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Response of Two Barley Cultivars to Three Seeding Rates Under Supplemental Irrigation

Abstract: A field trial was conducted at the Muwaqqar Research Station in the 1996/1997 growing season to evaluate the effect of three seeding rates and three water levels of supplemental irrigation on the forage and grain yield of two barley cultivars (ACSAD 176 and Rum). Supplemental irrigation was applied at three stages during the growth of the barley crop as follows: at germination, tillering and booting stages. A single clipping at the tillering stage produced the highest fresh and dry matter yield for both cultivars grown under the highest water level. By increasing both the seeding rate and supplemental irrigation, plant height, fresh matter yield, dry matter yield and biological yield were increased. Cultivar ACSAD 176 produced 1547 kg/ha of dry matter under the highest water level, while cultivar Rum produced 1454 kg/ha under the same water level. Meanwhile, the highest grain yield (505 kg/ha) was obtained from unclipped Rum plants grown at the highest water level and a seeding rate of 100 kg/ha. However, clipping reduced the grain yield for the same treatments by about 54%. It is concluded that barley can be grown in dry areas with water application at a rate of 140 mm distributed according to the growth stages of the crop.

Key words: Barley, Seeding rates, Supplementary irrigation

إنتاجيـــة صنفيـــن من الشعيـــر باستعمال ثلاثة معدلات بذار تحت ظروف الري التكميلي.

يحيـي عبـد الرحمـن السطري، عمـر محمـد الكفاويـن، إبراهيـم غاوي و هاني محمود الصعـوب

المستخلص: تم إجراء تجربـة حقلية في محطة الموقـر للبحوث الزراعيـة التابعـة للجامعة الأردنيـة في الموسـم الزراعـي 1997/1996 . تهدف هذه التجربـة لمعرفـة تأثيـر ثلاث معدلات بذار و ثلاث مستويات من الري التكميلي على إنتاجية العلف و الحـب لصنفين من الشعيـــر (أكسـاد 176 , رم). أضيفت المياه خلال مراحل نمو محصول الشعيـر كما يلي: مرحلة الإنبات، مرحلة تكون الأشطاء و مرحلة طرد السنابل.كان إنتاج المادة الجافة أعلى ما يمكن في مرحلة نمو الأشطاء لكلا الصنفيـن باستعمال أعلى كميـة من المياه. أدت الزيادة في معدل البذار و معدل الري التكميلي إلى زيادة في كل من: ارتفاع النبات، الوزن الأخضـر، الوزن الجاف و الوزن البيولوجـي. أعطى الصنف أكسـاد 176 حوالي 1547 كغم / هكتار من المادة الجافـة تحت أعلى معدل من المياه،في حين أعطى الصنـف رم 1454 كغم / هكتار تحت نفس المعدل من المياه. أما أعلى إنتاج من الحب (505 كغم / هكتار) فلقد تم الحصول عليه من الصنف رم بدون حش باستعمال أعلى معدل من المياه و 100 كغم/ هكتار من البذار . ولكن بعد الحش فلقد تبين أن إنتاج الحب تناقص بنسبة 54% .يمكن أن نستخلص إمكانية زراعة الشعير في المناطق الجافة وذلك بإضافة حوالي 140 ملم من المياه موزعة حسب مراحل النمو المختلفة للمحصول .

كلمات مدخلية: الشعير ، معدلات بذار، ري تكميلي

Introduction

Barley (*Hordeum vulgare* L.) is a widely adapted and important crop in the Mediterranean region. In the dry areas it grows under low soil fertility levels and moisture stress conditions where wheat performs poorly or fails to survive. It is grown for food, feed, or grazing. In addition, under stresses such as drought and cold the yield of barley is much higher than that of oat, wheat, or rye (Mekni and Kourieh, 1984). Barley is known for its tolerance to drought and cold stresses which are characterstics of the Muwaqqar region. During the period of 1990 to 1997, the average harvested area of barley in Jordan was 57.3 thousand hectares, with an average productivity of 880 kg/ha. The average productivity of the world was about 2650 kg/ha. Barley production in Jordan is considered relatively low and does not satisfy the ever increasing demand for livestock feed. Jordan imports about 253,859 ton of barley grain annually to cover the gap between production and livestock requirements (Statistical

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Year Book, 1984-1995). The most important factors responsible for the low productivity of barley in Jordan are: low and variable seasonal rainfall, poor soil moisture conservation and preparation practices, lack of crop rotation and poor stand establishment due to unsuitable planting methods.

One way to increase barley production is to grow barley in arid areas under supplementary irrigation. Barley dry matter production at tillering stage increased from 0.2 to 1.0 ton/ha when the seeding rate was increased from 120 to 240 kg/ha (Anderson, 1985). The best seeding rate depends on the purpose of planting barley, either for grain or for green forage (Droushiotis, 1984). Sepaskhah (1978) suggested that higher water use efficiency and grain yield of barley can be obtained by one irrigation at the flowering stage. Also, Yau (1987) reported that supplementary irrigation increased barley production. Muwaqqar area is characterized by low and erratic rainfall; however, via rainfall water harvesting behind earth dams, it is possible to use supplementary irrigation to grow barley in this area, without considering the cost of water. Because of the limited work being done in Jordan to investigate the effect of plant density and supplemental irrigation on barley productivity, this research was conducted. The main objective of this study was to determine the optimum seeding rate and water level of supplementary irrigation required for optimum grain and forage production of two barley cultivars under arid and semi-arid conditions.

Materials and Methods

The experiment was carried out during the 1996 /1997 growing season at the University of Jordan Agricultural Research Station at Muwaqqar. The site is 50 km southeast of Amman (latitude 36° 5′ N, longitude 31° 49′ E and altitude 760 m above sea level). The climate is typical Mediterranean arid with wet winter and dry summer. Rainfall varies from 80 to 200 mm with annual mean of 150 mm, falling mostly during January and February. Mean maximum and minimum temperatures during January (coldest month) are 13° and 3°C, respectively. The soil is fine silty, mixed, thermic, Typical calciorthid (Taimeh, 1989). Generally this location is characterized by weak vegetative cover, soil surface of high silt content, strong surface crust, low organic matter and weak aggregate stability.

A two factor factorial split block in RCBD arrangement design was used. The number of replications was three. The blocks represent the irrigation treatments, which consisted of three water levels: Low (W1): 25 mm water was applied at germination stage; Medium (W 2): 75 mm water was applied at three stages; High (W3): 141.7 mm water was applied at three stages (Table 1).

Table 1: Water level treatments, total water, rainfall received, amount of supplemental irrigation and stages of water application.

Water level	Total water received (mm)	Rainfall received (mm)	Supplemental irrigation (mm)	Stage of application
W1	106.5	81.5*	25	P**
W2	156.5	81.5	75	P,T,B
W3	223.7	81.5	141.7	P,T,B

* Rainfall received after planting date.
** P: Planting time, T: Tillering stage, B: Booting stage.

These amounts were chosen in addition to the average rainfall to give the barley its requirements of water, which is 304 mm as reported by Shatanawi *et al.* (1987). Twenty-five mm of water was applied at the sowing time for all treatments. It was applied on 23 December 1996 and 8 January 1997 in two equal applications (12.5 mm/application) because of the low infiltration rate and crust formation of the soil to ensure good germination. The sub-plot consisted of two factors: the first factor was two barley cultivars: ACSAD 176 and Rum. These are improved six row barley cultivars characterized by wide adaptability in Jordan. The second factor was the following three seeding rates: 50 kg/ha (S1), 100 kg/ha (S2) and 150 kg/ha (S3). Pure germinated seeds were used.

Soil was plowed by chisel plow. Bordered basins of 1.5 m x 4 m were prepared. Six rows of 25 cm spacing were opened. Soil was fertilized before planting by 18 kg N and 46 kg P_2O_5 per hectare. The seeds were sown on 21 December 1996 manually into soil fallowed the previous winter. Emergence was completed 25 days after the first irrigation. Weeds were controlled by hand.

One clipping from an area of 0.5 m^2 at 5 cm height above the soil surface to keep the growing points for regrowth, was taken at tillering stage. At maturity, the middle four rows of each treatment were harvested (unclipped area was 3.75 m^2). The clipped area for each treatment was harvested alone.

The total amounts of water used by the crop were calculated by soil water depletion as the difference between each two readings of the soil water status from sowing time, until harvest with the addition of the rainfall and irrigation water amounts for one

replication. Total amount of rainfall received during the 1996/1997 growing season was 134.5 mm from which only 81.5 mm fell after the planting date. The total precipitation was distributed as follows: November (47.0 mm); December (11.0 mm); January (43.0 mm); February (28.0 mm) and March (10.5 mm).

Results

Significant interaction was found between all treatments (Cultivar x Seeding rate x Water level) for both cases, clipped and unclipped plots. No grain was produced from applying water only at germination stage (W1). With clipping, the highest grain yield (231 kg/ha) was obtained from Cv Rum sown at a seeding rate of 100 kg/ha with the highest water level (Table 2 (a)). On the other hand, with out clipping the same treatment (Rum x 100 kg/ha x W3) gave the highest grain yield of 505 kg/ha (Table 2(b)). Cultivar ACSAD 176 produced the lowest amount of grain (97 and 112 kg/ha) with or without clipping, respectively under the medium water level (W2).

Table 2: Grain yield (kg/ha) of two barley cultivars as affected by three seeding rates and three water levels.

(a) Clipped

Cultivar	Seeding rate (Kg/ha)	Water level W2*	W3
Rum	50	139.7	208.8
	100	156.1	230.8
	150	106.4	139.3
ACSAD 176	50	131.6	158.8
	100	142.9	173.3
	150	97.2	149.1

LSD at 0.05=19.74

(b) Unclipped

Rum	50	279.1	376.5
	100	332.8	504.8
	150	247.4	410.1
ACSAD 176	50	185.1	347.8
	100	191.1	378.2
	150	112.3	341.4

LSD at 0.05=19.71

* No grain was produced from W1.
Low (W1): 25 mm water was applied at germination stage;
Medium (W 2): 75 mm water was applied at three stages;
High (W 3): 141.7 mm water was applied at three stages.

The highest biological yield was obtained from cultivar ACSAD 176 under the highest water level, both clipped and unclipped plots (Table 3). For example, the clipped barley ACSAD 176 produced 2067 kg/ha, at the highest level of supplementary irrigation, while Cv. Rum produced only 1670 kg/ha under the same irrigation treatment. Interaction between seeding rate and level of water significantly affected biological yield (Table 4). Sowing the barely at a rate of 150 kg/ha and water level (W3), gave the highest biological yield (1668 kg/ha) for unclipped treatment. On the other hand, with clipping, all tested seeding rates (50, 100 and 150 kg/ha), produced the largest amount of biological material when irrigated at the highest amount of water (Table 4). As for the harvest index, both clipped and unclipped plants of cultivar Rum with water levels of W2 or W3, gave the highest harvest index (Tables 3 and 4).

Table 5 shows that both barley cultivars irrigated at three different stages with a total amount of 142 mm (W3) gave the tallest plants and highest amount of herbage either fresh or dry when harvested at tillering stage. For example, dry matter production at water level (W3) was 1454 and 1547 kg/ha for cultivars Rum and ACSAD 176, respectively. Meanwhile, at water level (W1) dry matter production was 686 and 625 kg/ha. The tallest plant (37.7 cm) was obtained from cultivar ACSAD 176 grown under the highest water level (W3). On the other hand, the shortest plants were found under the lowest water level (W1), and for both cultivars.

Discussion

Clipping reduced grain yield for both cultivars used in this study. This reduction can be related to the effect of clipping on encouraging the crown area to produce more tillers (Stoskopf, 1981) which will cause an increase in the competition for growth factors, thus lower grain production. Similar results were obtained in other studies (Anderson, 1985; Yau and Mekni, 1985; Fukai *et al.* 1990). Grazing prior to harvest significantly reduced grain yield, plant height, and dry matter yields of spring barley cultivars (Droushiotis, 1984). Moreover, Hadjichristodoulou (1991) reported similar results and he concluded that the reduction was probably due to the reduction in top growth with a consequence effect on root growth.

Using supplementary irrigation at a rate of 142 mm, distributed during the growing season, resulted in a significant increase in plant height, grain yield

Table 3: Biological yield (kg/ha) and harvest index (HI) for clipped and unclipped for the two barley cultivars as affected by three water levels.

		Clipped		Unclipped	
Cultivar	Water level*	Biological yield	HI %	Biological yield	HI (%)
	W1	187	00.0	746	00.0
Rum	W2	1275	10.8	1015	29.5
	W3	1670	11.7	1464	29.7
	W1	179	00.0	647	00.0
ACSAD 176	W2	1356	9.3	1075	15.8
	W3	2067	7.8	1632	21.9
LSD (0.05)		111	1.16	98	2.1

*Low (W1): 25 mm water was applied at germination stage;
Medium (W 2): 75 mm water was applied at three stages;
High (W 3): 141.7 mm water was applied at three stages.

Table 4: Biological yield (kg/ha) and harvest index (HI) for clipped and unclipped barley cultivars as influenced by the interaction between three seeding rates and three water levels.

		Clipped		Unclipped	
Seeding rate	Water level*	Biological yield	HI %	Biological yield	HI (%)
	W1	287	00.0	642	00.0
50	W2	1194	11.5	908	26.3
	W3	1813	10.5	1146	25.3
	W1	183	00.0	753	00.0
100	W2	1312	11.5	997	26.8
	W3	1866	11.3	1530	29.3
	W1	149	00.0	695	00.0
150	W2	1440	7.1	1230	14.9
	W3	1926	7.6	1668	22.9
LSD (0.05)		136	1.42	120	2.54

*Low (W1): 25 mm water was applied at germination stage;
Medium (W 2): 75 mm water was applied at three stages;
High (W 3): 141.7 mm water was applied at three stages.

Table 5: Plant height (cm), fresh and dry matter yield (kg/ha), of two barley cultivars as affected by three water levels, when clipped at tillering stage.

Cultivar	Water level	Plant height	Fresh yield	Dry yield	Biological yield	HI (%)
	W1	23.6	2622	686	187	00.0
Rum	W2	25.8	3821	923	1275	10.8
	W3	31.7	7954	1454	1670	11.7
	W1	24.9	2507	625	179	00.0
ACSAD 176	W2	28.7	5174	1214	1356	9.3
	W3	37.7	8368	1547	2067	7.8
LSD (0.05)		1.8	450	134	111	1.16

*Low (W1): 25 mm water was applied at germination stage;
Medium (W 2): 75 mm water was applied at three stages;
High (W 3): 141.7 mm water was applied at three stages.

and biological yield. This can be attributed to the increase in vegetative growth as reflected in the increase of plant height and dry matter production measured at tillering stage. Sepaskhah (1978) suggested one irrigation at the flowering stage for higher grain yield of barley. Similar results were reported for wheat (Singh *et al.* 1979; Simmons *et al.* 1982; Bouzerzour and Odina, 1990; Al- Zuriqi *et al.* 1995), and for barley (Fardous *et al.* 1995 a and b). Dahkgan (1998) stated that cultivar Rum is better for grain production, while cultivar ACSAD 176 is better for straw when supplementary irrigation is available, but when supplementary irrigation is not available, then grain yield is worthless and both cultivars can be used for grazing. Planting barley crop at a seeding rate of 100 kg/ha produced the highest dry matter yield at tillering stage and biological and grain yield at maturity. These results are in agreement with others (Anderson, 1985; Marshal *et al.* 1987; Sharma and Smith, 1987; Blue *et al.* 1990; Fukai *et a*l. 1990; Jedal and Heln, 1995). It seems that under Muwaqqar conditions, the optimum seeding rate for barley cultivar ACSAD 176 and Rum is 100 kg/ha. Higher or lower seeding rates caused a decline in yield.

In conclusion, for grain production it is recommended to grow cultivar Rum at a seeding rate of 100 kg/ha, while for biological yield or dry matter production, cultivar ACSAD 176 is preferred, provided that supplementary irrigation is available.

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