J. Soil Sci. and Agric. Eng., Mansoura Univ., Vol. 3 (6): 633 - 645, 2012

EFFECT OF IRRIGATION SCHEDULING AND NITROGEN FERTILIZATION ON BARLEY YIELD AND WATER USE EFFICIENCY

Abd El-Rahman, M. F. S.[1] ; F. A. F. Khalil[2] and N. A. Anton [3]

(1) Barley Res. Dept., Field Crops Res. Inst., Agric. Res. Center.

(2) Water Requirements and Field Irrigation Res. Dept.; Soil, Water, and Environment Res. Inst., Agric. Res. Center.

(3) Crop Physiology Res. Dept.; Field Crops Res. Inst., Agric. Res. Center.

ABSTRACT

A field trial was conducted at Giza Agricultural Research Station during the two successive seasons 2009/2010 and 2010/2011 to study the response of barley to different irrigation regimes induced due to irrigating according to 1.1 (wet irrigation regime), 0.9 (medium irrigation regime) and 0.7(dry irrigation regime) coefficients for the accumulative pan evaporation (APE) records in combination with nitrogen fertilization rates of 0, 15, 30 and 45 kg Nfed^{-1}. Results of combined analysis could be summarized as follows:-

1. The assessed irrigation regimes had a significant effect on plant height, spike length, number of spikes m^{-2}, number of grains spike^{-1}, 1000 kernels weight, biological yield fed^{-1}., harvest index, grain and straw yields. The highest values of such characters were obtained for wet irrigation regime (1.1 APE) followed by medium (0.9 APE) and dry (0.7APE) ones, respectively. Protein content of barley grains increased as plants were imposed to severe water stress (dry irrigation regime, 0.7 APE).
2. Seasonal water consumptive use (WCU) was increased under wet irrigation regime (1.1 APE coefficient). Whereas, water use efficiency (WUE) increased under medium irrigation regime (0.9 APE coefficient).
3. Appling 45 kg N fed^{-1} significantly increased plant height, spike length, number of spikes m^{-2}, number of grains spike^{-1}, 1000 kernels weight, biological yield, harvest index, grain and straw yields. Furthermore, protein content of grains, seasonal water consumptive use (WCU) and water use efficiency (WUE) tended to increase due to the highest N- rate.
4. The interaction effect between irrigation regimes and nitrogen fertilization rates was found to be significant for growth, yield and its components characters. The maximum values of plant height, spike length, number of spikes m^{-2}, number of grains spike^{-1}, 1000- kernel weight, biological yield, harvest index, grain and straw yields were obtained as barley irrigated at 1.1 APE coefficient under 45 kg N fed^{-1} rate. Higher water consumptive use (WCU) values resulted from interaction of wet irrigation regime (1.1APE) and 45 kg N fed^{-1} rate. Whereas, the highest values of water use efficiency (WUE) were recorded as barley plants were irrigated at medium irrigation regime (0.9 APE) under 45 kg N fed^{-1}. The maximum values of protein content in barley grains were obtained due to irrigating at the dry irrigation regime (0.7 APE) in combination with 45 kg N fed^{-1} rate.

Keywords: Irrigation scheduling, N- fertilization, barley grain yield and yield components, Water consumptive use, water use efficiency

INTRODUCTION

In Egypt, barley (*Hordeum Vulgare* L.) is considered one of the most adapted cereal crops to water and nutrient deficiencies. Recently, a great interest was paid to barley because of its nutritive value as it is mixed with wheat in bread making industry. Barley is a very hardy crop, which could grow in adverse agro-climatic conditions, such as drought because of its ability to tolerate moderate levels of water stress. Irrigation scheduling means keeping soil moisture within a desired range, usually between field capacity (full point) and a predetermined refill point in order to avoid the problems resulted from either over or under – irrigation. Scheduling involves deciding when and how much water to apply and based on soil-based systems (monitoring soil moisture), climate-based systems or plant-based systems. Concerning climate-based systems, Phene *et al.* (1992) and Phene (1995) showed that frequent measurement of evaporation rates from an automated Class A evaporation pan corrected for water density and pan deformation errors can accurately estimate ET and be used as an irrigation scheduling tool. In addition, Ashraf *et al.* (2002) stated that the evaporation pan predicted the soil moisture close to that predicted by the gravimetric method and scheduling the irrigation, for wheat crop, saved about 50% of irrigation water irrespective of irrigation method used without affecting crop yield. Abdou *et al*. (2011) scheduled irrigation for wheat via cumulated pan evaporation(CPE) records and found that 1.2 coefficient for CPE produced the highest values of ET_c , comparable with 1.0 and 0.8 ones. El-Hawary (2000) scheduled irrigation on monitoring soil moisture basis and found that irrigating wheat plants as 75% of available water was depleted tended to reduce grain yield comparable with irrigating at 25% depletion of available soil water (control). In addition, Anton and Ahmed (2001) following the same irrigation scheduling system and reported that seasonal water consumptive use of barley increased under wet condition (irrigating as 40-45% of available soil moisture was depleted, whereas water use efficiency increased under irrigating as 60-65% of available soil moisture was depleted (medium soil moisture stress). El-Mobarak *et al*. (2007) on irrigation management, reported that irrigation in 10- day interval, comparable with 15- day one, gave the highest plant height, dry weight and grain yield of barley.

Many research trials has been postulated the importance of N-fertilization in improving growth, yield and yield components for barley crop, Radwan (1996); El-Hindi *et al* (1998) ; Nagez *et al*. (2001); Megahed (2003) and Roy and Singh (2006). Furthermore, Zeidan (2007) stated that increasing nitrogen rate increased plant height, flag leaf area, number of spikes m^{-2}, 1000-grain weight, grain yield as well as protein content of grains of barley.

The present investigation was carried out to study the effect of both different irrigation regimes(irrigation scheduling via 1.1, 0.9 and 0.7 coefficients for accumulated pan evaporation records) in combination with different rates of nitrogen fertilization e.g. zero, 15, 30 and 45 kg N fed^{-1} rates and interaction on growth, yield, some yield components and protein content of barley grains. Water relations i.e. water consumptive use (WCU) and water use efficiency (WUE) was considered.

MATERIALS AND METHODS

A field trial was carried out during 2009/10and 2010/11 seasons at Giza Agricultural Research Station (A.R.C) and some soil water constants and bulk density of the experimental site are shown in Table 1. The trials aiming at studying the effect of three irrigation scheduling treatments via 1.1, 0.9 and 0.7 coefficients for accumulative pan evaporation records and four nitrogen fertilization rates i.e. Zero, 15, 30 and 45 kg N fed^{-1} on new barely variety (Giza 132) . The experiments were laid out in a split plot design with three replicates. The main plots were occupied by irrigation scheduling treatments, while sub-plots contained nitrogen fertilization rates. The sub-plot area was10.5 m^2 (3.5×3 m), 15 rows 20 cm apart and 3.5 m long. Sowing dates were on 15/11/2009 and 17/11/2010 in the first and second seasons, respectively.

Table 1: Some soil water constants and bulk density of the experimental site.

Depth (cm)	Field capacity (%, w/w)	Wilting point (%, w/w)	Available water (%, w/w)	Available water (mm depth)	Bulk density (gcm^{-3})
0 0– 15	39.20	17.21	21.99	25.29	1.15
15 - 30	32.60	16.90	15.70	19.47	1.24
30 - 45	29.31	16.62	12.69	15.23	1.20
45 - 60	28.04	16.11	11.93	15.27	1.28
Mean	32.29	16.71	15.58	Total 75.26	1.22

The adopted treatments are as follows:

1- Main plots (irrigation scheduling treatments)

A- Irrigation according to 1.1 coefficient for accumulative pan evaporation records (designated as wet irrigation regime).

B-Irrigation according to 0.9 coefficient for accumulative pan evaporation records (designated as medium irrigation regime).

C- Irrigation according to 0.7 coefficient for accumulative pan evaporation records (designated as dry irrigation regime).

2-Sub-plots (Nitrogen fertilizer)

2.1. 0 kg N fed^{-1}. (Control) 2.2. 15 kg N fed^{-1}.

2.3. 30 kg N fed^{-1}. and 2.4. 45 kg N fed^{-1}.

In the present investigation, in order to determine the irrigation time, pan evaporation records were multiplied by the different adopted coefficient, and irrigation was practiced as the two sides of the following formula were the same.

Pan evaporation record (mm) x assessed coefficient = Available soil moisture(mm) in the root zone,60 cm depth

It is worthy to mention that 5, 4 and 3 irrigation events plus the planting one were practiced under the adopted wet, medium and dry irrigation regimes, respectively. Meteorological data for Giza region in 2009/10 and 2010/11 growing seasons are shown in Table 2.

Table 2: Meteorological data for Giza region in 2009/10 and 2010/11 growing seasons

Month	Tmax (ºC)	Tmin (ºC)	WS (ms^{-1})	RH (%)	SS (h)	SR (cal $cm^{-2}day^{-1}$)	Epan ($mmday^{-1}$)
	2009/10 growing season						
November	25.4	14.0	3.6	63	8.2	326	3.3
December	23.2	12.0	3.0	61	7.0	268	2.1
January	21.8	10.3	3.4	58	7.0	280	2.3
February	27.2	13.0	3.4	58	7.9	453	3.4
March	27.1	13.9	4.4	60	8.6	441	3.6
April	29.6	15.2	5.2	53	9.6	519	5.8
	2010/11 growing season						
Month	**Tmax (ºC)**	**Tmin (ºC)**	**WS (ms^{-1})**	**RH (%)**	**SS (h)**	**SR (cal $cm^{-2}day^{-1}$)**	**Epan ($mmday^{-1}$)**
November	27.6	14.6	3.6	67	8.2	326	2.6
December	22.3	11.5	3.0	65	7.0	268	2.1
January	21.8	9.4	3.4	61	7.0	280	2.2
February	22.9	9.8	3.4	54	7.9	453	3.5
March	24.0	11.0	4.4	58	8.6	441	4.3
April	29.3	14.7	5.2	55	9.6	519	5.3

Tmax = Maximum temperature; Tmin = Minimum temperature; WS = Wind speed; RH = Relative humidity; SS = Actual sunshine duration; SR = Solar radiation; Epan = Evaporation pan.

During seed bed preparation, 15 kg P_2O_5 fed^{-1}. was added in the form of single super phosphate (15.5 %P). Before life watering, 24 kg K fed^{-1} was added in the form of potassium sulfate (48 % K). Nitrogen fertilizer was assessed in the form of ammonium nitrate (33.5 %N) and applied in two equal doses before life irrigation and the next one. Other cultural practices were applied according to the common methods being adopted for growing barley crop at the region. Harvesting took place at 21/4/2010 and 25/4/2011 in the first and second seasons, respectively. At harvest time, ten guarded plants were randomly taken from the central row in each sub-plot to determine the following traits**:**

1- Plant height (cm). 2- Spike length (cm).
3- Number of grains $spike^{-1}$. 4- 1000-kernel weight (g).
5- number of spikes m^{-2} were determine from 1 m^2 area in each sub- plot.

In addition, plants in the central area (4 m^2) of each sub-plot were harvested to determine:

6- Grain yield (ton fed^{-1}). 7- Straw yield (ton fed^{-1})
8- Biological yield (ton fed^{-1}). 9- Harvest index (%)
10- Grain protein content was determined according to AOAC (1975).

Water Relations:

1. Water consumptive use (WCU):

On determining water consumptive use, soil samples were taken using a regular auger just before and 48 hours after each irrigation and at harvesting time in 15 cm increment system down word to 60cm of soil profile. Water consumptive use was calculated according to Israelsen and Hansen, 1962 as follows:

$$\textbf{WCU, m depth} = (\Theta_2 - \Theta_1)/100 \times (Bd) \times ERZ$$

Where:
WCU = water consumptive use, m depth
Θ_2 = Soil moisture percentage by weight 48 hours after irrigation
Θ_1 = Soil moisture percentage by weight before the following irrigation
Bd = Bulk density , g cm^{-3} and ERZ= Effective root zone, (0.6m).

Water consumptive use as ($m^3 fed^{-1}$) was obtained by multiplying the value WCU, m depth by 4200.

2. Water use efficiency (WUE):

Water use efficiency in k gm^{-3} was estimated for each treatment according to the equation described by Vites (1965*)* as follows:

$$\textbf{WUE, } kgm^{-3} = \text{grain yield}(kg\ fed^{-1}) / \text{seasonal water consumption}(m^3\ fed^{-1})$$

Data of grain yield and yield components in the two seasons were combined and statistically analyzed according to Steel and Torrie (1980). The discussion of the obtained results was carried out on the basis of combined analysis values.

RESULTS AND DISCUSSION

1. Plant height and spike length

Results in Table 3 indicate that both soil moisture regimes and nitrogen fertilization rates had significant effects on plant height and spike length. The maximum values of such characters were obtained from wet irrigation regime i.e. irrigating at 1.1 APE records. On the contrary, the minimum values were obtained from dry irrigation regime in which irrigating was practiced at 0.7 APE records. These findings could be attributed to increasing available soil moisture level, with irrigating at 1.1 APE coefficient, which enhanced plant growth by controlling the elongation of the above ground part of plant. These results are in harmony with those obtained by El-Hawary (2000) and El-Mobarak *et al*. (2007).

Regarding the effect of nitrogen fertilization rates, (Table 3), the maximum values of plant height and spike length were obtained when barley received 45 kg N fed^{-1}. In this respect, Megahed *et al*. (1999) indicated that increasing N- level for barley crop caused a significant increase in plant height.

The interaction effects between irrigation regimes and nitrogen fertilization rates on plant height and spike length was found to be significant. The maximum values of such traits were obtained from plants irrigated by wet irrigation regime (1.1 APE records) in combination with 45 kg N fed^{-1}. Similar results were obtained by Megahed *et al*. (2001).

3

2. Yield and yield components:

The adopted irrigation regimes resulted in significant effect on number of spikes m^{-2}, number of grainsspike^{-1}, 1000- kernel weight, biological yield, harvest index, grain and straw yields. (Tables 3 and 4). The highest values of such traits were scored from wet irrigation regime (irrigating at 1.1 APE records) followed by medium irrigation regime (irrigating at 0.9 APE records). While, the lowest values of barley yield and yield components were recorded from dry irrigation regime (irrigating at 0.7 APE records). Significant differences were observed between dry and wet or medium irrigation regimes. This trend could be attributed to the negative effect of soil water stress on barley growth and yield components which were in turn reflected on lower straw and grain yields. These results are in line with those reported by **Anton and Ahmed (2001).**

Concerning the effect of nitrogen fertilization, data in Table (3 and 4) show that nitrogen had a significant effect on number of spikes m^{-2}, number of grains spike^{-1}, 1000- kernel weight, biological yield, harvest index, straw and grain yields. The maximum values of such traits were obtained due to treated barley by 45 kg N fed^{-1}. However, with respect to biological yield, no significant differences were observed between applying 30 and 45 kg N fed^{-1}. These results could be ascribed to the enhancement effect of nitrogen on barley growth which, in turn reflected on higher yield components, grain and straw yields values. These results could be supported by those obtained by Roy and Singh (2006) and Zeidan (2007).

The interaction effects between the adopted irrigation regimes and nitrogen fertilization rates on number of spikes m^{-2}, number of grains spike^{-1}, 1000-kernel weight, biological yield, harvest index, straw and grain yields were found to be significant. Maximum values of such traits were obtained when barley plants were subjected to wet irrigation regime and received 45 kg N fed^{-1}. These results are in harmony with those obtained by Nagez *et al*. (2001).

3-Protein content of grains:

Data in Table 4 show that protein content in barley grains was significantly increased under dry irrigation regime (irrigating at 0.7 APE records). While, protein content was decreased significantly under wet irrigation regime (irrigating at 1.1 APE records). Plants under medium irrigation regime (irrigating at 0.9 APE records) had an intermediate value. These results are in harmony with those obtained by Anton and Ahmed (2001), who found that protein content of barley grains increased when plants were imposed to drought conditions.

Concerning the effect of nitrogen fertilization rates, data in Table 4 indicate that treated barley by 45 kg N fed^{-1} significantly increased grain protein content, compared with other three levels i. e. 0, 15 and 30 kg N fed^{-1}. Such result can be ascribed to the function of nitrogen in plant metabolism viz. constituent of amino and nucleic acids, many cofactors and cellular compounds. In this connection, Zeidan (2007) found that increasing nitrogen fertilizer rates from 30 to 70 kg N fed^{-1}. To barley plants increased protein content of grains.

4

The interaction effect between irrigation regimes and nitrogen fertilization rates exhibited a significant effect on protein content of barley grains. The highest value of such trait was obtained from barley plants irrigated according to dry irrigation regime (0.7 APE records) and received 45 kg N fed^{-1} rate.

4- Water relations:

4-1- Seasonal water consumption use (WCU):

Seasonal water consumptive uses by barley plant under the adopted treatments are presented in Table 5. Results indicated that the values of WCU for barley plant ranged from1286 to 889 $m^3 fed^{-1}$ with respect to the mean of both growing seasons. The results revealed that water consumption use (WCU) increased with increasing soil moisture by frequent irrigation. The highest (WCU) was achieved under wet irrigation regime (irrigating at 1.1 APE records), Nevertheless, the lowest value was obtained when dry irrigation regime was practiced (irrigating at 0.7 APE records). The medium irrigation regime (irrigating at 0.9 APE records) had an intermediate value. Such results could be explained on the basis that frequent irrigation provides chance for more luxuriant use of soil water. These finding could be ascribed to the availability of soil water to barley plants in addition to higher evaporation rate from the wet soil surface than the dry one. In this connection, El-Rais *et al*. (1999) showed that total water use by barley crop was increased with increasing the amount of applied water up to 400 mm $season^{-1}$.

Regarding to the effect of nitrogen fertilization rates, results indicated that the maximum value of WCU was obtained when barley plants treated with 45 kg N fed^{-1} rate. Such results may be due to that applying higher nitrogen rate enhancing barley growth which in turn increased plant canopy thereby increasing transpiring surface which reflected on higher seasonal water consumptive use. In this sense, Ouda *et al*, (2007) obtained similar trends with the same crop.

As for the interaction effect between irrigation regimes and nitrogen fertilization rates, data in (Table 5). It is clear that the highest value of WCU was scored from wet irrigation regime and applying 45kg N fed^{-1}.

4-2- Water use efficiency:

In arid regions where is the limiting factor in the expansion of cultivated area the primary management objective is the development of water use program that will provide maximum yield per unit of water consumed by plants. Water use efficiency (WUE) for barley expressed as kg of grains produced per m^3 of water consumed in the herein study is presented in Table 5. Results indicated that water use efficiency value was higher under medium irrigation regime (irrigating at 0.9 APE records), while lower values were recorded under wet and dry ones. These results may be due to the higher barley grain yield resulted from medium treatment and the less water consumed by such treatment. On the contrary, dry irrigation regime caused a drastic reduction in barley yield more than the reduction in water consumption thereby resulted in lower values of water use efficiency (WUE). Under wet irrigation regime (irrigating at 1.1 APE records) barley yield was slightly higher than under medium irrigation regime and consumed more water compared with medium irrigation regime which in turn resulted in a lower water use efficiency values. It could be concluded that barley crop consumed the soil water efficiently under medium irrigation regime comparable with either wet or dry irrigation regimes. In other words, maintaining soil moisture level at medium condition (irrigating at 0.9 APE records) not only increased crop productivity but also allows the plants to use the soil water efficiently. Similar results on barley was obtained by Anton and Ahmed (2001).

Table 5: Seasonal water consumptive use and Water use efficiency as affected by irrigation regimes and nitrogen fertilization rates in 2009/10 and 2010 / 11 seasons

Irrigation regime	Fertilizer Nitrogen rate	Seasonal water consumptive use (WCU, m^3 fed^{-1})			Water use efficiency (WUE, kg m^{-3})		
		Season 2009/10	Season 2010/11	Mean	Season 2009/10	Season 2010/11	Mean
1-1 APE (Wet)	0 kg N fed^{-1}.	1222	1199	1211	2.11	2.07	2.09
	15 kg N fed^{-1}.	1249	1216	1233	2.20	2.17	2.19
	30 kg N fed^{-1}.	1269	1250	1260	2.36	2.30	2.33
	45 kg N fed^{-1}.	1296	1275	1286	2.40	2.34	2.37
Mean		1259	1235	1248	2.27	2.22	2.25
0.9 APE (Medium)	0 kg N fed^{-1}.	1020	1013	1017	2.17	2.10	2.14
	15 kg N fed^{-1}.	1040	1019	1030	2.27	2.21	2.24
	30 kg N fed^{-1}.	1070	1057	1064	2.40	2.33	2.37
	45 kg N fed^{-1}.	1098	1078	1088	2.43	2.37	2.40
Mean		1057	1042	1050	2.32	2.25	2.29
0.7 APE (Dry)	0 kg N fed^{-1}.	891	886	889	1.86	1.80	1.83
	15 kg N fed^{-1}.	909	894	902	1.94	1.89	1.92
	30 kg N fed^{-1}.	947	934	941	2.04	1.98	2.01
	45 kg N fed^{-1}.	968	953	961	2.06	2.01	2.04
Mean		929	917	923	1.98	1.92	1.95
general mean of nitrogen fertilization	0 kg N fed^{-1}.	1044	1033	1039	2.05	1.99	2.02
	15 kg N fed^{-1}.	1066	1043	1055	2.14	2.09	2.12
	30 kg N fed^{-1}.	1095	1080	1088	2.27	2.20	2.24
	45 kg N fed^{-1}.	1120	1102	1112	2.30	2.24	2.27

Regarding the effect of nitrogen fertilizer rates on the values of water use efficiency (WUE), results in Table 5 show that increasing nitrogen rate up to 45 kg N fed^{-1} seemed to improve WUE, The increase in WUE values with increasing nitrogen rates could be attributed to that the increase in grain yield was higher than that in water consumed by barley plants, hence, WUE values tended to improve. These results are in harmony with those obtained by Megahed *et al*. (2001) and Nagaz *et al*. (2001).

The interaction effect between irrigation regimes and nitrogen fertilization rates, data in Table 5 showed that the maximum values of WUE for barley crop was obtained under irrigating via medium irrigation regime (irrigating at 0.9 APE records) in combination with 45 kg N fed^{-1} rate.

CONCLUSION

In the light of the present results, it is clearly that the maximum grain yield of barley was obtained due to wet irrigation regime (irrigating at 1.1 APE records) in combination with applying 45 kg N per feddan. However, from the economic point of view and water resources conservation, it is advisable to practice medium irrigation regime (irrigating at 0.9 APE records) in combination with 45 kg N fed^{-1} rate under Giza region conditions.

REFERENCES

Abdou, S.M.M.; R.M. F. Farrag ; M.F.I. EL- Akram and M.R.K. Ashry (2011). Water relations and yield of wheat under different N- fertilizer forms and scheduling irrigation. J. soil. Sci. and Agric. Eng., Mansoura Univ., 2(1): 25- 41.

Anton, N. A. and A. H. Ahmed (2001). Productivity of barley plant under water deficit and foliar application of Potassium. J. Agric. Sci., Mansoura Univ., 26 (6): 3341–3357.

A.O.A.C. (1975). Official Methods of Analysis 11th Ed., Association of Official Agriculture Chemists. Washington. D. C.,USA.

Doorenbos, J., Pruitt, W.O.,(1992). Guidelines for Predicting Crop Water Requirement. FAO, Irrigation and drainage. No. :24 Roma.

Ashraf, M.; M. M. Saeed and M. N. Asgher (2002).Evaporation Pan: A Tool for Irrigation Scheduling. Journal of Drainage and Water Management, Vol.6(1) :45 -51.

El–Hawary, M,A. (2000). Evaluation of some wheat varieties under water deficit condions. Zagaziz J. Agric. Res., 27 (4): 819 -830.

El- Hindi, M.H. :A.T. El-Kassabey; A.E. Sharief and K.A. Amer (1998). Yield of barley as affected by different sources and levels of nitrogen fertilization under the environmental conditions of newly reclaimed soils Northen Delta of Egypt. Proc. 8th Conf. Agron, Suez Canal Univ., Ismailia, Egypt, 28-29 Nov., 153-158.

El- Mobarak, A. A.: Mahasin Mohamed: M. A. Khair; A. Abdelwahab and C.Richter (2007). Effect of irrigation interval, sowing method and nitrogen application on forage and grain yield of barley in the Gezira Scheme, Sudan.Tropentag, October 9 -11, Witzenhausen “ Utilisatioin of diversity in land use systems : Sustainable and organic approaches to meet human needs.”

El-Rais, A. A.; N. A. Anton; F. A. Abbas and G. M. Gad El – Rab. (1999). Sprinkler irrigation management for barley in sandy soil. Third Conference of On-Farm Irrigation and Agroclimatology, January 25 – 27, 1 (1) : 297 – 312.

Israelsen, O. W. and V. E. Hansen (1962). Irrigation Principles and Practices. Third Ed., John Willey and Sons. Inc. New York.

Megahed, A. A. (2003). Effect of seeding rates and nitrogen fertilizer levels on newly hull–less barley line under sprinkler irrigation system in poor sandy soils at Ismailia Governorate. Egypt. J. Appl. Sci., 18 (2): 108 – 119.

Megahed, M. A.; A. M. Orabi and A. A. Badwy (1999). Effect of irrigation intervals and nitrogen levels on barley under New Valley conditions. Nile Valley and Red Sea Regional Program. ICARDA. 11th Annual Coordination Meeting. Egypt, ARC, Cairo, 5–9 September.,: 105 –109.

Megahed, M. A:. Samia G.A. Mohamed and A.M.A. Ali (2001). Determination of the important factors of barley yield under different NPK fertilizer regime in new reclaimed soil. Fayoum J. Agric. Res. Dev., 15(2):125-134.

Nagaz, K.:, N.B Mechlia and V. R. Onheld (2001). Effect of water quality and nitrogen on yield components and water use efficiency of barley. 14th International Plant Nutrition Conf. Hanover, Germany, 396 -397.

Ouda, S. A.: T. El-Mesiry and M.S. Gaballah. (2007). Effect of using stabilizing agents on increasing yield and water use efficiency in barley grown under water stress. Aust. J. Basic Appl. Sci., 1(4):571-577.

Phene, R.C. (1995). Class "A" evaporation pan for irrigation scheduling in real-time. Proc. Inter. Expo. And Tech. Conf., Phoenix, AZ. p153-160.

Phene, C.J.; W.R. DeTar and D.A. Clark (1992). Real-time irrigation scheduling of cotton with an automated pan evaporation system. App. Engineer in Agric, 8(6):787-793.

Radwan, F. I. (1996).Yield and yield attributes of barley and faba been as affected by different intercropping pattern and nitrogen fertilization. Annals Agric. Sci., Moshtohor, 34 (3):767- 788.

Roy, O. K. and B. P. Singh (2006). Effect of level and time of nitrogen application with and without vermicompost on yield, yield attributes and quality of malt barley (Hardeum vulgare). India J. Agron., 51 (1). 513-523.

Steel, R. G. D. and J. H. Torrie (1980). Principles and Procedures of Statistics, 2nd . Ed. McGraw. Co., New York, USA.

Vites, F. G. Jr. (1965). Increasing water use efficiency by soil management. In W. H. Pierre, D. Kirkham, J. Pesek and R. Shaw (Eds) . “Plant environment and efficient water use”. Amer. Soc. Agron. Madison, Wisc.,. 259 –274.

Zeidan, M. S. (2007). Response of some barley cultivars to nitrogen sources and rates grown in alkaline sandy soil. Res. J. Agric. and Bio. Sci., 3 (6) : 934 – 938.

تأثير جدوله الري والتسميد النيتروجيني على محصول الشعير وكفاءه استخدام المياه

محمود فهمى سعد عبد الرحمن[١] ، فؤاد أحمد فؤاد خليل[٢] و ناجى عبدة انطون[٣]
١- قسم بحوث الشعير – معهد بحوث المحاصيل الحقلية.
٢- قسم بحوث المقننات المائية والرى الحقلى – معهد بحوث الأراضى والمياه والبيئة
٣- قسم بحوث فسيولوجيا المحاصيل - معهد بحوث المحاصيل الحقلية.

أجريت تجربة حقلية بمحطة بحوث الجيزة خلال موسمي 2009 /2010 و 2010 / 2011 لدراسة استجابة الشعير لجدولة الري باستخدام معاملات مختلفة لقيم وعاء البخر القياسي هي ١.١ ،٠.٩ ، ٠.٧ , APE و عرفت معاملات رطبه ، متوسطه وجافه على الترتيب وكذلك التسميد النيتروجيني بدون ، ١٥ ؛ ٣٠ ؛ ٤٥ كجم نيتروجين / فدان

ويمكن تلخيص النتائج فيما يلى:

١- كان تأثير معاملات الري معنوي على طول النبات ، طول السنبلة ، عدد السنابل / م٢ ، عدد الحبوب /سنبلة ، وزن ال١٠٠٠ حبة ، المحصول البيولوجى / فدان ، دليل الحصاد ، محصول الحبوب والقش/ فدان . وكانت اعلى القيم للصفات السابقة عند الرى بالمعامله الرطبه (١.١ APE) يليها المعاملة المتوسطة (٠.٩ APE) ثم المعاملة الجافة (٠.٧ APE) على التوالى وكانت اعلى قيم لمحتوى حبوب الشعير من البروتين عند الرى بالمعاملة الجافة (٠.٧ APE) وقد أدى الرى بالمعاملة الرطبة (١.١APE) لزيادة الاستهلاك المائى الموسمى (WCU) بينما ادى الرى بالمعاملة المتوسطة (٠.٩ APE) الى زيادة قيمة كفاءة استعمال المياة (WUE).

٢- أدى اضافة ٤٥ كجم نيتروجين / فدان الى زيادة معنوية فى طول النبات ، طول السنبلة ، عدد السنابل /م٢ ، عدد الحبوب / سنبلة ، وزن ال ١٠٠٠ حبة ، المحصول البيولوجى / فدان، دليل الحصاد ، محصول الحبوب والقش / فدان وكذلك محتوى الحبوب من البروتين و الاستهلاك المائى الموسمى (WCU) وكفاءه استعمال المياه (WUE) .

٣- كان تأثير التفاعل بين معاملات الري والتسميد النيتروجيني معنويا على صفات النمو والمحصول ومكوناته . وقد سجلت أعلى قيم لطول النبات ، طول السنبله ، عدد السنابل / م٢، عدد الحبوب / سنبله ، وزن ال ١٠٠٠ حبه ، المحصول البيولوجى / فدان ، دليل الحصاد ، محصول الحبوب والقش / الفدان ، الاستهلاك المائى الموسمى (WCU) عند معاملة نباتات الشعير بالمعاملة الرطبة (١.١ APE) والتسميد بمعدل ٤٥ كجم نيتروجين / فدان بينما كانت أعلى قيمة لكفاءة استعمال المياه (WUE) مع معاملة الري المتوسطة (٠.٩ APE) واضافة ٤٥ كجم نيتروجين / فدان) وقد كانت أعلى قيمة لمحتوى الحبوب من البروتين مع معاملة الري الجافة (٠.٧ APE) مع اضافة ٤٥ كجم نيتروجين / فدان.

قام بتحكيم البحث

أ.د / خالد حسن الحامدى	**كلية الزراعة – جامعة المنصورة**
أ.د / حماده حسين عبد المقصود	**مركز البحوث الزراعية**

Table 3: Effect of irrigation treatments and nitrogen fertilizer levels on growth and yield components of barley in 2009 /10, 2010 /11 seasons and combine analysis.

Irrigation regime	Nitrogen rate	Plant height (cm)			Spike length (cm)			No of spikes m^{-2}			No .of grains $spike^{-1}$			1000-kernel weight (g)		
		2009/10	2010/11	Comb.	2009/10	2010/11	Comb.	2009/10	2010/11	comb.	2009/10	2010/11	Comb.	2009/10	2010/11	Comb.
1-1 APE (wet)	0KgN fed^{-1}	82.5	79.30	80.90	8.35	8.03	8.19	221.0	212.4	216.7	41.4	39.8	40.6	42.62	41.00	41.81
	15KgN fed^{-1}	88.0	84.20	86.10	8.91	8.53	8.72	235.8	225.6	230.7	44.2	42.2	43.2	45.51	43.45	44.48
	30KgN fed^{-1}	96.0	92.00	94.00	9.72	9.32	9.52	257.2	246.4	251.8	48.3	46.3	47.3	49.74	47.68	48.71
	45KgN fed^{-1}	99.5	95.30	97.40	10.07	9.65	9.86	266.5	255.3	260.9	50.0	47.8	48.9	51.49	49.23	50.36
Mean		91.5	87.70	89.60	9.26	8.88	9.07	245.1	234.9	240.0	46.0	44.0	45.0	47.34	45.34	46.34
0.9 APE (medium)	0KgN fed^{-1}	78.5	75.50	77.00	7.78	7.57	7.72	214.5	206.3	210.4	38.3	36.9	37.6	40.97	39.47	40.22
	15KgN fed^{-1}	83.8	80.20	82.00	8.40	8.04	8.22	227.9	218.1	223.0	40.9	39.1	40.0	43.75	41.83	42.79
	30KgN fed^{-1}	91.4	87.60	89.50	9.16	8.78	8.97	248.6	238.2	243.4	44.5	42.7	43.6	47.60	45.68	46.64
	45KgN fed^{-1}	94.7	90.70	92.70	9.49	9.09	9.29	256.5	245.7	251.1	46.2	44.2	45.2	49.42	47.28	48.35
Mean		87.1	83.50	85.30	8.73	8.37	8.55	236.9	227.1	232.0	42.5	40.7	41.6	45.44	43.56	44.50
0.7 APE (dry)	0KgN fed^{-1}	73.0	70.40	71.70	6.87	6.63	6.75	181.1	174.7	177.9	33.8	32.6	33.2	38.73	37.35	38.04
	15KgN fed^{-1}	77.9	74.70	76.30	7.33	7.03	7.18	193.3	185.3	189.3	36.1	34.7	35.4	41.36	39.76	40.56
	30KgN fed^{-1}	85.0	81.60	83.30	8.00	7.68	7.84	210.9	202.5	206.7	39.4	37.8	38.6	45.14	43.30	44.22
	45KgN fed^{-1}	88.1	84.50	86.30	8.29	7.95	8.12	218.6	209.6	214.1	40.8	39.2	40.0	46.75	44.91	45.83
Mean		81.0	77.80	79.40	7.62	7.32	7.47	201.0	193.0	197.0	37.5	36.1	36.8	43.00	41.33	42.16
General mean of nitrogen fertilization	0KgN fed^{-1}	78.0	75.10	76.50	7.70	7.41	7.55	205.5	197.8	201.7	37.8	36.4	37.1	40.77	39.27	40.02
	15KgN fed^{-1}	83.2	79.70	81.50	8.21	7.87	8.04	219.0	209.7	214.3	40.4	38.7	39.5	43.54	41.68	42.61
	30KgN fed^{-1}	90.8	87.10	88.90	8.96	8.59	8.78	238.9	229.0	234.0	44.1	42.3	43.2	47.49	45.55	46.52
	45KgN fed^{-1}	94.1	90.20	92.10	9.28	8.90	9.09	247.2	236.9	242.0	45.7	43.7	44.7	49.22	47.14	48.18
General mean		86.5	83.00	84.80	8.57	8.19	8.36	227.7	218.3	223.0	42.0	40.3	41.1	45.26	43.41	44.33
LSD 0.05	I	3.7	3.50	2.30	0.41	0.38	0.27	9.7	9.2	6.1	2.8	2.7	1.8	1.94	1.83	1.20
	N	2.6	2.50	1.60	0.30	0.28	0.19	6.8	6.6	3.2	2.0	1.9	1.3	1.36	1.31	0.84
	IXN	5.5	5.20	3.50	0.57	0.53	0.36	14.5	13.7	9.2	4.2	4.0	2.7	2.88	2.72	1.82
C.V				8.32			7.56			15.33			10.09			7.11

Table 4: Effect of irrigation treatments and nitrogen fertilizer levels on yield and grain protein content of barley in 2009/10, 2010/11 seasons and combine analysis.

Irrigation regime	Nitrogen rate	Biological yield (ton fed^{-1})			Grain yield (ton fed^{-1})			Straw yield (ton fed^{-1})			Harvest index (%)			Protein in grains (%)		
		2009/10	2010 /11	comb.	2009/10	2010/11	comb.	2009/1	2010/11	comb.	2009/10	2010/11	comb.	2009/10	2010 /11	comb.
1-1 APE (wet)	0KgN fed^{-1}	7.989	7.781	7.885	2.577	2.479	2.528	5.412	5.302	5.357	32.26	31.86	32.06	11.68	11.44	11.56
	15KgN fed^{-1}	8.303	8.047	8.175	2.751	2.633	2.692	5.552	5.414	5.483	33.13	32.72	32.93	12.32	12.04	12.18
	30KgN fed^{-1}	8.850	8.584	8.717	3.000	2.877	2.939	5.850	5.707	5.779	33.90	33.52	33.71	13.10	12.74	12.92
	45KgN fed^{-1}	8.970	8.694	8.832	3.109	2.979	3.044	5.861	5.715	5.788	34.66	34.26	34.46	13.46	13.06	13.26
Mean		8.528	8.276	8.402	2.859	2.742	2.801	5.669	5.534	5.602	33.49	33.09	33.29	12.64	12.32	12.48
0.9 APE (medium)	0KgN fed^{-1}	7.114	6.940	7.027	2.209	2.125	2.167	4.905	4.815	4.860	31.05	30.62	30.84	12.26	11.94	12.10
	15KgN fed^{-1}	7.371	7.153	7.262	2.358	2.256	2.307	5.013	4.897	4.955	32.00	31.54	31.77	13.00	12.62	12.81
	30KgN fed^{-1}	7.819	7.593	7.706	2.571	2.465	2.518	5.248	5.128	5.188	32.88	32.46	32.67	13.88	13.42	13.65
	45KgN fed^{-1}	7.923	7.687	7.805	2.664	2.552	2.608	5.259	5.135	5.197	33.62	33.20	33.41	14.37	13.85	14.11
Mean		7.557	7.343	7.450	2.450	2.350	2.400	5.106	4.994	5.050	32.39	31.95	32.17	13.38	12.96	13.17
0.7 APE (dry)	0KgN fed^{-1}	5.820	5.714	5.767	1.656	1.598	1.627	4.164	4.116	4.140	28.45	27.97	28.21	12.70	12.34	12.52
	15KgN fed^{-1}	5.989	5.841	5.915	1.766	1.694	1.730	4.223	4.147	4.185	29.49	29.00	29.25	13.55	13.13	13.34
	30KgN fed^{-1}	6.303	6.147	6.225	1.928	1.850	1.889	4.375	4.297	4.336	30.59	30.09	30.34	14.50	14.00	14.25
	45KgN fed^{-1}	6.382	6.220	6.301	1.998	1.916	1.957	4.384	4.304	4.344	31.31	30.80	31.05	15.05	14.45	14.75
Mean		6.123	5.981	6.052	1.837	1.765	1.801	4.286	4.216	4.251	29.96	29.46	29.71	13.95	13.48	13.71
General mean of nitrogen fertilization	0KgN fed^{-1}	6.974	6.812	6.893	2.147	2.067	2.107	4.827	4.744	4.786	30.59	30.15	30.37	12.21	11.91	12.06
	15KgN fed^{-1}	7.221	7.014	7.117	2.292	2.194	2.243	4.929	4.819	4.874	31.54	31.09	31.32	12.96	12.60	12.78
	30KgN fed^{-1}	7.657	7.441	7.549	2.500	2.397	2.449	5.158	5.044	5.101	32.46	32.02	32.24	13.83	13.39	13.61
	45KgN fed^{-1}	7.758	7.534	7.646	2.590	2.482	2.536	5.168	5.051	5.110	33.20	32.75	32.97	14.29	13.79	14.04
General mean		7.403	7.200	7.301	2.382	2.286	2.334	5.020	4.915	4.968	31.95	31.50	31.72	13.32	12.92	13.12
LSD 0.05	I	0.354	0.334	0.224	0.116	0.108	0.073	0.240	0.228	0.152	1.53	1.46	0.97	0.65	0.61	0.41
	N	0.259	0.246	0.164	0.085	0.080	0.054	0.176	0.168	0.112	1.12	1.08	0.71	0.48	0.45	0.30
	IXN	0.492	0.466	0.311	0.160	0.150	0.101	0.337	0.323	0.214	2.12	2.04	1.35	0.90	0.85	0.57
C.V				14.12			13.28			15.85			8.56			4.67

-٥