

Durum Response to Soil Water Depletion Levels at Stanfield, 2002

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Abstract

This research was conducted to test the effect of soil water depletion levels on durum productivity. An experiment was conducted at a commercial farm in Stanfield where irrigations were applied at 35, 50, or 65% depletion of plant available soil water. These soil water depletion levels were estimated from soil texture and weather data. The grain yields obtained with 35, 50, and 65% depletion were 6718, 6324, and 4752 lbs/acre, respectively. Grain protein decreased and HVAC increased by irrigating more frequently at lower depletion levels. Irrigating at 50% depletion was the most economical in this study considering irrigation costs and grain quality discounts.

Introduction

Wheat is an important crop in Arizona since it breaks insect and disease cycles, adds organic material to the soil due to its high straw content, and may actually increase yields of subsequent crops. Growing a crop of wheat can help control winter weeds since wheat is very competitive with other plants. Also, salts can be leached from the soil while growing wheat during the winter when water use is low.

Wheat should be irrigated when 55% of the plant available water is depleted in the root zone (Doorenbos and Pruitt, 1977). When crop water use is less than 0.10 inches/day this value should be increased by 30% (to 72% allowable depletion) and when crop water use is greater than 0.30 inches/day this value should be decreased by 30% (to 38% allowable depletion). During ripening, the maximum allowable depletion of plant available water is 90%. These guidelines are not always used in commercial practice in Arizona due to practical considerations. During the winter when water use is low and water is not needed by other crops, growers sometimes apply irrigation water to relatively wet soils to leach salts and to wet the subsoil. On the other hand, during its peak water use period, irrigation intervals often increase when water is needed to pre-irrigate cotton.

Research on several aspects of wheat irrigation has been conducted in Arizona. Consumptive use curves for wheat have been developed and published (Erie et al., 1968). The concept of the Crop Water Stress Index (CWSI), which is based on measuring canopy temperatures with an infrared thermometer, is an irrigation scheduling tool that was developed in Arizona (Jackson, 1982). The CWSI has been tested on wheat in Arizona and validated as a viable irrigation scheduling tool (Garrot et al., 1994). The effects of water stress at various growth stages has been studied for wheat in Arizona (Day et al., 1970). Roth et al. (1981) studied the effects of nitrogen levels and water application amounts on wheat.

Research has been conducted in Arizona at the Maricopa Agricultural Center to determine when to irrigate durum based on the allowable soil water depletion levels (Husman et al., 1999; Husman et al., 2000). In this work, highest grain yields were obtained by irrigating at 35% or 50% depletion. The purpose of the present research is to verify, under commercial conditions, the work conducted at the Maricopa Agricultural Center.

Materials and Methods

A durum irrigation study was conducted at the Bryan Hartman farm in Stanfield on a sandy clay loam soil. The previous crop was cotton. Fertilizer was applied preplant in the form of 11-52-0 at a rate of 200 lbs/acre. The durum variety, Kronos, was planted on 38-inch beds in dry soil at a rate of 180 lbs/acre and irrigated up on 29 December 2001. Each plot was separated by a border and contained 31 beds about ¼ mile in length. The first post-emergence irrigation was applied uniformly over the entire field on 16 January 02. Subsequently, irrigations were applied when 35, 50, or 65% of the plant available soil water was depleted. The experimental design was a complete block consisting of three irrigation treatments and four replications.

Depletion of plant available soil water was determined indirectly. Plant available soil water was estimated from textural class. Soil was sampled in 1-ft. increments to 4 ft. in four locations in the field. Soil texture was determined on these soils, and plant available soil water estimated based on average values for Arizona soils (Post, 1981). Crop water use was estimated by multiplying reference evapotranspiration (ET_o) from AZMET by a crop coefficient (K_c). The crop coefficient was developed from a concurrent experiment conducted at Maricopa where K_c was expressed as a function of heat units. The effective rooting zone was estimated from previous work relating rooting depth to heat units. Depletion of plant available soil water was thus calculated from crop water use divided by plant available soil water in the effective rooting zone. We assumed that enough water was applied at each irrigation to saturate the soil to 4 ft. and that 2 days of drainage were required to reach field capacity.

The amount and timing of irrigation water and fertilizer is presented in Table 1. Postplant nitrogen fertilizer was applied as urea ammonium nitrate solution (32-0-0) injected into the irrigation water. A commercial combine was used to harvest the entire plots on June 2, 2002. Two 1-qt. grain samples were obtained for each plot. Grain protein was measured using near infrared reflectance (NIR). Kernel weight and hard vitreous amber count (HVAC) were determined from a 10 g sample and test weight was measured using a 1 pint container. Plant height and lodging were determined at harvest.

Results and Discussion

The 2002 durum growing season from January through April was dry with an above average maximum temperature and a below average minimum temperature (Table 2). The amount of precipitation in the 2002 growing season was the lowest ever recorded by AZMET at Maricopa since its inception in 1987. The maximum temperature for the growing season was the 14th highest out of 16 seasons and minimum temperature was the 2nd lowest out of 16 seasons. The net effect of the 2002 temperature, however, was to produce a crop that was delayed in development due to the low temperatures.

The highest grain yields in this study were obtained at 35 and 50% depletion. The largest kernel weight was obtained at 65% depletion and the tallest plants were obtained at 35% depletion. Grain protein content decreased with more frequent irrigation. Test weight, lodging, and HVAC were not affected by irrigation treatment.

Irrigating at the 35% depletion resulted in a grain yield that was numerically higher than 50% depletion, but the difference was not statistically significant and was not economical (Table 4). The 35% depletion level resulted in an additional \$24/acre in income compared to 50% depletion due to higher yield without considering quality discounts. However, HVAC and protein discounts for 35% depletion amounted to \$131/acre. The 35% depletion level also had an increase in irrigation cost of \$66/acre due to three additional irrigations compared to 50% depletion. Irrigating at 50% depletion resulted in quality discounts also, but of a much lower magnitude than 35% depletion. The 65% depletion level received a protein premium of \$2/acre and cost \$44/acre less for irrigation than 50% depletion, but resulted in less income than 50% depletion due to much lower grain yields.

In previous studies, highest grain yields were obtained at 35% (Husman et al., 1999) and 35 and 50% (Husman et al., 2000) depletion of plant available water in the soil. Grain protein decreased and HVAC increased with more frequent irrigation in these previous studies. The results obtained in the present study under commercial conditions are similar to those obtained previously at the Maricopa Agricultural Center.

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Table 1. Irrigation and fertilization schedule for the durum irrigation study at Bryan Hartman, Stanfield, 2002.

35% target water depletion			50% target water depletion			65% target water depletion		
Date	Estimated water depletion	Nitrogen fertilizer amount	Date	Estimated water depletion	Nitrogen fertilizer amount	Date	Estimated water depletion	Nitrogen fertilizer amount
	%	lbs/acre		%	lbs/acre		%	lbs/acre
12/29/01	---	22.0	12/29/01	---	22.0	12/29/01	---	22.0
1/16/02	27	35.4	1/16/02	27	35.4	1/16/02	27	35.4
2/8	31	35.4	2/23	55	53.1	2/27	65	70.8
2/25	35	35.4	3/8	33	53.1	3/19	51	70.8
3/7	23	35.4	3/23	42	53.1	4/8	59	70.8
3/18	30	35.4	4/8	46	53.1	4/25	66	---
3/28	26	35.4	4/22	51	---			
4/8	32	35.4	5/8	63	---			
4/18	32	---						
4/29	37	---						
5/10	42	---						
SUM		270			270			270

Table 2. Climatic data from AZMET for Maricopa (near Stanfield) during the 2002 growing season compared to the long-term average.

Climate variable	Unit	Year(s)	Jan	Feb	Mar	Apr	Jan-Apr
Max Temp. (°F)	°F	2002	67	<u>Maricopa</u> 74	77	88	76
	Rank of 16	2002	12	15	9	13	14
	°F	1987-2002	66	70	76	85	74
Min Temp. (°F)	°F	2002	34	35	40	54	41
	Rank of 16	2002	7	1	1	16	2
	°F	1987-2002	36	39	44	51	42
Ppt. (in)	°F	2002	0.04	0.00	0.00	0.00	0.04
	Rank of 16	2002	3	1	1	1	1
	°F	1987-2002	0.66	0.78	0.81	0.28	2.53

Table 3. Grain yield and kernel and plant characteristics as affected by soil water depletion at irrigation (as a % of plant available water).

Soil water depletion	Grain yield	Test weight	Kernel weight	Plant height	Lodging	HVAC	Protein
%	lbs/acre	lb/bu	g/1000	inches	%	%	%
35	6718 a*	64.4 a	55.0 a	32.3 a	19 a	80 a	11.2 a
50	6324 a	64.2 a	57.0 a	29.3 b	0 a	93 a	12.2 b
65	4762 b	64.0 a	59.9 b	29.0 b	0 a	98 a	13.2 c

* Means followed by the same letter are not significantly different according to an F-test protected LSD at P=0.05.

Table 4. Economics of irrigating at various depletion levels considering discounts and irrigation costs.

Soil water depletion	Grain yield	HVAC discount		Protein discount		Grain price*	Grain value	Irrigation Cost***	Grain value less irrigation cost
		\$/bu	\$/acre	\$/bu	\$/acre				
%	bu								
35	104.3	-0.21**	22	-1.26	-131	2.85**	297	242	55
50	98.5	0	0	-0.45	-44	3.66	361	176	185
65	74.4	0	0	0.03	2	4.14	308	132	176

* The contract grain price without discounts or premiums is \$4.11/bu.

** The maximum combined discount for HVAC and protein is \$1.26/bu, or a floor price of \$2.85/bu.

*** The irrigation cost is \$22 per irrigation, \$17 for water and \$5 for labor.