

IRRIGATION MANAGEMENT STRATEGIES FOR SORGHUM: DEFICIT IRRIGATION APPROACHES AND IMPACTS OF DIFFERENT CULTIVARS

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ABSTRACT

Several irrigation trials were conducted in forage and grain sorghum cultivars over a three year period (2012-2014) at the Kearney REC to evaluate the impacts of irrigation at levels ranging from severe deficit to full evapotranspiration replacement on yields and crop total water use (applied water plus soil water use). The irrigation treatments differed in the total amount of water applied during the season, and in the deficit irrigated treatments, they differed in the timing (growth stage) when water deficits were the most severe. These trials in the sandy loam soil at UC Kearney REC were a match to identical treatment trials done also at the UC West Side REC in the clay loam soil at that site. Net soil water use by the cultivars in each of five irrigation treatments was measured in addition to applied water. In the 2012 study, total estimated crop water use ranged from a low of about 12 inches in the most water stressed treatment to a high of approximately 20 inches in the high water application treatment. Irrigation treatments were modified somewhat for the 2013 and 2014 studies, and the low water application treatment had total estimated crop water use of about 13 inches versus about 21-22 inches in the highest water application treatment. Across most treatments, grain sorghum cultivars used an average of about 1.5 inches less water than forage sorghum entries grown at the same KAREC site. Yields of grain and forage sorghum cultivars generally declined the most with the more severe deficit irrigation treatments, and yields with the modest deficit irrigation treatments were not reduced as much as reductions in water use, resulting in some potential improvements in water use efficiency in mild to moderate deficit treatments. Trial total water use and yields for 2014 trials are not yet available, and the trials will continue at least one more year (2015) to complete the work.

Key Words: sorghum, grain sorghum, forage sorghum, drip irrigation, furrow irrigation, evapotranspiration, deficit irrigation

INTRODUCTION

Sorghum is becoming a crop of interest in the San Joaquin Valley due to some observations of potential for acceptable yields, quality under our production conditions, plus the promise that it may be a lower water use crop than some other forage crops. There is only limited data, and not much

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recent research to identify yield levels and responses to irrigation ranging from deficit to full ET replacement, so the objectives of this study were to determine yield responses and water use responses to a range of deficit irrigation treatments of some modern sorghum grain and forage cultivars differing in growth habit or maturity classes.

PROCEDURES

These irrigation studies were initiated originally in 2009-2012 at multiple sites located at the College of Sequoias farm near Tulare and at the University of California West Side REC. Starting in 2012, we expanded the study to include the location at UC KAREC, and the project was expanded in 2013 and 2014 as part of a joint UC-ANR sponsored project led by Dr. Jeff Dahlberg of UC KAREC. Figures and tables below show the range of applied water, total water use, and yield responses observed across cultivars in our 2012 and 2013 studies at UC KAREC (data is not shown for 2014 since analyses of harvest data have not been completed at the time of preparation of this report, and data from the UC WSREC site is also not being shown, for brevity. Application amount and timing differences across irrigation treatments are shown in Tables 1 and 2. Applied fertilizer nitrogen was 120 lbs N/acre and approximately 150 lbs K/acre, with moderately low residual soil nitrate-N (less than 8 ppm) in the upper 4 feet of the soil profile pre-plant.

RESULTS AND DISCUSSION

Average applied water (during growing season), measured soil water depletion during the period from planting through post-harvest in eight feet of soil profile, and total estimated crop evapotranspiration (ETc) are shown in Table 3 for the UC Kearney REC site in 2012. Data are shown for forage sorghum cultivar type (SiloKing) averaging about 7 to 8 feet final height versus a more dual purpose grain sorghum type (AG2101) which had an average final plant height of 5 to 5.5 feet in irrigation treatment #1 and 2.

Table 1. Irrigation amounts and dates of application as a function of irrigation treatments at UC Kearney REC site in 2012. Irrigation applications were made using metered gated pipe furrow irrigation.

Irrig. Treatment #	2012 KAREC Irrigation Dates and Amounts (inches (mm) water) <i>- Planted 6/22</i>									
	Date	7/06	7/23	8/02	8/10	8/20	8/30	9/10	9/19	Total
T1		2.59	1.8	2.1	2.0	1.96	2.08	2.1	1.93	16.6
T2		2.59	1.8	2.06	2.0	1.96	2.08			12.7
T3		2.59		2.06		1.96	2.08	2.1	1.93	12.5
T0		2.59		2.1						4.7

Table 2. Irrigation amounts and dates of application as a function of irrigation treatments at UC Kearney REC site in 2013. Irrigation water was applied using every furrow surface drip irrigation.

Irrig. Treatment #	2013 Kearney KAREC Irrigation Dates and Amounts (inches water) - Planted 6/17 - <i>Pre-irrigations to apply total of 5.5 inches</i>										
	Date	7/07	7/14	7/24	7/30	8/10	8/17	8/29	9/02	9/15	9/23
T1	2.4	1.9	1.6	1.8	1.7	1.8	1.9	1.6	1.9	1.9	18.5
T2	2.4	1.9	1.6	1.8	1.7	1.8	1.9	1.6			14.7
T3	2.4		1.6	1.8	1.7	1.8	1.9	1.6	1.7	1.0	15.2
T4	2.4	1.9			1.7	1.8			1.7	1.8	11.3
T5	2.4	1.9			1.7	1.8					7.9

Table 3. Applied water, soil water use and total estimated evapotranspiration at the UC Kearney Research and Extension Center site (sandy loam soil) in 2012.

Sorghum Calculated Evapotranspiration
2012 – Kearney REC site (*inches applied or soil water use*) -
sandy loam soil

Year	Type of Sorghum	Irrigation Trt #	In-Season Applied Water (inches)	Soil Water Use (in)	Total Est. Etc (in)
2012	Grain Sorghum	1	16.6	-1.0	17.6
		2	12.7	-3.0	15.7
		3	12.5	-3.9	16.4
		0	4.7	-6.9	11.6
2012	Forage Sorghum	1	16.6	-2.3	18.9
		2	12.7	-4.1	16.8
		3	12.5	-4.4	16.9
		0	4.7	-8.5	13.2

**Sorghum Silage Yields and Average Moisture Content
2012 – Kearney REC site**

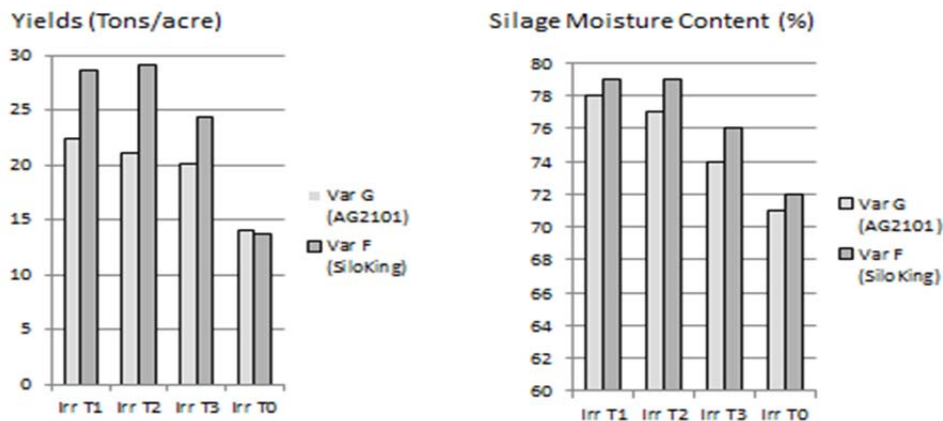


Figure 1. Average yields of sorghum cultivar types in UC Kearney REC site in 2012 (forage yields are in Tons/acre corrected to uniform moisture content of 70%).

In 2013, there were five irrigation treatments as shown in Table 2, with slightly different patterns of water application than in the 2012 studies. Total applied water ranged from a low of 7.85 inches (Irrigation Treatment #5) to a high of about 18.5 inches (Irrigation Treatment #1) as shown in Fig. 2.

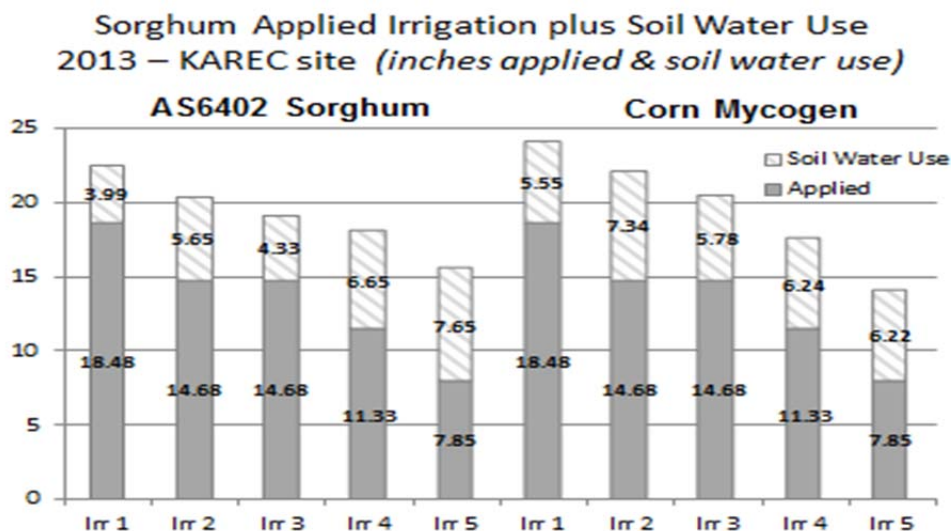


Figure 2. Applied water, soil water use and total estimated evapotranspiration at the UC Kearney Research and Extension Center site (sandy loam soil) in 2013 for a silage sorghum type (AS 6402) compared to a corn variety.

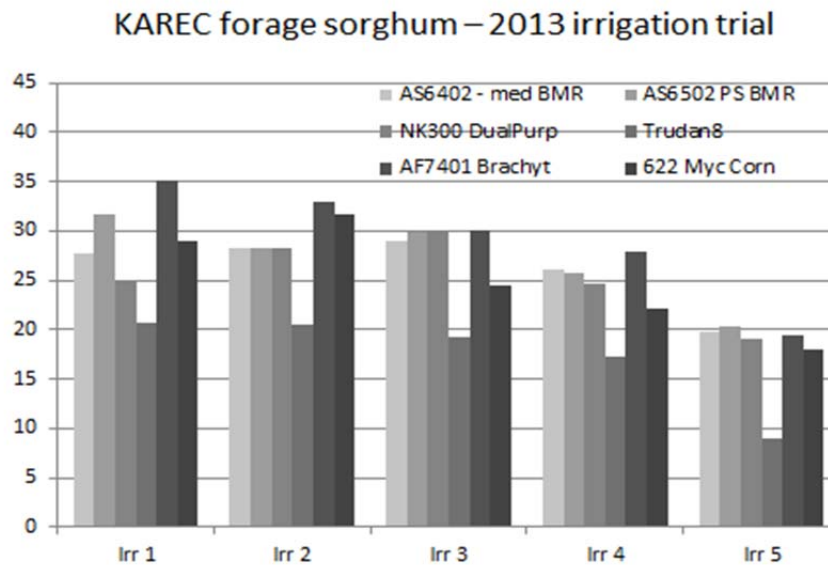


Figure 3. Average yields of sorghum cultivar types in UC Kearney REC site in 2013 (forage yields are in Tons/acre corrected to uniform moisture content of 70%).

Data collected at both the UC Kearney REC site (sandy loam soil, data represented in tables and figures shown in this paper) and at the UC West Side REC site (clay loam soil) demonstrate total evapotranspiration amounts ranging from a low of about 12 to 13 inches (Irrigation treatment #0) to a high of about 19 inches (irrigation treatment #1) in 2012 data. With slightly higher total applied water in 2013, total evapotranspiration estimates across irrigation treatments ranged from a low of about 15 inches (irrigation treatment #5) to a high of about 22 inches (irrigation treatment #1).

Yields corrected to 70% moisture content across treatments were recorded across both sorghum types (forage and grain types) in 2012, and across the five different sorghum types plus one corn variety grown in 2013 (and 2014) studies. This corn cultivar was grown to evaluate comparative responses when the corn received irrigation amounts and limited N fertilizer imposed on the sorghum cultivars in this study. Cultivars included in the study were chosen to represent differences in photoperiod response, relative height, BMR characteristics, brachytic leaf characteristics, and a more dual purpose cultivar that produces more grain than other forage types. Some of these cultivar differences will be discussed in the presentation, and will be discussed in much more detail when more data is available for analysis from both 2013 and 2014 studies. Irrigation treatments done in 2014 field trials at UC West Side REC and UC Kearney REC sites were a very close match to the applied water treatments accomplished in 2013. The same treatments will be imposed in planned 2015 field studies at the same sites to provide evaluations of water use and crop yield responses across several years and somewhat different environmental conditions.

SUMMARY OF WORK TO DATE IN THESE STUDIES

All sites had significant pre-plant irrigations and/or rainfall to provide stored soil moisture in upper 4-6 feet of profile, and it should be recognized that this situation has significant impacts on plant responses to deficit irrigation amounts and irrigation timing. Forage sorghum entries used about 12-14” inches in the lowest applied water treatments, versus about 19-22” in the highest applied irrigation water treatments. In 2012 and 2013 evaluation of responses to irrigation treatments, in terms of timing of deficit irrigation periods, there is evidence that eliminating or reducing early season irrigations reduced yields more than eliminating late season irrigations (useful for planning deficit irrigations when irrigators are short on water supplies). Although data was not presented in this paper, the overall sorghum irrigation study included the same irrigation treatments evaluated for six grain sorghum cultivars ranging from relatively early to relatively late maturity. Calculations from 2013 studies were that grain sorghum entries had about 1-2” lower calculated total water use (as compared to averages for forage sorghum cultivars) in same irrigation treatments used for the forage sorghum entries. This in general would be attributed to a more determinate growth habit in the sorghum cultivars as compared with most of the forage sorghum cultivars.

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