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EFFECT OF IRRIGATION REGIMES ON YIELD, YIELD COMPONENTS AND GRAIN QUALITY OF TORSH BARLEY[1]

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ABSTRACT

Irrigation frequency and amounts for a local cultivar of barley (*Hordeum spontaneum* L. cv. Torsh) in Bajgah valley, Shiraz, Iran, was determined experimentally. The barley was fully irrigated at the early stage of growth and irrigation treatments were started at booting stage. Irrigation interval of 8 days with a minimum soil moisture of 50% of available soil water resulted in high grain yields mainly as a result of high number of tillers per plant and high number of grains per spike. Low water stress of early growth and flowering stages of barley plant is recommended.

Weighted average crop coefficient of 0.85 was obtained for estimating barley consumptive use from pan evaporation data.

INTRODUCTION

The basic purpose of irrigation is to supply soil and plant with water as needed to obtain optimum yield and quality of a desired plant constitutent. Criteria most suit-

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able for scheduling irrigation vary from one situation to another. Generally, irrigation should be scheduled to favor optimum crop production and efficient water use. Considerable research has been done to determine optimum irrigation for corn, sorghum, wheat and rice and to a lesser extent for barley (4).

The percentage of available soil moisture and soil water potential, corresponding to near maximum crop production, are not clearly defined in many irrigation reference books and the specific recommendations often differe. Jensen et al. (6) concluded that crops grown in the Columbia basin were not harmed by lack of water if soil moisture was maintained above 35% of the available moisture range. Hammon and Code (5) found that row crops were injured when the level of available moisture was lower than 25% at the 15 to 30 cm depth. Taylor and Slater (12) in general recommended that irrigation should not be delayed when less than 30% of the available moisture remains in the soil. Hobbs *et al.* (4) stated that as a general rule, irrigation for barley should not be delayed after the soil moisture has been depleted to the 50% level.

Taylor and Aschcroft (11) reported that small grains responded to soil matric potential especially during the first period of vegetative growth. Decrease in seasonal average soil matric potential of one bar reduced the yield of barley by about 376.3 kg/ha (12). However, no reduction in yield was observed when water was withheld after the crop began to blossom. According to Stanberry and Lowrey (9), barley yield in wet treatment (water potential at 20 cm depth more than – 0.15 bar) exceeded the dry treatment (water potential more than an estimated -8 to -10 bars) by 36%.

Because of soil and climatic variations, the above findings and recommendations do not necessarily apply to the irrigated areas of Shiraz, Iran. This paper presents and discusses data relating to barley yield response and consumptive use of water to available soil moisture in the Shiraz area. The effect of soil moisture variations from field capacity to less than wilting point, at different stages of barley growth, on yield are also discussed.

MATERIALS AND METHODS

The experiment was conducted on the experimental farm of the College of Agriculture of Pahlavi University, 15 km north of Shiraz, Iran. The mean maximum and minimum temperatures during the growing season were 32.24 and 3.19 C, respectively. The mean evaporation rate from the class A pan was 7.69 mm/day during the same period. The roots of barley in this experiment were shallow and mostly at depths of 0-40 cm. The soil sample taken at 0-30 cm depth was silt loam and composed of 24.6, 48.2 and 27.2% sand, silt and clay, respectively. The soil water contents measured by pressure plate in laboratory at field capacity (-1/3 bars) and permanent wilting point (-15 bars) were 22.83 and 7.87% on dry weight basis, respectively. The soil also had a 1.66 g/cm^3 bulk density.

Phosphorous at the rate of 27 kg/ha in the form of mono-ammonium phosphate and 25 kg/ha nitrogen in the form of urea and mono-ammonium phosphate were applied to the soil prior to planting. Seeds of a local cultivar of six-rowed barley (cv. Torsh) were planted on August 6 at a rate of 132 kg/ha on rows 4.5 m long and 20 cm apart. This cultivar of barley is usually planted in late spring or in early summer. There was no summer rainfall. Two irrigations amounting to 9.54 and 9.37 cm were applied six days after seedling emergence and tillering stage, respectively. The main irrigation treatments started at booting state. The irrigation regimes consisted of applying water at 8-, 12- and 16-day intervals, total amount of water applied being 50.42, 51.68 and 47.97 cm, respectively. Sixteen-day irrigation was considered a drought treatment. The experimental design was a randomized block with three replications.

Water requirement for each irrigation regime was calculated by soil water determination at depths of 0-20 and 20-40 cm prior to irrigation. The soil water content was raised to field capacity by irrigation using an irrigation application efficiency of 0.70 (3). The required amount of water was applied to the plots by means of siphons from the plastic covered equalizing ditches. The water measurement at the entrance of equalizing ditch was made by a 7.5 cm Parshall flume.

Plants were closely observed during their growth period and notes were taken at different stages of growth.

Average soil water contents in root zone were measured gravimetrically at 4-day intervals between irrigations. Soil was sampled in 20 cm increments up to a depth of 40 cm. Final plant height from ground level to the tip of spike was measured at time of maturity.

After maturity, grain and straw were weighed separately and the average weight of grains per spike, length of spike and weight of 1000 seeds were recorded. Finally the crude protein content of the grain was determined by micro-Kjeldahl method (1).

RESULTS AND DISCUSSION

The rates of water consumption at three different regimes of irrigation and the evaporation from class A pan are shown in Fig. 1. The rates of water consumption were higher in the more frequent water application. This resulted from the wetter soil with higher soil water potential which led to higher evapotranspiration rate (10). Although barley roots are mostly distributed in the 0-40 cm soil depths, some roots may grow deeper and draw water from lower depths.

A further step was taken to calculate the ratio of water consumption rate to evaporation rate from class A pan ,C, in 8-day irrigation regime. The weighted average of this ratio throughout the growing season was 0.85 which is very close to that reported by Jensen *et al.* (6).

The mean percentages of available soil moisture at which irrigation was applied were 54, 81 and 110 for 8-, 12- and 16-day irrigation intervals, respectively. Soil water content was depleted below conventional permanent wilting point in the 16-day irrigation interval.

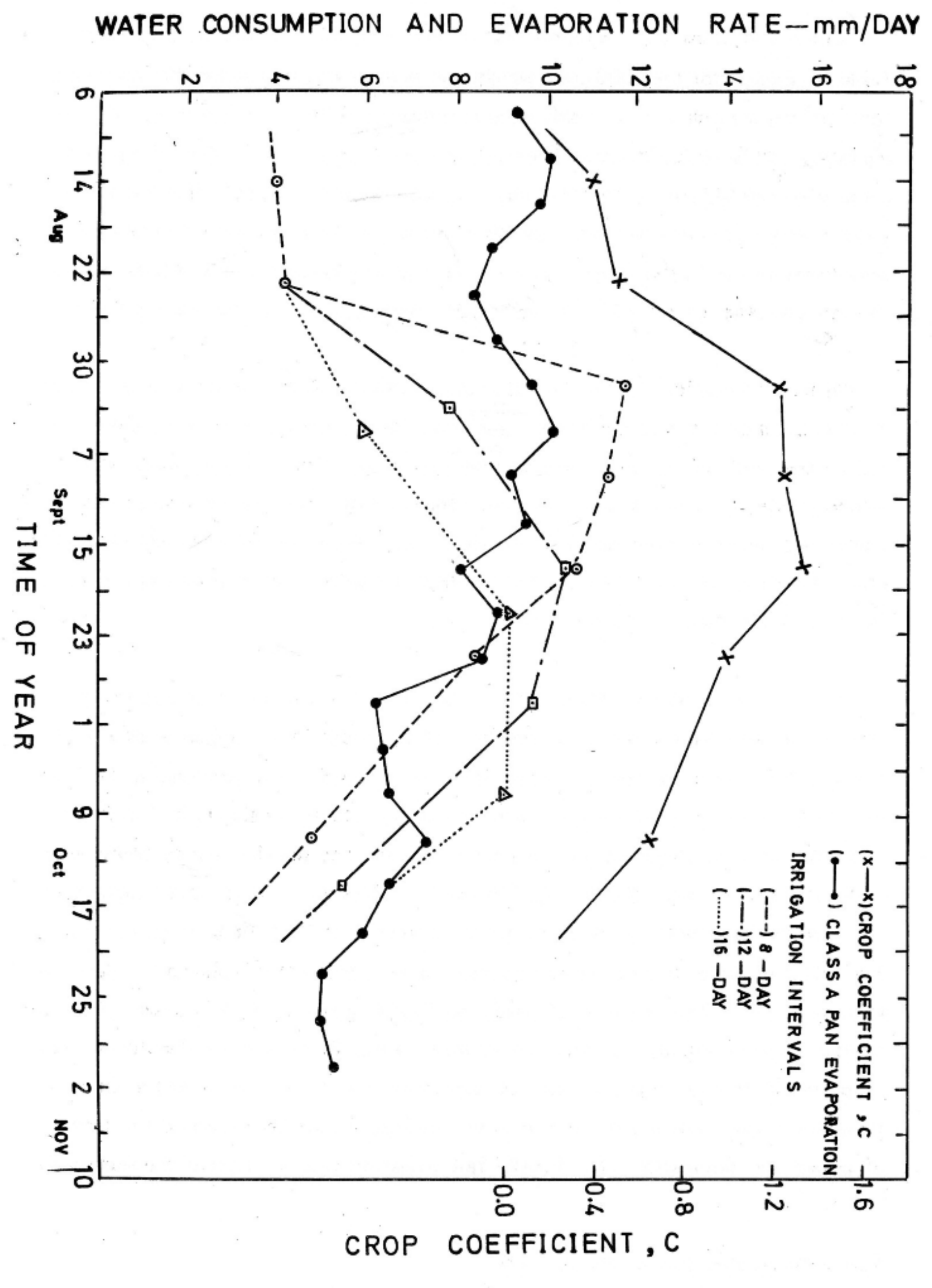

Fig. 1. Plant water consumption at different irrigation regimes, pan evaporation rate and crop coefficient as a function of time.

Grain and straw yield components at three irrigation regimes are presented in Table 1. Except for the 1000-grain weight and average length of spike, the other yield components, grain and straw yields, were significantly different in the three irrigation regimes. In the 8-day irrigation interval, the grain yield and number of tillers per plant were higher than in the other two irrigation regimes. On the other hand, straw yield, number of grains per spike, weight of grains per 60 spikes and final plant height were lower in the 16-day irrigation regime. The grain and straw yields of 8-day regime showed increases of up to 17.7 and 16.0%, respectively, over the 16-day regime .

Different irrigation regimes may alter one or more yield components. From Table 1 it was concluded that the highest grain yield at the wettest irrigation regime was mainly the result of higher number of tillers per plant. This is in agreement with the results of Stanberry and Lowrey (9) who concluded that barley yield in wet irrigation regime was increased dominantly by increasing heads per plant (tillering) and seeds per head. Similarly, the low straw yield at the driest irrigation regime could be mainly the result of shorter plants and fewer tillers.

There is accumulating evidence that soil moisture stress at particular stages of plant growth has adverse effects on subsequent development in a number of plants (8). Variations of soil water content during the time at which different irrigation regimes were impaired in accordance with different growth stages are shown in Fig. 2. It is clear that at early stages of growth namely jointing and booting, barley plants were under stress in 12- and 16-day irrigation regimes. This water stress could explain the significantly lower grain yields of irrigation regimes with 12-day and 16-day intervals. The effect of water stress at early growth on grain yield is also reported by May and Milthorpe (7). The number of seeds per spike was significantly lower only in 16-day irrigation regime. Careful examination of Fig. 2 shows that soil water content in plots of 16-day irrigation interval was lowest and resulted in water stress at flowering stage. The water stress at flowering stage might have lowered the fertility of pollen and pollination (2). Finally this irrigation regime affected the quality of

Table 1. Effects of irrigation regimes on yield, grain quality and yield components of barley

Irrigation Intervals, days	Yield, kg/ha			Yield components			Grain quality		
	Grain	Straw	Spike length, cm	No. seeds/ spike	Grain wt./ 60 spikes, g	No. tillers/ plant	Plant height, cm	Protein content, %	1000 grain, g
8	3307a*	2375a	4.10a	23.7a	50.5a	6.0a	56.7a	9.03b	35.7a
12	2952b	2263a	4.02a	23.8a	52.5a	5.5b	51.7a	9.55b	35.4a
16	2823b	1495b	3.98b	20.7b	46.9b	5.5b	47.1b	10.69a	36.7a

* Means followed by the same letter are not different at the 5% level of probability (Duncan's test).

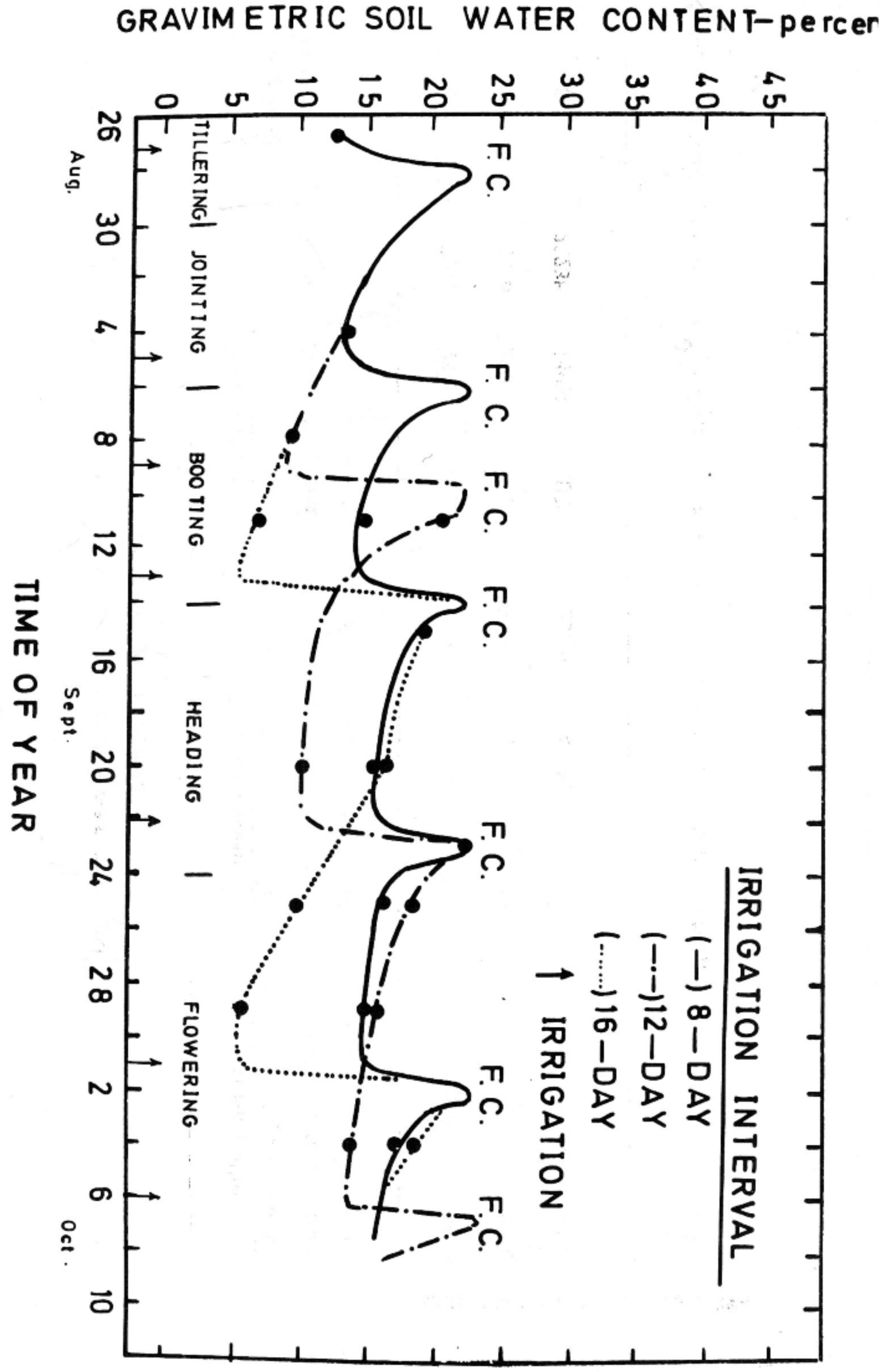

Fig. 2. Soil water content variations versus time of year (F.C. stands for field capacity of soil).

grains and caused a grain protein content increase of up to 18%. However, the 1000-grain weight was not changed by irrigation regimes.

The results of this experiment are in agreement with those of Hobbs et al. (4) who indicated that a minimum soil water content of about 50% of available soil water at the time of irrigation resulted in higher grain yields. This is equivalent to irrigation interval of 8 day in the present study. Grain yield of barley in irrigation regime of 16-day interval after booting stage (minimum soil water content lower than wilting point) was lowered up to 16.6% but the protein content of grains was 11.8% higher compared with 8-day regime. Grain yield of 12-day treatment was only 4.6% (not significant) higher than 16-day treatment. Consequently, in areas with scarce water in late stages of barley growth, two irrigations seems to be as good as three irrigations after booting stage. However, to avoid water stress at flowering stage, it is recommended that one irrigation be applied at booting and another at flowering stage.

Furthermore, a weighted average crop coefficient of 0.85 could be helpful in estimating barley consumptive use from class A pan evaporation in Shiraz area.

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