EFFECT OF SEEDING RATE AND IRRIGATION REGIME ON BARLEY UNDER SANDY SOIL CONDITIONS

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ABSTRACT

This experiment was conducted in the Experimental Farm of the Environmental Agricultural Science Faculty, El-Arish, Suez Canal University, North Sinai Governorate during two successive seasons (2006/2007 and 2007/2008). This work aims to investigate the effect of four irrigation regimes namely; control treatment (without supplemental irrigation) and three supplementary irrigation regimes of 50, 75, 100 mm cumulative pan evaporation and three seeding rate (30, 50 and 70 kg/fed.) on yield and yield attributes of the barley cultivar Giza 126. The experimental design was randomized complete block (RCBD) in split plot design with three replications. The experimental unit area was 7.5 m^2 (10 rows of 15 cm width and 5 m length for each row). Drip irrigation system was used for supplementary irrigation with saline water of salt concentration ranging between 3500 and 4600 ppm. The accumulated rainfall during the two growing season ranged between 160 - 180 mm and sowing dates were Nov. 5^{th} and 10^{th} in the 1^{st} and 2^{nd} seasons, respectively. Soil texture was sandy clayey. Results showed that irrigation at 50 mm evaporation increased most of yield traits. There was no significant difference between75 and 100 mm evaporation treatments on 1000-grain weight, but it was higher than the control and irrigation at 50 mm. The superiority of grain yields (781.6 and 778.3 kg fed^{-1}) were gained with irrigation at 50 and 75 mm evaporation treatments, respectively, while, highest biological and straw yield was obtained with irrigation at 50 mm evaporation. The best water use efficiency (WUE) of barley was with irrigation at 75 mm evaporation. Non-irrigated treatment (control) fowlled by 100 mm evaporation treatment had the greatest value of grain protein content. Seeding rate of 70 kg fed^{-1} decreased plant height, flag leaf area, spike length and number of grains/spike, but increased plant fresh and dry weights as compared to seeding rate of 30 kg fed.$^{-1}$. Moderate seeding rate (50 kg fed.$^{-1}$) gave the highest number of tillers and leaves per plant. Increasing seeding rate from 30 to 70 kg fed.$^{-1}$ increased straw and biological yield by 9.03 and 19.44 %, respectively. Maximum grain yield (787.0 kg fed^{-1}), 1000-grain weight (25.22 g) and harvest index (36.2 %) were obtained by seeding rate of 30 kg fed^{-1}. There was no significant effect of seeding rate on the grain protein content.

To gain high productivity of barley cultivar Giza 126 under North Sinai environmental conditions, seeding rate of 30 kg fed^{-1} and irrigation at 75 mm evaporation could be recommended to achieve an economic use of scarce water.

Key words: Barely, seeding rate, irrigation, cumulative pan evaporation, yield attributes, harvest index, grain yield, water use efficiency, grain protein content

INTRODUCTION

Increasing grain yield of cereal crops is considered one of the most important national goals in Egypt to cover the needs of increment of Egyptian population. Barley (*Hordium vulgare*) is considered the main cereal crop in arid and semi arid areas as compared with wheat, maize or other cereal crops (**Bauder, 2001**). It is one of the few crops adapted to unfavourable agro climatic conditions and tolerant to stresses, such as drought, salinity and low soil fertility which are the features of newly reclaimed areas; e.g. North Sinai. Barley flour could be mixed with wheat flour for bread making to reduce import of wheat (**El-Afandy and El-Morsy, 2005**). Also, stable barley production is necessary to assure resource-poor farmers a stable income and livestock production. Hence, information on the suitable agricultural practices requirement of barley grown in North Sinai region is meager.

In arid and semi-arid regions, where rainfall is insufficient, barley responded significantly to water supply, so, it is important to determine water requirements for maximizing its production (**Ghandorah *et al.*, 1997; Hussain and Al-Jaloud, 1998; Brown, 1999 and Bauder, 2001**). Growing conditions such as moisture stress usually result in less barley yields (**Hohm, 1999**). The maximum grain yield and water use efficiency of irrigated barley were obtained with highest water quantities either by sprinkle irrigation or accumulative pan evaporation (**El-Rais *et al.*, 1999 and Al-derfasi, 2000**). Increasing irrigation supply increased significantly grain and biological yield of barley (**Satari *et al.*, 2001 and Lyons, 2002**). Crude protein content was greater for barley grain grown under dryland vs irrigated conditions (**Honeyfield *et al.*, 1987**). Also, barley receiving the low quantity of irrigation water had greater crude protein content than the higher irrigation levels (**Grove *et al.*, 2003**). Increased levels of irrigation water tended to decrease grain β- glucan content and there was a high positive correlation between it and protein content in barley (**Guler, 2003**). The highest value of water use efficiency (WUE) for grain yield of winter barley were mainly observed by effective rainfalls during the time from stem elongation to harvest (**Moret *et al.*, 2007**). Compared with non-irrigation treatment, wheat grain yield under irrigation treatments was significantly increased, but the content of grain protein was reduced (**Wang *et al.*, 2008**)

Water consumed by barley plants and irrigation intervals depend mainly on meteorological conditions during growing season, so, using the cumulative pan evaporation (CPE) is considered the best method for determining irrigation requirements of winter barley (**Al-derfasi, 2000**). Improvement of WUE of field crops specially cereal crops in arid and semi-arid regions is an imperative imposed by the critical situation of water resources of the region and is affected by many factors; the most important of them were fertilizers and water management (**Katerji *et al.*, 2008**).

Seeding rate is considered one of the most important agronomic factors determining barley productivity. It depends on environmental conditions, cultivar, sowing date, soil fertility and is affected greatly by the use of barley production; e.g. grain, forage or both uses (**Moustafa and El-Refaee, 1998**). The best grain yield of barley under rainfed or irrigation condition was obtained with seeding rate of 100 kg $fed.^{-1}$ (**Saber, 1994**); 120 kg ha^{-1} (**Kabirian *et al.*, 1998**) and 80 kg ha^{-1} (**Mohammadi, 1999**). Under sandy soil conditions, **Gomma (1997)** found that the lowest seeding rate (119 kg.fed^{-1}) gave the highest grain weight and number per spike and total yield, while, the highest seeding rate (178 kg. fed^{-1}) gave the greatest number of spike M^{-2}. Increasing seeding rate from 100, 84 and 50 to 180, 155 and 100 kg ha^{-1}, respectively, increased significantly plant height, flag leaf area, harvest index and grain yield, but, decreased grain weight/spike and 1000-grain weight (**Salem, *et al.*, 2000 & Satari *et al.*, 2001**). There was no significant effect of seeding rate on barley grain protein content (**Yin *et al.*, 2002**).

Therefore, the objective of this study was to recognize the suitable seeding rates and irrigation requirement for maximizing barley yield and its components under the conditions of North Sinai region.

MATERIALS AND METHODS

This study was conducted during the winter seasons of 2006/2007 and 2007/2008 under saline water irrigation conditions at the Experimental Farm of Faculty of Environmental Agricultural Science, El-Arish, Suez Canal University, North Sinai Governorate. It aims to investigate the effect of four irrigation treatments (irrigation at the depletion of 50, 75, 100 mm cumulative pan evaporation and no supplementary irrigation) and three seeding rates (30, 50 & 70 kg fed^{-1}) and on yield and yield attributes of barley (Giza 126 cultivar). Planting dates were at 5th and 10th Nov. in the 1st and 2nd seasons, respectively. Soil texture was sandy clayey with pH 8.45 and containing 3.11 % CaCO3. Drip irrigation system was used for supplementary irrigation with water salinity ranging between 3500 and 4600 ppm. The average growing season precipitation ranged between 160 and 180 mm.

A split-plot design was used with randomized complete blocks arrangement in three replications. Irrigation regimes were randomly devoted in the main plots, while, seeding rate treatments were arranged in the sub-plots. The experimental unit area was 7.5 m^2 and contained 10 rows of 15 cm width and 5 m length for each row. All the agricultural practices were carried out as recommended for barley growing under North Sinai conditions. Barley plants were harvested after 150 days from sowing date. The observations for growth and yield traits, viz.

plant height, plant fresh and dry weights, number of tillers plant^{-1}, 1000-grain weight, spike length, number of grains spike^{-1}, grain yield fed^{-1}, straw yield fed^{-1}, biological yield fed^{-1}, harvest index % and water use efficiency (kg grains/m^3/fed) were estimated. Water use efficiency (WUE) was calculated as the ratio of grain yield (kg fed^{-1}) to total water consumed by barley plants (m^3). Grain protein content on a dry weight basis (P % = N x 6.25) was determined by Kjeldahl method (**A.O.A.C., 1990**). Pooled data were subjected to analysis of variance by using M-STAT C, (**Freed, 1991**). Mean values were compared at P< 0.05 using Duncan's multiple range test according to **Duncan (1990).**

RESULTS AND DISCUSSION

1. Effect of irrigation regimes:

All studied growth traits of barley responded significantly to the supplementary irrigation (Table, 1). Combined data across seasons indicated that irrigation at 50 mm evaporation gave the highest means of plant height (66.01cm), number of tillers (3.66) and number of leaves (14.87) per plant. Also, the superiority of flag leaf area was recorded with 50 mm evaporation, which increased by 12.41 and 27.92 % as compared with 75 and 100 mm evaporation, respectively and by 42.62 % as compared with control treatment. The same trend was found for fresh and dry weights, as the highest means were 4.86 and 2.22g, respectively that were recorded from the lowest level of irrigation depletion.

Irrigation levels affected significantly on number of grains and grain weight per spike at P< 0.01 and on spike length and 1000-grain weight at P<0.05 (Table 2). Irrigating barley plants at 50 mm evaporation increased spike length by 8.29, 8.82 and 3.74 % as compared with control treatment, 75 and 100 mm evaporation, respectively. Contrarily, subjecting plants to water stress by irrigation at 100 mm evaporation reduced the number of grains/spike by 11.68, 11.98 and 5.36 % as compared with rainfed treatment (control), irrigation at 50 and 75 mm evaporation, respectively.

Table (1): Means of growth traits of barley grown under different irrigation regimes (Data are combined across two seasons) :

Irrigation depletion (mm evaporation)	Growth traits					
	Plant height (cm)	No. Tillers/plant	No. leaves/plant	Flag Leaf area (cm^2)	Plant fresh weight (g)	Plant dry weight (g)
50	66.01 a	3.66 a	14.87 a	15.76 a	4.86 a	2.22 a
75	63.22 b	3.13 b	12.22 b	14.02 b	4.65 b	1.92 b
100	60.60 c	3.02 b	12.01 b	12.32 c	3.70 c	1.80 b
Control (1)	56.33 d	2.64 d	10.65 c	11.05 d	2.88 d	1.01 c
F-test	**	**	*	**	**	*

(1) No supplementary irrigation = under rainfed conditions. * = significant at $P< 0.05$ and ** = significant at $P< 0.01$. Means have the same letters in the same column are not significantly different at $P < 0.05$ level

Table (2): Means of yield components of barley grown under different irrigation regimes (Data are combined across two seasons) :

Irrigation depletion (mm evaporation)	Spike length (cm)	No. grains/ spike	Grain Weight (g/spike)	1000-grainweight (g)
50	6.66 a	33.13 a	0.92 d	26.66 c
75	6.42 b	30.81 b	1.11 c	28.64 b
100	6.12 c	29.16 c	1.22 b	28.81 ab
Control (1)	6.15 c	26.11 d	1.35 a	28.88 a
F-test	*	**	**	*

(1) No supplementary irrigation = under rainfed conditions. * = significant at $P < 0.05$ and ** = significant at $P < 0.01$. Means have the same letters in the same column are not significantly different at $P < 0.05$ level

Control treatment, moderate and/or severe water stress (irrigation at 75 and 100 mm evaporation) gave similar 1000-grain weight (28.88, 28.64 & 28.81g, respectively), which were more heavy than low water stress level (26.66 g). This reduction in 1000-grain weight may de due to the negative correlation between number of grains and grain weight, where, as number of initiated grains/spike increased, the photosynthetic products which transferred to the grains (sink) distributed to a large number of grains which reflected to small and light grains. These results are in full agreement with those obtained by **Salama and Hanna (1993); Abu–Awwad (1998); El-Rais *et al.*, (1999); Lyons (2002) and Moret *et al.*, (2007).**

Highly significant effect of irrigation levels on barley grain, straw and biological yields as well as water use efficiency and grain protein content (Table 3, Fig. 1 and 2). There was no significant difference between irrigation at 50 and 75 mm evaporation for grain yield, but the two treatments gave superiority over irrigation at 100 mm evaporation. This means that decreasing the number of irrigations and/or increasing irrigation interval by irrigation at 75 mm evaporation did not significantly affect barley (Giza 126 cultivar) grain yield. So, for economic water supply, it could be recommended to irrigate barley at the depletion of 75mm evaporation.

Table (3): Means of grain, straw, and biological yield, harvest index, water use efficiency (WUE) grain protein content of barley grown under different irrigation regimes (Data are combined across two seasons):

Irrigation Depletion (mm evaporation)	Grain Yield (kg/fed.)	Straw Yield (kg/fed.)	Biological Yield (kg/fed.)	Harvest Index (%)	WUE (kg grains/m^3/ fed)	Protein Content (%)
50	781.6 a	1613.1 a	2622.0 a	33.1 a	0.847 b	10.44 c
75	778.3 b	1580.3 b	2442.3 b	29.3 b	0.931 a	12.54 b
100	681.1 c	1556.1 c	2345.2 c	29.4 b	0.929 a	13.22 a
Control (1)	611.5 d	1445.3 d	2033.6 d	27.7 c	0.788 c	12.35 b
F-test	**	**	**	**	**	*

(1) No supplementary irrigation = under rainfed conditions. * = significant at P< 0.05 and ** = significant at P< 0.01 . Means have the same letters in the same column are not significantly different at P < 0.05 level.

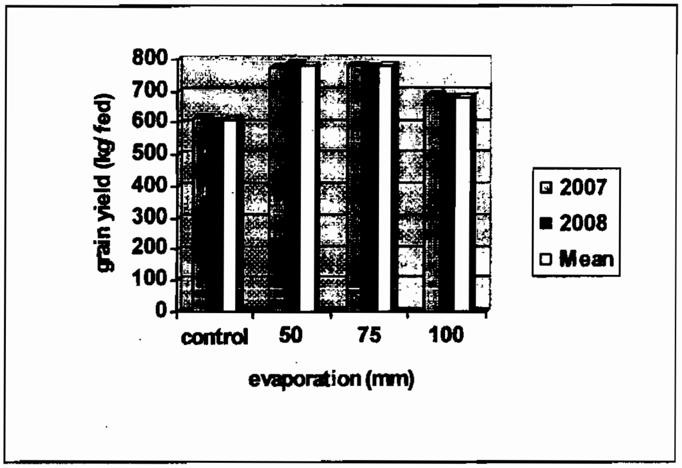

Fig.1: **Effect of irrigation depletion on barley grain yield**

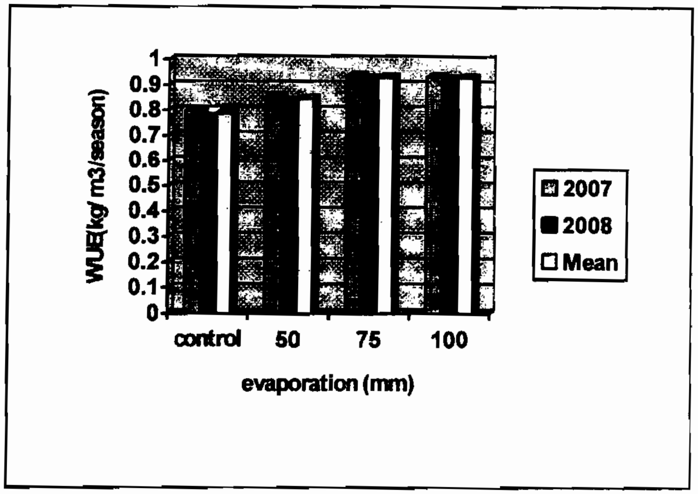

Fig. 2: Effect of irrigation depletion on barley water use efficiency

The highest means of straw and biological yield (1613 and 622 kg fed^{-1}) were obtained when plants were irrigated at 50 mm evaporation, while, the lowest mean was observed with irrigation at 100 mm water vapor depletion. However, irrigation at 50 mm evaporation showed superiority in harvest index, but differences between irrigation at 75 and 100 mm were not significant.

The water use efficiency was significantly higher by irrigation at 75 and 100 mm evaporation as compared with 50 mm evaporation. These results mean that irrigating barley with an excess of water will not result in significant increase in grain yield. This is true as WUE value was decreased with irrigation at 50 mm evaporation, where more number of irrigations was applied.

Subjecting barley plants to water stress by non-giving supplemental irrigations or by irrigating at 100 mm evaporation treatments gave the maximum value of grain protein content (13.35 and 13.22 %, respectively). These results are in line with those obtained by **Honeyfield *et al.* (1987) and Grove *et al.* (2003)**, who concluded that barley receiving low irrigation or grown under dryland conditions gave maximum crude protein contents as compared with the other irrigated treatments..

Widening irrigation intervals (irrigation at 100 mm evaporation) make the soil-water supply not adequate to meet the transpirational demands, then water stress occurs. Hence, stomata conductance will be reduced and will limit water loss and CO2 diffusion into the leaves to support photosynthetic activity. So, all growth traits (plant height, fresh and dry weight, number of tillers, leaves and flag leaf area) of barley will be reduced, and consequently number of grains/spike and grains yield as well as straw and biological yield will be decreased.

Furthermore, the promising superiority of irrigation at 75 mm evaporation for grain yield and some yield attributing parameters may reflect the ability of barley plants to develop more extensive root system under water stress, which absorb more water and nutrients from deeper soil layers for higher photosynthetic activity and translocation of metabolites to the sink, and consequently increase the means of studied traits. This conclusion is in accordance with that of **Salama and Hanna (1993); El-Rais *et al.* (1999); Bauder (2001); Satari *et al.* (2001); Kassem *et al.* (2002) and Katerji *et al.* (2008).** Also, **El-Koliey and Abd El-Hamid (2000)** reported that barley Giza 126 cultivar may be recommended under drought conditions to achieve maximum yield snd water use efficiency.

According to the results of this study, it could be recommended to irrigate Giza 126 barley cultivar at the depletion of 50-75 mm evaporation to obtain a high grain yield under North Sinai environmental conditions.

2. Effect of seeding rate:

Increasing seeding rate from 30 to 70 kg/fed decreased plant height from 65.19 to 60.12 cm and flag leaf area from 15.52 to 14.36 cm^2 (Table, 4). While, cultivating barley at the rate of 50 kg/fed gave the highest number of tillers and leaves per plant (3.82 and 14.95, respectively). Plant fresh and dry weights increased by 34.98 and 25.46 % with the seeding rate of 70 kg/fed as compared with the rate of 30 kg/fed. These results may be attributed to the increase of the competition between plants under high-seeding rate for water, nutrients and light.

Table (4): Means of growth traits of barley grown by using different seeding rate (Data are combined across two seasons):

Seeding rate (kg/fed.)	Growth criteria					
	Plant height (cm)	No. Tillers/ plant	No. leaves/ plant	Flag Leaf area (cm^2)	Plant fresh weight (g)	Plant dry weight (g)
30	65.19 a	2.85 c	13.77 c	15.52 a	3.63 c	1.61 c
50	63.44 b	3.82 a	14.95 a	14.44 b	3.89 b	1.83 b
70	60.12 c	3.14 b	14.55 b	14.36 b	4.90 a	2.02 a
F-test	**	*	*	**	**	*

* = significant at P< 0.05 and ** = significant at P< 0.01 .Means have the same letters in the same column are not significantly different at P < 0.05 level

The maximum values of spike length (6.54 cm), number of grains/spike (31.81) and grain weight/spike (1.09 g) were obtained when barley was cultivated at the rate of 30 kg/fed (Table, 5). While, increasing seeding rate caused a significant increase in 1000-grain weight by 5.51 and 14.23 % with 50 and 70 kg/fed., respectively as compared with 30 kg/fed. These results may be due to that the highest seeding rate increased the competition between plants for water, nutrients and light which lowed the number of fertile flowers/spike and thus affected negatively on number of grains per spike.

Table (5): Means of yield attributes of barley cultivated using different seeding rate (Data are combined across two seasons):

Seeding rate (kg/fed.)	Grain yield attributes			
	Spike length (cm)	No. Grains spike	Grain weight (g/spike)	1000-grain weight (g)
30	6.54 a	31.81 a	1.09 a	25.22 c
50	6.35 b	27.21 b	0.78 b	26.61 b
70	6.13 c	27.03 b	0.58 c	28.81 a
F-test	**	*	**	**

* = significant at P< 0.05 and ** = significant at P< 0.01 .Means have the same letters iin the same column are not significantly different at P < 0.05 level

The maximum barley grain yield (787.0 kg fed^{-1}) and harvest index (36.2 %) were obtained by the lowest seeding rate (30 kg fed^{-1}) (Table 6 and Fig 3). While, straw and biological yield (kg fed^{-1}) increased as seeding rate increased from 30 kg fed-^{1} up to 70 kg fed^{-1} by 9.03 and 19.44 %, respectively. These results may be due to the highest number of plants resulted from the highest seeding rate.

The best ability of barley to use irrigation water (0.963 kg/m^3/season) was obtained with the moderate seeding rate (50 kg/fed) (Table 6 and Fig. 4). However, barley grain protein content did not respond significantly to different seeding rates though it ranged between 11.11 and 12.06 % (Table, 6).

Table (6): Means of grain, straw and biological yield as well as water use efficiency (WUE) and grain protein content of barley grown by using different seeding rate (Data are combined across two seasons):

Seeding rate (kg/fed.)	Grain Yield (kg/fed.)	Straw Yield (kg/fed.)	Biological yield (kg/fed.)	Harvest index (%)	WUE (kg grains/ m^3/fed)	Protein Content (%)
30	787.0 a	1507.8 bc	2181.2 c	36.2 a	0.832 c	12.06
50	753.1 b	1588.1 b	2443.3 b	30.7 b	0.963 a	12.32
70	688.5 c	1644.0 a	2605.0 a	26.6 c	0.884 b	11.11
F-test	**	*	**	**	**	NS

* = significant at P< 0.05 and ** = significant at P< 0.01 .Means have the same letters in the same column are not significantly different at P < 0.05 level

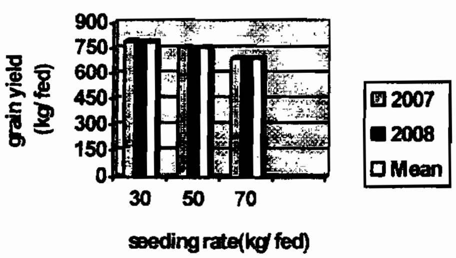

Fig.3 : **Effect of seeding drate on barley grain yield**

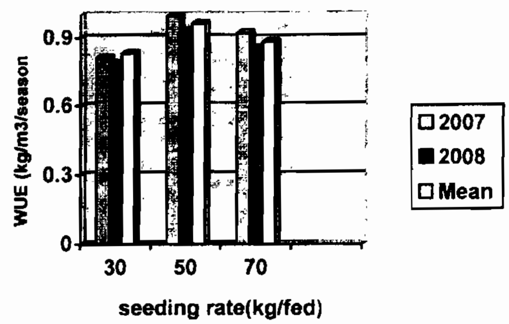

Fig. 4: **Effect of seeding rate on barley water use efficiency**

Low seeding rate (30 kg/fed.) decreased the competition among barley plants, and favoured more utilization of available environmental resources. This inturn stimulated growth and photosynthetic activity of wide spaced plants and consequently increased spike length, number of grains per spike and grain yield per feddan.

Low seeding rate (wide plant spacing) not only increased metabolities synthesized by barley plant, but also activated their migration to fruiting sites (grains) to obtain the highest value of harvest index. Moreover, low seeding rate increased the ability of barley to uptake soil water with its good root deeply and laterally distribution since there is a good balance between the number of plants and soil resources. These results are in harmony with those obtained by **Pageau (1991); Gomma (1997); Kabirian *et al.* (1998); Salem *et al.* (2000); Satari *et al.*(2001) and Katerji *et al.* (2008).** Also, the non- significant effect of seeding rate on protein content was reported by **Yin *et al.* (2002)**.

3. Effect of irrigation regimes and seeding rate interaction:

There was a significant effect of the interaction between irrigation regimes and seeding rate on some studied traits (Table, 7, 8 and 9). The highest means of plant height, number of tillers/plant and flag leaf area were obtained with irrigation at 50 mm evaporation and seeding rate of 30 kg fed^{-1}, meanwhile, the same irrigation treatment with seeding rate of 50 kg fed^{-1} gave the highest number of leaves (Table 7). Also, the heaviest plant fresh and dry weights (5.39 and 2.33 g/plant, respectively) were achieved when plants irrigated at 50 mm evaporation and cultivated at the rate of 70 kg fed^{-1}.

The longest spike (6.68 cm) and highest number of grains (33.20 grain/spike) were obtained with irrigation at 50 mm evaporation and 30 kg fed^{-1} seeding rate, while, the lowest values (5.77 cm and 24.11 grain/spike, respectively) were gained with the interaction of control treatment (without irrigation) and 70 kg fed^{-1} (Table, 8). However, control treatment and 30 kg fed^{-1} interaction gave the highest grain weight (1.37 g/spike). meanwhile, the lowest mean (0.93 g/spike) was achieved with irrigation at 50 mm evaporation and seeding rate of 70 kg fed^{-1} .
Under the control treatment, there was no significant difference

between seeding rate of 30 and 50 kg fed^{-1} in concern to 1000-grain weight (29.11 and 29.13 g, respectively), while, the lowest value (26.11 g) was achieved with the interaction of irrigation at 50 mm evaporation and seeding rate of 30 kg fed^{-1}.

Table (7) : Some growth criteria of barley as affected by irrigation regimes and seeding rate interaction (Data combined across two seasons):

Irrigation depletion (mm evaporation)	Seeding rate (kg/fed)	Plant height (cm)	No Tillers/ plant	No. leaves /plant	Flag leaf Area (cm²/plant)	Plant fresh Weight (g)	Plant Dry weight (g)
50	30	69.42 a	3.88 a	13.82 c	16.02 a	4.68 c	1.88 f
	50	66.31 bc	3.65 d	15.28 a	14.36 c	4.86 bc	2.01 d
	70	62.98 fg	3.72 c	11.80 i	12.13 f	5.39 a	2.33 a
75	30	66.01 c	3.81 b	13.33 e	15.11 b	3.34 h	1.75 g
	50	64.12 d	3.38 g	14.92 b	14.02 d	3.76 ef	1.92 ef
	70	60.13 e	3.40f g	13.45 de	11.13 h	3.96 d	2.25 b
100	30	63.12 e	3.52 e	11.12 j	14.06 d	3.05 i	1.75 g
	50	62.61 g	3.23 h	13.11 fg	13.67 e	3.66 g	1.88 f
	70	59.03 hi	3.66 d	13.06 g	10.56 k	3.75 f	2.11 c
Control [1]	30	58.22 i	2.45 i	10.68 j	10.66 jk	2.67 kl	1.08 j
	50	55.38 j	2.13 j	11.22 i	10.82 i	2.64 l	1.11 ij
	70	53.39 k	2.01 k	12.01 h	11.56 gh	2.81 j	1.15 hij
F-test		**	**	*	**	**	*

* = significant at P< 0.05 and ** = significant at P< 0.01 .Means have the same letters in the same column are not significantly different at P < 0.05 level

Irrigating barley at 75 mm evaporation with seeding rate of 30 kg fed^{-1} interaction gave the highest mean of grain yield (822.6 kg fed^{-1}, Table, 9). The same seeding rate with irrigation at 50 mm evaporation gave the highest value of harvest index (36.5 %), but the highest mean of straw yield (1640.1 kg fed^{-1}) was achieved with irrigation at 50 mm evaporation and 50 kg fed^{-1}. However, the control treatment with seeding rate of 70 kg fed^{-1} gave the lowest means of grain yield, straw yield and harvest index (596.11, 1448.6 kg fed $^{-1}$and 26.0 %, respectively).

Table (8) : Some yield attributes of barley as affected by irrigation regimes and seeding rate interaction (Data combined across two seasons):

Irrigation depletion (mm evaporation)	Seeding rate (kg/fed)	Spike Length (cm)	No. Grains /spike	Grain Weight (g/spike)	1000-grain Weight (g)
	30	6.68 a	33.20 a	1.06 i	26.11 i
50	50	6.62 b	31.82 c	0.71 j	26.51 gh
	70	6.53 c	30.95 de	0.93 k	26.65 fg
	30	6.44 d	31.88 bc	1.27 d	28.88 c
75	50	6.31 e	29.17 fg	1.09 hi	26.45 h
	70	6.23 f	29.11 ef	1.10 hi	27.72 de
	30	6.12 gh	30.17 e	1.15 g	26.22 i
100	50	6.11 h	29.07 g	1.20 ef	27.85 de
	70	6.12 gh	29.05 g	1.18 fg	27.08 e
	30	6.32 i	27.12 hi	1.37 a	29.11 b
Control [1]	50	6.07 j	26.04 i	1.31 c	29.13 ab
	70	6.00 k	24.11 j	1.35 b	26.05 j
F-test		**	*	**	**

* = significant at P< 0.05 and ** = significant at P< 0.01 .Means have the same letters in the same column are not significantly different at P < 0.05 level

This high relation between the two studied factors refers to that seeding rate determine the number of plants which affects greatly on the interaspecific competition of plants for available water, light and nutrients. The water loss from cumulative pan evaporation is affected by meteorological conditions and the population of canopy which is affected by seeding rate. These results are in agreement with those of **Saber (1994); Kabirian *et al.* (1998); Mohammadi (1999) and Satari *et al.* (2001).**

According to the aforementioned results of this investigation, it could be recommended to cultivate barley under North Sinai conditions at the seeding rate of 50 kg fed^{-1} and irrigated at 75 mm evaporation to obtain a higher grain yield and the most economical use of water supply.

Table (9) : Grain, straw yield and harvest index of barley as affected by irrigation regimes and seeding rate interaction (Data combined across two seasons):

Irrigation depletion (mm evaporation)	Seeding rate (kg/fed)	Grain yield ($kgfed^{-1}$)	Straw yield (kg fed^{-1})	Harvest index (%)
	30	816.2 b	1592.1 e	36.5 a
50	50	810.4 cd	1640.1 a	29.4 d
	70	716.3 e	1609.1 cd	28.4f
	30	822.6 a	1524.3 f	36.1 b
75	50	801.6 d	1623.6 b	29.6 d
	70	708.7 f	1602.5 d	28.5 e
	30	691.2 g	1508.0 g	33.8 c
100	50	680.5 hi	1601.1 d	27.4 g
	70	678.6 i	1578.3 f	26.5 h
	30	621.3 j	1492.2 ij	28.1 f
Control (1)	50	614.5 k	1453.4 h	27.3 g
	70	**596.1 l**	**1448.6 j**	**26.0 i**
F-test		**	*	**

* = significant at $P< 0.05$ and ** = significant at $P< 0.01$ .Means have the same letters in the same column are not significantly different at $P < 0.05$ level

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الملخص العربى

تأثير معدلات التقاوى وأنظمة الرى على محصول الشعير تحت ظروف الأراضى الرملية

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أقيمت تجربة حقلية فى المزرعة التجريبية لكلية العلوم الزراعية البيئية بالعريش, جامعة قناة السويس, خلال موسمى شـــتاء ٢٠٠٦/٢٠٠٧, ٢٠٠٧/٢٠٠٨ م بهدف دراسة تأثير أربع مستويات للـــرى معاملـــة الكنترول (رى مطرى ، والرى التكميلى عند فقد ٥٠, ٧٥, ١٠٠ مـــم بخر وثلاث معدلات تقاوى (٣٠, ٥٠, ٧٠ كجم/ ف) على محـــصول الشعير (صنف جيزة ١٢٦) ومكوناته. وكـــان التـــصميم المـــستخدم قطاعات كاملة العشوائية منشقة مرة واحدة فى ثلاث مكررات. مساحة

القطعة التجريبية كانت ٧,٥ م^{٢} (١٠ خطوط : المسافة بينها ١٥ سم , وطول الخط ٥ م). استخدم نظام الرى بـــالتنقيط للـــرى التكميلـــى ، وتراوحت ملوحة مياة الرى بين ٣٥٠٠-٤٦٠٠ جزء فـــى المليـــون. وكان متوسط معدل سقوط الأمطار ١٦٠-١٨٠ مم خـــلال موســـمى الزراعة وتمت الزراعة فى ١٥, ١٠ نوفمبر فى موســـمى الزراعـــة الأول والثانى على التوالى. وكان قوام التربة رملى طينى. أوضـــحت النتائج أن الرى عند فقد ٥٠ مم بخر أعطى زيادة لمعظـــم الـــصفات المساهمة للمحصول. لم يكن هناك اختلاف معنوى بين الرى عند بخر ٧٥ و ١٠٠ مم على وزن ال ١٠٠٠ حبة , ولكنهما أعطيا قيمة أعلى من معاملة الكنترول والرى عند ٥٠ مم بخر. وأمكن الحصول علـــى أفضل محصول حبوب (٧٨١,٦ & ٧٧٨,٣ كجم/ ف) من الرى عنـــد ٥٠ و ٧٥ مم بخر, على التوالى. وعلى النقيض , فأن أعلى محصول بيولوجى ومحصول قش كان مع الرى عند ٥٠ مم بخر. وكانت أفضل كفاءة لاستخدام الماء مع الرى عند ٧٥ مم بخر, كما سجلت معاملـــة الكنترول (بدون رى) تتبعها معاملة الرى عند ١٠٠ مم بخـــر أعلـــى نسبة بروتين فى الحبوب . استخدام معدل التقاوى ٧٠ كجم/ف خفض ارتفاع النبات، مساحة ورقة العلم, طول السنبلة, وعدد الحبوب/السنبلة, ولكن زاد الوزن الغض والجاف للنبات مقارنة بمعدلات التقـــاوى ٥٠ ،و ١٠٠ كجم/ف. كما أعطى معدل التقاوى المتوسط أعلى قيما لعـــدد الأشطاء والأوراق. زاد محصول القش والمحصول البيولوجى بنـــسبة ٩,٠٣ و١٩,٤٤ % على التوالى مع زيادة معدل التقاوى من ٣٠ الى ٧٠ كجم/ف. تم الحصول على أعلـــى محـــصول حبـــوب (٧٨٧,٠ كجم/ف) , وأعلى وزن لل ١٠٠٠ حبة (25.22جم)، وأعلـــى دليـــل الحصاد (٣٦,٢ %) عند استخدام معدل التقاوى ٣٠ كجم/ف . لم يكن هناك تأثير معنوى لمعدل التقاوى على محتوى الحبوب من البروتين.

وعموما نوصى للحصول على أعلى إنتاجية من الشعير (صنف ١٢٦) تحت ظروف شمال سيناء بزراعته بمعدل تقـــاوى ٣٠ كجـــم /ف , والرى عند ٧٥ مم بخر لتحقيق أفضل استخدام اقتصادي للمياه .