Water Use of Perennial Grasses Under Limited to Full Irrigation in a Semi-Arid Climate

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INTRODUCTION

Ethanol production from grains, after 2015, is capped at 15 billion gallons (EISA/RFS). This will require new biofuel materials. The High Plains is a short grass prairie ecosystem that supports both cool season (CS) and warm season (WS) native species, but water is generally a limiting factor affecting productivity.

OBJECTIVE

To determine the yield-water use productivity of several CS and WS grasses at different levels of irrigation in a semi-arid climate on a sandy and silt loam soil.

EXPERIMENTAL DESIGN

- Split-plot design with 3 replications. Whole plots = irrigations of 0, 127, 254 and 381 mm (or non-ET limiting). Subplots = CS or WS grasses.
  - ✓ CS grasses: 1) orchard grass (cv Extend); 2) mix of western (cv Barton), intermediate (cv Beefmaker) and pubescent (cv Manska) wheatgrasses; and 3) mix of meadow (cv Regar) and smooth (cv VNS) bromegrasses, creeping foxtail (cv Garrison) and orchard grass.
  - ✓ WS grasses: 1) switchgrass (cv Trailblazer); 2) mix of big bluestem (cv Bonanza) and Indian grass (cv Holt); and 3) mix of switchgrass, big bluestem and Indian grass.

MATERIALS AND METHODS

- Field studies, initiated in 2009, at Scottsbluff, NE (SBAL) on a Tripp very fine sandy loam and near Sidney, NE (HPAL) on a Keith silt loam.
- N fertilizer rates for limited irrigation treatments developed from dry matter and N relationships from published dryland and full-ET research data.
- Weed control required for both CS and WS grasses.
- Weekly water use (ET) calculated from water balance equation:

$$ET = P + I - \Delta S$$

  - ✓ P = precipitation, I = irrigation and ΔS = change in soil water content
  - ✓ Assumed negligible losses to deep percolation.
  - ✓ Runoff from intense rainfall was estimated from differences in neutron probe readings taken prior to and after each event.
  - ✓ Rain gauges, within plots, recorded irrigation and precipitation.
  - ✓ Neutron probe measurements at soil depths of 30, 61, 91 and 122 cm.
- Plots harvested with tractor-mounted, flail-type chopper (1.5 m cutting width), with dumping hopper (2.3 m^3) instrumented with an electronic scale.

RESULTS AND DISCUSSION

- SBAL precip: 30 yr avg = 390 mm; 2011 = 480 mm; 2012 = 134 mm to 9/30.
- HPAL precip: 30 yr avg = 396 mm; 2011 = 607 mm; 2012 = 190 mm to 9/30.
- Production functions for CS and WS grasses defined by linear regressions; the slope corresponds to water productivity and x-intercept corresponds to threshold water use (Figures 1-4).
- At both locations, lower threshold water use for WS grasses (124mm, SBAL and 94 mm, HPAL) compared to CS grasses (167mm, SBAL and 143 mm, HPAL).
- At SBAL, for every 25.4 mm of water use (above threshold), CS and WS grasses produced 0.86 and 0.66 Mg ha^{-1} dry matter; at HPAL, CS and WS grasses produced 0.46 and 0.48 Mg ha^{-1}.
- At HPAL, in 2012, water use and maximum forage yields of CS grasses were negatively impacted by frosts (May 20 and May 29) and loss of irrigation during drought/heat (June 7-16); however, effects were less on WS grasses.
- Maximum CS forage yields at SBAL (17.7 Mg ha^{-1}) and HPAL (11.8 Mg ha^{-1}) corresponded to a total water use of 660 and 670 mm, respectively.
- Maximum WS forage yields at SBAL (13.7 Mg ha^{-1}) and HPAL (11.3 Mg ha^{-1}) corresponded to a total water use of 610 and 660 mm, respectively.

Figure 1. Water Productivity for CS Grasses at Scottsbluff, NE (2011-2012)

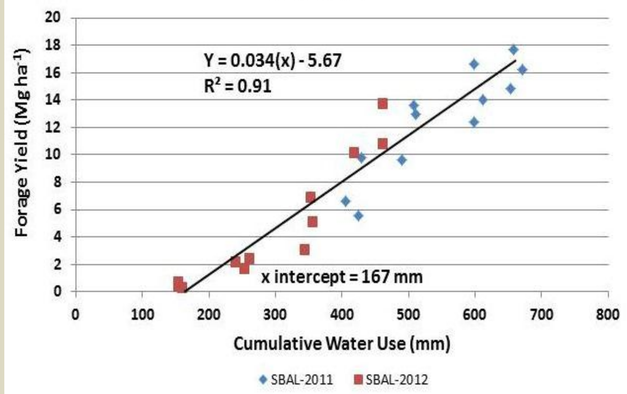


Figure 2. Water Productivity for WS Grasses at Scottsbluff, NE (2011-2012)

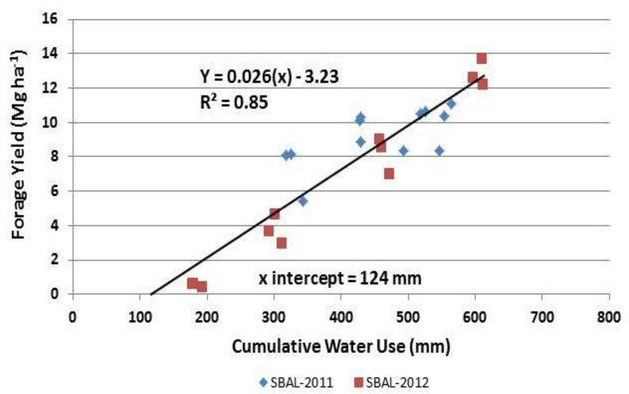


Figure 3. Water Productivity for CS Grasses at Sidney, NE (2011-2012)

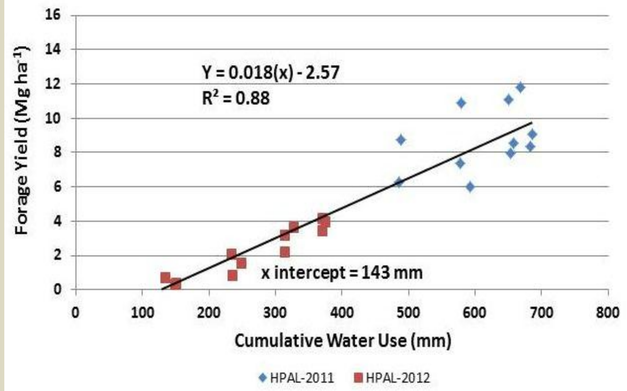
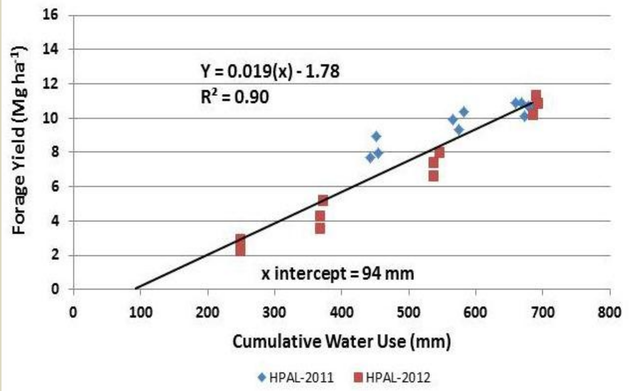


Figure 4. Water Productivity for WS Grasses at Sidney, NE (2011-2012)



Flail-type plot harvester equipped with self-dumping container and electronic scale.

Growth differences for WS grasses, at different levels of irrigation (0, 127, 254 and 381 mm), prior to September, 2012 harvest at Scottsbluff, NE.

CONCLUSIONS

- Production functions indicated a yield advantage for CS grasses over WS grasses at SBAL (~ 25%) for non-ET limiting conditions.
- Yields of CS and WS grasses were similar at HPAL due to weather/irrigation problems that reduced CS yields.
- Water productivity for CS grasses was greater than WS grasses at SBAL.
- Water productivity was similar for CS and WS grasses at HPAL.
- In the semi-arid NE panhandle, with average precipitation, maximum biomass production from CS grasses will require 250-300 mm of irrigation, whereas WS grasses will require 200-250 mm of irrigation.