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**PREDICTING CONSUMPTIVE USE
WITH CLIMATOLOGICAL DATA**

Technical Completion Report

Project No. A-043-NMEX

PREDICTING CONSUMPTIVE USE
WITH
CLIMATOLOGICAL DATA

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INTRODUCTION AND OBJECTIVES

Consumptive-use coefficients currently used for determining irrigation requirements and water rights in New Mexico have been imported from other states for most crops because of lack of measurements made in the State. This condition exists also for most of the states because of the great expense incurred to make measurements for all crops in any one state.

A major objective of this project is to enlarge the store of consumptive use (evapotranspiration) information in New Mexico by making additional consumptive-use measurements for selected crops in the State and to extract consumptive-use data from earlier irrigation research projects in which soil moisture depletion measurements have been made for scheduling irrigations.

The specific objectives of the project are:

1. to determine the quantity and rate of moisture depletion by consumptive use throughout the growing season of selected crops grown in San Juan and Dona Ana Counties, New Mexico;
2. to determine the relationship between consumptive use of water by selected crops and pan evaporation; and
3. to determine the accuracy of coefficients used presently in the Blaney-Criddle method and modifications of coefficients that may be needed to compute consumptive use by this method for conditions in New Mexico.

SUMMARY

During 1973-74, five sites were established on plots in fields to measure consumptive use of water by crops using the soil moisture depletion method according to the procedure described in the project proposal. Two sites with alfalfa and corn were located at the San Juan Branch Experiment Station near Farmington, New Mexico, and three sites with alfalfa, onions, and cotton were located at or near the Plant Science Farm of the New Mexico Agricultural Experiment Station near Las Cruces, New Mexico.

During 1974-75, five lysimeters were installed for measuring consumptive use with potatoes and lettuce at the Plant Science Farm, and alfalfa and field corn at the San Juan Branch Station.

Additional consumptive-use data for onions and sweet corn, 1971 to 1973, and alfalfa, 1963 and 1964 have been computed for this report from records of other projects which used moisture depletion measurements for scheduling irrigation treatments. No data are included for the 1973-74 alfalfa sampling site near the Plant Science Farm inasmuch as the water table rose sufficiently during the latter part of the season to irrigate the lower portion of the root zone. During 1974-75 consumptive-use measurements for alfalfa were made at another site on a nearby farm where the land was sufficiently high to keep the crop from being influenced by a rising water table.

The occurrence of deep drainage, which has long been a question with moisture depletion measurements in the field, is identified and discussed. A relatively low-cost lysimeter was developed in 1973-74 to monitor deep drainage and to measure consumptive use. The construction of the lysimeter is described in detail in the 1973-74 report.

Weather data collected at the Plant Science Farm and the San Juan Experiment Station consists of precipitation, pan evaporation, temperature, wind movement, humidity, and solar radiation measurements.

PROCEDURE AND DISCUSSION

In determining consumptive use, the march of moisture in the soil was measured with the neutron probe before and after irrigations with additional measurement between irrigations. For measurements in field plots, it is customary to make the first measurement two or three days after irrigations during which time the major part of the gravity water will have percolated below the root zone in the more open soils. Some deep drainage may continue from irrigation to irrigation in finer-textured soils. When this occurs, some deep drainage will be included in moisture depletion measurements in field plots which otherwise should represent consumptive use (evapotranspiration).

Deep drainage may be accounted for with lysimeters or by computations using the Darcy equation, but both of these methods have been very expensive as conventionally used. Therefore, a considerable part of consumptive-use research in the country has been done in field plots with the soil moisture depletion method as cited in this project and in references (1,2,3,4,6, and 7).

During 1974-75, five 6-ft. by 6-ft. by 4-ft.-deep lysimeters were installed using plywood and plastic sheeting according to the design which was developed the previous year and described in the 1973-74 report of this project. Drain tubes and suction candles were placed near the bottom before backfilling with soil which had been excavated.

The soil was backfilled in six-inch layers according to its original location in the soil profile. A pipe line connected all lysimeters to vacuum pumps to provide for removal and measurement of drainage water and to provide suction for the candles.

Of the five lysimeters cited, three were used at the Plant Science Farm in 1975 to grow potatoes with three replications during February to July, and lettuce during August to November; and two were used singly at the San Juan Branch Station to grow alfalfa and field corn. The lysimeter crops were grown in plots or fields with similar crops. Consumptive use was determined for the crops in the lysimeters using the general formula:

$$U = \frac{I + P + SMD - D}{\Delta T} \quad \text{where,}$$

U = Consumptive use (evapotranspiration)

I = Irrigation water applied

P = Precipitation

SMD = Soil moisture depletion

D = Drainage water removed by pumping

$\Delta T = t_2 - t_1$, the monthly or seasonal time interval.

Measured consumptive use was used to compute consumptive-use coefficients pertaining to the Blaney-Criddle method as specified in the objectives. With this method, monthly consumptive-use coefficients, k , and seasonal consumptive-use coefficients, K , may be computed from the formulas $k = \frac{u}{f}$ and $K = \frac{U}{F}$, respectively, where,

U = Seasonal consumptive use (measured)

u = Monthly consumptive use (measured)

$u = kf$

$f = \frac{pt}{100}$

$U = KF$

$F = \Sigma f = \frac{\Sigma(pt)}{100}$

t = mean monthly temperature in degrees Fahrenheit

p = percentage of day-time hours of the year which occur during the month or period

Temperature was measured at each station. Percentage of day-time hours of the year which occurred during the months was obtained from Sunshine Tables of the U.S. Weather Bureau (9).

RESULTS AND DISCUSSION

Consumptive Use and Relation to Evaporation.

Computed consumptive-use coefficients and ratios of measured consumptive use to measured pan evaporation are presented with climatological data and moisture depletion measurements for crops indicated in the Appendix.

The data in the Appendix are tabulated to separate the frost-free seasonal coefficients from the coefficients in the frost season. Where the crop-growing seasons do not extend through an entire month, the data are adjusted according to the portion of the month utilized. These values will be identified with an asterisk.

Comparison of Computed Coefficients with Coefficients Used Currently

The seasonal consumptive-use coefficients which are computed and tabulated in the Appendix are summarized in Table 1 for seasonal measurements made at the Plant Science Farm, and in Table 2 for seasonal measurements made at the San Juan Branch Station.

These coefficients in Tables 1 and 2 may be compared with coefficients in current use in New Mexico which are tabulated in Table 3.

All of the computed coefficients in Tables 1 and 2 are equal to or greater than the ones in Table 3 except for five of the six coefficients computed for onions and the 1971 coefficient for sweet corn. The corn coefficients are not necessarily comparable inasmuch as the "Merit"

Table 1. Summary of seasonal consumptive-use coefficients by crops grown at or near the Plant Science Farm, Las Cruces, N. M.

Year	Crop	Location	Seasonal Consumptive Use Coefficients K	
			Frost-free period	Frost period
1963	Alfalfa (N.M. 11-1)	College Farm	1.13	0.62
1964	Alfalfa (N.M. 11-1)	College Farm	1.00	0.60
1975	Alfalfa (Zia)	Plant Science Farm	1.12	0.73
1963, 64 & 75	Average for Alfalfa		1.08	0.65
1971	Sweet Corn (Merit)	Plant Science Farm	0.68	*
1972	Sweet Corn (Merit)	Plant Science Farm	0.90	*
1973	Sweet Corn (Merit)	Plant Science Farm	1.09	*
1971-1973	Average for Corn		0.89	*
1971-72	Onions (Yellow Grano)	Plant Science Farm	0.56	0.36
1972-73	Onions (White Granex)	Plant Science Farm	0.79	0.34
1973-74	Onions (Yellow Grano)	Plant Science Farm	0.50	0.38
1971-1974	Average for Onions		0.62	0.36
1973	Cotton (Irrig. Eff. = 80%)	Plant Science Farm	0.75	*
1973	Cotton (Irrig. Eff. = 100%)	Plant Science Farm	0.62	*
1975	Potatoes (Kenebec)	Plant Science Farm	0.84	0.32

* Crops not grown during the frost period.

Table 2. Summary of seasonal consumptive-use coefficients by crops grown at the San Juan Branch Station near Farmington, N. M.

Year	Crop	Seasonal Consumptive-Use Coefficient K	
		Frost-free period	Frost period
1974	Field Corn (In a variety test)	0.96	*
1975	Field Corn (Dekalb 372)	1.12	*
1974-1975	Average for field corn	1.04	*
1974	Alfalfa (Mesilla)	1.47	0.63
1975	Alfalfa (Mesilla)	1.28	0.55
1974-1975	Average for Alfalfa	1.38	0.59
1975	Alfalfa (Mesilla) during establishment of stand in lysimeter, June 1 to Oct.10	1.34	0.88
1975	Spring Barley (In a variety test)	0.94	*

* Crops not grown during the frost period.

Table 3. Seasonal consumptive use coefficients (K) for irrigated crops in New Mexico which are in current use*

Crop	Normal Growing Season or Period	Consumptive-Use Coefficient (K)	
		Frost-free period	Frost period
Alfalfa ***	6 to 7 months	0.85	0.50
Corn (grain) ***	4 months	0.75	--
Cotton	7 months	0.62	0.40#
Grain (Spring barley)	3 months	0.70	--
Lettuce	--	0.65	0.40
Onions		0.65	0.40
Potatoes (Irish)		0.70	--

* See Reference 2.

Between preplant irrigation and planting date.

corn in Table 1 has a 60-day growing season as compared to the 4-month growing season for grain corn in Table 2.

With the variability inherent in nature, measurements should be conducted for several more years for each crop to provide greater stability in the coefficients.

The 1973 cotton K-values in Table 1 are 0.75 and 0.62 for 80 percent and 100 percent irrigation efficiencies, respectively, as computed in Appendix Table 9A. Inasmuch as 100 percent irrigation efficiency should have no excess water in the soil after each irrigation, deep drainage should be minimal and the seasonal K-value of 0.62 should be the most reliable figure. It is of interest that this value agrees with the cotton coefficient in current use as listed in Table 2.

The possibilities of deep drainage influencing the coefficient ($K = 0.75$) for the cotton which was irrigated with 80 percent efficiency, is discussed in the next section with respect to other data presented in Table 4.

Table 4. The influence of irrigation efficiency on measurements of consumptive use of water by cotton grown at the Plant Science Farm, April 24 to October 1, 1973 (Project WRRI 13030 GLM)

Treat- ment	Yield bales/acre	Depletion ^{1/} percent	Efficiency ^{2/} percent	Consumptive Use inches
1	2.65	25	80	27.45
2	2.48	50	80	25.26
3	2.36	75	80	23.43
Average	2.50		80	26.07
4	2.27	25	90	31.48
5	2.51	50	90	22.73
6	2.29	75	90	26.12
Average	2.36		90	26.77
7	2.18	25	100	25.02
8	2.48	50	100	19.85
9	2.33	75	100	19.70
Average	2.33		100	21.47

1/ Percent of available moisture depleted at time of irrigation

2/ Water-application efficiency. The percent of water applied that is stored in the root zone during each irrigation.

Influence of Irrigation Efficiency on Consumptive-Use Measurements

Table 4 presents moisture depletion measurements made separately on plots that were irrigated with irrigation efficiencies of 100, 90, and 80 percent. The measured consumptive use is greatest in the treatments which had 80 and 90 percent irrigation efficiencies. Since these respective treatments had 20 and 10 percent more water applied than could be held in the root zone refill capacity at time of irrigation, the extra water was subject to deep drainage. Some of this excess water during slow drainage could well have influenced the moisture depletion measurements between irrigation.

There is a slight reversal in the data of Table 3. The moisture depletion should be greater for the 80 percent than the 90 percent efficiency inasmuch as there was more excess water to drain downward with the 80 percent treatment. There is also a slight decline in yield for the treatments which had smaller irrigation application resulting in the higher irrigation efficiencies, but the difference is not significant.

Considering that the alfalfa coefficients for 1963 and 1964 (Table 1) appear to be unduly high in comparison to alfalfa coefficients used currently in Table 3, the depletion curves in the original report (4) were reviewed to evaluate deep drainage possibilities. There is no evidence of deep drainage existing with these alfalfa data since the moisture depletion measurements were slightly larger for the treatments which received the least amount of irrigation water.

Reevaluation of Alfalfa Data for 1963 and 1964

During 1973 and 1974 the Bureau of Reclamation conducted an Irrigation Management Services (IMS) program of applied research to provide assistance to the Elephant Butte Irrigation District on irrigation scheduling. Technicians in the field provided field data and researchers at the Agricultural Experiment Station provided solar radiation and other weather data which were required to run a computer program to assist farmers on determining when to irrigate and how much water to apply. Under this program, cooperative arrangements were made with the Bureau to use the IMS program to compute consumptive use according to the IMS program for the 1963 and 1964 alfalfa to compare with data listed in Appendix Tables 1A and 2A. Inasmuch as the IMS program used the Jensen Method (5) which required solar radiation data, the El Paso daily solar radiation data (Langleys) for 1963 and 1964 were obtained for the National Climate Center, Ashville, North Carolina. The consumptive use computed by this program is shown in Figures 1 and 2 in comparison to the measured consumptive use. The total consumptive use in 1963 was approximately 62.3 inches for both methods. In 1964 the IMS curve totaled 59 inches as compared to the measured total of 54.3 inches. This comparison indicates that the consumptive-use measurements and coefficients for alfalfa in Table 1 are in reasonable agreement with data computed by the Jensen Method. Also, the 1975 data for alfalfa is well in agreement with the 1963-1964 data.

Variability of Monthly and Seasonal Coefficients

Appendix Tables show that the monthly coefficients are highly variable as compared to the seasonal coefficients. For example in Appendix Table 4A, which summarizes three years of alfalfa data, the frost-free seasonal

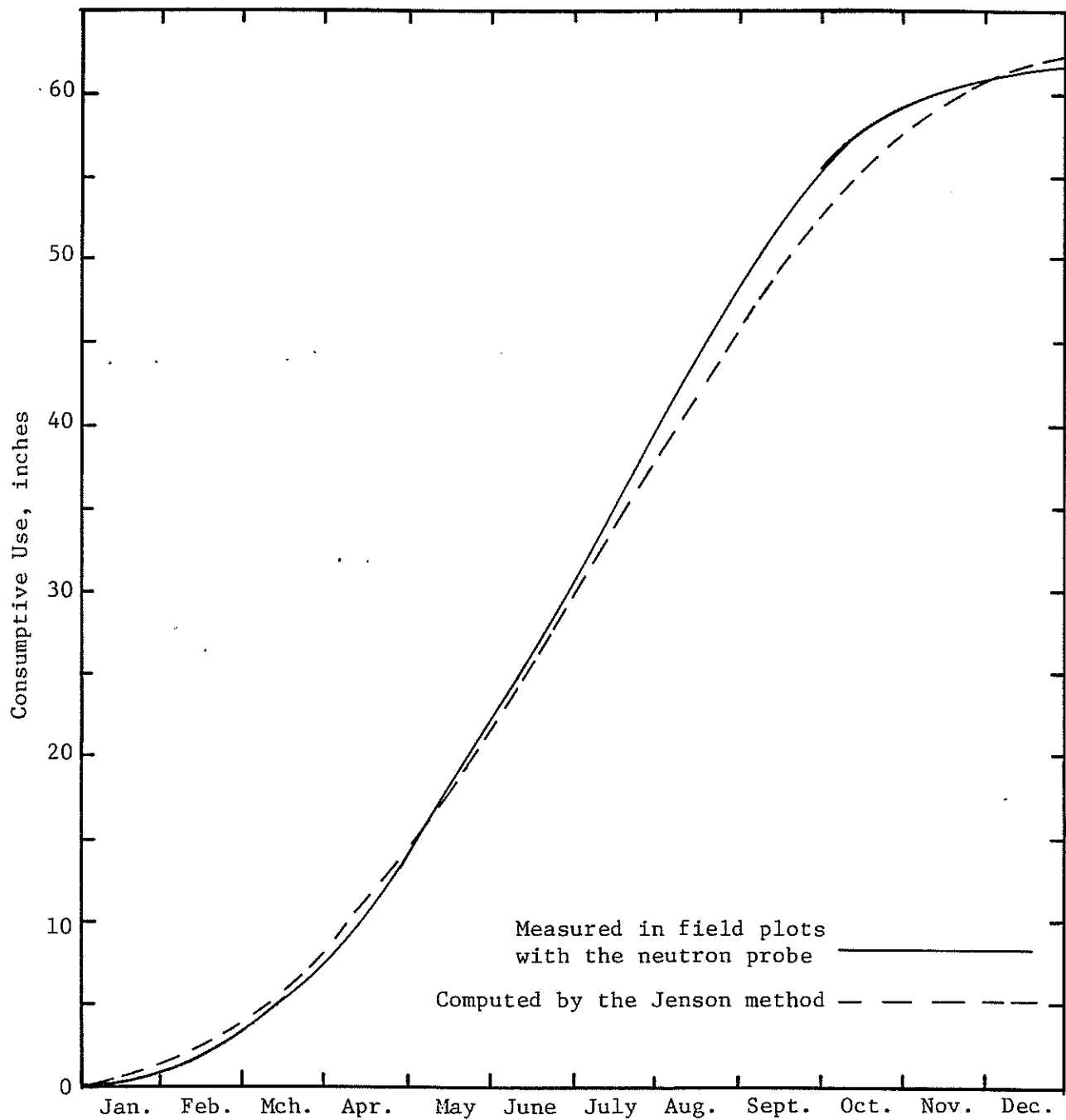


Figure 1. Comparison of measured and computed consumptive use for alfalfa (College Farm, Mesilla Park, N. M., 1963).

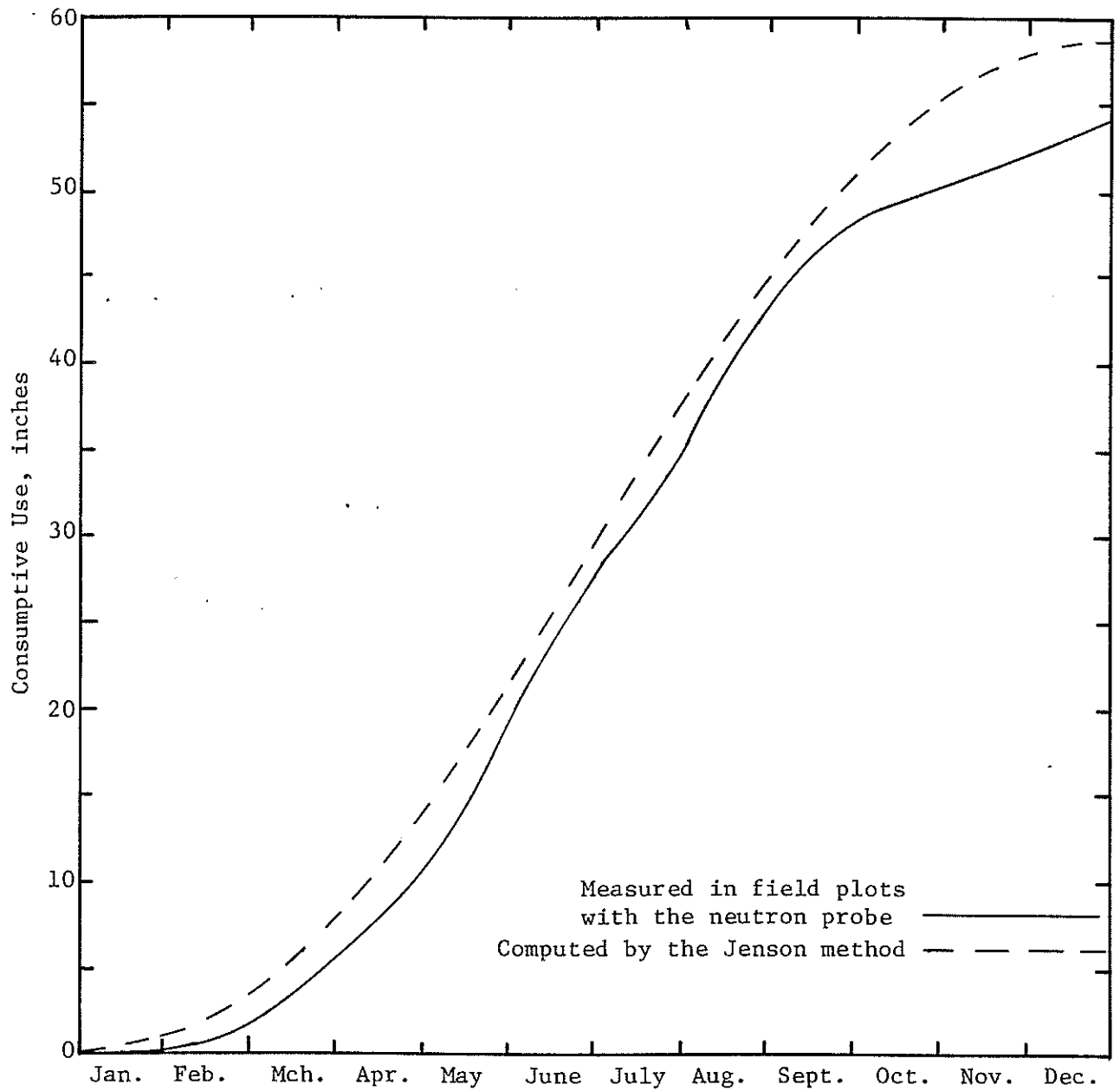


Figure 2. Comparison of measured and computed consumptive use for alfalfa (College Farm, Mesilla Park, N. M., 1964).

consumptive-use coefficients are 1.13, 1.00, and 1.12, respectively, for 1963, 1964, and 1975. The range of error of these values is within eight percent of the average value of $K = 1.08$ shown in the table. The three-year average value of $K = 0.65$ for the seasonal frost period is within 12 percent of any of the yearly seasonal values. The variations among the monthly data is several times that of the seasonal data.

Ratios of Consumptive Use to Evaporation

Ratios of consumptive use to evaporation are tabulated in the Appendix and summaries of seasonal ratios are presented in Table 5 and 6. The variability of these data to be similar to the variability among consumptive-use coefficients.

CONCLUSION

The practical use of the monthly consumptive-use coefficients data for the Blaney-Criddle formula is limited due to the excessive variability. The seasonal values are more stable but measurements should be continued for several more years to evaluate their reliability. The high variability is caused in part by not including weather factors other than temperature and length of daylight hours.

Additional measurements to extend these data will be made available in an ongoing project which has been established for cooperative research between the New Mexico Water Resources Research Institute and five branches or stations of the New Mexico Agricultural Experiment Stations. In this project, the objectives have been expanded to measure and evaluate solar radiation, humidity, wind movement, precipitation, consumptive use, evaporation, and temperature. All consumptive use will be measured with crops growing in lysimeters.

Table 5. Summary of ratios of seasonal consumptive use (U) to seasonal evaporation (E). Basic data are presented in the Appendix.

Year	Crop	Location	Seasonal Ratios: U/E	
			Normal frost-free period	Frost period
1963	Alfalfa (N.M. 11-1)	College Farm	0.70	0.47
1964	Alfalfa (N.M. 11-1)	College Farm	0.60	0.43
1975	Alfalfa (Zia)	Plant Science Farm	0.73	0.53
1963,64,65	Average for Alfalfa		0.68	0.48
1971	Sweet Corn (Merit)	Plant Science Farm	0.42	*
1972	Sweet Corn (Merit)	Plant Science Farm	0.60	*
1973	Sweet Corn (Merit)	Plant Science Farm	0.71	*
1971,72,73	Average for Sweet Corn		0.58	*
1971-72	Onions (Yellow Grano)	Plant Science Farm	0.33	0.26
1972-73	Onions (White Granex)	Plant Science Farm	0.48	0.29
1973-74	Onions (Yellow Grano)	Plant Science Farm	0.44	0.18
1971-1974	Average for Onions		0.42	0.24
1973	Cotton (Irrig. Eff. = 80%)	Plant Science Farm	0.46	*
1973	Cotton (Irrig. Eff. = 100%)	Plant Science Farm	0.38	*
1975	Potatoes (Kenebec)	Plant Science Farm	0.48	0.16
1975	Lettuce (GL-659)	Plant Science Farm	0.98	*

* Crops were not grown during the frost period.

Table 6. Summary of ratios of seasonal consumptive use (U) to seasonal evaporation (E) at the San Juan Branch Station. Basic data are presented in the Appendix.

Year	Crop	Seasonal Ratios: U/E	
		Normal frost-free-period	Frost period
1974	Field Corn (Variety test)	0.55	*
1975	Field corn (Dekalb 372)	0.67	*
1974 & 1975	Average for Field Corn	0.61	*
1974	Alfalfa (Mesilla)	0.81	*
1975	Alfalfa (Mesilla)	0.72	*
1974 & 1975	Average for alfalfa	0.76	*
1975	Alfalfa (Mesilla) during establishment of stand in lysimeter, June 1 to October 10	0.99	*
1975	Barley (Variety test)	0.54	*

* Evaporation not measured due to freezing weather.

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APPENDIX

LEGEND OF VARIABLES AND COEFFICIENTS USED IN APPENDIX TABLES

U = seasonal consumptive use (evapotranspiration), inches

u = monthly consumptive use (evapotranspiration), inches

u = kf or U = KF

where

$f = \frac{t \times p}{100}$ = monthly consumptive-use factor

$k = \frac{u}{f}$ = monthly empirical crop consumptive-use coefficient

t = mean monthly temperature, in degrees Fahrenheit

p = monthly percent of daytime hours of the year

F = sum of the monthly consumptive-use factors for the season
or period (sum of the products of mean monthly temperature
and monthly percent of daytime hours of the year or

$$F = \frac{\Sigma(pt)}{100}$$

$K = \frac{U}{F}$ = seasonal empirical crop consumptive-use coefficient

E = pan evaporation, inches (seasonal)

e = pan evaporation, inches (monthly)

Table 1A. Consumptive-use coefficients, and pan evaporation in relation to consumptive use by alfalfa (N.M. 11-1) grown on plots near Las Cruces, N. M. in 1963.

<u>Month</u>	<u>Consumptive- use coef. (k)</u>	<u>Pan evapo- ration(e) inches</u>	<u>Consumptive use(u) inches</u>	<u>Ratio u/e</u>	<u>Consumptive use inches/day</u>
January	0.26	2.77	0.75	0.27	0.02
February	0.80	4.63	2.75	0.59	0.10
March	0.83	8.35	3.75	0.45	0.12
Apr. 1-9	--	3.27*	2.10*	--	--
April	1.29	10.89	7.00	0.64	0.23
Apr. 10-30#	--	7.62*	4.90*	--	--
May	1.15	13.02	8.00	0.61	0.26
June	1.08	14.51	8.00	0.55	0.27
July	1.25	13.06	10.00	0.77	0.32
August	1.15	9.01	8.25	0.92	0.27
September	1.18	8.50	7.25	0.85	0.24
Oct. 1-28#	--	5.45	3.39*	--	--
October	0.74	6.03	3.75	0.62	0.12
Oct. 29-31	--	0.58*	0.36*	--	--
November	0.41	3.78	1.50	0.40	0.05
December	0.34	2.63	1.00	0.38	0.03
#Seasonal total: normal frost-free period, Apr. 10- October 28	1.13	71.17	49.79	0.70	--
Seasonal total: frost period	0.62	26.01	12.21	0.47	--

* Figures are prorated according to the portion of the month represented.

Table 2A Consumptive-use coefficients, and pan evaporation in relation to consumptive use by alfalfa (N.M. 11-1) grown on plots near Las Cruces, N. M. in 1964

Month	Consumptive-use coef. (k)	Pan evaporation(e) inches	Consumptive use(u) inches	Ratio u/e	Consumptive use inches/day
January	0.09	3.08	0.25	0.08	0.01
February	0.45	4.12	1.25	0.30	0.04
March	0.94	8.06	4.00	0.50	0.13
Apr. 1-9		3.19*	1.42*		
April	0.92	10.64	4.75	0.45	0.16
Apr. 10-30#		7.45*	3.33*		
May	1.34	13.96	9.00	0.64	0.29
June	1.19	13.80	8.75	0.63	0.29
July	0.88	12.25	7.00	0.57	0.23
August	1.08	11.47	8.00	0.70	0.26
September	0.91	8.31	5.50	0.66	0.18
Oct. 1-28#		5.59*	1.81*		
October	0.41	6.19	2.00	0.32	0.06
Oct. 29-31		0.60*	0.19*		
November	0.57	4.28	2.00	0.47	0.07
December	0.67	2.38	2.00	0.84	0.06
#Seasonal total: Normal frost-free months, Apr. 10 to Oct. 28	1.00	72.83	43.39	0.60	--
Seasonal total: frost period	0.60	25.71	11.11	0.43	--

* Figures are prorated according to the portion of the month represented.

Table 3A. Consumptive-use coefficients, and pan evaporation in relation to consumptive use by alfalfa (Zia) grown on plots near Las Cruces, N. M. in 1975.

Month	Consumptive-use coef. (k)	Pan evaporation(e) inches	Consumptive use(u) inches	Ratio u/e	Consumptive use inches/day
January	0.57	3.12	1.67	0.54	0.05
February	0.54	4.42	1.67	0.38	0.06
March	0.40	8.13	1.68	0.21	0.05
April 1-9		2.78*	2.24	--	--
April	1.54	9.28	7.48	0.81	0.25
April 10-30 [#]		6.50*	5.24*	--	--
May	1.50	11.07	9.25	0.84	0.30
June	1.44	13.10	10.50	0.80	0.35
July	1.17	10.98	8.95	0.43	0.29
August	0.85	10.09	6.05	0.60	0.20
September	0.84	7.01	4.75	0.68	0.16
October 1-28 [#]	--	5.10*	1.81*	--	--
October	0.44	5.65	2.00	0.35	0.06
October 29-31	--	0.55*	0.19*	--	--
November	1.33	3.67	4.50	1.22	0.15
December	0.52	2.78	1.50	0.54	0.05
[#] Seasonal total: Normal frost-free period, Apr. 10 through Oct. 28	1.12	63.85	46.55	0.73	--
Seasonal values for frost period	0.73	25.45	13.45	0.53	--

* Figures are prorated according to the portion of the month represented.

Table 4A. Summary of consumptive-use coefficients, and pan evaporation in relation to consumptive use by alfalfa grown on plots near Las Cruces, N. M. during 1963, 1964, and 1975.

	<u>Consumptive Use Coefficients (k)</u>				<u>Ratios: Consumptive use to pan evaporation, (u/e)</u>			
	<u>1963</u>	<u>1964</u>	<u>1975</u>	<u>Av.</u>	<u>1963</u>	<u>1964</u>	<u>1975</u>	<u>Av.</u>
Jan.	0.26	0.09	0.57	0.31	0.27	0.08	0.54	0.30
Feb.	0.80	0.45	0.54	0.60	0.59	0.30	0.38	0.42
Mar.	0.83	0.94	0.40	0.72	0.45	0.50	0.21	0.39
Apr.	1.29	0.92	1.54	1.25	0.64	0.45	0.81	0.63
May	1.15	1.34	1.50	1.33	0.61	0.64	0.84	0.70
June	1.08	1.19	1.44	1.24	0.55	0.63	0.80	0.66
July	1.25	0.88	1.17	1.10	0.77	0.57	0.43	0.59
Aug.	1.15	1.08	0.85	1.03	0.92	0.70	0.60	0.74
Sept.	1.18	0.91	0.84	0.98	0.85	0.66	0.68	0.73
Oct.	0.74	0.41	0.44	0.53	0.62	0.32	0.35	0.43
Nov.	0.41	0.57	1.33	0.77	0.40	0.47	1.22	0.70
Dec.	0.34	0.67	0.52	0.51	0.38	0.84	0.54	0.59
Seasonal total for normal frost-free period Apr.10-Oct.- 18	1.13	1.00	1.12	1.08	0.70	0.60	0.73	0.68
Seasonal values for frost period	0.62	0.60	0.73	0.65	0.47	0.43	0.53	0.48

Table 5A. Consumptive-use coefficients, and pan evaporation in relation to consumptive use by sweet corn (Merit) grown on plots at the Plant Science Farm in 1971.

<u>Month</u>	<u>Consumptive- use coef. (k)</u>	<u>Pan evapo- ration(e) inches</u>	<u>Consumptive use(u) inches</u>	<u>Ratio u/e</u>	<u>Consumptive use inches/day</u>
June 10-30	0.33	8.84	1.65	0.19	0.08
July	0.85	13.63	6.80	0.50	0.22
Aug. 1-25	0.76	7.68	4.30	0.56	0.17
Seasonal Values	0.68	30.15	12.75	0.42	--

Table 6A. Consumptive-use coefficients, and pan evaporation in relation to consumptive use by sweet corn (Merit) grown on plots at the Plant Science Farm in 1972.

<u>Month</u>	<u>Consumptive- use coef. (k)</u>	<u>Pan evapo- ration(e) inches</u>	<u>Consumptive use(u) inches</u>	<u>Ratio u/e</u>	<u>Consumptive use inches/day</u>
June 25-30	0.54	2.89	0.8	0.28	0.16
July	0.73	12.55	5.8	0.46	0.19
August	1.09	9.92	7.8	0.79	0.25
Sept. 1-7	1.30	1.67	1.8	1.08	0.26
Seasonal values	0.90	27.03	16.2	0.60	--

Table 7A. Consumptive-use coefficients, and pan evaporation in relation to consumptive use by sweet corn (Merit) grown on plots at the Plant Science Farm in 1973.

<u>Month</u>	<u>Consumptive- use coef. (k)</u>	<u>Pan evapo- ration(e) inches</u>	<u>Consumptive use(u) inches</u>	<u>Ratio u/e</u>	<u>Consumptive use inches/day</u>
June 20-30	0.50	5.13	1.2	0.23	0.12
July	0.96	11.31	7.4	0.65	0.24
August	1.22	10.30	8.7	0.84	0.28
Sept. 1-10	1.78	2.78	3.6	1.29	0.36
Seasonal values	1.09	29.52	20.9	0.71	--

Table 8A. Summary of consumptive-use coefficients, and pan evaporation in relation to consumptive use by sweet corn (Merit) grown on plots at the Plant Science Farm in 1971, 1972, and 1973.

	<u>Monthly consumptive-use coefficients (k)</u>				<u>Monthly ratios: Consumptive use to pan evaporation (u/e)</u>			
	<u>1971</u>	<u>1972</u>	<u>1973</u>	<u>Av.</u>	<u>1971</u>	<u>1972</u>	<u>1973</u>	<u>Av.</u>
June 18-30(Av)	0.33	0.54	0.50	0.46	0.19	0.28	0.23	0.23
July	0.85	0.73	0.96	0.85	0.50	0.46	0.65	0.54
Aug.	0.76	1.09	1.22	1.02	0.56	0.79	0.84	0.73
Sept. 1-8(Av)	--	1.30	1.78	1.54	--	1.08	1.29	1.18
Seasonal values	0.68	0.90	1.09	0.89	0.42	0.60	0.71	0.58

Table 9A. Summary of consumptive-use coefficients, and pan evaporation in relation to consumptive use as measured on cotton plots irrigated with irrigation efficiencies of 80 percent, and near 100 percent in 1973.

	<u>Monthly consumptive-use coefficients (k)</u>		<u>Monthly ratios: Consumptive use to pan evaporation (u/e)</u>	
	<u>80% Effic.</u>	<u>100% Effic.</u>	<u>80% Effic.</u>	<u>100% Effic.</u>
April 24-30	0.62	0.48	0.23	0.18
May	0.49	0.14	0.29	0.08
June	0.38	0.52	0.21	0.29
July	0.79	0.61	0.54	0.41
August	1.58	1.44	1.09	0.99
September	0.36	0.22	0.26	0.16
Seasonal values	0.75	0.62	0.46	0.38

Table 10A. Consumptive-use coefficients, and pan evaporation in relation to consumptive use by onions (Yellow Grano) grown on plots at the Plant Science Farm, 1971-72.

<u>Month</u>	<u>Consumptive- use coef. (k)</u>	<u>Pan evapo- ration(e) inches</u>	<u>Consumptive use(u) inches</u>	<u>Ratio u/e</u>	<u>Consumptive use inches/day</u>
Oct. 10-28#		3.47*	1.46*		
Oct. 10-31	0.52	4.02	1.7	0.42	0.08
Oct. 29-31		0.55*	0.24*		
November	0.33	3.90	1.2	0.31	0.04
December	0.33	2.47	1.0	0.40	0.03
January	0.35	3.46	1.1	0.32	0.03
February	0.35	5.39	1.2	0.22	0.04
March	0.38	9.40	1.9	0.20	0.06
April 1-9		3.29*	0.78*		
April	0.49	10.97	2.6	0.24	0.09
April 10-30#		7.68*	1.82*		
May	0.53	11.60	3.5	0.30	0.11
June 1-10	0.77	3.24	1.9	0.59	0.19
#Seasonal total:					
Normal frost-free period					
April 10-Oct. 28	0.56	25.99	8.68	0.33	--
Seasonal total:					
frost period	0.36	28.46	7.42	0.26	--

* Figures are prorated according to the portion of the month represented.

Table 11A. Consumptive-use coefficients, and pan evaporation in relation to consumptive use by onions (White Granex) grown on plots at the Plant Science Farm, 1972-73.

<u>Month</u>	<u>Consumptive- use coef. (k)</u>	<u>Pan evapo- ration(e) inches</u>	<u>Consumptive use(u) inches</u>	<u>Ratio u/e</u>	<u>Consumptive use inches/day</u>
Oct. 10-28#		3.55*	1.37*		
Oct. 10-31	0.46	4.11	1.6	0.39	0.07
Oct. 29-31		0.56*	0.23*		
November	0.57	3.47	1.9	0.55	0.06
December	0.19	3.14	0.6	0.19	0.02
January	0.21	2.66	0.6	0.23	0.02
February	0.22	2.80	0.7	0.25	0.03
March	0.24	6.56	1.0	0.15	0.03
Apr. 1-9		2.83*	1.26*		
April	0.86	9.43	4.2	0.45	0.14
Apr. 10-30#		6.60*	2.94*		
May	0.85	11.13	5.5	0.49	0.18
June 1-6	1.03	2.38	1.5	0.63	0.25
# Seasonal total: normal frost-free period April 10 to October 28	0.79	23.66	11.31	0.48	--
Seasonal Total: frost period	0.34	22.02	6.29	0.29	--

Table 12A. Consumptive-use coefficients, and pan evaporation in relation to consumptive use by onions (Yellow Grano) grown on plots at the Plant Science Farm, 1973-74.

<u>Month</u>	<u>Consumptive- use coef. (k)</u>	<u>Pan evapo- ration(e) inches</u>	<u>Consumptive use(u) inches</u>	<u>Ratio u/e</u>	<u>Consumptive use inches/day</u>
Oct. 6-28#		4.69*	1.23*		
Oct. 6-31	0.29	5.30	1.4	0.26	0.056
Oct. 29-31		0.61*	0.17*		
November	0.55	4.49	2.0	0.45	0.067
December	0.59	4.78	1.8	0.38	0.058
January	0.55	3.35	1.7	0.51	0.055
February	0.49	4.03	1.4	0.35	0.050
March	0.41	8.25	1.9	0.23	0.061
Apr. 1-9		3.01*	0.63*		
April	0.41	10.04	2.1	0.21	0.070
Apr. 10-30#		7.03*	1.47*		
May 1-28	0.42	9.97	2.5	0.25	0.089
#Seasonal total:					
Normal frost-free					
period April 10 to					
October 28	0.50	21.69	9.60	0.44	---
Seasonal total:					
frost period					
	0.38	28.52	5.20	0.18	---

* Figures are prorated according to the portion of the month represented.

Table 13A. Summary of consumptive-use coefficients, and pan evaporation in relation to consumptive use by onions grown on plots at the Plant Science Farm, 1971-74.

	<u>Consumptive Use Coefficients (K)</u>				<u>Ratios: Consumptive use to pan evaporation, (u/e)</u>			
	<u>1971-72</u>	<u>1972-73</u>	<u>1973-74</u>	<u>Av.</u>	<u>1971-72</u>	<u>1972-73</u>	<u>1973-74</u>	<u>Av.</u>
Oct. 9-28#	--	--	--	--	--	--	--	--
Oct. 10-31	0.52	0.46	0.29	.42	0.42	0.39	0.26	.36
November	0.33	0.57	0.55	.48	0.31	0.55	0.45	.44
December	0.33	0.19	0.59	.37	0.40	0.19	0.38	.32
January	0.35	0.21	0.55	.37	0.32	0.23	0.51	.35
February	0.35	0.22	0.49	.35	0.22	0.25	0.35	.27
March	0.38	0.24	0.41	.34	0.20	0.15	0.23	.19
Apr. 1-9	--	--	--	--	--	--	--	--
April	0.49	0.86	0.41	.59	0.24	0.45	0.21	.30
Apr. 10-30#	--	--	--	--	--	--	--	--
May	0.53	0.85	0.42	.60	0.30	0.49	0.25	.35
June 1-10	0.77	1.03	--	.90	0.59	0.63	--	.61
#Seasonal total for normal frost-free period Apr. 10 to Oct. 28	0.56	0.79	0.50	0.62	0.33	0.48	0.44	0.42
Seasonal values for frost period	0.36	0.34	0.38	0.36	0.26	0.29	0.18	0.24

Table 14A. Consumptive use by potatoes (Kenebec) grown in three lysimeters at the Plant Science Farm, 1975.

<u>Month</u>	<u>I N C H E S</u>			<u>Ave.</u>
	<u>P1C</u>	<u>P2C</u>	<u>P3E</u>	
Feb.27-Mar.31	2.6	2.3	2.7	2.5
April	2.9	2.1	1.8	2.3
May	4.9	4.2	6.9	5.3
June	5.2	9.0	7.5	7.2
July 1-15	4.7	6.1	5.4	5.4
Seasonal total:	20.3	23.7	24.3	22.7

Table 15A. Consumptive-use coefficients, and pan evaporation in relation to consumptive use by potatoes (Kenebec) grown in lysimeters at the Plant Science Farm, 1975.

<u>Month</u>	<u>Consumptive- use coef. (k)</u>	<u>Pan evapo- ration(e) inches</u>	<u>Consumptive use(u) inches</u>	<u>Ratio u/e</u>	<u>Consumptive use inches/day</u>
Feb. 27 to March 31	0.19	8.56	0.8	0.09	0.02
April 1-9	---	2.78*	1.00*	---	---
April	0.69	9.28	3.33	0.36	0.11
April 10-30	---	6.50*	2.33*	---	---
May	0.82	11.07	5.03	0.45	0.16
June	0.89	13.10	6.53	0.50	0.22
July 1-15	0.93	5.44	3.53	0.65	0.24
Seasonal total: Normal frost-free period after April 10	0.84	36.11	17.42	0.48	---
Seasonal total: frost period	0.32	11.34	1.80	0.16	---

* Figures are prorated according to the month represented.

Table 16A. Consumptive use by lettuce (GL-659) grown in three lysimeters at the Plant Science Farm, 1975.

<u>Month</u>	<u>I N C H E S</u>			<u>Av.</u>
	<u>1C</u>	<u>2C</u>	<u>3E</u>	
August 18-31	1.8	2.8	1.7	2.1
September	4.7	6.2	4.3	5.1
October	9.4	10.7	9.0	9.7
November 1-13	1.1	.7	1.0	.9
Season Total:	17.0	20.4	16.0	17.8

Table 17A. Consumptive-use coefficients, and pan evaporation in relation to consumptive use by lettuce (GL-659) grown in lysimeters at the Plant Science Farm, 1975.

<u>Month</u>	<u>Consumptive- use coef. (k)</u>	<u>Pan evapo- ration(e) inches</u>	<u>Consumptive use(u) inches</u>	<u>Ratio u/e</u>	<u>Consumptive use inches/day</u>
Aug. 18-31	0.83	3.96	2.65	0.67	0.19
September	1.01	7.01	5.70	0.81	0.19
October	1.77	5.65	8.16	1.44	0.26
Nov. 1-13,	1.04	1.82	1.52	0.84	0.12
Seasonal values	1.21	18.44	18.03	0.98	--

Table 1B. Consumptive use coefficients, and pan evaporation in relation to consumptive use by alfalfa (Mesilla) grown on plots at the San Juan Branch Station, 1974.

<u>Month</u>	<u>Consumptive- use coef. (k)</u>	<u>Pan evapo- ration(e) inches</u>	<u>Consumptive use(u) inches</u>	<u>Ratio u/e</u>	<u>Consumptive use inches/day</u>
January	.47	**	.78	**	.02
February	.36	**	.70	**	.02
March	.20	**	.78	**	.02
April	.47	**	2.01	**	.06
May 1-11			4.84*		
May	2.01	12.98	12.51	.96	.42
May 12-31#		7.96	7.67*		
June	1.58	15.26	11.52	.75	.38
July	1.64	12.87	12.35	.96	.40
August	1.03	12.23	7.15	.58	.23
September	1.40	9.33	7.62	.82	.25
October 1-10#		1.48	1.42*		
October	1.03	4.59	4.42	.96	.14
October 11-31			2.99*		
November	.28	**	.78	**	.02
December	.43	**	.81	**	.02
# Normal frost- free period					
May 12 to Oct. 10	1.47	59.16	47.75	.81	-
Frost period					
Oct. 11 to May 11	.63	**	13.70	**	-

* Figures are prorated according to the portion of the month represented.

** Evaporation not measured due to freezing weather.

Table 2B. Consumptive use coefficients, and pan evaporation in relation to consumptive use by alfalfa (Mesilla) grown on plots at the San Juan Branch Station, 1975.

Month	Consumptive- use coef. (k)	Pan evapo- ration(e) inches	Consumptive use(u) inches	Ratio u/e	Consumptive use inches/day
January	.44	**	.78	**	.02
February	.31	**	.70	**	.02
March	.23	**	.78	**	.02
April	.70	**	2.86	**	.09
May 1-12			3.51*		
May	1.65	9.25	9.06	.98	.29
May 13-31#		5.67	5.55*	.98	
June	1.41	12.02	9.25	.77	.31
July	.97	12.26	7.30	.60	.24
August	1.23	12.50	8.4	.67	.27
September	1.57	8.10	8.47	1.08	.28
Oct. 1-10#		2.43	.80*	.33	
October	.51	7.52	2.45	.33	.07
Oct. 11-31			1.66*		
November	.29	**	.78	**	.02
December	.39	**	.81	**	.02
# Normal frost-free period					
May 12-Oct. 10	1.28	53.01	39.77	.72	-
Frost period					
Oct. 11-May 11	.55	**	11.88	**	-

* Figures are prorated according to the portion of the month represented.

** Evaporation not measured due to freezing weather.

Table 3B. Summary of consumptive-use coefficients, and pan evaporation in relation to consumptive use by alfalfa (Mesilla) grown on plots at the San Juan Branch Station, 1974 and 1975.

	<u>Consumptive-use coef. k</u>			<u>Ratios: Consumptive use to pan evaporation u/e</u>		
	<u>1974</u>	<u>1975</u>	<u>Av.</u>	<u>1974</u>	<u>1975</u>	<u>Av.</u>
January	.47	.44	.46	*	*	*
February	.36	.31	.34	*	*	*
March	.20	.23	.22	*	*	*
April	.47	.70	.59	*	*	*
May	2.01	1.65	1.83	.96	.98	.97
June	1.58	1.41	1.50	.75	.77	.76
July	1.64	.97	1.31	.96	.60	.78
August	1.03	1.23	1.13	.58	.67	.64
September	1.40	1.57	1.49	.82	1.08	.95
October	1.03	.51	.77	.96	.33	.65
November	.28	.29	.29	*	*	*
December	.43	.39	.41	*	*	*
Normal frost-free seasonal total	1.47	1.28	1.38	.81	.72	.77
Frost period	.63	.55	.59	*	*	*

* Evaporation not measured due to freezing weather.

Table 4B. Consumptive-use coefficients, and pan evaporation in relation to consumptive use by alfalfa (Mesilla) during stand establishment in lysimeters, San Juan Branch Station, 1975.

<u>Month</u>	<u>Consumptive use coef. (k)</u>	<u>Pan evaporation(e) inches</u>	<u>Consumptive use(u) inches</u>	<u>Ratio u/e</u>	<u>Consumptive use inches/day</u>
June	.53	12.03	3.49	.29	.12
July	1.29	12.27	9.68	.79	.31
August	1.91	12.51	13.06	1.04	.42
September	1.57	8.11	8.47	1.04	.28
Oct. 1-10	--	2.43*	2.63*	--	.26
October	1.70	7.53	8.16	1.08	.26
Oct. 11-31	--	5.10*	5.53*	--	.26
November	.38	**	.81	**	.03
December	.30	**	.62	**	.02
# Partial seasonal frost-free period	1.34	47.35	37.33	.99	--
Frost period	.88	**	6.96	**	--

* Figures are prorated according to the portion of the month represented.

** Evaporation not measured due to freezing weather.

Alfalfa was planted June 1.

Table 5B. Consumptive-use coefficients, and pan evaporation in relation to consumptive use by field corn grown in a variety test on plots at the San Juan Branch Station, 1974.

<u>Month</u>	<u>Consumptive- use coef. (k)</u>	<u>Pan evapo- ration(e) inches</u>	<u>Consumptive use(u) inches</u>	<u>Ratio u/e</u>	<u>Consumptive use inches/day</u>
May 9-31	0.54	9.67	2.68	0.28	--
June	1.06	15.26	7.73	.51	.26
July	1.30	12.87	9.82	.76	.32
August	1.46	12.23	10.08	.82	.32
September	0.81	9.33	4.40	.47	.15
Oct. 1-10	--	1.48	.10	--	.15
October	0.07	4.59	.31	.07	.15
Oct. 10-31	--	3.11	.21	--	.15
Seasonal Total	0.96	63.9	35.04	0.55	--

Table 6B. Consumptive-use coefficients, and pan evaporation in relation to consumptive use of field corn (Dekalb 372) grown in a lysimeter at the San Juan Branch Station, 1975.

<u>Month</u>	<u>Consumptive- use coef. (k)</u>	<u>Pan evapo- ration(e) inches</u>	<u>Consumptive use (u) inches</u>	<u>Ratio u/e</u>	<u>Consumptive use inches/day</u>
May 12-31	0.55	5.98	2.15	.36	.11
June	.54	12.03	3.54	.29	.12
July	1.60	12.27	11.96	.97	.39
August	1.84	12.51	12.52	1.00	.40
September	.75	8.11	4.05	.50	.14
Oct. 1-10	.82	2.10	1.13	.54	.11
Seasonal Total	1.12	53.0	35.35	.67	--

Table 7B. Summary of consumptive-use coefficients, and pan evaporation in relation to consumptive ratios with use by field corn grown on plots at the San Juan Branch Station, 1974 and 1975.

	<u>Consumptive use coef. k</u>			<u>Ratios: Consumptive use to pan evaporation, u/e</u>		
	<u>1974*</u>	<u>1975**</u>	<u>Av.</u>	<u>1974*</u>	<u>1975**</u>	<u>Av.</u>
May 12-31	.54	.55	.56	.28	.36	.32
June	1.06	.54	.80	.51	.29	.40
July	1.30	1.60	1.45	.76	.97	.87
August	1.46	1.84	1.65	.82	1.00	.91
September	.81	.75	.78	.47	.50	.49
Oct. 1-10	.07	.82	.45	.07	.54	.31
Seasonal Total	.96	1.12	1.04	.55	.67	.61

* 1974 . Consumptive use measured in a field variety test

** 1975 . Consumptive use Dekalb 372 measured in a lysimeter

Table 8B. Consumptive-use coefficients, and pan evaporation in relation to consumptive use of spring barley grown in a variety test on plots at the San Juan Branch Station, 1975.

<u>Month</u>	<u>Consumptive- use coef. (k)</u>	<u>Pan evapo- ration(e) inches</u>	<u>Consumptive use(u) inches</u>	<u>Ratio u/e</u>	<u>Consumptive use inches/day</u>
May	1.34	9.25	7.33	.79	.24
June	.81	12.08	5.31	.44	.18
July	.87	12.27	6.51	.53	.21
August 1-15	.70	6.44	2.31	.36	.15
Seasonal Total	.94	39.99	21.46	.54	--