Fig 1. Recovery from extended quiescence as measured on plugs collected at dates throughout the summer of 2003. Bars on each point represent the standard error of the mean.

Experiment 2 - Similar to experiment 1, Kentucky bluegrass quickly entered quiescence in the non-irrigated plots as indicated by visual appearance, surface temperature (data not shown), stomatal conductance (Fig. 3), and plant water potential (Fig. 4). Well-watered plots had lower leaf temperature compared to the non-irrigated plots. Tall fescue in the non-irrigated treatment was cooler than in the Kentucky bluegrass because of active growth and green leaf tissue still present. Tall fescue maintained a high water potential (Fig. 4) and slightly reduced stomatal conductance (Fig. 3). Maintenance of water potential in tall fescue is likely possible because of its deep rooting characteristics mentioned above. We observed similar responses in appearance, surface temperature, stomatal conductance, and water potential in 2008 (data not shown).

Experiment 3 - All plots entered quiescence quickly and were completely quiescent by late June in both years. We observed variation among the varieties in how quickly they entered quiescence and recovery in fall including significant differences; however those differences were not consistent over time. Most varieties experienced some stand loss after 2006, some near 100%, but nearly all the plots were lost after the second year of the study (2007).

all species showed reduced recovery. Tall fescue and perennial ryegrass recovered best. Kentucky bluegrass fully recovered at earlier collection dates but showed damage, equal to crested hairgrass, hard fescue, and creeping red fescue. Supplemental irrigation treatments did not show any effect in 2003 on any of the grasses at any of the collection dates.

Soil moisture extraction data from 2004 indicated water extraction as deep as 100cm in tall fescue compared to 50 cm in Kentucky bluegrass (Fig. 2).

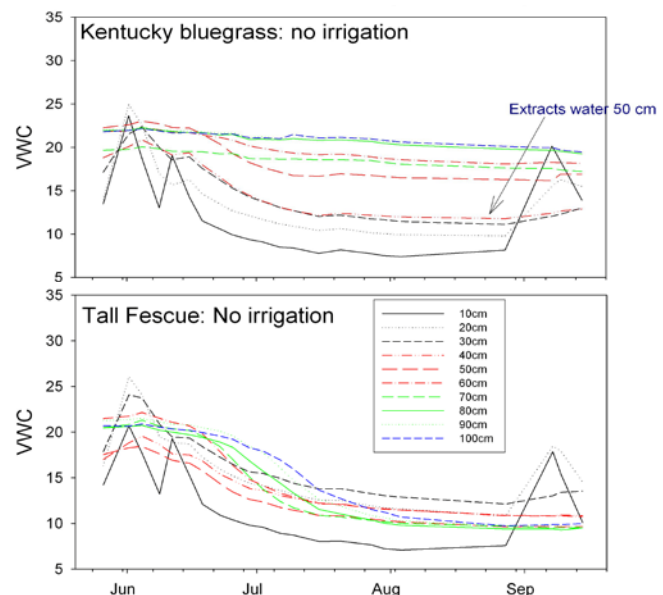


Fig. 2. Soil profile water extraction by Kentucky bluegrass and tall fescue. Kentucky bluegrass water extraction occurs to 50cm compared to at least 100cm deep for tall fescue

CONCLUSION

Commonly used turfgrass species vary in their ability to tolerate the dry summers of the Intermountain West with perennial ryegrass and Kentucky bluegrass best able to survive long periods of quiescence. One year's data indicates that perennial ryegrass tolerates this better than Kentucky bluegrass.

Tall fescue survived well, but that survival may be due to its ability to root deeply in landscapes.

Anecdotal evidence however places doubt in its survival in areas where it cannot root deeply as once tall fescue exhausts the available water, it does not persist (T. Koski, personal communication).

These species also vary in how they deal with dry conditions physiologically. Kentucky bluegrass enters a quiescent state quickly while tall fescue maintains plant function, albeit at a lower level. Tall fescue retains a relatively high water content (water potential) but closes the stomata to conserve water.

Variation among Kentucky bluegrass varieties exists in how quickly varieties enter quiescence and recover. However, we observed very large overlaps in statistically similar groupings among the varieties (60-70 varieties in the top statistical group). But any differences in tolerance of extended quiescence disappeared in year 2. Essentially none of the varieties we tested survived at an acceptable level after two years of extended quiescence without precipitation during the summer, a very typical summer weather pattern in the Intermountain West.

Quiescence helps ensure survival for many plants in our climate and landscape managers can often use it as insurance when irrigation water is temporarily cut off. Those traits are well developed in native grasses, but less so in our typically used turfgrass species. Our program is investigating additional mechanisms of drought tolerance in these species.

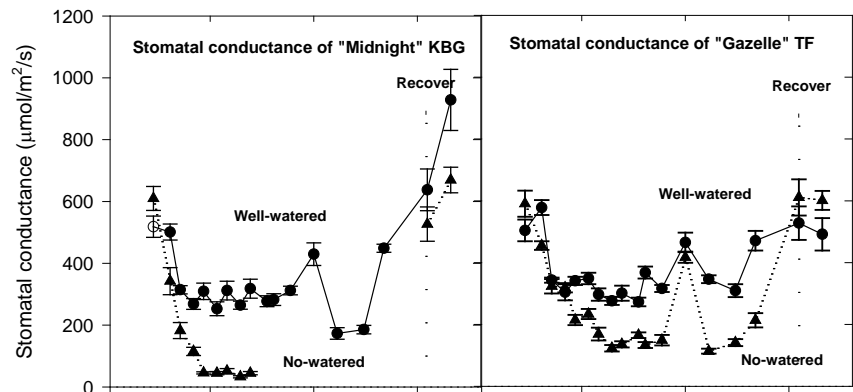


Fig. 3. Water potential of Kentucky bluegrass and tall fescue in 2007. Bars at each point represent the standard error of the mean.

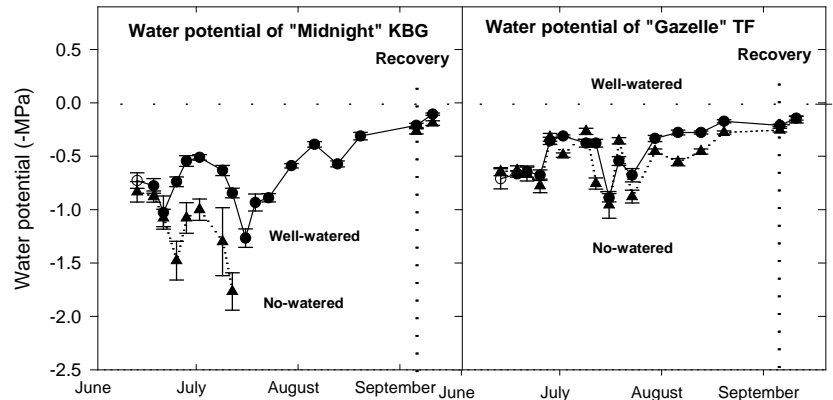


Fig. 4. Stomatal conductance of Kentucky bluegrass and tall fescue in 2007. Bars at each point represent the standard error of the mean.