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Effect of Different Irrigation Treatments on Growth and Yield of Barley Crop

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ABSTRACT. An experimental study was carried out to estimate the effect of different irrigation levels on growth and productivity of barley crop. The experiment was conducted at Hada Al-Sham Station of King Abdulaziz University in Saudi Arabia. The irrigation treatments were designed based on the depletion ratio method, where, the considered depletion ratios for the treatments were 50%, 30%, and 10% from the total available water in soil-root depth. The applied irrigation water, and the irrigation intervals corresponding to the different irrigation treatments were calculated. The soil-water properties and interrelationship were measured in field and laboratory. The flood irrigation system (basin method) was applied for irrigation. The main conclusions of the study are that, the irrigation levels have a highly significant effect on the crop dry yield than that of the other plant variables. Meanwhile, the crop yield is increased as the applied depletion percentage is decreased.

Introduction

The effect of irrigation levels on the yield of barley crop does have a strong relationship, where the nutrients, minerals, and fertilizers in soil would leached downward by intensive irrigation. The crop water requirements must be updated to the climatic conditions to achieve the actual crop water consumption. Different researches and experiments were made to study the effect of irrigation, fertilizers, and plant intensities on the barley crop yield. Simpson and Siddique (1994), studied the relative yield of barley and wheat in the Western Australia as influenced by soil type. Raddatz *et al.* (1994), modeled the crop yield as a function of water use. Koesmarno and Sedcole (1994) studied a method for analyzing the barley kernel growth from designed experiments. Gunasekera *et al.* (1994), studied the effect of soil water deficits

on the wild and cultivated barley. Leon and Geisler (1994) established field experiments to evaluate the variation in rate and duration of growth among spring barley cultivars. Mandal and Mahapatra (1993), estimated the effect of irrigation on growth and water use of barley. Febrero *et al.* (1994), found the effect of irrigation on barley grain yield and mineral content in mature kernels. Sharratt (1994) modeled and observed the interaction between barley yield and evapotranspiration. Other numerous investigators studied the barley yield, some of them are, Rimovsky and Chloupek (1987), Radford and Wildermuth (1987).

Materials and Methods

Experiment Design

A field experiment at Hada Al-Sham Station of King Abdulaziz University in Saudi Arabia is carried out to study the effect of different irrigation levels on the growth and productivity of the barley crop. A simple complete randomized block design is followed with three replications. Nine plots illustrating the irrigation treatments are designated. The plot size for each irrigation treatments is 9.0 square meters. The planting season is between 1994 and 1995. The climatic data is collected for the Hada Al-Sham area to calculate the crop water consumptive use.

Irrigation System and Soil-Water Properties

The flood irrigation system is applied for crop irrigation, where small basin method with 3 m by 3 m dimensions is designated. The water is delivered to the basin by using PVC pipe network, with a discharge meter at inlet of network. The application of water and irrigation intervals are executed for each treatment by the discharge meter and network control valves. The physical soil properties are measured in laboratory using different samples of soil layers, where these properties are tabulated in Table (1).

TABLE 1. The physical properties of soil and water.

Physical properties of soil and water		Value
Mechanical analysis		
	% Coarse sand	5.4 %
	% Medium sand	31.5 %
	% Fine sand	55.5 %
	% Silt and clay	8.0 %
	% Error	– 0.4 %
	Soil texture	Sandy soil
Soil-water properties		
	Field capacity (%)	35 %
	Wilting point (%)	10 %
	Soil porosity (%)	46 %

Irrigation Treatments

Three different irrigation treatments are chosen based on the water depletion ratio method. The depletion ratio method is based on the water losses fraction from the

total available water (TAW) in soil-root depth. In this experiment, three considered ratios 50%, 30%, and 10% from the total available water are applied, where the corresponding treatments are titled by I1, I2, and I3, respectively. However, each irrigation treatment is defined by estimating the irrigation water requirements and the irrigation interval time corresponding to its designed depletion ratio from the total available water. These relations can be expressed as follows ,

$$TAW = [\{(FC\text{-}WP) / 100\} \times Bd / Wd] \times dr \quad (1)$$

$$Dn = R \times TAW \quad (2)$$

$$T = Dn / ET \quad (3)$$

$$Dg = Dn / Ea \quad (4)$$

where, TAW is the total available water for plant extraction (cm), FC, and WP are the moisture contents (based on weights) corresponding to the field capacity and wilting point (g/g), respectively, Bd is the soil bulk density (g/cm^3), Wd is the water density (g/cm^3), dr is the soil-root depth (cm), Dn is the net water depth required for irrigation (cm), R is the depletion ratio (fraction), T is the irrigation frequency (day), ET is the crop potential evapotranspiration (cm/day), Dg is the gross required irrigation water depth (cm), and Ea is the water application efficiency on field level.

The different irrigation treatments illustrated in this study are shown in Table (2) during the different plant stages of growth.

TABLE 2. The irrigation design for barley crop in Hada Al-Sham Station.

Plant stage no.	I	II	III	IV
Duration (days)	20	30	45	25
Evapotranspiration ET (cm/day)	0.24	0.368	0.512	0.228
Irrigation treatments				
a – Net water depth				
I1 : Dn1 (cm)	1.20	2.21	3.59	3.42
I2 : Dn2 (cm)	0.72	1.47	2.05	2.28
I3 : Dn3 (cm)	0.24	0.37	0.69	0.69
b – Gross water depth				
I1 : Dg1 (cm)	1.71	3.16	5.12	4.89
I2 : Dg2 (cm)	1.03	2.10	2.93	3.26
I3 : Dg3 (cm)	0.34	0.53	0.43	0.98
Irrigation frequencies				
T1 (day)	5	6	7	15
T2 (day)	3	4	4	10
T3 (day)	1	1	1	3
Applied water per stage	6.85 cm	15.80 cm	32.90 cm	8.15 cm
Total applied water	63.70 cm = 6370 m^3/hec. = 2675 m^3/feddan			

Crop Calendar and Evapotranspiration Rate

The experimental area is located at the Western Region of Saudi Arabia, where the Kingdom is classified into 13 sub-areas from the meteorological point of view, as described by FAO (1988). The data of reference evapotranspiration and the crop coefficients during the different four crop stages are based on the FAO report (1988). As shown in Table (2), the crop potential evapotranspiration and the irrigation treatments and frequencies are tabulated. Moreover, the total applied water during each plant stage and the total season are calculated and shown in the Table (2).

Measuring Variables

The crop growth rate and the crop production are the main two measuring sets of data during the experimental time. At each plot area of irrigation treatment, the root length, the crop height, the leaf area, and the wet and dry weights of plant samples are measured during the different plant growth stages. Meanwhile, the total crop yield and the dry matter yield are also measured at the harvest of plant, *i.e.* the weights of grains in spike, the number of grains per spike, and the average length of spike.

Results and Analysis

Soil-Water Analysis

The physical properties of soil layers were estimated by analysis of undisturbed samples in laboratory. The main soil texture is sandy soil with physical properties shown in Table (1), where, the soil particles and bulk densities, the soil porosity, and the grain size distribution were measured. The soil-moisture characteristic function was estimated in the laboratory using the pressure plate device, where, the field capacity and the wilting point were estimated. The total available water is then calculated using the Eqn. (1). The infiltration rate of soil was measured in the field by using the double-ring infiltrometer device, where the relation between the application rate and soil intake rate was estimated.

Crop Yield and Other Variables Analysis

The crop data are collected during the growing season and at the final time of harvest. The rate of plant growing is observed during the four stages of plant. The crop yield at harvest is collected and analyzed. Table (3) shows the results of statistical analysis of variance for the different plant data variables, where, the level of significant effects of irrigation treatments on the mean of variables are estimated. As seen from Table (3), four crop variables are found to have certain level of mean difference. The total plant dry weight (ton/hec.) has a highly significant mean difference (less than 1%) under the irrigation treatments. There is a difference in crop height between the means with a certain level of probability less than 10%. The dry weights of stem and leaf by ton/hec. have a mean difference under different treatments but not significant effect. The irrigation treatment number I3 has a higher crop dry yield than that of the yields of other treatments (I1, and I2). As shown in Fig. (1), the crop

dry yield for irrigation treatments I3 (corresponding to 10% depletion ratio) has an average yield of 11.83 ton/hec., while the other treatments have average yields of 9.295 ton/hec. and 7.96 ton/hec., respectively. The relation between the average total dry weight and the depletion ratios of irrigation treatments method is shown in Fig. (1), where, as the depletion ratio increases, the associated dry yield decreases.

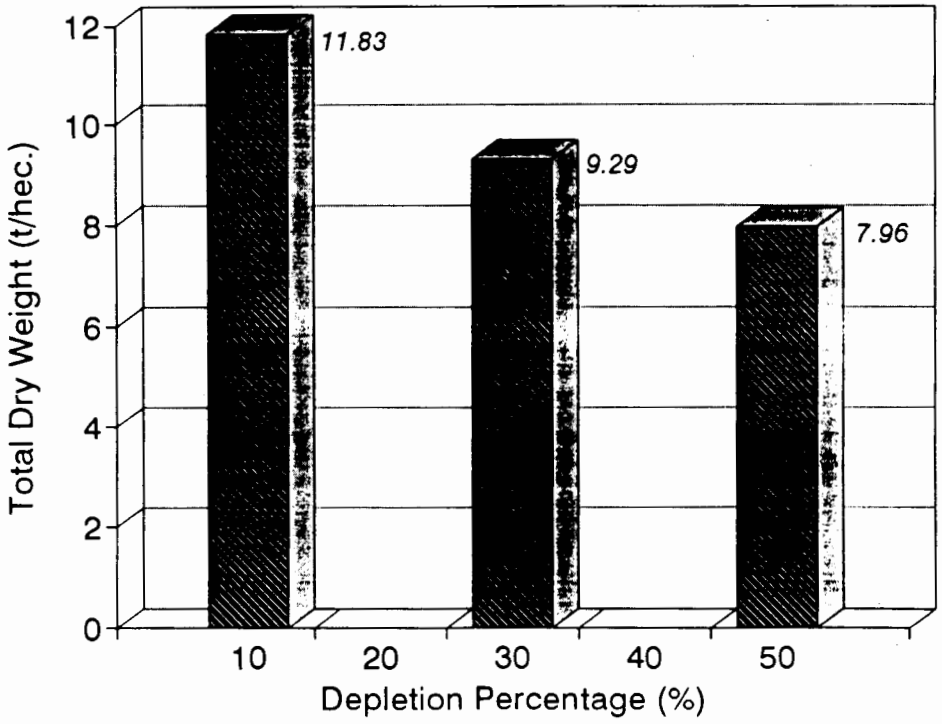

FIG. 1. Barley yield variation under three different irrigation treatments.

TABLE 3. The analysis of variance of barley crop yield.

Variable	F-value	Prob.	Coef. of var. Cv (%)	Stand. dev. of. mean Sy	Total mean	Level of signific.
Total plant dry weight (t/hec.)	18	0.009	8.05	0.45	9.696	HS
Weight of 1000 grains (g)	0.72	–	14.55	2.80	33.367	–
Total weight of grains (t/hec.)	0.64	–	53.75	0.722	2.327	–
Weight of grains in spike (g)	0.09	–	69.18	0.44	1.102	–
Average grains in spike (No)	0.09	–	39.35	5.96	26.22	–
Average weight of spike (g)	0.92	–	34.49	0.314	1.578	–

TABLE 3. Contd.

Variable	F-value	Prob.	Coef. of var. Cv (%)	Stand. dev. of. mean Sy	Total mean	Level of signific.
Dry weight of roots (t/hec.)	0.66	–	26.99	0.0771	0.495	–
Dry weight of stem (t/hec.)	1.68	0.294	18.59	0.632	5.897	NS
Dry weight of leaf (t/hec.)	2.82	0.172	11.02	0.358	5.64	NS
Total weight of spikes (t/hec.)	0.96	–	38.64	1.06	4.756	–
Average length of spike (cm)	0.08	–	16.43	0.60	6.33	–
Number of spikes (no./m^2)	0.73	–	26.32	73.34	482.67	–
Number of stem (no./m^2)	0.37	–	15.92	53.56	583.1	–
Crop height (cm)	4.89	0.089	3.68	1.45	68.33	S
Plant intensity per m^2 (no./m^2)	0.78	–	35.0	40.68	202.3	–

HS : Highly Significant.
S : Significant.
NS : Non Significant.

Conclusions

The main conclusion is that, the applied irrigation treatments have a highly significant effect on barley crop dry yield. The applied 10% depletion ratio method has a maximum dry yield compared to the other levels of depletion ratios (30% and 50%), where the maximum yield is 11.83 ton/hec. The applied irrigation treatments method has an advantage of estimating the maximum crop yield at the same applied quantity of irrigation water which is 2675 m^3/feddan.

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تأثير معاملات مختلفة من الري على معدل نمو وإنتاجية محصول الشعير

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المستخلص . تم تنفيذ دراسة حقلية لإيجاد مدى تأثير مستويات مختلفة من الري على نمو وإنتاجية محصول الشعير ، حيث تم عمل التجربة بمحطة أبحاث هدى الشام التابعة لجامعة الملك عبدالعزيز بالمملكة العربية السعودية ، ولقد تم تحديد معاملات الري على أساس مبدأ نسبة الاستنزاف وذلك لثلاث قيم هي ٥٠٪ ، ٣٠٪ ، ١٠٪ من إجمالي المياه المتاحة في عمق التربة الجذري .

ولقد تم تقدير حجم المياه في كل معاملة وفترات الري ، حيث تم تحليل خواص التربة الطبيعية وإيجاد العلاقات المائية وذلك في المعمل والحقل حيث استخدمت طريقة الري الحوضي لمختلف معاملات الري ، وكانت أهم النتائج تنحصر في أن هناك تأثير عالي المستوى لمعاملات الري المستخدمة على قيمة إنتاجية النبات للمادة الجافة مناظرة لباقي المتغيرات المتعلقة بخواص النبات ، وفي نفس الوقت كان معدل إنتاجية النبات ذات علاقة مع نسبة الاستنزاف المائي حيث تزداد قيمة إنتاجية النبات مع تقليل نسبة الاستنزاف المائي من التربة .