Water consumptive use for wheat and barley in the San Joaquin Valley

Jerry St. Andre ■ Hidemi Yamada ■ Charles McNiesh

Water resources in the San Joaquin Valley of central California and in many other locations of the western United States are becoming scarce and expensive. Proper water management is essential if growers are to be competitive: they must know how much water to apply and when to apply it to any given crop. Consumptive use is defined as the amount of water utilized by plants to carry out their physiological functions and the evaporation loss from soil surface within a given area. A knowledge of crop consumptive use is necessary to utilize the available water efficiently for irrigation.

This study determined the consumptive use for wheat and barley in the San Joaquin Valley, and established irrigation guidelines that could be used in crop planning and management of water resources.

Water consumptive use is influenced by climate, type of crop, soil type, fertility, water quantity and quality, and other agronomic characteristics. Generally, consumptive use is low in the early stages of plant growth, and increases gradually as the season progresses. After a plant's peak consumptive use is reached, the demand for water decreases until maturation.

Plant water requirements can be supplied by normal irrigation practices (furrow, flood, sprinkler, and drip), perched water table, water stored in the soil profile, and effective precipitation. The amount of seasonal irrigation water to apply to meet plant requirements is found by subtracting the soil moisture and the effective precipitation present in the root zone from the total consumptive use. If perched ground water contributes to plant water requirements, it must be taken into account.

Procedures

The following consumptive-use study was conducted from 1974 to 1976 on a Panoche clay loam soil series at the University of California West Side Field Station, situated near Five Points in central San Joaquin Valley. CM 67 barley cultivar was grown all three years; Inia 66R wheat cultivar was grown the first year; and Anza cultivar was grown the last two years. Each year of testing, the experimental trial was planted during the second week of November. The size of each of the four test areas was approximately 30 × 300 feet. Before planting, the experimental area was pre-irrigated with enough water to bring the soil profile to field capacity to a depth between 8 and 9 feet. (Usually the amount of pre-irrigation water was 16 inches.) Subsequent crop irrigations were applied during the year—one irrigation in March and another in late April or early May. Six inches of water were applied at each crop irrigation. The total amount of water applied during the season, including the pre-irrigation, was 28 inches.

The experimental area was enclosed by levee so that a border flood irrigation method was employed with no loss of tail water. The amount of water was measured volumetrically to determine the amount of water applied to each plot.

The same grain drill was used for the three-year period. Barley and wheat were seeded at 110 and 130 pounds per acre, respectively. The amount and type of fertilizer applied remained constant for all three years: approximately 150 pounds of nitrogen and 30 pounds of phosphorus per acre were applied preplant to both crops.

Gravimetric and neutron probe methods were used to determine soil moisture at one foot increments to a depth of 7 feet. Two permanent aluminum access tubes were installed in each test area to accommodate the neutron probe.

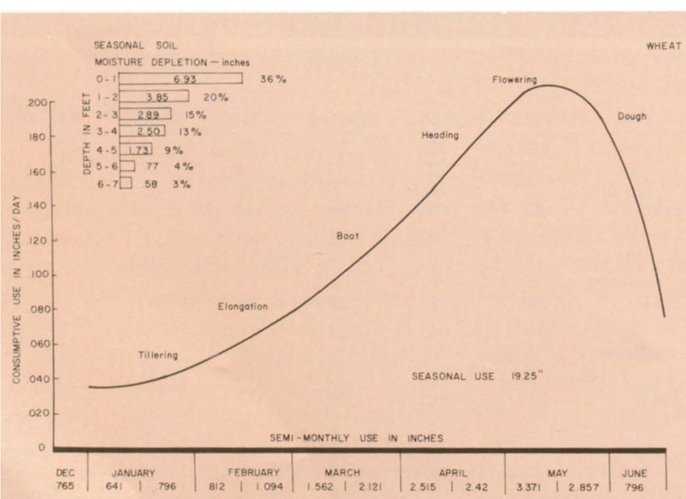

Figure 1

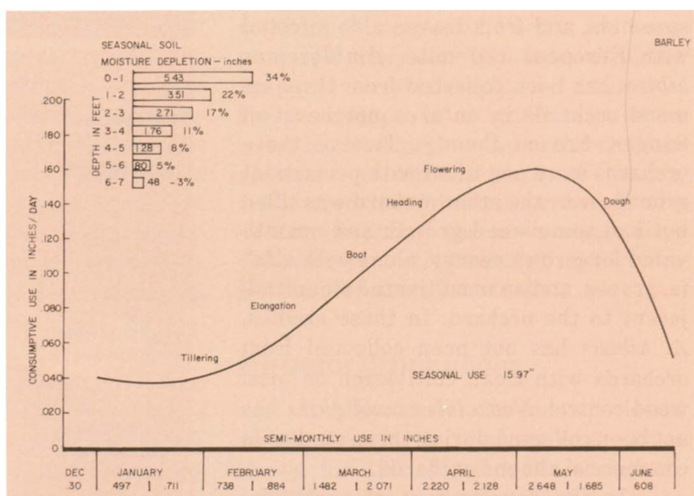

Figure 2

Gravimetric samples were taken near the access tubes, at the same time the neutron readings were made, to determine if the two readings were interchangeable. Soil samples and soil moisture readings were taken before and a few days following each irrigation. Additional soil samplings and readings were obtained throughout the crop year. Twelve samples and readings were taken during the season. Gravimetric soil samples were dried in an oven at 220°F for 24 to 36 hours. Because the two methods produced essentially the same moisture readings, the data used to construct the mean consumptive-use curve for wheat and barley were obtained from the neutron probe readings. A fourth-degree polynomial equation was utilized to best fit the consumptive-use curve (Standard Error 1.5 percent, $r = .98$).

Values from three years of field data were used to construct the consumptive-use curve for barley and wheat.

Applying the data

It is the practice in the San Joaquin Valley to irrigate wheat later than barley with an additional 5 to 6 inches of water. The basis for this practice is found in the data from the past three years. (The average maximum and minimum temperatures for the three years of testing are shown in Table 1.) High maximum mean temperatures occur during the last part of April and continue to increase for the remainder of the season. Consumptive-use is directly affected by temperatures: in regions with lower maximum temperatures, peak water demand is reduced appreciably.

Total seasonal consumptive use for barley and wheat is 15.97 and 19.25 inches, respectively. The difference of 3.28 inches between wheat and barley represents one extra irrigation that must be applied to wheat. To apply 3.28 inches of water, with an irrigation system with 60 percent efficiency, 5.46 inches of water must be applied.

The difference in consumptive use of water between wheat and barley becomes appreciable during the latter part of the season (see Table 2). Up to the first of April the difference is .1 inch or less for each 15-day period. The difference increases to .3 inch during the last part of April and .7 for the first half of May. The greatest difference occurs during the last part of May. Wheat consumptive use for this period is 1.2 inches more than barley. The data indicate that because wheat matures later than barley, it would use more water during the final stages of maturation. During the month of May, 6.22 and 4.33 inches of water are used by wheat and barley, respectively.

The peak period of consumptive use for barley follows the flowering period, which occurs around the first week of May. The peak consumptive use of wheat is 7 to 10 days later than barley. This was expected since the morphological development of wheat is slightly later than barley. Maximum consumptive use for wheat and barley occurs during the period of flowering and soft dough stage. At their peak consumptive use, the daily evapotranspiration for wheat and barley is .206 and .158 inches of water per day; approximately 30 percent more water is utilized by wheat during this period of development (see figures 1 and 2). The soil moisture depletion from each foot increment is approximately the same for wheat and barley.

It is interesting to note that more than 70 percent of the moisture utilized during the crop year by wheat and barley comes from the 0 to 3-foot soil profile. This is partially due to the two irrigations that were applied to refill the soil profile during the season. This is not to detract from the necessity of having deep moisture. The depletion of soil moisture from the 3- to 7-foot profile would have been greater if no irrigation had been applied. Approximately 25 to 30 percent of the moisture supplied to the plants during the season came from the 3- to 7-foot soil profile (see figures 1 and 2).

With 2.5 inches of water available per foot of soil depth, a maximum of 10 inches would be available, and barley and wheat extracted 4.3 and 5.6 inches, respectively, from the 3- to 7-foot profile. Without the availability of deep moisture during the later part of the season, yields could be reduced.

A managerial tool

The data obtained in the study can be used to supplement managerial decisions concerning efficient water resource utilization for winter cereals grown in the San Joaquin Valley. Knowledge of a crop's water consumption for a given period is a managerial tool that can be used in scheduling crop irrigations. This type of information is invaluable during periods of limited water availability and high-cost energy to obtain water. For example, if, on April 1, a soil profile contains 10 inches of available water and we wish to irrigate wheat when 50 percent (5 inches) of the available water is depleted, we could look at figure 1 and determine that 5 inches will be used by the end of April and that irrigation should be planned for the first week of May. The daily consumptive use can be used in projecting crop need and allocating water resources.

Peak water consumptive use for wheat and barley occurs in May, coinciding with the start of the crop-maturation process, at which time moisture stress must be avoided. It is important to recognize the different water requirements for each crop to maximize yields with optimum water efficiency.

Jerry St. Andre is Farm Advisor, Fresno County; Hidemi Yamada is Staff Research Associate, University of California, West Side Field Station, Five Points; and Charles McNiesh is Natural Resource Specialist, Bureau of Reclamation, Fresno.

TABLE 1. Mean Temperature (3-yr. Avg.—1974, 1975, 1976)*

	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.
Maximum	55	56	62	66	71	87	93
Minimum	34	34	39	41	43	51	57

* °F.

TABLE 2. Consumptive Use of Water

	Semi-monthly use (inches)		Cumulative use (inches)		Cumulative percent of use	
	barley	wheat	barley	wheat	barley	wheat
Dec. 16-31	.30	.265	.30	.265	1.87	1.37
Jan. 1-15	.497	.641	.797	.906	4.99	4.70
Jan. 16-31	.711	.796	1.508	1.702	9.44	8.84
Feb. 1-15	.738	.812	2.245	2.514	14.05	13.05
Feb. 16-29	.884	1.094	3.130	3.608	19.59	18.74
Mar. 1-15	1.482	1.562	4.612	5.170	28.87	26.85
Mar. 16-31	2.071	2.121	6.683	7.291	41.84	37.87
Apr. 1-15	2.220	2.515	8.903	9.806	55.74	50.94
Apr. 16-30	2.128	2.420	11.031	12.226	69.07	63.51
May 1-15	2.648	3.371	13.679	15.597	85.65	81.02
May 16-31	1.685	2.857	15.364	18.454	96.20	95.86
Jun. 1-15	.608	.796	15.97	19.250	100.00	100.00