Galling of bentgrass roots caused by root-knot nematodes

Carbon Fixation and Water Use Efficiency of Warm and Cool-Season Turfgrasses

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Turfgrass is a key component of urban landscapes. In Southern California, recent estimates have suggested 41% of urbanized lands are covered with turfgrass, and throughout the United States, turfgrass is the predominant irrigated crop species. Climate change resulting in increasing temperature and drought coupled with diminishing water resources offer the greatest potential for severely impacting turfgrass and landscape use. Understanding that carbon sequestration (and denitrification) are dependent upon inputs of water and nutrients, our research strives to determine ways in which water and nutrient use can be minimized while at the same time maximizing carbon sequestration of turfgrasses and groundcovers.

As a means of launching a long-term research program in turfgrass ecology, commonly used cultivars of five cool-season (C3) and eleven warm-season (C4) turfgrass species and cultivars in mono- or polystands were monitored for 12 months beginning in March 2009 through March 2010. Whole plot CO_2 and H_2O exchange was measured every two weeks under non-limiting conditions for irrigation, fertility, and mowing height. Gross ecosystem photosynthesis (GEP), or the amount of carbon dioxide exchanged between the turf and the atmosphere (μmole CO_2-C/m^2/sec) was evaluated. Water use efficiency (WUE), or the amount of CO_2 fixated by the turf per unit of water lost by evapotranspiration (ET) was also determined for each plot as GEP/ET. These data will serve as a baseline for future experiments.

2009-2010 Research Objectives
Determine association between water use efficiency and carbon dynamics among different turfgrass species and cultivars under non-limiting cultural practices.
Expand knowledge base about ecological role of turf in the landscape.

Location: UCR Turfgrass Research Facility

Soil: Hanford fine sandy loam

Mowing Heights: 2.5’’ for cool-season grasses except fine fescues (no mow), 2.0’’ warm-season grasses, except St. Augustinegrass and buffalograss (3’’)

Experimental Design: Randomized complete block with 3 replications

Plot Size: 6’ by 10’

Establishment: Sod and plugs were established in July and August 2008

Fertility: 1 lb N/1000 ft2 at planting; 0.5 lb N/1000 ft2/wk during establishment and approximately once/month thereafter

Irrigation Regimes: Once it was established, turfgrasses were subjected to warm-season irrigation regimes (approximately 60% ETo/DU). Supplemental irrigation is applied to the cool-season turf as necessary by hand watering.

Data Collection: A LI-COR 7500 open path infrared carbon dioxide and water analyzer was used to measure carbon flux and evapotranspiration (ET) within each plot on a bi-weekly basis throughout the experiment (March 2009 to April 2010). The LI-COR was attached to a tripod and placed on each turfgrass plot. A transparent chamber was used to cover the LI-COR during gas exchange measurements. Attached to the tri-pod was a small fan that helped mix the air within the chamber. Data were logged on a computer using the LI-COR software.

For each turfgrass plot, two measurements were taken. The first is net ecosystem exchange (NEE), which is gas exchange during photosynthesis and respiration. Placing the tripod on the center of the plot and covering it with the transparent chamber logged carbon dioxide and evapotranspiration measurements logged on the computer for approximately one minute. After the measurement was taken, the chamber was removed and vented. The second measurement was ecosystem respiration. The chamber was placed back over the tri-pod, which was covered by a shade cloth, allowing no light to penetrate the chamber. Data were logged for another minute while the chamber was covered. Additional measurements taken were canopy temperature using an infrared thermometer, soil temperature using a fluke thermometer with probe, as well as soil moisture content using a Hydrosense™. Turfgrass samples were collected in each plot and analyzed for leaf area, carbon and nitrogen isotope analyses. Measurements of NEE and respiration per plot determined gross ecosystem productivity (GEP) or how much carbon dioxide is being exchanged between the plant and the atmosphere/m^2/second. Water use efficiency or the amount of carbon dioxide taken up by a plant per unit of water lost was also determined for each plot using the LI-COR. A plant with high WUE takes up more carbon dioxide and transpires less water, which helps increase its ability to withstand drought.

Results:

- ✓ Carbon fixation potential and water use efficiency of all species/cultivars during one year are presented in Figures 1 and 2, respectively.
- ✓ The warm-season species Tifgreen 328 bermudagrass demonstrated the greatest carbon fixation potential under the parameters of this study (Fig. 1). Of the cool-season species, the highest carbon fixation potential was detected in Bayside Blend (80% Kentucky bluegrass/20% perennial ryegrass). It appeared that shoot density might play an important role in carbon fixation potential of turfgrasses.
- ✓ Data from Fig. 2 substantiates the greater water use efficiency (WUE) of warm-season turfgrasses compared to cool-season turfgrasses.
- ✓ Highest WUE was determined for common St. Augustinegrass for the warm-season turfgrass species and, once again, Bayside Blend Kentucky bluegrass and perennial ryegrass for the cool-season turf.
- ✓ These data are "preliminary" in the sense of statistical evaluation and interpretation and thus should not be used for demonstrating superiority of one species/cultivar over another.

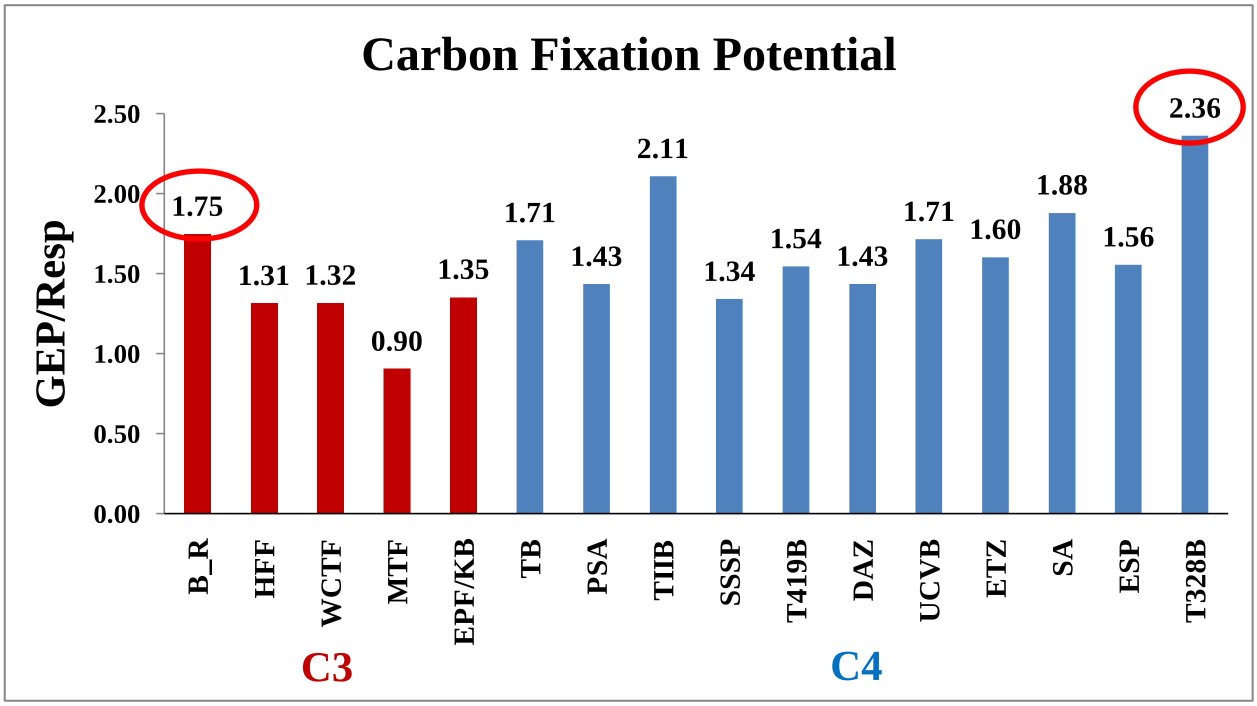

Figure 1: Carbon fixation potential (GEP/R) of all cultivars during March 2009-April 2010. Values greater than 1 indicate a cultivar that acts as a carbon "sink" storing carbon dioxide. Values less than 1 indicate a cultivar that acts as a carbon "source" releasing carbon dioxide. B_R = Bayside Blend (80%KB/20%PR); HFF=Hillside Fine Fescue (Strong/Slender/Chewings); WCTF = West Coaster Tall Fescue; MTF= Medallion Tall Fescue; EPF/KB=Elite Plus (TF/KB); TB=Tifsport Hybrid Bermuda; PSA= Palmetto St. Aug; TIIB = Tifway II HB; SSSP=Sea Spry Seashore Paspalum; T419=Tifway 419 HB; DAZ=De Anza Zoysia; UCVB=UC Verde Buffalo; ETZ= El Toro Zoysia; SA=St. Aug; ESP= Excalibre Seashore Paspalum; T328B=Tifgreen 328 HB.

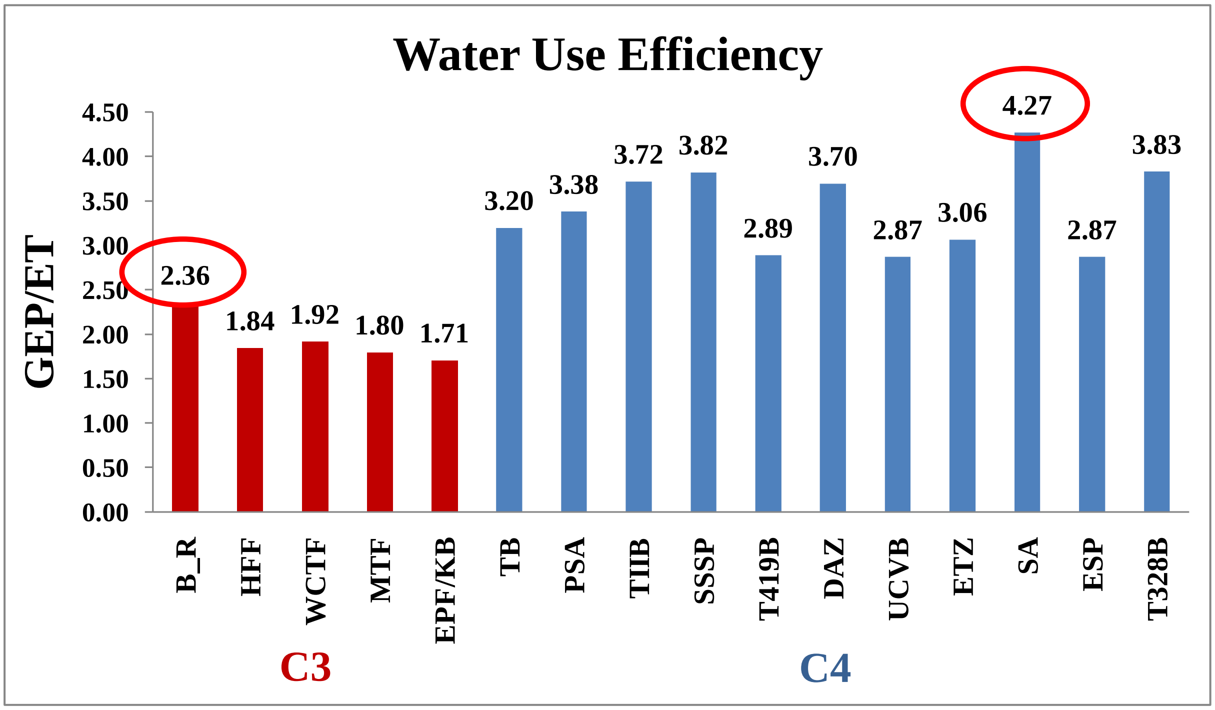

Figure 2: Water use efficiency (GEP/ET) of all cultivars during March 2009-April 2010. Values greater than 1 indicate a cultivar that is water use efficient. Values less than 1 indicate a cultivar that is not water use efficient. B_R = Bayside Blend (80%KB/20%PR); HFF=Hillside Fine Fescue (Strong/Slender/Chewings); WCTF = West Coaster Tall Fescue; MTF= Medallion Tall Fescue; EPF/KB=Elite Plus (TF/KB); TB=Tifsport Hybrid Bermuda; PSA= Palmetto St. Aug; TIIB=Tifway II HB; SSSP=Sea Spry Seashore Paspalum; T419=Tifway 419 HB; DAZ=De Anza Zoysia; UCVB=UC Verde Buffalo; ETZ= El Toro Zoysia; SA=St. Aug; ESP= Excalibre Seashore Paspalum; T328B=Tifgreen 328 HB.

2010-11 Plot Plan

North

4	12	3	14	7
17	2	9	5	16
19	8	20	18	15
10	1	13	11	6
10	20	8	12	5
19	3	17	1	14
9	15	11	16	6
18	2	4	7	13
20	19	18	17	16
15	14	13	12	11
10	9	8	7	6
5	4	3	2	1

Treatments:

1. Tifsport Bermudagrass	**11. West Coaster Tall Fescue**
2. Chaparral Perennial Ryegrass	**12. UC Verde Buffalograss**
3. Palmetto St. Augustinegrass	**13. El Toro Zoysiagrass**
4. Whittet Kikuyugrass	**14. A-4 Creeping Bentgrass**
5. Sea Spray Seashore Paspalum	**15. Common St. Augustinegrass**
6. Tifway 419 Bermudagrass	**16. Tifdwarf Bermuda**
7. De Anza Zoysiagrass	**17. Excalibre Seashore Paspalum**
8. Tifgreen 328 Bermudagrass	**18. Medallion Tall Fescue**
9. Bayside Blend Kentucky Bluegrass/Perennial Ryegrass	**19. Kurapia (Lippia nodiflora L.)**
10. Hillside Fine Fescue	**20. Elite Plus Tall Fescue/Kentucky Bluegrass**

Commercial Variety/Species	Variety/Composition	Origin/Producer	Mowing Height
Hillside Fine Fescue	„Florentine GT' Strong Creeping Red Fescue, „Seabreeze GT' Slender Creeping Red Fescue, and „Tiffany' Chewings Fescue.	Sod from West Coast Turf	Mow once/yr
Chaparral Perennial Ryegrass	Unstated varietal blend	Sod from West Coast Turf	1.25" reel
Creeping Bentgrass	A-4	Sod from West Coast Turf	0.75" reel
Bayside Blend Kentucky Bluegrass and Perennial Ryegrass	Unstated varietal mixture; 80% KB/20% PR	Sod from West Coast Turf	2.25" rotary
West Coaster Tall Fescue	Unstated varietal blend	Sod from West Coast Turf	2.25" rotary
Medallion Tall Fescue	Unstated varietal blend	Sod from Pacific Sod	2.25" rotary
Elite Plus Tall Fescue and Kentucky Bluegrass	Unstated varietal mixture	Sod from A-G Sod	2.25" rotary
Tifway 419 Hybrid Bermuda	Tifway 419	Sod from West Coast Turf	1.25" reel
Tifsport Hybrid Bermuda	Tifsport	Sod from West Coast Turf	1.25" reel
Tifdwarf Hybrid Bermuda	Tifdwarf	Sod from West Coast Turf	0.75" reel
Tifgreen 328 Hybrid Bermuda	Tifgreen 328	Sod from A-G Sod	0.75" reel
El Toro Zoysiagrass	El Toro	Sod from Southland Sod	1.25" reel
DeAnza Zoysiagrass	DeAnza	Sod from West Coast Turf	1.25" reel
Palmetto St. Augustinegrass	Palmetto	Sod from West Coast Turf	2.25" rotary
Common St. Augustinegrass	Variety unknown	Sod from Southland Sod	2.25" rotary
UC Verde Buffalograss	UC Verde	Plugs from Florasource	2.25" rotary
Excalibre Seashore Paspalum	Excalibre	Sod from Pacific Sod	1.25" reel
Sea Spray Seashore Paspalum	Sea Spray	Sod from West Coast Turf	1.25" reel
Kurapia	*Lippia nodiflora* L.	Green Geo Co., Japan	No mowing
Kikuyugrass	Whittet	Sod from Emerald Sod	0.75" reel

2011 Research Objectives

1. Determine association between water use efficiency and carbon dynamics among different turfgrass systems and Kurapia.
2. Determine how turfgrass species/cultivars affect the magnitude, seasonal patterns, and annual emissions of N_2O.
3. Examine aforementioned objectives under reduced water and, in the future, reduced nutrient and light conditions.

Building upon our preliminary research in 2009-2010, beginning in 2011 we will commence bi-weekly measurements on the following species and cultivars under deficit irrigation according to physiology (C3 vs. C4). Baseline measurements of gas exchange and soil properties will be taken under non-limiting irrigation. Then, warm-season turfgrasses will be hand watered to replace 50% ETo (based on CIMIS data from previous week) and cool-season turfgrasses will receive 70% ETo. Experimental design is a randomized complete block with three replications of 6-ft by 10-ft plots. All measurements will continue through 2011, and into 2012 if necessary. Nitrogen fertility will be applied according the "average" requirements of the warm-season turfgrasses and the same for the cool-season turfgrasses. This research will provide improved understanding of how turfgrass functions with ever increasing water restrictions, and will use measurement tools and new models recently developed to identify pulse dynamics in turfgrass.

Since the research area where the plots reside already contains scaffolding for attachment of shade cloth (from previous shade research), future research on this experimental area will involve similar measurements under reduced light conditions. Evaluation of gas exchange and WUE under varying soil fertility levels is another long-term goal of our research.

In conjunction with the aforementioned study, we will also estimate photosynthesis and water use efficiencies in commonly managed turf landscapes around Riverside, CA. This analysis will survey 10 distinct owner plots of golf course, institutional, urban park, and residential in both the winter and summer of 2010. This analysis will provide information on ranges of turf growth rates compared to expectations from our field plot research.

In subsequent years, we will conduct a similar survey study, however here we will survey turf along the strong climate gradient associated with the coastal to inland transect in Southern California. Here we will pick representative turf from the Pacific Ocean through the Coachella Valley for surveys. This research will extend our research database by examining the effect of climate on turfgrass function.

To examine the long-term consequences of turfgrass management, we will estimate carbon pools in the turfgrass in all aforementioned studies. We have extensive experience conducting carbon pool analyses in both wild land and urban environments and will use standard methods for calculating individual pools and expected turnover times.

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