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Nitrogen and Water Utilization Efficiency of Barley Subjected To Desiccated Conditions in Moderately Salt-Affected Soil

E. M. Hafez[#] and W. H. Abou El Hassan[*]
Agronomy Department, Faculty of Agriculture, Kafrelsheikh University, Kafrelsheikh and [*]Water Management Research Institute, National Water Research Center, Delta Barrage, Qalubia, Egypt.

TRANSLOCATION of dry matter (DM) and nitrogen (N) in barley (*Hordeum vulgare* L. Giza 2000) subjected to desiccated conditions during pre and post heading in moderately salt-affected soil are important for food production. Nitrogen and water utilization efficiencies are paid an attention in the current investigation and prospected into account of both economic production and environment. The aim of the current study was to investigate the effects of water treatments [fully watering (FW) and desiccated watering (DW)] in response to five N applications 0, 35, 70,105 and 140 kg N ha^{-1} (0,15,30,45 and 60 kg N fed^{-1}) (ha.=2.38 fed) on N harvest index (NHI), N and DM translocation, N contribution, nitrogen use efficiency (NUE), nitrogen utilization efficiency (NUtE), N uptake efficiency (NUpE), apparent fertilizer N recovery (AFNR) and water utilization efficiency (WUtE) of barley. The application of either 105 or 140 kg N ha^{-1} resulted in the highest grain yield, NHI, DM translocation, N contribution and WUtE. Increasing the N application up to 70 kg N ha^{-1} resulted in the highest NUpE. NUE and NUtE were increased by increasing N application from 35 to 70 kg N ha^{-1}, and were decreased gradually when higher N application was applied. On the other hand, there were no significant differences between the effects of water treatments on all above mentioned parameters, this could due to the timing of water application during water deficit. In conclusion, there were no significant between water treatments in terms of NHI, N and DM translocation, N contribution, NUE, NUtE, N uptake efficiency (NUpE), AFNR and WUtE, which support the hypothesis of better performance for barley plants when grown in desiccated conditions at 105 kg N^{-1} in moderately salt-affected soil.

Keywords: Barley, Apparent fertilizer N recovery, Nitrogen fertilization, Nitrogen utilization efficiency, Water utilization efficiency.

Barley (*Hordeum vulgare* L.) is moderate-tolerant plant for stresses and the major cereal in many dry areas of the world and is vital for the livelihoods of many farmers. Barley is an annual cereal crop and grown in environments ranging from the desert of the Middle East to the high elevation of Himalayas

[#] Corresponding author: emadhafez2014 @gmail. com

(Alazmani, 2015), it is the major food source in many North African countries. In Egypt, barley can replace wheat as the dominant crop in the North Coastal Region and also in the newly reclaimed lands with saline soils and shortage of fresh water. Due to its tolerance to drought and salinity (El-Awady *et al.,* 2012). Barley is more productive under adverse environments than other cereals. Barley serves as a major animal fodder, base malt for beer and certain other distilled beverages (Ghanbari *et al*., 2012). Barley assumes fourth position in total cereal production in the world after wheat, rice and maize.

Water is considered as one of the most limiting factors that can determine the pattern of agricultural land usage (Ryan *et al*., 2009). Nitrogen availability in the soil represents another main factor that can limit barley yield, since barley needs large quantities of N to achieve the higher yield. Salinity and N supply are also considered the major environmental factors that can control barley growth and its development during the different growth and productivity stages (Smithson & Sanchez, 2001).

A saline soil is defined as one in which the electrical conductivity (EC) of the saturation extract (EC_e) in the root zone exceeds 4 dS m^{-1} (approximately 40 mM NaCl) at 25 °C and has an exchangeable sodium percentage of 15%. Most of crops is decreased at this EC_e, however many crops exposed to reduction in crops at lower EC_es (Munns, 2005 and Jamil *et al*., 2011). It has been determined that worldwide 20% of total cultivated and 33% of irrigated agricultural lands are affected by high salinity. Moreover, the salinized areas are increasing at a level of 10% annually for many reasons, including low precipitation, high surface evaporation, weathering of native rocks, irrigation with saline water, and poor cultural practices. It has been estimated that more than 50 % of the arable land could be salinized by the year 2050 (Jamil *et al*., 2011). In Egypt <0.75 dS m^{-1} suitable for use with all crops. Above 0.75 dS m^{-1} sensitive plants will suffer some yield loss as soil salinity increases.

Barley plants reserved most of their N pre-heading, and low N was reserved at post-heading (Gebbing *et al*., 1999). N absorbed from soil and translocated from plant stem and leaves to grain filling is affected by the amount of water applied into the crop (Clarke *et al.*, 1990). Water shortage substantially can increase the N translocation divided from soil and the contributions of N in different vegetative organs to grain N uptake, although it can reduce the availability of N to the plants (Xu *et al*., 2006). The DM translocation at heading and also N translocation were related to N content at heading (Pampana *et al*., 2007). At grain filling period, contribution of N assimilates to the grains exceeded the post-heading N uptake and reduced N translocation of pre-heading (Papakosta & Gagianas, 1991). Determination of NUE in barley relied on agronomic and environmental issues that are related to N use as grain yield, N accumulation and NHI (Huggins & Pan, 2003). The NUE in barley varied between 10 and 81 kg grain kg fertilizer N^{-1} (Angás *et al*., 2006). Hirel *et al*. **(**2011) stated that NUE is the product of uptake efficiency (amount of uptake N/quantity of available N) and the utilization efficiency (yield/uptake N).

Egypt is suffered from water stress due to the limited source of the renewable freshwater alongside rainfall on the coast (El Hakeem, 2007). In Egypt, barley is grown mainly on the Northern coastal region and Delta area. In addition, it is grown on the newly reclaimed lands due to its tolerance to salinity and drought of these areas (Hussein *et al.,* 2013). Therefore, our study was conducted to investigate the effects of desiccated conditions and N applications on translocation and contribution of DM and N during pre-heading and grain filling periods. The objectives of the study were to investigate how desiccated conditions can promote the translocation of prestored N to grains in different vegetative organs when barley is grown on saline soil, and how N-uptake and N-efficiency responded to barley grown in saline soil under desiccated condition relative to well-water condition.

Material and Methods

Plant material and experimental design

Two field experiments were conducted at Water Requirements Research Station (El-Karada), Water Management Research Institute, National Water Research Centre, Kafrelsheikh Governorate (North Delta, Latitude: 31°6' N/Longitude: 30° 56' E), Egypt, during the growing seasons of 2012/2013 and 2013/2014, to investigate the nitrogen and water utilization efficiency of barley (*Hordeum vulgare* L., Giza 2000) subjected to desiccated condition in saline soil. Specific attention was paid to translocation and contribution of dry matter and nitrogen during pre-heading and grain filling periods as well as to nitrogen-uptake and nitrogen-efficiencies of barley. Giza 2000 barley cultivar was chosen to represent successful and well-adapted modern cultivars sown in the region. The study included two factors: N fertilization and irrigation. It was conducted in split-block-plot design with four replicates. Irrigation treatments [fully well-watered (FW) and desiccated condition (DW)] were placed in main plots and separated well to avoid infiltration when different irrigation treatments were applied. Fully well-watered (FW) was four irrigations applied at sowing, tillering, heading, and grain filling stages, while the water withheld during two stress periods (heading and grain filling stage) in the desiccated condition (DW). N fertilization was added in the following applications: 0,35,70,105 and 140 kg N ha^{-1} (0,15,30,45 and 60 kg N fed^{-1}), and was placed in sub-plots. N applications were applied in the form of ammonium nitrate (33.5-0-0) at two equal doses: The first dose was at sowing, while the second one was at tillering stage in order to minimalize potential losses. Sub-plot size was 10.5 m^2 consisting of 20 rows with 15 cm part by drilling machine (3.0 m width × 3.5 m length). Plots were separated by 0.5 m allays.

Phosphorus fertilizer was added at level of 70 kg P_2O_5 ha^{-1} during tillage practice as supplementary for barley based on the soil analysis and also crop requirements for phosphorus. Seeding rate was 120 kg ha^{-1}, and seeds were sown on November 28*th* in growing season of 2012/2013 and on December 4*th* in growing season of 2013/2014. The preceding crop was maize (*Zea mays* L.) in both growing seasons. The control of weeds and pests was done following practices recommended to farmers of the region by the Egyptian Ministry of Agriculture. The soil was clayey in texture during both of the growing seasons. The average electrical conductivity (EC) of soil was 3.03 and 3.12 dS m^{-1} and soil pH was 8.1 and 8.0 during the both of growing seasons 2012/2013 and 2013/2014, respectively. The recorded meteorological data of the current study are presented in Table 1. The harvest date coincided with physiological maturity for barley and was on 5^{th} May and 10^{th} May in first and second seasons, respectively.

TABLE 1. The recorded data of El-Karada meteorological station during growing seasons.

Year / Month	2012/ 2013				2013/ 2014			
	Temperature (°C)		Precipitation (mm)	RH (%)	Temperature (°C)		Precipitation (mm)	RH (%)
	max	min			max	min		
Dec	18.7	10.6	0.50	38.8	16.9	11.4	0.80	30.7
Jan	23.6	10.0	7.50	42.5	23.5	9.4	3.50	41.4
Feb	23.9	12.9	5.50	47.5	22.0	11.0	7.00	45.1
Mar	23.5	15.7	0.00	48.4	24.0	16.2	0.00	47.9
April	28.5	18.0	0.00	54.5	27.4	17.2	0.00	55.4
May	32.4	19.2	0.00	64.3	31.9	17.8	0.00	64.1

max = maximum, min = minimum, RH = *relative humidity*

Soil analysis

The chemical properties of the soil were analyzed and presented in Table 2. Field capacity, permanent wilting point, bulk density and soil moisture content were measured in the soil from 0 to 60 cm depth as described in Klut (1986) (see Table 3). About 0.2 g of soil sample from each plot was taken for analyzing total nitrogen content by Kjeldahl method (Bremner, 1960).

TABLE 2. Chemical properties of soil used in both growing seasons.

	Chemical properties						
Year	Ca^{++} (meq L^{-1})	Mg^{++} (meq L^{-1})	K^{+} (meq L^{-1})	Na^{+} (meq L^{-1})	Cl^{-} (meq L^{-1})	HCo_3^{-} (meq L^{-1})	So_4^{--} (meq L^{-1})
S_1	5.1	3.0	0.4	12.0	14.0	3.5	1.3
S_2	5.0	3.1	0.6	12.2	14.2	3.7	1.4

S_1= Season 2012/ 2013, S_2= 2013/ 2014.

TABLE 3. Soil moisture constants for experimental site during both growing seasons as average .

Soil depth (cm)	Field capacity (%)	Wilting point (%)	Bulk density (g cm^{-3})	Available soil water (%)
0-15	45.2	24.5	1.1	20.6
15-30	44.0	23.9	1.2	20.1
30-45	40.0	21.7	1.2	18.0
45-60	39.9	21.7	1.3	18.2
Average	42.3	23.0	1.2	19.3

Plant measurements and analysis

Plant samples (biomass aboveground, one m^2) from each sub-plot were collected at flowering and maturity stages, and oven dried for 2-3 days at 65˚C before being weighted to determine whole plant biomass (dry matter), grain and straw yields. Ten plants were randomly chosen, and different parts were separated and then were grounded in a mill to produce a fine powder for analyzing nitrogen in straw and grains. About 0.2 g of each sample was used to analyze nitrogen content using the standard procedure of Kjeldahl method.

Nitrogen harvest index (NHI) at maturity was calculated as described by Jones *et al*. (1990).

$$\mathrm{NHI} = \frac{\text{Grain nitrgoen accumulation (kg ha}^{-1}\text{)}}{\text{Total nitrgoen accumulation (kg ha}^{-1}\text{)}}$$

where, the total nitrogen accumulation was determined by multiplying dry weight of whole plants by N content. In addition, nitrogen accumulation (kg N ha^{-1}) in straw or grains of barley was calculated as described by Michael (1978) as follows:

$$\text{Nitrogen accumulation(kg ha}^{-1}\text{)} = \frac{\text{nitrogen content (g kg}^{-1}\text{)} \times \text{dry matter (kg ha}^{-1}\text{)}}{1000}$$

$$\text{Grains nitrogen accumulation (kg ha}^{-1}\text{)} = \frac{\text{Grains nitrogen content (g kg}^{-1}\text{)} \times \text{Grains dry matter (kg ha}^{-1}\text{)}}{1000}$$

The following parameters related to dry matter and nitrogen accumulation were calculated:

- Pre-heading and post-heading dry matter accumulation (kg ha^{-1}).

$$\text{Dry matter translocation(g kg}^{-1}\text{)} = \text{Dry matter at heading (g kg}^{-1}\text{)} - \text{Dry matter (leaves + culm + chaff) at maturity (g kg}^{-1}\text{)} \quad \textbf{(Arduini } \textbf{\textit{et al.}}\textbf{, 2006)}$$

$$\text{Contribution of pre-heading assimilates to grain (\%)} = \frac{\text{Dry matter translocation}}{\text{Grain yield}} \times 100$$

(Papakosta & Gagianas, 1991).

- Pre-heading and post-heading nitrogen accumulation (g kg^{-1}) was also calculate.

$$\text{Nitrogen translocation from vegetative tissues at heading to kernel (g kg}^{-1}\text{)} = \text{Nitrogrn content at heading (g kg}^{-1}\text{)} - \text{Nitrogrn content (leaves + culm + chaff) at maturity (g kg}^{-1}\text{)} \quad \textbf{(Cox } \textbf{\textit{et al.}}\textbf{, 1986)}$$

Nitrogen use efficiency (NUE), apparent nitrogen fertilizer recovery (AFNR) was calculated as it is described by Azizian & Sepaskhah (2014). In addition, nitrogen uptake efficiency and nitrogen utilization efficiency were calculated. Nitrogen utilization efficiency was calculated as described by Xu *et al*. (2006).

$$\text{NUE}\ (\text{kg kg}_N{}^{-1}) = \frac{GY_t - GY_c\ (\text{kg ha}^{-1})}{NF_t - NF_c (\text{kg ha}^{-1})}$$

where, GY_t and GY_c express the grain yield at different N treatments and control, respectively. While, NF_t and NF_c express the N applications for different N treatments and control, respectively.

$$\text{AFNR}\ (\text{kg kg}^{-1}) = \frac{\text{Total nitrogen accumulation}_t - \text{Total nitrogen accumulation}_c\ (\text{kg ha}^{-1})}{NF_t - NF_c (\text{kg ha}^{-1})}$$

$$\text{NUtE}\ (\text{kg kg}^{-1}{}_{\text{plantN}}) = \frac{GY_t - GY_c\ (\text{kg ha}^{-1})}{\text{Nitrogen uptake}_t - \text{Nitrogen uptake}_c (\text{kg ha}^{-1})}$$

where, GY_t and GY_c express the grain yield at different N treatments and control, respectively. While, N $uptake_t$ and N $uptake_c$ express the total N accumulation in whole plant biomass above ground for different N treatments and control, respectively.

$$\text{NU}_P\text{E}(\%) = \frac{(\text{GN uptake}_t - \text{GN uptake}_c)(\text{kg ha}^{-1}) + (\text{SN uptake} - \text{SN uptake})}{NF_t - NF_c (\text{kg ha}^{-1})}\ x\ 100$$

where, GN uptake and GN uptake express the grain nitrogen uptake at different N treatments and control, respectively. While, SN uptake and SN uptake express the straw (leaf + culm + chaff) nitrogen uptake at different N treatments and control, respectively. While, NF_t and NF_c express the N applications for different N treatments and control, respectively. NUE is the product of uptake efficiency (amount of uptake N/quantity of available N) and the utilization efficiency (yield/uptake N) (Hirel *et al*., 2011).

Irrigation water applied (IWA) was recorded (*m*) using Woltmann Removable Dry Type Water Flow Meter (Model: LXLC-50 -500, ECVV, Ningbo Yinzhou Tongda Meter Factory, Zhejiang, China).

TABLE 4. Amount of irrigation water applied and total rainfall in m^3 ha^{-1} for different treatments.

Treatment	Amounts of irrigation water (m^3) applied					Rainfall (m^3)	Total
	Sowing	Tillering	Elongation	Heading	Filling		
DW	1190	1190	0	0	0	322	2702
FW	1190	1190	714	714	714	322	4844

DW= is desiccated watering, FW= is fully watering

Barley water utilization efficiency (WUtE) was calculated using the following Equation (Michael, 1978):

$$\text{WUtE } (kg\ ha^{-1}) = \frac{\text{Barley grain yield (kg ha}^{-1})}{\text{Total water applied } (m)}$$

Statistical analysis

Data obtained from the current investigation were subjected to analysis of variance (ANOVA) using PASW statistics 20.0 (IBM Inc., Chicago, IL, USA). Different Means were compared using Standard error of means (S.E.M.) when the ANOVA showed significant differences ($P < 0.05$).

Results and Discussions

Dry matter (kg ha^{-1}) *and N content (g kg^{-1}) at heading and maturity stages of barley plants 2012/2013 and 2013/2014 seasons*

There was significant difference between water treatments (FW and DW) at heading stage of barley plants. The dry matter and N content at heading were increased with the increase in N applied in comparison with the lowest N level (Table 5). The highest N level (140 kg ha^{-1}) resulted in an increase in the dry matter at heading by 61.0 % and an increase in N content by 23.5% when plants grown with water treatments during the two growing seasons in comparison to unfertilized plants (Table 5). Przulj & Momčilović (2003) found that in adverse growing conditions during vegetative stage, regardless of the N level, less than 50% of total dry matter at maturity had been accumulated by heading. Przulj & Momčilović (2003) demonstrated that much of photoasimilate may be used for the maintenance of green parts instead of being translocated into the kernel.

There were differences at maturity between the water treatments in terms of dry matter which was the highest with FW than DW in the second season only. While no significant difference in N content (Table 5). Soil N-treated with 105 and 140 kg N ha^{-1} was the highest among N applied in desiccated treatment (DW) with dry matter and N content at maturity in the second season (Table 5). While Soil N-treated with 140 kg N ha^{-1} was the highest among N applied in fully watered treatment (FW) with both characters at maturity (Table 4). Hafez & Kobata (2012) pointed out that the increase in dry matter by increased N content was the result of high assimilation until anthesis, *i.e.,* dry matter production at anthesis increased with the increase in the amount of N applied. The lower N absorption from FW than DW might result from greater leakage of N. The water leaked with N should increase when the amount of supplied water is greater than water deficit conditions (Hafez & Kobata, 2012).

TABLE 5. Vegetative dry matter *(kg ha^{-1})* and N content (g kg^{-1}) at heading and maturity stages of barley plants grown with water treatments and N applied during 2012/2013 and 2013/2014 growing seasons.

Water treatment	N applied (kg ha^{-1})	At heading				At maturity			
		Dry matter (kg ha^{-1})		N content (g kg^{-1})		Dry matter (kg ha^{-1})		N content (g kg^{-1})	
		S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2
DW	0	4800.0	4683.3	12.17	11.68	4006.6	3873.3	5.37	5.22
	35	5733.3	5353.3	13.21	12.58	4666.7	4426.7	6.73	6.65
	70	6546.7	5946.7	14.14	13.51	5316.5	5293.3	7.35	7.26
	105	6966.7	6966.6	15.18	15.08	6016.7	5913.3	8.55	8.29
	140	7950.0	7500.0	15.64	15.68	6050.0	6070.0	8.77	8.39
FW	0	4973.3	4806.7	12.57	11.81	4240.0	4083.3	5.06	4.47
	35	5883.3	5576.7	13.43	12.75	4933.3	4703.4	6.40	5.87
	70	6710.0	6303.3	14.40	13.79	5650.0	5373.6	7.27	6.71
	105	7266.7	7140.0	15.37	15.24	6123.3	6050.0	8.30	7.88
	140	8040.0	7750.0	16.10	15.86	6036.7	6063.3	8.34	7.53
SEM		38.64	42.65	0.09	0.08	52.53	51.65	0.12	0.16
ANOVA	N applied(N)	**	**	**	**	**	**	**	**
	W treatment(W)	ns	ns	ns	ns	*	*	ns	ns
	N X W	ns	ns	ns	ns	ns	ns	**	**

DW= desicated watering, FW= fully watering. SEM = Standard error of means. *= $P \leq 0.05$ and **= $P \leq 0.01$.

Grain yield (kg ha^{-1}), grain-N content (g kg^{-1}), straw yield (kg ha^{-1}) of barley plants in 2012/2013 and 2013/2014 seasons

Grain yield, grain N content and straw yield were affected significantly by irrigation and nitrogen levels in 2012/2013 and 2013/2014 seasons (Table 6). Grain yield and straw yield were reduced with reduction of water supply compared to complete irrigation while grain N content was reduced with complete irrigation compared to water stress in both seasons.

Water deficit led to negative impacts on grain yield and straw yield by lessen of photosynthesis and acceleration of leaves senescence, restriction of cell division, leaf area and transpiration Hoseinlou *et al.* (2013). It seems that water deficit limited contribution of current photosynthesis in formation of grain yield and straw yield. On the other hand, Xu *et al*. (2006) proved that the N translocation amount of total above-parts for N from the soil significantly increased at water deficit.

Data illustrated in Table 6 showed that a significant ($p < 0.05$) effect of N levels in both seasons. The highest grain yield (3460.0 and 2753.4 kg ha^{-1}) and straw yield (6833.3 and 5820.1 kg ha^{-1}) respectively, with 105 kg N ha^{-1} in both seasons in case of water desiccated (DW) treatment compared to other N levels.While, the highest grain N content (23.07 and 22.16 g kg^{-1}) respectively, with 140 kg N ha^{-1} in both seasons. The same trend found in complete irrigation (FW) treatment, the highest grain yield (3730.1 and 3606.8 kg ha^{-1}) and straw yield (7113.4 and 6866.6 kg ha^{-1}) respectively, with 105 kg N ha^{-1} in both seasons compared to other N levels. While, the highest grain N content (19.65 and 17.26 g kg^{-1}) respectively, with 140 kg N ha^{-1} in both seasons. Ali (2011) found that split nitrogen equally between sowing and tillering with the greater proportion applied at tillering led to higher grain yield and straw yield. This is logic since the splitting nitrogen to multi doses make plants don't suffer any shortage in nitrogen through life cycle which led to an increased in yield component and consequently grain yield and straw yield. Hafez & Kobata (2012) cleared that the leaked nitrate N increased with the increase in the amount of applied N, and amount of leaked N from FW treatment was higher than that from DW treatment. Leaked N ranged from 50% of total amounts of absorbed N at low fertilizer applications to 10% at high fertilizer applications in both seasons. Hoseinlou *et al.* (2013) who reported that efficiency of N application is dependent to water supply. When there were no or mild water deficiency increasing of N to 80 kg ha^{-1} increased grain yield but more application of N reduced that significantly. Under salt or drought stress conditions, higher rates of grain N accumulation and lower rates of carbohydrate accumulation are primarily responsible for the increased grain N concentration (Panozzo & Eagles, 1999) resulting in negative correlation between grain yield and grain N concentration.

TABLE 6. Grain yield (kg ha^{-1}), grain-N content (g kg^{-1}), straw yield (kg ha^{-1}) of barley grown with water treatments and N applied in 2012/2013 and 2013/2014 seasons.

Water treatment	N applied (kg ha^{-1})	Grain yield (kg ha^{-1})		Grain-N content (g kg^{-1})		Straw yield (kg ha^{-1})	
		S_1	S_2	S_1	S_2	S_1	S_2
DW	0	1131.7	951.7	13.50	13.24	4476.6	4250.0
	35	1893.3	1236.8	15.47	15.22	5016.7	4846.6
	70	2796.6	1990.2	16.43	16.08	6166.8	5546.7
	105	3460.0	2753.4	18.37	18.01	6833.3	5820.1
	140	3383.4	2680.1	23.07	22.16	6466.5	5491.8
FW	0	1230.0	1156.6	13.04	11.08	4810.0	4640.2
	35	1946.7	1970.0	14.92	12.62	5566.6	5126.7
	70	3043.4	2850.2	15.74	14.11	6373.3	6210.0
	105	3730.1	3606.8	17.87	15.84	7113.4	6866.6
	140	3513.3	3543.3	19.65	17.26	7040.1	6540.1
SEM		36.71	31.53	0.15	0.12	83.23	88.35
ANOVA	N applied(N)	**	**	**	**	**	**
	W treatment (W)	ns	ns	**	**	**	ns
	N X W	ns	ns	*	*	**	*

DW= desicated watering, FW= fully watering. SEM = Standard error of means. *= P≤ 0.05 and **=P≤ 0.01, ns=Not significant.

N uptake at heading (kg ha^{-1}), straw N uptake at maturity (kg ha^{-1}), grain N uptake (kg ha^{-1}) and N harvest index (%) of barley in 2012/2013 and 2013/2014 seasons

Results in Fig. 1 presented the significant effect of water treatments and N applied on N uptake at heading, straw N uptake at maturity, grain N uptake and N harvest index. These characters were significantly increased with N applied upto 140 kg N ha^{-1} (Fig. 1) in both FW and DW treatments. In addition, the data did not show any differences between water treatments in 2012/2013 and 2013/2014 seasons. Furthermore, there are not significant differences between 105 and 140 kg N ha^{-1} for straw N uptake, grain N uptake and N harvest index in both water treatments. The highest N uptake at heading was at 140 kg N ha^{-1} (129.43 and 118.09 kg ha^{-1}) in water treatments. The highest N grain uptake and N straw uptake were at 105 kg ha^{-1} in both water treatments (Fig. 1) (66.67, 63.55 kg ha^{-1}) and (50.81, 51.46 kg ha^{-1}). Thus, the response of NHI to applied N was much parallel with N grain uptake and N straw uptake whereas at applied N of 105 kg ha^{-1} in FW and DW treatments was (56.76, 55.25%) and (54.52, 53.91%) in 2012/2013 and 2013/2014 seasons, respectively. Mobilization of photosynthetic material from leaves to grain also effects on grain,straw yields and N uptake (Khan & Naqvi, 2011). The shortage of moisture forces plant to complete its grain formation and N uptake in relatively lesser time (Riaz & Chowdhrv, 2003). According to Bayoumi *et al.* (2008) under drought conditions the availability of current assimilates for extending seed filling will often be severely reduced. In such circumstances, a genotype that can mobilize reserves of carbohydrates in the stem will be able to maintain better N uptake in grain and straw. Shirazi *et al.* (2014) reported that water deficit at anthesis affects N yield by reducing the number of grains per ear rather than ear number or grain size. In the present studies, the stress was imposed during heading and maturity therefore the reduction in grain yield might be result of all the growth factors (Shirazi *et al.*, 2014).

Dry matter translocation (kg ha^{-1}), contribution pre-heading assimilates to grains (%) and N-translocation (kg ha^{-1}) of barley in 2012/2013 and 2013/2014 seasons

Dry matter translocation, contribution of pre-heading to the grains and N translocations were affected positively by N applied, water treatments and the interaction between water and N treatments (Table 7). The highest dry matter translocation was at 140 kg N ha^{-1} in FW and DW treatment (2003.4 and 1500.3 kg N ha^{-1}) in 2012/2013 and (1896.7 and 1840.1 kg N ha^{-1}) in 2013/2014, respectively. Also, contribution of pre heading to the grains in FW and DW were 51.40 % and 54.00 % in 2012/2013 and 49.09% and 52.79 % in 2013/2014, respectively. However, N translocation in FW and DW were 79.11 and 66.36 kg N ha^{-1} in 2012/2013 and 77.34 and 62.23 kg N ha^{-1} in 2013/2014, respectively. Some authors found that nitrogen (N) in leaves declines with increment of desiccated conditions, however modest desiccated conditions is probably to enhance N transfer from leaf to grain (Sinclair *et al*., 2000). The current research found that desiccated conditions increased the contributions pre-heading assimilates to grains, which led to accelerate of N transfer from the vegetative growth to the grains. The data indicated by Seligman & Sinclair (1995) that desiccated conditions could decline DM and N translocation amount.

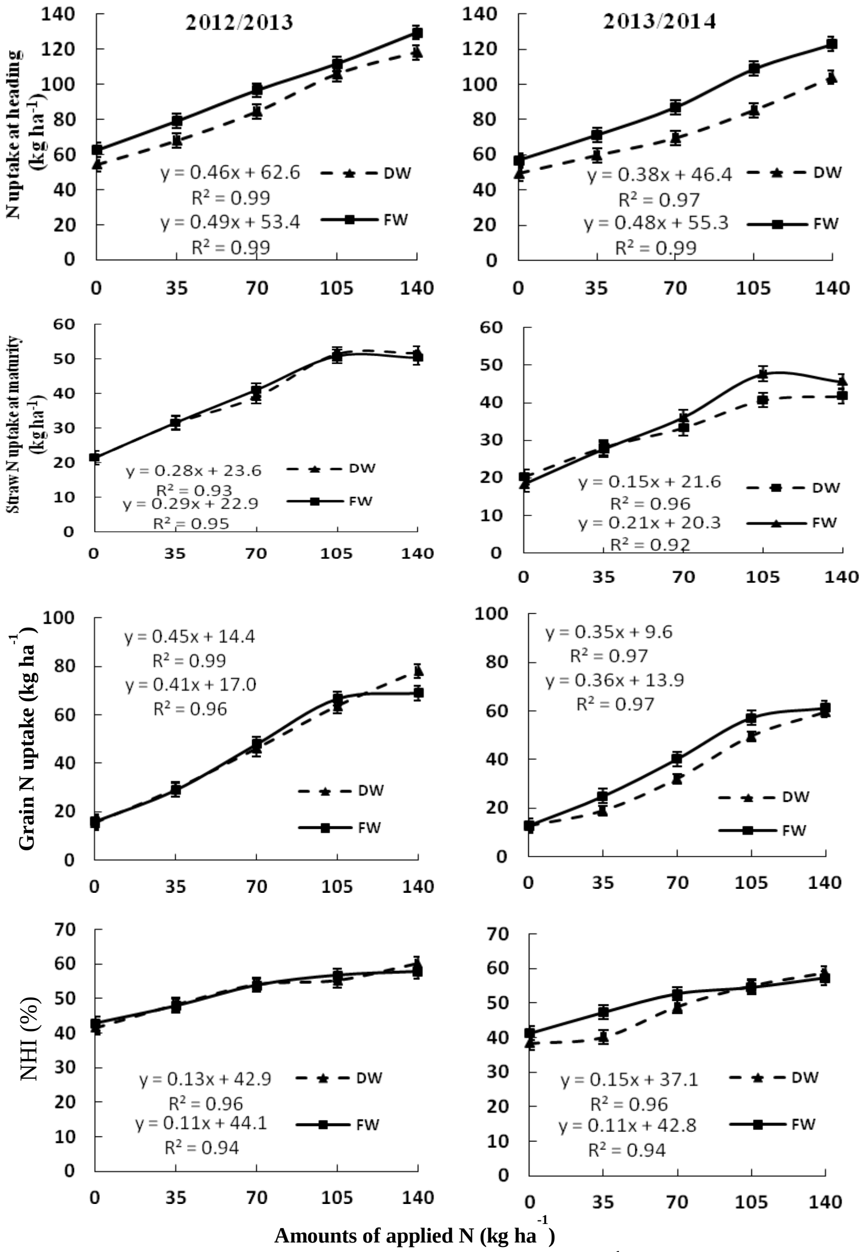

Fig.1. Relationships between N uptake at heading (*kg ha^{-1}*), straw N uptake at maturity (*kg ha^{-1}*) , grain N uptake (*kg ha^{-1}*) and N harvest index (NHI) (*%*) of barley grown under desiccated (DW) and fully watered (FW) and different amounts of N applied (0,35,70,105 and 140 kg N ha^{-1}) during 2012/2013 and 2013/2014 growing seasons. Data are mean ± SE, r= 4.

TABLE 7. Dry matter translocation (*kg ha^{-1}*), contribution pre-heading to grains (*%*) and N-translocation *(kg ha^{-1}*) of barley grown with water treatments (W) and N applications in 2012/2013 and 2013/2014 seasons.

Year	N applied (kg ha^{-1})	DM translocation (kg ha^{-1})		Contribution of pre-heading to grains (%)		N translocation (kg ha^{-1})	
		DW	FW	DW	FW	DW	FW
2012	0	693.3	733.4	21.58	23.10	32.85	41.04
	35	766.6	950.1	24.90	27.51	36.55	47.46
	70	830.0	1060.2	26.37	31.04	45.35	55.56
	105	950.2	1143.3	36.07	39.29	54.27	60.85
	140	1500.3	2003.4	54.00	51.40	66.36	79.11
2013	0	610.0	723.4	31.81	23.92	29.01	38.50
	35	826.6	873.3	34.28	27.45	31.43	43.48
	70	953.3	930.1	38.28	28.73	36.04	50.83
	105	1053.4	1090.0	47.78	37.82	44.49	61.15
	140	1840.1	1896.7	52.79	49.09	62.23	77.34
SEM		55.17	51.26	2.07	2.15	1.09	1.05
ANOVA	N applied(N)	**	**	**	**	**	**
	W treatment(W)	**	**	ns	ns	**	**
	N X W	ns	ns	ns	ns	ns	ns

DW= desicated watering, FW= fully watering. SEM = Standard error of means. *= P≤ 0.05 and **=P≤ 0.01, ns=Not significant.

In the current research the N translocation amount decreased under desiccated condition, suggesting that the proportion utilizing N in the fertilizers decreased under desiccated treatment. While calculation of N translocation values in our research, did not take in our consideration N losses from crops through heading to maturity. C_3 plants lose N by volatilization, which differs according to environmental conditions (Hafez *et al.*, 2014).

Nitrogen utilization efficiency (kg kg^{-1}), nitrogen use efficiency (kg kg^{-1}), nitrogen uptake efficiency (%) and apparent fertilizer nitrogen recovery (%) of barley during 2012/2013 and 2013/2014 seasons

Nitrogen utilization efficiency (NU_tE), nitrogen use efficiency (NUE), nitrogen uptake efficiency (NUpE) and apparent fertilizer nitrogen recovery (AFNR) by N applied and water treatments (Fig. 2). The highest amount of N applied (140 kg N ha^{-1}) in both water treatments led to decrement all N efficiencies in 2012/2013 and 2013/2014 seasons. In our study, increasing amount of N applied from the lowest level upto the highest level led to decreasing Nitrogen utilization efficiency, nitrogen use efficiency, nitrogen uptake efficiency and apparent fertilizer nitrogen recovery. In addition, there was no significant difference between water treatments under all amounts of N applied. In NU_tE, applied of 140 N kg ha^{-1} recorded (30.09 and 26.55 kg kg^{-1}) in FW and DW treatments, respectively. In addition NUE, applied of 140 N kg ha^{-1} recorded (18.95 and 17.26 kg kg^{-1}) in FW and DW treatments, respectively. However NUpE, applied of 140 N kg ha^{-1} recorded (54.47 and 51.39 %) in FW and DW treatments, respectively. Concerning AFNR, applied of 140 N kg ha^{-1} recorded (27.86 and 24.81%) in FW and DW treatments, respectively.

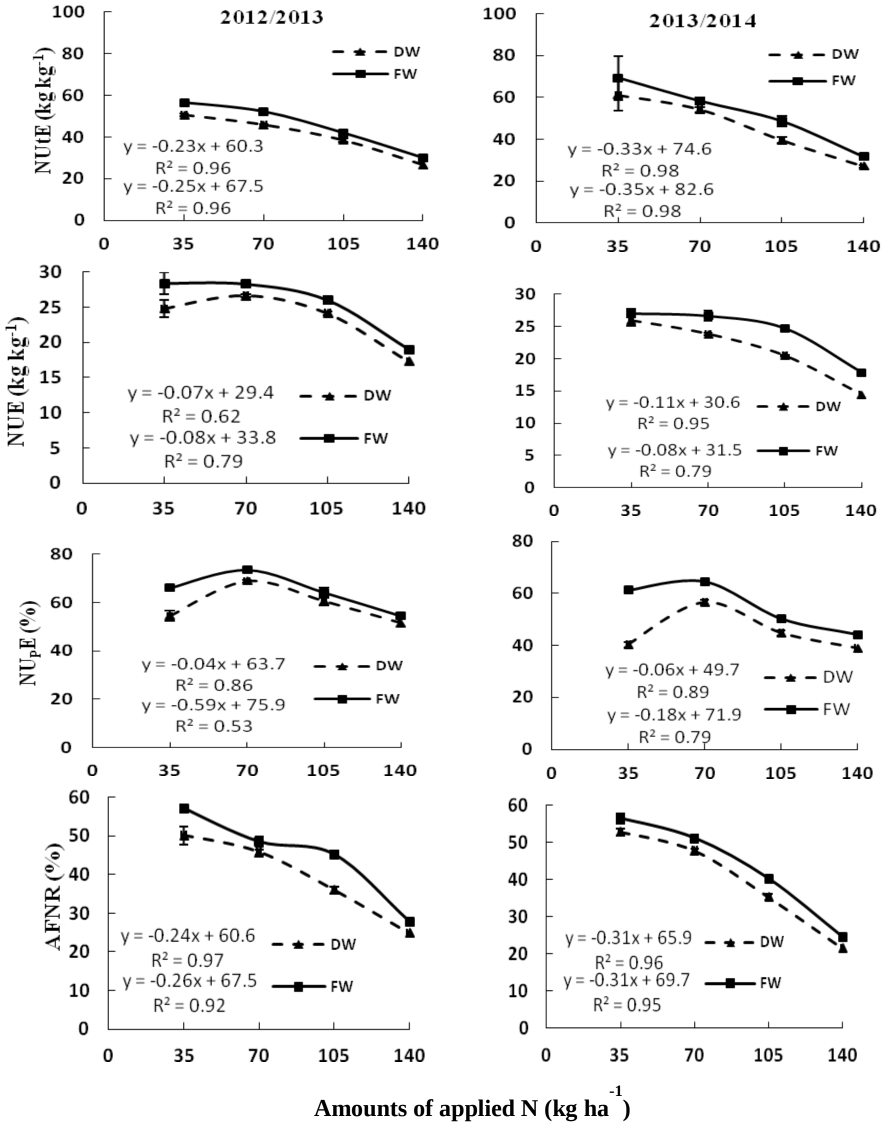

Fig. 2. Relationships between nitrogen utilization efficiency (NUtE) (*kg kg*$^{-1}$), Nitrogen use efficiency (NUE) (*kg kg*$^{-1}$), nitrogen uptake efficiency (NU_PE) (%) and apparent fertilizer nitrogen recovery (AFNR) (%) of barley grown under desiccated (DW) and fully watered (FW) and different amounts of N applied (0,35,70,105 and 140 kg N ha^{-1}) during 2012/2013 and 2013/2014 growing seasons. Data are mean ± SE, r= 4.

The current study pointed out that desiccated conditions decreased dry matter and N translocation, though desiccated conditions increased the efficiencies of N and the contribution assimilates from vegetative growth to grains. Li *et al*. (2003) found that desiccated conditions and a high amount of N applied could result in a low N efficiency. Furthermore, water stress could negative affect the movement of nutrient in the soil, resulting in a decrease in its absorb by the roots of plant Yuan *et al*. (2005).

In barley, Volatilization of N, leaching of N fertilizer from the soil (Hafez & Kobata, 2012), environmental factors (high temperature and low air humidity during grain filling) (Austin *et al*., 1980) and inappropriate utilize of nitrogen fertilizer are the basic reasons of N losses (Przulj & Momčilović, 2001a). N losses from heading to maturity in the biomass might because of loss of some plant parts through the grain filling phase, *e.g.*, the old lower leaves or due to N translocation (Przulj & Momčilović, 2001b).

Applied water amounts (mm) and water utilization efficiency (kg ha^{-1} mm^{-1}) in barley in 2012/2013 and 2013/2014 seasons

The amounts of irrigation water delivered to different treatments were measured and statically analyzed. In general, the amounts of water applied and water utilization efficiency in different treatments increased with the increase in N application for barley crop in both seasons. In addition, no significant difference between FW and DW in both seasons for WU_tE. The highest value recorded for the total amounts of irrigation water when N (140 kg ha^{-1}). WUtE tended to decrease with FW than DW treatment (Fig. 3). It was also increased with the application of N in both seasons (Fig. 3). The greatest WUtE was recorded from 105 kg ha^{-1} N in both FW and DW treatments (12.4 and 12.1 kg ha^{-1} mm^{-1}, respectively). Desiccated conditions negatively affected the 1000-grain weight and number of grains (Plaut *et al.*, 2004) however, accelerate the contribution and assimilation of pre-heading carbon reserves, *i.e.* leaves to grains (Plaut *et al*., 2004) and roots (Xu & Zhou, 2005). A moderately water stress conditions could accelerate N translocation and distribution from leaves to grains, resulting in a higher sink N content (Sinclair *et al.,* 2000). Desiccated conditions may also increase water utilization efficiency (Li *et al*., 2003 and Abou El-Hassan *et al*., 2014).

Conclusion

In the present study, the soil was moderately salt-affected. Desiccated treatment (DW) had positive effect on grain N uptake, NHI, NU_tE and NUE compared with fully watering (FW) treatment at 140 kg N ha^{-1} however, increasing N amounts led to decrease N efficiencies and increased water utilization efficiency in both seasons. There were no significant between water treatments in terms of NHI, N and DM translocation, N contribution, NUE, NUtE, N uptake efficiency (NUpE), AFNR and WUtE, which support the hypothesis of better performance for barley plants when grown in desiccated conditions at 105 kg N^{-1} in moderately salt-affected soil.

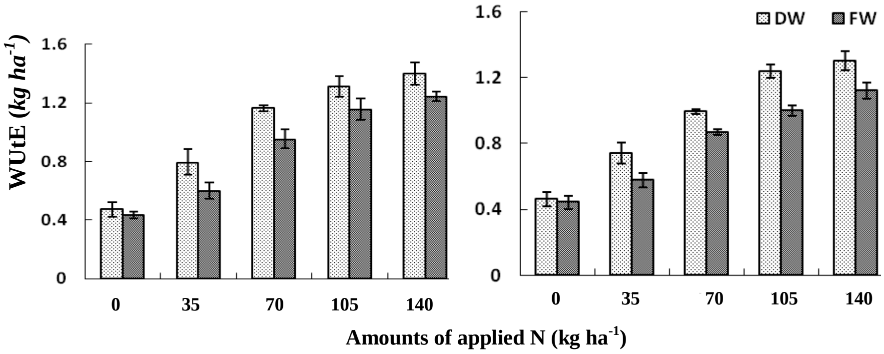

Fig. 3. Relationship between water utilization efficiency (*kg ha^{-1}*) and amounts of applied N (0, 35, 70, 105 and 140 kg N ha^{-1}) in barley grown with water treatments (DW and FW) in 2012/2013 and 2013/2014 seasons.

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كفاءة الاستفادة من النتروجين والماء فى الشعير المعرض لظروف الجفاف فى الأرض الملحية

عماد الدين ماهر حافظ و وليد حسن أبوالحسن*
قسم المحاصيل- كلية الزراعة- جامعة كفرالشيخ- كفر الشيخ و *معهد بحوث موارد المياه- المركز القومى لبحوث المياه- القليوبية- مصر.

يعتبر انتقال ومساهمة المادة الجافة والنتروجين فى النمو الخضرى وحبوب الشعير(صنف جيزة 2000) المعرض لنقص الماء قبل و أثناء التزهير فى الأرض الملحية موضوع هام لإنتاج الطعام. فى ضوء هذه الدراسة تم الاهتمام بكفاءة الاستفادة من النتروجين والمياه اخذا فى الاعتبار كل من الانتاج الاقتصادى والبيئى. الهدف من الدراسة الحالية هو دراسة تاثير معاملات المياه، (اضافة المياه، ونقص المياه و خمس معاملات تسميد نتروجينى (صفر ، 35 ، 70 ، 105 و 140 كجم نتروجين /هكتار) على نتروجين دليل الحصاد و كفاءة الانتقال المادة الجافة والنتروجين و مساهمة النتروجين و كفاءة استخدام النتروجين وكفاءة الاستفادة من النتروجين وكفاءة امتصاص النتروجين وتكشف السماد النتروجينى وكفاءة الاستفادة من المياه فى الشعير أثناء موسمى النمو 2013/2012 و 2014/2013. اضافة كل من 105 و 140 كجم نتروجين/هكتار أدى الى اعلى محصول حبوب ونتروجين دليل الحصاد وكفاءة انتقال المادة الجافة ومساهمة النتروجين وكفاءة الاستفادة من المياه. زيادة اضافة النتروجين إلى 70 كجم نتروجين/هكتار أدى إلى أعلى كفاءة امتصاص نتروجين بينما تكشف السماد النتروجينى كان الاقل عندما النباتات تمت زراعتها مع هذا المستوى من التسميد. كفاءة إستخدام والإستفادة من النتروجين زادت بواسطة الزيادة فى إضافة السماد النتروجينى من 35 إلى 70 كجم/هكتار وانخفضت تدريجيا تحت اضافة السماد النتروجينى الأعلى. على النقيض لم يكن هناك اختلافا معنويا بين تاثيرات معاملات المياه المختلفة وتطور الجذر خاصة فى حالات العجز المائى. من هذا يتم تلخيص ماسبق ان هناك لم يوجد أى اختلافات معنوية بين معاملات المياه المختلفة من حيث نتروجين معامل الحصاد وكفاءة انتقال النتروجين والمادة الجافة ومساهمة النتروجين وكفاءة استخدام النتروجين وكفاءة الاستفادة من النتروجين وكفاءة امتصاص النتروجين وتكشف النتروجين وكفاءة الاستفادة من المياه التى تدعم النظرية ان الآداء الأفضل لنباتات الشعير عندما زرعت فى الظروف الجفاف عند معدل 105 كجم سماد / هكتار فى الارض متوسطة الملوحة خلال موسمى الزراعة الشتوى.