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

Ryan Nichols, Alea Miehls, Darrel Jenerette, Jim Baird, and Lindy Allsman
Department of Botany and Plant Sciences
University of California, Riverside

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 under non-limiting conditions, which served as a baseline for the current experiment. Starting in May 2011, six cool-season (C3), eight warm-season (C4) and one groundcover, Kurapia (*Lippia nodiflora* L.) will be monitored for 2 years under deficit irrigation. All cultivars were subjected to deficit irrigation (water stress) based on a percentage of the previous week's reference evapotranspiration (ET_o). Whole plot CO_2 and H_2O exchange was measured monthly for each cultivar. 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.

2011-2013 Research Objectives
Determine association between water use efficiency and carbon dynamics among different turfgrass species and cultivars under deficit irrigation.
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 inches for cool-season grasses except fine fescues (mow once annually) and A-4 creeping bentgrass (0.5 inches). 1.25 inches for warm-season grasses, except St. Augustinegrass and buffalograss (2.5 inches) and Tifdwarf bermudagrass (0.5 inches).
Experimental Design:	Randomized complete block with 3 replications
Plot Size:	6' by 10'
Establishment:	Sod and plugs were established either in July and August 2008 or in 2010
Fertility:	Treatments 4,10,12: 2 lbs N/1000 ft^2/yr All other treatments: 4 lbs N/1000 ft^2/yr

Irrigation Regimes: Starting on May 1st 2011, all cultivars were hand irrigated at 80% reference evapotranspiration (ET_o) to establish uniform soil moisture throughout all the treatments. Two weeks later all cultivars were subjected to deficit irrigation (water stress) based on a percentage of the previous week's ET_o. From May 2011 to September 2011 deficit irrigation rates ranged 75-95% ET_o for cool-season grasses, 55-75% ET_o for warm-season grasses, and 55-75% ET_o for Kurapia. Hand watering was used to maintain uniform and accurate irrigation distribution.

Data Collection: A LI-COR 7500 open path infrared carbon dioxide and water analyzer are used to measure carbon flux and evapotranspiration (ET) within each plot on a monthly basis throughout the experiment. 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™. Leaf 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.

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Results:

- ✓ Water use efficiency of all selected species/cultivars during May – September 2011 are presented in Figure 1.
- ✓ Data from Fig. 2 substantiates the greater water use efficiency (WUE) of warm-season turfgrasses compared to cool-season turfgrasses.
- ✓ Highest WUE under deficit irrigation was measured on Tifdwarf bermudagrass for the warm-season turfgrass species and, once again, Bayside Blend Kentucky bluegrass and perennial ryegrass for the cool-season turf.
- ✓ Kurapia was planted in May 2011 and required time to establish during much of the evaluation period. Thus, low WUE was indicative of bare ground during establishment.
- ✓ 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.

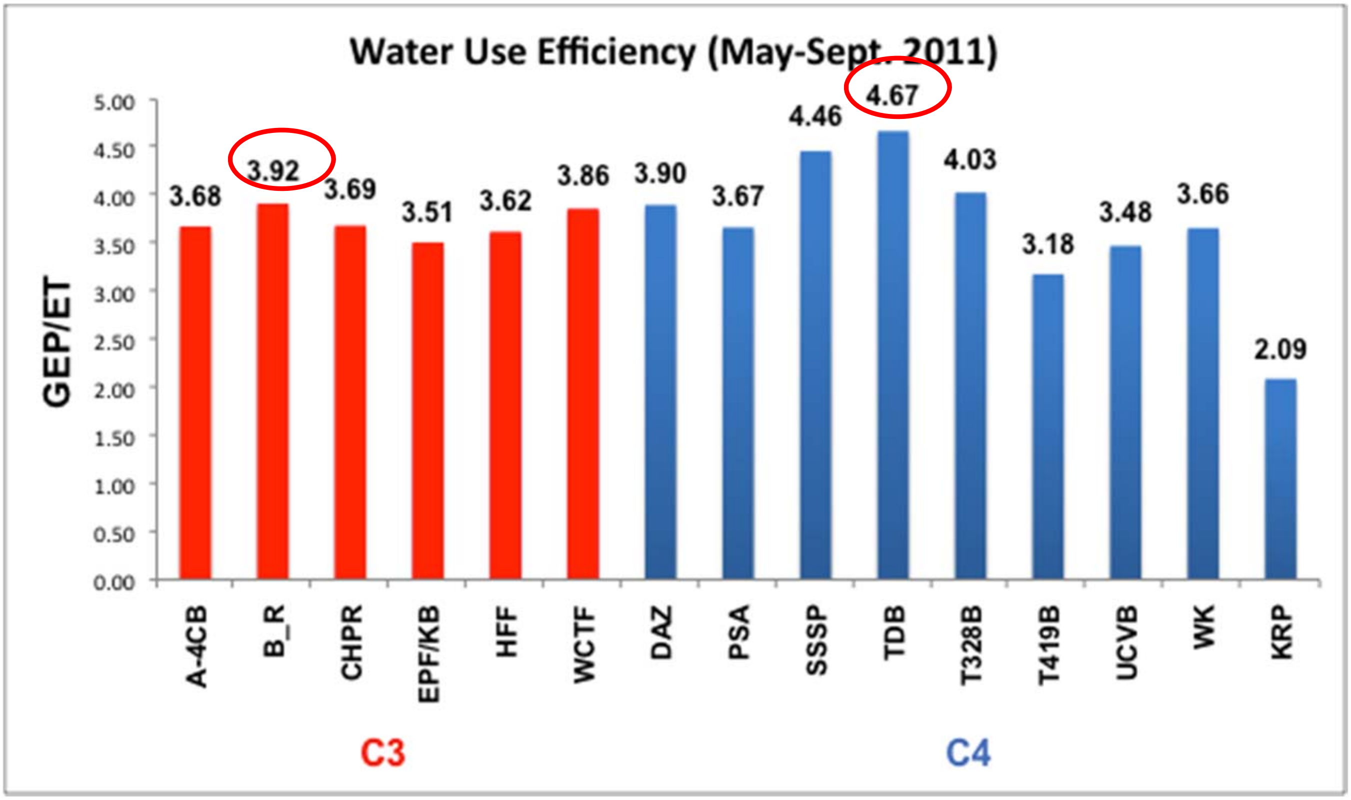

Figure 1: Water use efficiency (GEP/ET) of selected cultivars under deficit irrigation during May-Sept 2011. A-4CB= A-4 Creeping Bentgrass; B_R = Bayside Blend (80%KB/20%PR); CHPR= Chaparral Perennial Ryegrass; EPF/KB=Elite Plus (TF/KB); HFF=Hillside Fine Fescue (Strong/Slender/Chewings); WCTF = West Coaster Tall Fescue; DAZ=De Anza Zoysia; PSA= Palmetto St. Aug; SSSP=Sea Spray Seashore Paspalum; TDB=Tifdwarf Bermuda; T328B=Tifgreen 328 HB; T419=Tifway 419 HB; UCVB=UC Verde Buffalo; KRP= Kurapia.

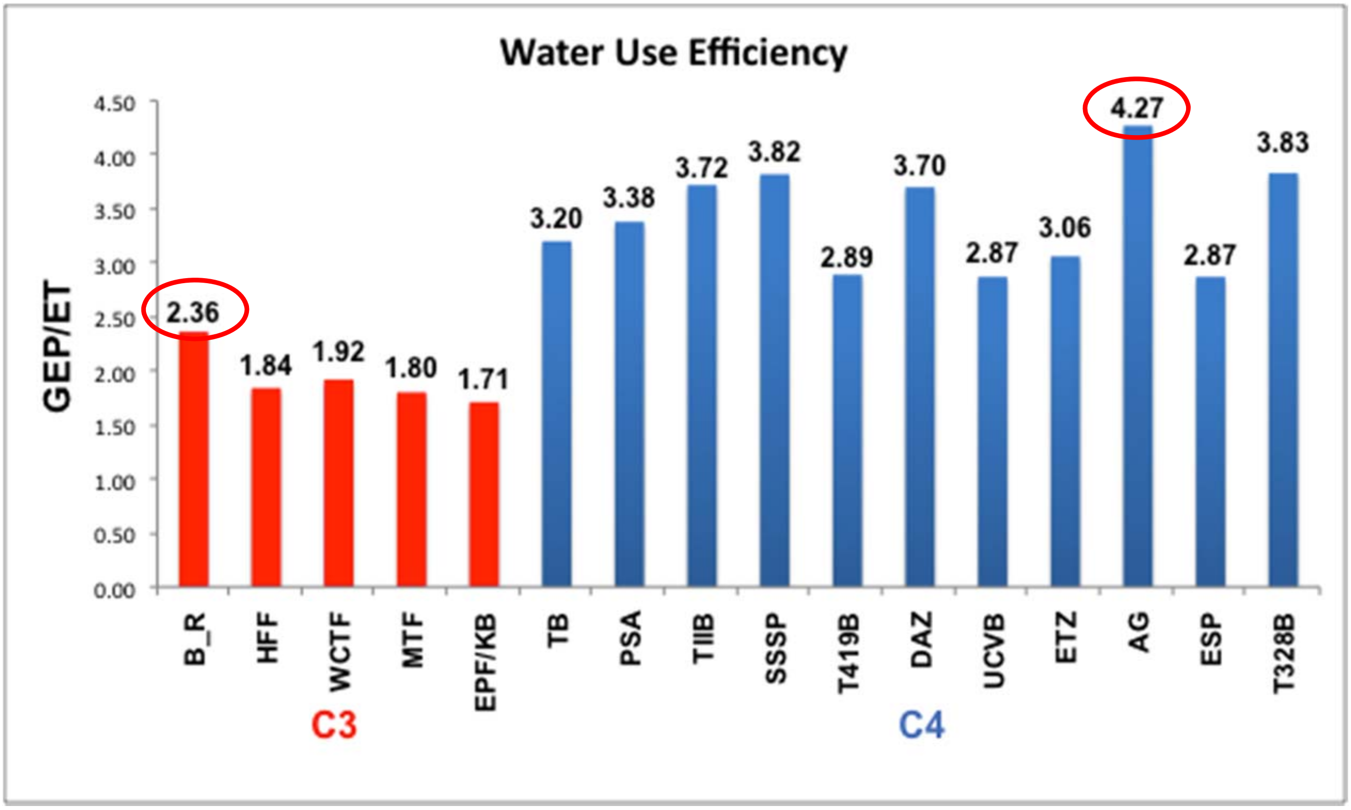

Figure 2: Water use efficiency (GEP/ET) of all cultivars under non-limiting conditions during March 2009-April 2010. Values greater than 1 indicate a cultivar that is water use efficient. Values less than 1 indicate a cultivar that is not water use efficient. B_R = Bayside Blend (80%KB/20%PR); HFF=Hillside 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	2.5” rotary
Creeping Bentgrass	A-4	Sod from West Coast Turf	0.5” reel
Bayside Blend Kentucky Bluegrass and Perennial Ryegrass	Unstated varietal mixture; 80% KB/20% PR	Sod from West Coast Turf	2.5” rotary
West Coaster Tall Fescue	Unstated varietal blend	Sod from West Coast Turf	2.5” rotary
Medallion Tall Fescue	Unstated varietal blend	Sod from Pacific Sod	2.5” rotary
Elite Plus Tall Fescue and Kentucky Bluegrass	Unstated varietal mixture	Sod from A-G Sod	2.5” 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	0.5” reel
Tifgreen 328 Hybrid Bermuda	Tifgreen 328	Sod from A-G Sod	1.25” 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	2.5” rotary
Common St. Augustinegrass	Variety unknown	Sod from Southland Sod	2.5” rotary
UC Verde Buffalograss	UC Verde	Plugs from Florasource	2.5” 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	1.25” reel

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