EFFECT OF IRRIGATION PERIODS ON BARLEY GRASS FODDER PRODUCTION USING HYDROPONICS SYSTEM

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ABSTRACT

A laboratory experiments were conducted during 2011 and 2012 at the growth room of the Plant Production Laboratory, Environmental Studies and Research Institute, Sadat City University, using complete randomized design with four replications in order to evaluate yield, water use efficiency (WUE) and quality of barley fodder irrigated with three irrigation periods: (2, 3 and 4 min / 4h), under hydroponics system. Barley grains (Giza 124) of a commercial grade with good viability (80-85%) were sterilized with 20% sodium hypochlorite solution to control fungal growth. Seeds were sown in stacked trays in a temperature controlled room. Plants were harvested 7 days after sowing. Fresh fodder and dry fodder weight, the germination percentages and the amount of water used were recorded. Representative fresh green fodder samples from each treatment were oven-dried at 70^{o}C for 48 hrs and analyzed. Crude protein and crude fiber were determined. Results indicated that germination percent and yield of barley increased as the increasing of irrigation periods increased; however, the increase in WUE was increased with the decreasing of irrigation periods. Proximate chemical analyses indicated that there was significant effect of treated sewage on moisture, crude protein, crude fiber and fat of the barley fodder.

Keywords: *Irrigation; barley; grass fodder and hydroponics system*

INTRODUCTION

The Egyptian Agriculture is one of the oldest agriculture civilizations in the world. Egypt occupies a total area of about 100 million hectares, out of this area, is about 3.1 million hectares as cultivated area covering three different production zones:

1. The old irrigated lands with an area of 2.3 millions hectares lying in the Nile Valley and Delta and most is fertile soils. 2. The newly reclaimed lands (0.8 million hectares included sandy and calcareous soils, the soil is poor in organic matter and macro-and micronutrients). 3. The rain fed area is about 0.1 million hectares of sandy soil located in the Northwest Coast and North Sinai (Abd El Hadi, 2004)

Egypt is almost entirely dependent upon a single water resource, the Nile, and uses 100% of its water allocation of 55.5 billion m^3, allocated under the terms of the 1959 Nile water agreement *(Radwan, 1998).* Agriculture presently accounts for an estimated 86% of water use in Egypt *(CAPMAS, 2008).* In the face of growing demand for - and dwindling supplies of - water, evidence based water allocation policies will be needed to help make the most productive use of water.

Where water resources are limited the availability for agricultural production is constrained and consequently the need to increase water productivity - the ratio of the net benefits from crop, forestry, fishery, livestock, and mixed agricultural systems to the amount of water required to produce these benefits *(CA, 2007)* - becomes essential in order to increases the availability of water for other human productive and non-productive uses.

Hydroponics technique can be used to produce fodder in very short periods (7-10 days) and it has been proven to be efficient both financially and environmentally *(*Rotar, 2004*).* It is estimated that with this technique, the costs of agricultural inputs are at least 10 times lower than under field conditions (Mooney, 2005). High water use efficiency is, however, a major

advantage of this technique which saves about 95-97% of used water in comparison to conventional agriculture with small piece of land (Al Hashmi, 2006).

The present study aimed to investigates yield and WUE of the hydroponically produced barley sprouts using three irrigation periods (2, 3 and 4 min / 4h).

MATERIALS AND METHODS

The research has been carried out during 2011and 2012 at the growth room of the Plant Production Laboratory, Environmental Studies and Research Institute, Sadat City University.

The hydroponics system:

The hydroponics system is composed of two cabinets (units) with metal frame and four shelves each with a length of 200 cm, a width of 50 cm, and a height of 240 cm. Each unit of the system could carry 28 planting trays with capacity to produce approximately 80-100 kg green fodder per growth cycle (7 days). The number of units of the hydroponics system can be increased and planting date scheduled for daily production of green fodder to meet the daily demand of animals in the farm. Polystyrene trays with a length of 40 cm, a width of 20 cm and a depth of 8 cm were used for growing grains (100g/tray) to produce green fodder. The units of hydroponics system have been arranged in the growth room close to window to utilize natural illumination. An air conditioning unit was used to control temperature inside the growth room which was maintained at 24±2ºC. The relative humidity in the growth room ranged between 65 ±5 percent.

Plant material:

Barley (Giza 124) grains were subjected to a germination test to check for their viability before being used. The results showed that the germination percentage was 95%.

Treatment of seeds and planting:

Grains of barley were cleaned from debris and other foreign materials. Then the cleaned seeds were surface sterilized by soaking for 30 minutes in a 20% sodium hypochlorite solution (Clorox bleach) to prevent the formation of mould. Planting trays and the growing cabinet also were cleaned and disinfected. The seeds were washed well from residues of bleach and re-soaked in tap water overnight (about 12 hours) before sowing.

Irrigation treatments:

Trays were irrigated daily with three Irrigation periods: (2, 3 and 4 min / 4h). Some physical and chemical properties of water used for irrigation in this study are presented in Table (1a).

Table (1a): Some physical and chemical properties of water used for irrigation in this study.

SAR	EC	PH	SO_4	CL	$CaCo_3$	K	Na	Mg	Ca
	ds/m		Meq/L						
3.3	2.17	7.10	7.5	12.3	1.9	0.22	8.4	8.5	4.5

Water use efficiency:

Water use efficiency (WUE) was computed according to:

WUE= kg. Green fodder produced/ L water used.

Nutrient solution:

(M.S) were applied at rate of 0.5 g/litter of water, Murashige and Skoog (1962) Table (1b).

Table (1b): Composition of basal medium of Murashige and Skoog (1962).

Constituent	Concentration
Marco-nutrients: (mg/L)	
NH_4NO_3	1650
KNO_3	1900
$CaCl_2.2H_2O$	440
$MgSO_4.7H_2O$	370
KH_2PO_4	170
Micro- nutrients: (mg/L)	
$MnSO_4.4H_20$	22.30
$ZnSO_4.4H_2O$	8.60
H_3BO_3	8.20
KI	0.83
$NaMo0_4.2H_20$	0.25
$CuS0_4.5H_20$	0.025
$CoCl_2.6H_2O$	0.025
Iron: (mg/L)	
Na_2EDAT	37.25
$FeSO_4.7H2O$	27.25
Vitamin: (mg/L)	
Nicotinic acid	0.5
Pyridoxine-HCL	0.5
Thiamine-HCL	0.1
Myo -inositol	100.0
Amino: (mg/L)	
Glycine	2.0
Sucrose (g/L)	30.0

Fodder yield:

At the end of experiment (7 days after seeding), the produced green fodder was ready for harvest, and green plants with their root mats in the trays (Figure 1) were harvested and the following data were recorded: Herb fresh yield (kg/m^2), Root fresh yield (kg/m^2), herb dry yield (kg/m^2), root dry yield (kg/m^2), moisture content of herb (%) and root, protein content in herb(%) and root, WUE (kg/L), ratio of produced fodder/ planted seed weight , fat content in herb and root (%), and fiber content in herb and root (%).

Fig. (1): Green fodder was ready for harvest

Fig. (2)

Experimental design and statistical analysis:

The completely randomized design (CRD) was used with four replicates. Data were statistically analyzed using analysis of variance (ANOVA) according to the statistical package MSTAT-C (Michigan State Univ., East Lansing, MI, USA). Probabilities of significance among treatments and LSD (a 0.05) were used to compare means among treatments.

RESULTS AND DISCUSSION

Herb, root fresh weight and dry weight of plant were significantly increased with increasing irrigation treatment up to the highest rate of water Table (2). Application of water at the period of 4 min. /4h. recorded the highest values of herb, root fresh weight and dry weight of barely (21.936, 4.364, 2.343 and 0.433 kg/m^2, respectively), while the lowest values were obtained with the lowest irrigation time 2 min./4h (21.136, 3.822 , 1.999 and 0.411 kg/m^2) for herb, root fresh weight and herb, root dry weight, respectively.

The favorable effect of water quantity on plant growth through the important functions of water in plant metabolism, cell division, and differentiation and enlargement of cells and that might be due to its favorable effect on all fresh weight of different plant organs. Similar results were obtained by Al-Ajmi *et al*. (2009) and Fazaeli *et al*. (2011).

Table (2): Effect of irrigation period on herb, root fresh weight and dry weight of barley (combined data).

Irrigation treatments	Herb fresh yield (kg/m^2)	Root fresh yield (kg/m^2)	Herb dry yield (kg/m^2)	Root dry yield (kg/m^2)
2 min./4h.	21.136	3.822	1.999	0.411
3 min./4h.	21.506	4.097	2.207	0.414
4 min./4h.	21.936	4.364	2.343	0.433
LSD at 0.05 level	0.04	0.04	0.05	0.002

Moisture content in herb significantly increased with irrigation treatment 2 min./4h and recorded 90.21 % , while 4 min./4ha irrigation gave the lowest value of moisture content (89.04%) as shown in (Table 3). On the contrary, the maximum moisture content in root (88.01 %) was obtained with 4 min. /4h irrigation, while the minimum value (87.45 %) was obtained with 2 min./ 4ha irrigation. These findings are in agreement with those indicated by Morgen *et al*. (1992) and Mona El-Deeba *et al*. (2009).

While the Protein % in herb significantly increased with increasing irrigation treatment up to 4 min./4h and recorded 26.178 % , while 2 min./4ha irrigation gave the lowest value of protein content (25.533%) as in (Table 3).

On the contrary, protein % in root significantly increased with decreasing irrigation treatments up to the lowest rate (15.964 %), while irrigation treatments up to the highest rate 4 min. / 4h gave the lowest protein content in root (15.433 %). These results are in harmony with those obtained by Mona El-Deeba *et al.* (2009).

Table (3): Effect of irrigation period on herb, root moisture content and protein content of barley (combined data).

Irrigation treatments	Moisture content of herb (%)	Moisture content of roots (%)	Protein content in herb	Protein content in roots
2 min./4h.	90.217	87.450	25.533	15.964
3 min./4h.	89.536	87.733	25.639	15.728
4 min./4h.	89.025	88.011	26.178	15.433
LSD at 0.05 level	0.22	0.30	0.103	0.09

Water use efficiency by barely was significantly decreased with increasing irrigation treatment up to the highest rate of water. (Table 4)

Application of water at the period of 2 min./4h. recorded the highest value of herb WUE (1.968 kg/L), while the lowest values were obtained with the highest irrigation period 4 min./4h (1.812 kg/L). Irrigation at 3 min/4h recorded intermediate value (1.863 kg/L). Morgen *et al.* (1992) and Mona El-Deeba *et al.* (2009).

While the ratio of produced fodder planted seed weight of barely was significantly increased with increasing irrigation treatments up to the highest rate (4 min/4h.) and gave the highest value (5.817) as shown (Table 4).

While the lowest value (5.433) was obtained with irrigation treatment at 2 min/4h. On, the other side, irrigation treatment at 3 min/4h. gave intermediate value between them (5.650). These findings are in agreement with those reported by Al-Hashimi (2008) and Al-Karaki (2008).

Table (4): Effect of irrigation period on water use efficiency and the ratio of produced fodder planted seed weight of barely.

Irrigation treatments	WUE (kg/L)	Ratio of produced fodder/ planted seed weight
2 min./4h.	1.968	5.433
3 min./4h.	1.863	5.650
4 min./4h.	1.812	5.817
LSD at 0.05 level	0.03	0.096

Irrigation treatments of barely under hydroponics system had significantly increased fat content in herb and root. (Table 5). Fat content% in herb was significantly decreased with increasing irrigation treatment up to the highest rate of water. Application of water at the time of 2 min./4h. recorded the highest value in herb (5.106%). while the lowest value was obtained with the highest irrigation time 4 min./4h (5.058%) without significant differences between irrigation time 3 min./4h. As for root fat content, the highest value was obtained by irrigation treatments 3 min./4h. (6.017%) without significant differences between irrigation time 4 min./4h, while the lowest value was obtained by irrigation treatments 2 min./4h. (5.983%). Al-Karaki (2011) recorded similar results .Fiber content in herb was significantly increased with decreasing irrigation treatment up to the lowest irrigation rate (Table 5). Application of water at the time of 2 min./4h. recorded the highest value of herb fiber content (15.786%), while the lowest values were obtained with the highest irrigation time 4 min./4h (15.122%) . Irrigation 3 min/4h recorded intermediate value (15.550%).

Root fiber content significantly increased by increasing irrigation treatments up to the highest rate 4 min./4h (15.883%), while the decreasing of irrigation water quantity decreased root fiber content (15.283%).

Table (5): Effect of irrigation period on Herb, root fat content and fiber content of barley

Irrigation treatments	Fat content in herb	Fat content in roots	Fiber content in herb	Fiber content in roots
2 min./4h.	5.106	5.983	15.786	15.283
3 min./4h.	5.075	6.017	15.550	15.594
4 min./4h.	5.058	6.000	15.122	15.883
LSD at 0.05 level	0.023	0.019	0.14	0.033

CONCLUSIONS

Hydroponics system is a potential technique for barley fodder production with less water consumption where water is the main limiting factor for agricultural production. The current study shows the superiority of 4min irrigated fodder barley over that irrigated with 2min in several aspects related to production and quality of the produced barley crop. This indicated that 4min is a good period of nutrients needed for plant growth to promote high yields.

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تأثير فترات الرى على انتاج علف الشعير الاخضر استخدام نظام الزراعة المائية

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تعتبر الزراعة المائية هى حجر الأساس الذى إرتكزت عليه الزراعات اللاأرضية وتعرف على أنها تكنولوجيا إنماء النباتات فى المحاليل المغذيه مع استخدام أو عدم استخدام بيئه خاملة كعامل تثبيت ميكانيكى

ولها عدة مزايا و أهداف من الأهمية بمكان أن توضع فى الاعتبار عند صانعى قرار السياسات الزراعية على مستوى الأفراد و المجتمعات اهمها ارتفاع انتاجية المحصول (الانتاج على مدار العام) وجودته وسرعة نضجة(الحصاد بعد 7 ايام من الزراعة) كما العائد الاقتصادى يكون مرتفعاً.

- تم هذا البحث بمعهد الدراسات و البحوث البيئية جامعة مدينة السادات خلال الاعوام 2011و 2012 لدراسة تاثير فترات الرى (2 ، 3 و 4 دقيقة كل 4 ساعة) على محصول العلف الاخضر للشعير صنف جيزة 124 و خصائصة الطبيعية و الكميائية و كفاءة استخدام المياه و ذلك باستخدام وحدة زراعة مائية تم انشائها و تطويرها لتناسب متطلبات الدراسة .

- وقد تم دراسة الخصائص التالية:

الوزن الرطب للمجموع الخضرى(كجم/م^2), الوزن الرطب للمجموع الجذرى (كجم/م^2), الوزن الجاف للمجموع الخضرى (كجم/م2), الوزن الجاف للمجموع الجذرى (كجم/م^2), محتوى الرطوبة فى المجموع الخضرى(%),محتوى الرطوبة فى المجموع الجذرى(%),معدل انتاج المادة الجافة للعلف المنتج الى وزن البذور المزروعة , محتوى الدهون للمجموع الخضرى (%), محتوى الدهون للمجموع الجذرى%), محتوى الالياف للمجموع الخضرى (%) محتوى الالياف للمجموع الجذرى (%),محتوى البروتين للمجموع الخضرى (%),محتوى البروتين للمجموع الجذرى (%)ودراسة كفاءة استخدام المياه (كجم/لتر).

وكانت افضل النتائج لمعظم الصفات عند ثبات درجة الحرارة عند $\pm$ 24^o 2^0 ورطوبة تتراوح بين 65 % $\pm$ 5. عند فترة الرى 4 دقائق كل 4 ساعات.