State Ex Rel. State Engineer, Zuni Indian Tribe, Navajo Nation v. A & R Productions, et al.

Civ. No. 07-00681 BDB/WDS
Zuni River Basin Adjudication
Subproceeding 1 Zuni Indian Claims

Calculation of Crop Coefficients (K_c)

for Zuni Pueblo

Prepared for:

State of New Mexico
Office of the State Engineer
Santa Fe, New Mexico

By:

Zohrab A. Samani, Ph.D., P.E.
Samani Global Inc.
2705 Claude Dove
Las Cruces, New Mexico 88011

Zohrab A. Samani, Ph.D., P.E.

February 26, 2010

Calculation of Crop Coefficients (K_c) for Zuni Pueblo

2/26/2010

Zohrab Samani, PhD. PE.

The calculation of crop coefficients K_c were determined for various crops using two sources. The sources for calculation of Kc were James Wright (1981) Kc-GDD data and FAO-56 (Allen et al, 1998). Preference was given to Wright (1981) data, but when the information was not available, FAO-56 was used to define the Kc values. A modification was made in case of alfalfa where the GDD data from Smeal (1995) were used to determine the length of each cut due to the proximity of the Smeal's experiments location in Farmington, NM to the study site.

The crop coefficients for the crops of grain corn, barley, spring Wheat, Beans, sweet corn, squash, zucchini and alfalfa were determined as follows:

Small grains:

Small grains included spring barley and spring wheat. The following Kc-GDD were determined for the small grains from Wright (1981).

Spring wheat. The planting date for spring wheat was set based on criteria from FAO-56 which defines the planting date as the time when the 10 days running average temperature reaches 5 C^0 (41 F). The starting date can be set at 45 F as defined in SCS TR-21, but it was determined that the starting date recommended by FAO-56 is more conservative and will result in higher ET_c. In addition, the FAO-56 start date is more realistic as a wheat crop can be planted a few days before the minimum temperature. The difference between FAO-56 and SCS-TR-21 starting dates is about 10 mm in ET_c

The following Table 1 shows the Kc-GDD data derived from Wright (1981).

Table-1. Kc-GDD relationship for spring wheat derived from Wright (1981)

Spring-wheat										
Cover %	10	20	30	40	50	60	70	80	90	100
GDD	6.18	6.18	8.23	8.59	27.5	67	150	205	281	382
Kc-spring-before full cov	0.345	0.345	0.575	0.86	1.035	1.127	1.15	1.15	1.15	1.15
Days after full cover	10	20	30	40	50	60				
GDD	563	756	981	1224	1472	1827				
Kc	1.15	1.15	1.15	1.093	0.633	0.288				

Table 2 shows the K_c-GDD relationship for Spring Barley. The planting date for spring barley was set at mean temperature of 45 F as recommended by SCS TR-21. No recommendation was available in FAO-56.

Table-2. Kc-GDD relationship for spring barley derived from Wright (1981).

Spring-Barley										
Cover %	10	20	30	40	50	60	70	80	90	100
Barley-GDD	8.23	8.23	25.6	67.1	140	204	293	421	531	613
Kc	0.345	0.345	0.368	0.46	0.748	0.978	1.093	1.14	1.15	1.15
Days after full-cover	10	20	30	40	50	55				
GDD	813	1030	1276	1529	1781	1827				
Kc	1.15	1.15	1.035	0.575	0.288	0.173				

Grain Corn

The planting date for grain corn was set at mean temperature of 55 F as recommended by SCS-TR-21. Table 3 shows the Kc-GDD for grain corn. It was noted that there was not sufficient GDD in Zuni for full ripening of grain corn.

Table-3 Kc-GDD relationship for grain corn derived from Wright (1981).

Corn-Grain										
Cover %	10	20	30	40	50	60	70	80	90	100
GDD	15.5	48.3	78.86	137	224.5	296	396	494	609.8	759.5
Kc, before full cover	0.345	0.345	0.345	0.345	0.368	0.66	0.79	0.886	0.943	0.98
Days-after-full cover	10	20	30	40	50	60	68			
GDD	957	1160	1351	1498	1632	1737	1776			
Kc	1.104	1.093	1.081	1.035	0.978	0.909	0.85			

Alfalfa

Starting date for alfalfa was set at mean ambient temperature of 41 F according to Smeal (1995) and Wright (1981). The growing degree days for each cut were taken from Smeal (1995) and the Kc values for each cut were taken from Wright (1981). Table 4 shows GDD and Kc values for each cut for alfalfa.

Table-4 Kc and GDD values for each cut for alfalfa

GDD (smeal Farmington)	1027	1146	1146	1146						
percent time	10	20	30	40	50	60	70	80	90	100
Kc (Wright 1991)										
1st cut	0.805	0.943	1.047	1.104	1.15	1.15	1.127	1.104	1.093	1.093
2nd cut	0.46	0.575	0.92	1.104	1.127	1.15	1.15	1.127	1.093	1.093
3rd cut	0.46	0.575	0.92	1.104	1.127	1.15	1.15	1.127	1.093	1.093
4th cut	0.46	0.506	0.69	0.75	0.63	0.575	0.5175	0.4	0.345	0.29

Irrigated pasture

The K_c values for irrigated pasture were taken from FAO-56. The FAO-56 defines K_c values for rotated grazing and extensive grazing pasture. The average K_c values for each stage were used. The start temperature for irrigated pasture was set at 7 days before the last -4 C^0 in spring and 7 days after the first -4 C^0 in the fall. Table 5 shows the Kc values for each stage of irrigated pasture.

Table-5 Kc as a function of growing season, FAO-56.

Irrigated pasture
7 days before the last -4 c to 7 days after the first -4 c minimum temp.

source FAO-56		growing periods , days		
days	10	20 mid season		end
kc	0.35	0.85		0.8

Vegetable garden

The ET_c values for vegetable garden were calculated for sweet corn, beans, squash and zucchini. The planting mean ambient temperature for sweet corn was 55 F, and for beans, squash and zucchini was 60 F (SCS TR-21 and NMSU extension service).

The K_c values for sweet corn and bean were taken from Wright (1981) and k_c values for squash and zucchini were taken from FAO-56. for May planting. Tables 6 and 7 shows the K_c-GDD relationship for sweet corn and bean derived from Wright (1981) and Table 8 shows the Kc-growing season values for squash and zucchini from FAO-56.

Table-6 K_c-GDD relationship for sweet corn derived from Wright (1981).

Sweet corn										
Cover %	10	20	30	40	50	60	70	80	90	100
GDD	15.5	48.3	78.86	137	224.5	296	396	494	609.8	759.5
Kc,before full cover	0.345	0.345	0.345	0.345	0.368	0.66	0.79	0.886	0.943	0.98
Days after full cover	10	20	30							
GDD	957	1160	1351							
kc, after full cover	1.07	1.07	1.035							

Table-7 K_c-GDD relationship for beans derived from Wright (1981)

Bean										
Cover %	10	20	30	40	50	60	70	80	90	100
GDD	4.6	14.7	31	53	83	123	164	223	290	362
Kc	0.345	0.345	0.345	0.403	0.518	0.633	0.78	0.92	1.035	1.093
Days after full cover	10	20	30	40	45					
GDD	505	643	783	895	941					
Kc	1.093	1.035	0.77	0.38	0.173					

Table -8 Growing season K_c values for squash and zucchini, FAO-56

Squash & zucchini, Starting Temp. 60 F source FAO-56					
		growing periods			
	days	20.00	30	25	15.00	end
	kc	0.50		0.95		0.75

References:

FAO-56 Crop Evapotranspiration, Allen et al 1998, Food and Agricultural Organization of the United Nations, Rome Italy.

SCS-TR-21. Irrigation water requirements. United States Department of Agriculture, Soil Conservation Service Technical Report # 21, April 1967.

Smeal, D., E.J. Gregory, R.N. Arnold, J. Tomko. Water use and yield of alfalfa in Northernern New Mexico. NMSU agricultural experiment station, Bulletin 770.

Wright J. L. 1981. Proceedings of the Irrigation Scheduling Conference ASCE , Dec. 1981. Chicago, Ill..