Crop Coefficients for Estimating Small Grain Water Use, 2004

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Summary

Crop coefficients are used to estimate water use from reference evapotranspiration values provided by weather stations. Four varieties of barley and durum were planted at the Maricopa Agricultural Center early December and early January and one durum variety was planted at the Yuma Valley Agricultural Center in late December and mid-February. Water use was estimated from neutron probe readings and crop coefficients were calculated by dividing water use by reference evapotranspiration. The crop coefficients calculated in this study peaked from 1.0 to 1.3, and the peak averaged about 1.16. Some differences were detected among planting dates and varieties, but it has yet to be determined if these differences are of practical significance.

Introduction

Crop coefficients are used to calculate water use from weather data. The crop coefficient increases as the crop develops, reaches a peak, and then decreases as the crop senesces. Crop coefficients are most accurate if locally developed using current cropping practices. Crop coefficients have not been developed for Arizona, and we currently rely on values from California or values estimated indirectly from water use work done on outdated varieties by the Water Conservation Research Laboratory in Phoenix in the 1950's and 1960's. We intend to use the crop coefficients developed in Arizona to provide water use estimates for the Small Grain Advisory and for AZSCHED, irrigation scheduling software for Arizona. The purpose of this study is to develop crop coefficients for wheat and barley in Arizona.

Procedures

Four durum varieties (Duraking, Kronos Orita, and WPB 881) and four barley varieties (Barcott, Baretta, Max, and Mucho) were planted at two dates (Dec 3, 2003 and Jan 7, 2004) at the Maricopa Agricultural Center. The plots were 42 ft by 40 ft in size and replicated twice in a randomized complete block design. Two neutron access tubes were installed per plot. Cultural practices are presented in Table 1. Water use was estimated in 1 ft depth increments to 5 ft from neutron probe readings before and after each irrigation. Crop coefficients were calculated by dividing water use by reference evapotranspiration (ETo, original AZMET calculation method) from AZMET.

Kofa durum was planted at two dates (Dec 29, 2003 and Feb 13, 2004) at the Yuma Valley Agricultural Center in 5 acre fields. Six neutron access tubes were installed in the center portion of each field. Cultural practices for this site can be found in Table 1. Water use and crop coefficients were calculated similarly to the Maricopa location.

Results and Discussion

This was a poor growing season for small grains and yields were lower than usual in these tests compared to past years. Total precipitation was near the average for the growing season (Table 2). Growing season temperature was near or above average. However, the defining characteristic of this growing season was the hottest March on record at all locations. This, combined with one of the coldest February on record, resulted in hot temperatures occurring earlier than usual and may have been responsible for the lower yields measured this year.

Small grain crop coefficients according to the FAO Irrigation and Drainage Paper 56 are 1.15 at midseason and 0.25 at the end of the season (Allen et al., 1998). Initial values are not provided. At Maricopa, the midseason values for the December planting were 1.15 (barley) and 1.07 (durum) for the December planting and were 1.21 (barley) and 1.20 (durum) for the January planting (Table 6). At Yuma, the midseason values for durum were 1.18 for the January planting and 1.13 for the February planting (Table 7). The end of the season values varied from 0.04 to 0.62 depending on exactly when the last measurements were recorded and when the last irrigation was applied. The Kc values were higher at the second planting at Maricopa, but not at Yuma, in contrast to previous years. Varietal differences in Kc values exist, but whether or not these differences are of practical significance is yet to be determined.

References

Allen, R. G., L. S. Pereira, D. Raes, and M. Smith. 1998. Crop Evapotranspiration: Guidelines for computing crop water requirements. FAO Irrigation and Drainage Paper 56. FAO, Rome.

Acknowledgements

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Table 1. Cultural practices for the small grains planted at Maricopa and Yuma.

	Maricopa		Yuma Valley	
Cultural practice	Dec 3 planting	Jan 7 planting	Dec 29 planting	Feb 13 planting
Field	6	6	B19	A6
Border	8-9	10-11	23	9
Soil type	Sandy clay loam	Sandy clay loam	Clay	Clay
Previous crop	Sudangrass	Sudangrass	Vegetables	Vegetables
Preplant soil NO_3-N	7.7 ppm	7.7 ppm	---	---
Preplant soil P	6.5 ppm	6.5 ppm	---	---
Row spacing	7 inches	7 inches	7 inches	7 inches
Barley seeding rate	80 lbs/acre	80 lbs/acre	---	---
Durum seeding rate	100 lbs/acre	100 lbs/acre	150 lbs/acre	150 lbs/acre
Irrigation and fertilization	12/03 + 48 lbs N/a and 60 lbs P_2O_5/a	---	12/29 + 100 lbs N/a	---
	01/29 + 23 lbs N/a	01/07 + 48 lbs N/a and 60 lbs P_2O_5/a	2/06 + 50 lbs N/a	2/13 + 100 lbs N/a
	03/01 + 55 lbs N/a	03/01 + 55 lbs N/a	2/26 + 50 lbs N/a	2/26 + 50 lbs N/a
	03/18 + 46 lbs N/a	03/18 + 46 lbs N/a	3/12 + 50 lbs N/a	3/12 + 50 lbs N/a
	04/01 + 46 lbs N/a	04/01 + 46 lbs N/a	3/26	3/26 + 50 lbs N/a
	04/16	04/16	4/08	4/08
	04/30	04/30	4/22	4/22
			5/06	5/06
Total N applied	218 lbs N/a	172 lbs N/a	250 lbs N/a	250 lbs N/a

Table 2. Climatic data from AZMET for Maricopa and Yuma Valley during the 2004 growing season ranked and compared to the long-term average. The rankings of the months are from low to high.

Climate variable	Unit	Year(s)	Dec	Jan	Feb	Mar	Apr	May	Dec-May
					Maricopa				
Max Temp.	Rank of 18	2004	14	13	3	18	9	14	14
	ºF	2004	67	67	66	84	84	97	78
	ºF	1987-2004	65	66	70	77	85	94	76
Min Temp.	Rank of 18	2004	10	15	3	18	13	11	14
	ºF	2004	34	39	36	51	52	60	45
	ºF	1987-2004	35	36	39	44	51	59	44
Ppt.	Rank of 18	2004	7	12	10	8	15	1	12
	inches	2004	0.16	0.71	0.91	0.28	0.98	0.00	3.03
	inches	1987-2004	0.64	0.66	0.81	0.75	0.31	0.14	3.27
					Yuma				
Max Temp.	Rank of 18	2004	10	9	3	18	9	11	11
	ºF	2004	68	68	69	86	85	94	78
	ºF	1987-2004	67	69	73	79	86	94	78
Min Temp.	Rank of 18	2004	5	12	2	18	11	9	9
	ºF	2004	40	42	42	53	54	60	49
	ºF	1987-2004	41	42	45	49	54	60	48
Ppt.	Rank of 18	2004	1	8	10	8	17	1	8
	inches	2004	0.00	0.06	0.20	0.10	0.69	0.00	1.05
	inches	1987-2004	0.37	0.31	0.34	0.35	0.16	0.04	1.55

Table 3. Heading, flowering and physiological maturity for the varieties planted at two dates at Maricopa.

		Barley				Durum			
Planting date	Stage	Barcott	Baretta	Max	Mucho	Duraking	Kronos	Orita	WPB 881
Dec 3	Heading	3/07	3/15	3/22	3/10	3/21	3/16	3/22	3/16
	Flowering	3/07	3/16	3/24	3/12	3/25	3/24	3/30	3/21
	Maturity	4/22	4/25	4/29	4/24	4/31	4/25	4/30	4/25
Jan 7	Heading	3/23	3/30	4/05	3/24	3/31	3/28	4/01	3/28
	Flowering	3/23	3/30	4/08	3/25	4/07	4/10	4/08	4/06
	Maturity	4/27	5/06	5/09	4/30	5/06	5/07	5/08	5/05

Table 4. Crop growth stages when neutron probe readings were recorded for the two planting dates at Yuma.

	Planting date	
Date	December 29	February 13
2/18	1-2 nodes	---
3/04	2-3 nodes	2.75 leaf
3/09	Last leaf visible	4.4 leaf
3/18	Boot	5.5 leaf
3/24	Heading	---
3/31	Flowering + 2 days	2 nodes
4/07	Kernel watery	Boot
4/13	Milk	Heading
4/21	Soft dough	Flowering
4/26	Late soft dough	Early kernel watery
5/05	Physiological maturity	---
5/11	Straw dead except lodged	Soft dough
5/27	Harvest ripe	Physiological maturity – 3 days

Table 5. Grain yields for the varieties planted at two dates at Maricopa.

	Grain yield							
	Barley				Durum			
Planting date	Barcott	Baretta	Max	Mucho	Duraking	Kronos	Orita	WPB 881
	lbs/acre							
Dec 3	4473	6153	7261	5160	6506	6078	6264	6244
Jan 7	3131	3990	3741	3330	3886	3115	3538	4087

Table 6. Crop coefficients calculated for various growth periods for the two plantings at Maricopa.

		Barley				Durum							
Growth period		Barcott	Baretta	Max	Mucho	Dura-king	Kronos	Orita	WPB 881	Barley	Wheat	All	$LSD_{.05}$
Dec 3 planting													
12/22-1/28		0.459	0.394	0.454	0.456	0.404	0.394	0.444	0.460	0.441	0.425	0.433	NS
2/2-2/20		1.052	1.022	0.975	0.897	1.018	0.996	1.032	1.126	0.986	1.043	1.015	0.087
3/4-3/17		1.252	0.967	1.112	1.107	1.057	1.052	0.907	1.166	1.109	1.046	1.078	0.170
3/22-3/31		1.107	1.145	1.229	1.157	1.099	1.028	1.035	1.103	1.159	1.066	1.113	NS
4/6-4/15		1.030	1.116	1.217	1.053	1.114	1.053	1.004	1.063	1.104	1.059	1.081	0.123
4/22-4/29		0.711	0.849	1.080	0.792	1.063	1.100	1.093	0.969	0.858	1.056	0.957	0.179
5/6-5/20		0.410	0.449	0.572	0.373	0.118	0.110	0.131	0.113	0.451	0.118	0.279	0.074
Jan 7 planting													
2/2-2/20		0.393	0.374	0.454	0.360	0.392	0.353	0.361	0.348	0.395	0.363	0.379	NS
3/4-3/17		1.063	0.957	1.090	0.921	1.175	1.154	1.058	1.020	1.008	1.102	1.055	0.142
3/22-3/31		1.168	1.203	1.284	1.142	1.239	1.229	1.208	1.119	1.199	1.199	1.199	NS
4/6-4/15		1.186	1.213	1.285	1.147	1.263	1.216	1.217	1.105	1.208	1.200	1.204	NS
4/22-4/29		1.180	1.132	1.336	0.866	1.096	1.084	0.954	1.105	1.128	1.060	1.094	0.234
5/6-5/13		0.656	0.707	0.775	0.546	0.594	0.476	0.687	0.597	0.671	0.589	0.630	0.204
5/13-5/26		0.181	0.037	0.074	0.104	0.019	0.190	-0.025	-0.043	0.099	0.035	0.067	0.122

Table 7. Crop coefficients calculated for various growth periods for the two plantings at Yuma.

	Dec 29 planting	Feb 13 planting
Time period	Crop coefficient	Crop coefficient
3/4 - 3/9	0.885	0.560
3/18 - 3/24	1.039	0.819
3/31 - 4/7	1.185	1.127
4/13 - 4/21	1.039	0.818
4/26 - 5/5	0.616	---
5/11 - 5/27	0.193	0.618