MINERAL NUTRIENT STATUS OF SOME MEDITERRANEAN BARLEY VARIETIES AS AFFECTED BY DROUGHT STRESS IN EGYPT

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ABSTRACT

Field experiment was carried out at the experimental research station of Nubaria, representing the newly reclaimed sandy loam soils of Egypt. The study was done to evaluate the nutrient status of barley varieties (Egyptian, Tunisian, Algerian and Morocco) grown under normal (75% water holding capacity=WHC) and stress condition (40% WHC). Results indicated that the Egyptian variety El-Arish scored the highest values of N% under normal and drought stress condition and Giza 127 for P and Giza 123 for K in same sequence. The lowest values of N, P and Ca content observed with Giza 2000 variety. As for the Tunisian varieties, the lowest reduction percentage was attained at Raihane (9.38%, 3.54% and 3.62%) for N, K and Ca, respectively. Algerian barley varieties, N in Naïlia/Techedrett, P in Temacine/Ksar Megrine, K in Ras El-Mouche/Temacine, Ca in Saida/Ksar Megrine, got the highest and lowest values under normal and stress conditions, respectively. Morocco varieties, lowest values of N, P, K and Ca were recorded for Massine, Taffa and Amalou under water stress condition. The highest and lowest value of Fe, Zn and Mn were recorded for barley varieties Giza 2000, Giza 131 and Giza 127, respectively. Results concluded that the Egyptian varieties (Giza 127, Giza131, Giza 2000), Tunisian varieties (Kebili-3 and Tozeur-2), Algerian varieties (Techedrett, Naïlia) and Morocco varieties (Laanaceur, Amira) registered the lowest reduction percentage in nutrient content indicating their tolerance to sustain its productivity under water stress condition.

Key words: sandy loam, water stress, nitrogen, phosphorus, potassium, iron

المغذيات المعدنية فى بعض أصناف شعير دول البحر الابيض المتوسط المتأثرة بإجهاد الجفاف تحت الظروف المصرية

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المستخلص

تم إجراء تجرية حقلية في محطة التجارب الخاصه بالمركز القومي للبحوث الواقعه فى زمام منطقة النوبارية التابع لمحافظة البحيره بجمهوريه مصر العربيه لدراسة حالة العناصر المغذية فى أصناف الشعير (المصرية والتونسية والجزائرية والمغربية) التي زرعت تحت ظروف رى طبيعيه بدون اجهاد (والتى تمثل 75٪ من قدرة التربه على الاحتفاظ بالماء) ومقارنتها مع حالة الزراعه تحت ظروف إجهاد الجفاف ونقص المياه (والتى تمثل 40٪ من قدرة التربه على الاحتفاظ بالماء).أشارت النتائج إلى أنالاصناف المصرية عريش وجيزة 127 وجيزة 123 سجلت اعلى القيم فى محتواها من النيتروجين والفوسفور والبوتاسيوم تحت ظروف الرى الطبيعى وظروف اجهاد الجفاف. بينما تم الحصول على أدنى قيم للمغذيات الكبرى السابقه في الصنف جيزة 125 تحت ظروف اجهاد نقص المياه. أما بالنسبة للأصناف التونسيه، فقد كانت أدنى نسبة انخفاض فى محتوى المغذيات فى الصنف ريحان وهى (9.38% ، 3.54%، 3.62%) لعناصر النيتروجين والبوتاسيوم والكالسيوم ، على التوالي. الصنف توزير 2 سجل ادنى نسبة انخفاض فى محتواه من الفوسفور (3.32 ٪) تحت ظروف اجهاد نقص المياه مقارنة مع ظروف الرى الطبيعى الموصى به حسب الاحتياجات المائية للشعير.أما بالنسبة للأصناف الجزائريه اظهرت الدراسه ان الاصناف نائله وتيماسين و رأس الموش وصيدا سجلت اعلى قيم من العناصر الغذائيه النيتروجين والفوسفور والبوتاسيوم والكالسيوم.كما اظهرت الدراسه انخفاض تركيز العناصر الغذائيه الصغرى الحديد والزنك والمنجنيز فى الاصناف جيزه 125 وقصر وجيزه 127 في حالة الرى الطبيعية بدون اجهاد بينما تحت ظروف الإجهاد تم تسجيل أعلى وأدنى قيمه للحديد والزنك والمنجنيز لأصناف الشعير جيزة 2000 وجيزة 131 وجيزة 127 على التوالي. ونخلص من النتائج الى أن الأصناف المصرية (جيزة 127، جيزة 131 ، جيزة 2000)، الأصناف التونسية (قبيلي 3 وتوزير 2)، الأصناف الجزائرية (نائله وتشيدريت) والأصناف المغربية (اميرة ولاناسير) سجلت أقل نسبة انخفاض في محتواها من العناصر المغذية ويشير إلى مدى قدرة هذه الاصناف للحفاظ على محتواها من العناصر فى حدود قياسية وبالتالى انتاجيتها تحت ظروف الإجهاد المائي ونقص المياه.

كلمات مفتاحية: اصناف الشعير، الإجهاد المائي، النيتروجين، الفوسفور، البوتاسيوم، الحديد

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INTRODUCTION

In Egypt, barley is mainly grown under rainfed conditions in the north coastal regions and under irrigation in the newly reclaimed lands, and in saline soils where irrigation water is limited. The total area under barley cultivation in Egypt fluctuates according to the amount and distribution of annual rainfall. Deficit of water is a worldwide problem particularly in arid and semiarid region as a result of not only to climate change, but also rapid expansion in domestic and agricultural use (9). Drought is a nature produced but temporary imbalance of water availability, consisting of a persistent lower-than-average precipitation, of uncertain frequency, duration and severity, the occurrence of which is difficult to predict, resulting in diminished water resources availability and carrying capacity of the ecosystems (29). Droughts are hazards because they are natural accidents of almost unpredictable occurrence, and disasters because they consist of the failure of the precipitation regime, causing the disruption of the water supply to the natural and agricultural ecosystems as well as to the human activities. Water management under drought requires measures and policies which are common with aridity such as those to avoid water wastage, reduce demand, make water use more efficient and increase the public awareness on the proper use of water (25). Water is the most precious agricultural resource after land in the water-limited environments. However, few studies have dealt with the effect of limited irrigation on the concentration of minerals in grains. Different moisture stress treatments during pre and after anthesis on maize did not affect the mineral concentration in grain (12). Barley (*Hordeum vulgare* L.) ranks fifth among field crops in grain production in the world after maize, wheat, rice and soybean. In recent years, about two thirds of barley crop has been used for feed, one-third for malting and about 2% directly for food (3). Barley (*Hordeum vulgare* L.)is a typical crop of marginal areas in North Africa and Mediterranean regions specially in the Northern coastal areas which precipitation fluctuated from year to year and in most years the barley cultivated area, as in Egypt, that suffer from lack of water in the time of sowing and/or at the later stages of growth which need supplemental irrigation. Water shortage is the major constraint affecting cereal production in the Mediterranean Basin. The climate of this region is characterized by erratic and unpredictable precipitations (26**).** Barley also in Egypt is grown under wide range of environmental conditions. It is grown in areas where water supply is limited and where crop production depends mainly upon rainfed. In Egypt, Also, barley cultivated mainly in the Northern coastal region and in the marginal areas of Nile Valley and Delta and in the new reclaimed soils in order to its tolerance to salinity and drought than wheat. The supply of nutrients via plant roots might be restricted under high pH, high calcium carbonate content, as well as inadequate irrigation water. Thus, foliar application of nutrients is necessary to compensate the shortage of nutrients via roots or to correct the deficiency of these nutrients especially at critical growth stages such as fruiting stage. The highest N content was recorded for barley varieties (Giza123, 124, 125, 126,129, 130 and 2000) that grown under normal conditions, whereas, content of P, K, and Na in all varieties decreased dramatically under water stress condition (10). Abdulameer and Ahmed (1) concluded that addition of humic acid levels to the soil improved the plant's tolerance to water stress by giving the highest values of the studied qualities compared to the treatment without addition, indicating the possibility of maintaining the growth of maize in case of lack of water available. Dhahi and Baktash (7) found significant differences in interactions between genotypes and water stress in most characters studied, this shows of genotypes tolerance differences to water stress. The aims of this study were to evaluate the influence of drought stress on macro and micronutrient contents of Mediterranean barley varieties grown in newly reclaimed soil of Egypt.

MATERIALS AND METHODS

Field experiments were conducted during two winter seasons (2016/2017 and 2017/2018) to evaluate the nutrient content of Mediterranean barley (*Hordeum vulgare* L.) varieties grown under water stress condition. at the experimental farm of National Research Centre, Nubaria region, Egypt (latitude

30.8667 N, and longitude 31.1667 E, and mean altitude 21 m above sea level). The experimental area was classified as arid region with cool winter and hot dry summer prevailing in the experimental area. There was no effective rainfall (low intensity) that can be taken into consideration throughout the two growing seasons and to the pacing between rainfall events. The soil of experimental site is classified as sandy soil. The field capacity of the experimental soil was 31 ml /100g soil; pH 7.8; EC 1.1 dS m^{-1} and available N was 42 mg/kg soil. A randomized complete block design was used with three replications. Drip irrigation regime was applied through two types of in line emitter according to its discharge (4 and 2 liter), which fulfill 75 and 40 % of water holding capacity named as Normal and Stress condition, respectively. Mediterranean barley varieties were used for the field experiment were Egyptian varieties (Giza 123, Giza 125, Giza 126, Giza 127, Giza 130, Giza 131, Giza 2000, El-Arich and Ksar), Tunisian Varieties (Kebili 1, Tozeur-2, Kebili 3, Kairouan, Manel, Raihane, Sidi-Bou, Sabra, Tombari, Lemsi), Algerian varieties (Temacine, Ksar-Megrine, Techedrett, Saida, Sedi Mahdi, Ras El-Mouche, Naïlia) and Morocco Varieties (Adrar, Oussama, Amalou, Massine, Taffa, Firdaws, Amira, Tamellalet, Laanaceur). The grains of the cultivated Egyptian, Tunisian, Algerian and Morocco barley varieties were obtained from National gene bank of Tunisia. Sowing dates were November 25th 2016 and 2017 season. Seeding rate was 50 Kg fed^{-1}(ha=2.4 fed).The soil was prepared as usually done in traditional cultivation. All other agronomic practices followed during the growing season as usually recommended in the Agriculture Research Centre, Ministry of Agriculture, Giza, Egypt. Phosphorous fertilizer was applied during seedbed preparation at the rate of 60 Kg P_2O_5 fed^{-1} in the form of super phosphate (15.5% P_2O_5). Potassium fertilizer was applied at 24 Kg K_2O fed^{-1} in the form of potassium sulphate (48% K_2O) at two equal doses. The first dose was applied during seedbed preparation, while the second was applied after 30 days from sowing. Nitrogen fertilizer was applied at the rate of 60 Kg N fed^{-1} in the form of ammonium sulfate (20.0 %) in three doses; the first dose was at sowing and the other two doses were applied at 21 and 45 days after sowing. All other agronomic practices were followed during the growing season as usually recommended in the surrounding barley production farms.

Nutrient content analysis

At heading and harvest stage, representative leaves and grain samples of barley dried at 70 ^{O}C, grinded and digested by mixture of sulfuric and perchloric acids then analyzed for macro and micronutrients in barley varieties and determined according to [6 , 23].Nitrogen in plant analyzed using Microkjeldahl technique. Phosphorus determined by vando molybdtae color reagent and analyzed calorimetrically. Potassium determined using flame photometer and micronutrients (Fe, Mn and Zn) determined by atomic absorption spectroscopy.

Statistical analysis

Data were statistically analyzed as a Randomized Complete Block Design (RCBD) using analysis of variance (ANOVA) and the means of varieties included in this trial compared using fisher test run by Least Significant Difference (L.S.D.) at ($P \leq 0.05$) according to (13).

RESULTS AND DISCUSSION

Macronutrient at heading stage

With respect to the macronutrients content in barley at heading stage, data in Table 1 indicate that El-Arish variety scored the highest values of N% under normal condition and drought stress while Giza 127 for P and Giza 123 for K in same sequence. Whereas, the lowest values of the previous macronutrients were obtained at Giza 125. While, recorded the lowest values of N, P and Ca content with Giza 2000 variety. According to the reduction percentage in the studied plant nutrients, the obtained results indicated that the lowest reduction were observed at Giza 127 (4.63%) for N%. For P content, barley varieties Giza126 (9.62%), as for Ca percentage Giza 131 it has been 18.90%, which mean that these represent the ability of the selected varieties to tolerance to drought whereas, the highest reduction percentage were attained at El-Arish (24.45%, 39.22%, 41.27% and 30.00%) for N, P, K and Ca, respectively. Drought reduces both nutrients uptake by roots and its transport from roots to shoots, due to limited transpiration rates and impaired active transport and membrane permeability (2). Data of the macronutrients (N,P, K and Ca) content of Tunisian varieties were represented in Table 1. The obtained data revealed that the highest values were obtained at Manel- Sabra, Sidi-Bou, and Tombari varieties for N, P, K and Ca, respectively under normal and stress condition. While, the lowest ones were attained at Sidi-Bou, Kairaouan, Tombari and Tozeur-2, in same previous sequences. However, the highest reduction percentage resulted from drought comparing with normal condition, was attained at Manel, Kairaouan, Sabra, and Kairaouan varieties for N, P, K and Ca, respectively. In other ward, the lowest reduction % was recorded at Tozeur-2 cultivar (9.6%, 10.45%, 2.47% and 5.43% for N, P, K and Ca, respectively. Water stress during growth cycles of plants adversely affects many physiological growth processes (photosynthesis, translocation of carbohydrates and growth regulators, ion uptake transport and assimilation, N_2 fixation, turgidity, respiration) (11). Regarding to the estimated macronutrient of Algerian varieties data indicated that the highest values were attained at the following varieties: Temacine (N), Naïlia (P), Temacine, (K) and Temacine (Ca) in both normal and stress conditions. While, the lowest values were recorded at Naïlia (N), Temacine (P), Saida (K), and Naïlia (Ca). According to the reduction percentage of macronutrient content as affected by drought stress, data noticed that the highest reduction percentage were recorded at Sedi Mahdi (58.37%), Ras El-Mouche (56.74%, 51.91%, and 45.22%) for N, P, K, and Ca, respectively. However, the following varieties scored the lowest reduction percentage Naïlia (4.93% and11.74%), Techedrett (15.76 and 13.19%)in same sequences. This finding proves that those varieties were highly tolerant and have ability to uptake the examined plant nutrients. Values of determined macronutrients of Morocco barley indicate in Table 1. Results noticed that Firdaws varieties scored the highest values of N, P, K, and Ca withers under normal or stress conditions, except Amira for K. The decline in soil moisture also resulted in a decrease in the absorbing root surface. The N uptake decreased with both drought dates but the drought effect was more with the treatment at milk ripe stage where, P, K and Na uptake were decreased with water deficit at elongation and the effect was lesser when water stress was done at milk ripe stage of barley cultivated in Nubaria at the northern western parts of River Nile delta (17). Khattab (20) observed that the potassium and/or proline content in plants should be increased by applying their foliar spray to the soybean plant to increase yields under water stress conditions.

Macronutrient content of grains At harvest, concerning the studied macronutrient contents of grain Egyptian barley, data in Table 2shows that Giza 123, Ksar, Giza 131 and El-Arish varieties fulfilled the highest macronutrients content N, P, K and Ca, respectively wither exposed or to drought treatments. Whereas, the lowest content values were recorded at Giza 2000, Giza 131, Ksar and Giza 123 varieties in same sequence. Drought stress may cause negatively effects; calculated reduction percentage is very useful to recognize the most tolerant plants and high sensitive ones. Data on hand revealed that Giza 2000 (10.86%) for N, Giza 125 (15.20%) for P, Ksar (5.1%) for K and Giza 2000 (4.47%) for Ca. However, the highest reduction percentage were attained for Giza 125 (25.68%) for N and Ksar (38.14% and 40.57%) for P and K and Giza 127 (18.35%) for Ca. Potassium plays an important role in combating the adverse effect of drought through its effect on different physiological process. The availability of K^+ to the plant decreases with decreasing soil water content (drought condition) due to the decreasing mobility of K^+ under these conditions. Low levels of soil moisture reduced root growth and the rate of potassium inflow in plants in terms of both per unit of root growth and per unit of root length. Under drought conditions, wilting in plants suggests possible K^+ deficiency (15). According to reduction percentage under comparing values of macronutrients content under stress with normal condition, data in Table 2 indicate that the lowest reduction % were attained at Raihane (9.38%, 3.54% and 3.62%) for N, K and Ca, respectively. As for P content Tozeur-

2 variety record at (3.32%).From the other hand, the highest reduction % could be arranged in the following ranks: Sabra (25.29%), Tombari (23.18%), and Manel (15.88%and 16.37%) for N, P, K and Ca, respectively.

Table 1. Nutrient contents of barley leaves at heading stage

Barley Varieties	Nitrogen (%)		Phosphorus (%)		Potassium (%)		Calcium (%)	
	Normal	*Stress*	*Normal*	*Stress*	*Normal*	*Stress*	*Normal*	*Stress*
Giza123	1.81	1.57	0.25	0.20	2.17	1.85	0.35	0.33
Giza125	3.53	2.49	0.18	0.11	2.23	1.83	0.50	0.45
Giza126	1.97	1.28	0.52	0.47	1.89	1.54	0.63	0.57
Giza127	3.24	3.09	1.04	0.80	1.35	1.00	0.51	0.39
Giza130	2.63	2.21	0.37	0.27	1.99	1.53	0.89	0.76
Giza131	2.63	2.28	0.90	0.73	1.20	1.15	0.63	0.59
Giza2000	2.75	2.51	0.73	0.55	1.16	0.86	0.45	0.37
El-Arich	4.08	2.96	0.51	0.21	1.89	1.11	0.70	0.49
Ksar	3.97	2.26	0.28	0.20	1.64	1.28	0.61	0.48
Kebili 1	2.17	1.96	0.24	0.21	0.88	0.84	0.57	0.47
Tozeur-2	2.08	1.88	0.20	0.18	0.81	0.76	0.39	0.37
Kebili 3	2.44	2.03	0.26	0.17	0.65	0.54	0.54	0.41
Kairaouan	1.93	1.69	0.08	0.04	1.07	0.73	0.62	0.42
Manel	2.97	1.64	0.09	0.05	0.79	0.50	0.49	0.45
Raihane	2.57	1.97	0.22	0.17	0.86	0.83	0.44	0.35
Sidi-Bou	1.64	1.48	0.18	0.14	1.10	0.95	0.48	0.41
Sabra	2.04	1.44	0.27	0.15	0.74	0.43	0.62	0.53
Tombari	2.12	1.65	0.21	0.17	0.62	0.49	0.62	0.50
Lemsi	1.89	1.35	0.27	0.13	1.05	0.77	0.53	0.46
Temacine	3.65	2.58	0.15	0.11	1.82	0.97	1.94	0.64
Ksar-Megrine	2.61	1.96	0.35	0.29	1.75	1.22	1.25	0.53
Techedrett	2.90	2.46	0.38	0.32	1.65	1.39	0.91	0.79
Saida	2.46	2.18	0.58	0.44	0.91	0.66	1.09	0.93
Sedi Mahdi	2.57	1.07	0.42	0.20	1.65	1.16	1.20	0.30
Ras El-Mouche	2.14	1.33	0.28	0.12	1.66	0.80	1.15	0.33
Naïlia	2.07	1.97	0.60	0.53	1.43	1.16	0.82	0.68
Adrar	2.78	1.73	0.19	0.18	1.11	0.75	0.62	0.44
Oussama	2.79	1.87	0.25	0.17	1.13	0.98	0.65	0.54
Amalou	2.60	1.97	0.16	0.14	0.83	0.79	0.52	0.44
Massine	2.25	1.93	0.23	0.18	1.00	0.89	0.61	0.44
Taffa	2.22	1.73	0.17	0.12	0.85	0.78	0.73	0.62
Firdaws	3.85	2.12	0.49	0.34	0.41	0.37	0.79	0.72
Amira	2.87	1.90	0.19	0.16	1.25	0.93	0.63	0.45
Tamellalet	2.79	1.80	0.29	0.17	1.07	0.81	0.60	0.52
Laanaceur	2.22	2.11	0.26	0.16	0.88	0.70	0.51	0.49
LSD (0.05)	0.128	0.083	0.045	0.037	0.042	0.046	0.035	0.020

With Respect to the estimated macronutrients content of Algerian barley varieties, Data in Table 2 shows that for N in Naïlia/Techedrett, for P in Temacine/Ksar Megrine, for K in Ras El-Mouche/Temacine, for Ca in Saida/Ksar Megrine, got the highest and lowest values of the studied macronutrients under normal and stress conditions, respectively. Data of reduction percentage indicated that Saida cultivar was superior (24.87%) followed by Sedi Mahdi cultivar for N and Ras El-Mouche-Naïlia for P and K, Temacine and Ksar-Megrine for Ca. and Saida followed by Techedrett varieties for Ca. From the above mentioned, the most sensitive varieties were Ras El-Mouche, Naïlia, Sedi Mahdi and Temacine varieties for N, P, K and Ca, respectively. Kandil [18] on maize, found that N and protein content in grains considerably depressed by widening irrigation intervals from 18 to 24 days. Also, data in Table 2 shows that Morocco varieties Firdaws, Amira, Adrar and Laanaceur, recorded the highest values under both studied drought conditions for these nutrients, respectively. While the lowest values of N, P, K and Ca were recorded at the following varieties: Massine-Taffa-Massine-Amalou in same sequence. In other ward it could be easy to select barley varieties that most tolerant to drought regarding to the reduction percentage that estimated relative to the normal conditions, data on hand revealed that Tamellalet cultivar was the superior one, Firdaws cultivar appeared as the most tolerant one and scored the lowest reduction percentage followed by varieties Oussama for (N, P, K and Ca). Also, the highest sensitive Morocco barley varieties to drought were Tamellalet variety for above nutrient mentioned. Drought can also have a strong impact on plant nutrient relations (14). Drought stress decreases the concentration of nitrogen (N) and phosphorus (P) in plant tissue, and several studies have shown that drought can decrease nutrient uptake from soil (28). Decreases in nutrient uptake during drought may occur for several reasons, including the reduction of nutrient supply through mineralization (27), and by reducing nutrient diffusion and mass flow in the soil (21). Drought could also decrease nutrient uptake by affecting the kinetics of nutrient uptake by roots, but this has been little studied (5).

Table2. Nutrient contents of barley grain at harvest stage

Barley Varieties	N (%)		P (%)		K (%)		Ca (%)	
	Normal	*Stress*	*Normal*	*Stress*	*Normal*	*Stress*	*Normal*	*Stress*
Giza123	1.978	1.760	0.750	0.636	0.521	0.490	0.108	0.101
Giza125	1.352	1.005	0.621	0.518	0.606	0.458	0.129	0.118
Giza126	1.384	1.123	0.669	0.557	0.562	0.475	0.125	0.120
Giza127	1.672	1.341	0.679	0.530	0.596	0.439	0.218	0.178
Giza130	1.411	1.251	0.538	0.431	0.568	0.468	0.138	0.130
Giza131	1.422	1.184	0.563	0.462	0.667	0.518	0.140	0.124
Giza2000	1.341	1.195	0.693	0.581	0.500	0.437	0.150	0.143
El-Arich	1.406	1.144	0.700	0.433	0.594	0.353	0.218	0.196
Ksar	1.771	1.453	0.776	0.633	0.430	0.408	0.204	0.188
Kebili 1	1.760	1.568	1.072	0.976	0.495	0.455	0.231	0.210
Tozeur-2	1.936	1.728	0.722	0.698	0.482	0.451	0.207	0.195
Kebili 3	2.080	1.600	0.813	0.762	0.451	0.406	0.225	0.205
Kairaouan	1.472	1.216	0.895	0.746	0.510	0.441	0.177	0.164
Manel	1.456	1.152	0.736	0.670	0.510	0.429	0.226	0.189
Raihane	1.536	1.392	0.761	0.701	0.508	0.490	0.221	0.213
Sidi-Bou	1.456	1.264	0.786	0.660	0.505	0.462	0.255	0.224
Sabra	1.392	1.040	0.739	0.594	0.463	0.390	0.203	0.170
Tombari	1.472	1.280	0.548	0.421	0.366	0.314	0.235	0.204
Lemsi	1.392	1.200	0.670	0.563	0.449	0.384	0.242	0.206
Temacine	1.646	1.443	0.618	0.543	0.434	0.397	0.344	0.277
Ksar-Megrine	1.770	1.498	0.332	0.280	0.434	0.413	0.286	0.243
Techedrett	1.517	1.395	0.414	0.395	0.502	0.461	0.378	0.357
Saida	1.605	1.522	0.508	0.496	0.473	0.451	0.379	0.368
Sedi Mahdi	1.834	1.443	0.423	0.406	0.452	0.407	0.379	0.329
Ras El-Mouche	1.866	1.402	0.557	0.451	0.542	0.463	0.345	0.328
Naïlia	2.024	1.888	0.481	0.391	0.492	0.438	0.317	0.294
Adrar	1.392	1.160	0.652	0.436	0.452	0.383	0.224	0.201
Oussama	1.226	1.192	0.701	0.682	0.440	0.415	0.256	0.240
Amalou	1.192	1.096	0.613	0.574	0.435	0.395	0.217	0.197
Massine	1.070	0.990	0.631	0.580	0.381	0.351	0.229	0.208
Taffa	1.182	1.098	0.528	0.471	0.435	0.383	0.238	0.223
Firdaws	1.534	1.230	0.694	0.629	0.441	0.379	0.294	0.260
Amira	1.382	1.061	0.751	0.547	0.399	0.277	0.270	0.195
Tamellalet	1.294	0.910	0.713	0.477	0.397	0.236	0.238	0.101
Laanaceur	1.306	1.190	0.608	0.532	0.397	0.356	0.274	0.252
LSD 0.05	0.017	0.013	0.020	0.019	0.021	0.014	0.012	0.010

Micronutrient content

Micronutrient (Fe, Zn and Mn) content in Egyptian barley varieties as affected by normal and stress condition were recorded in Table 3. The Results observed that the iron, zinc and manganese increased when imposed in stress condition (Fe) and the opposite was true in case of Zn and Mn. The maximum content of the determined micronutrients under normal condition were recorded at barley varieties Giza 2000 (339 ppm, 40 ppm) and Giza 131 (16.5 ppm) for Fe, Zn and Mn, respectively.

The minimum ones were attained for barley varieties Giza 125 for Fe and Ksar for Zn and Giza 126 for Mn under normal condition. However, under stress condition the highest and lowest value of Fe, Zn and Mn were recorded for barley varieties Giza 2000, Giza 131 and Giza 127, respectively. In Nubaria areas (new cultivated areas) in Egypt, Hussein (17) concluded that the grain nutrient concentration slightly affected by drought treatments except of Zinc which increased sharply in grains of plants subjected to drought at milk ripe stage to be one-fold compared to that in plants grown under regular irrigation. The contribution of these responses to tiller survival under severe drought in controlled environments is contrasted with performance and persistence of swards in the field in the harsher Mediterranean environment. Micronutrients like Fe, Zn and Cu concentration of the kernels decreased with increasing water deficiency (24). Regarding to the grain micronutrients contents of Tunisian barley (Table 3) data on hand revealed that imposed plants to stress progressively increased micronutrients values for Fe under most studied verities while the opposite was true in case of Zn and Mn. Kairaouan varieties followed by Manel were highly accumulated for Fe under normal and drought stress conditions, respectively. Whereas, Lemsi, was the less studied micronutrients accumulated one. In case of Zn and Mn, the highest values under both studied conditions at Tombari followed by Tozeur-2 (normal) and Tombari - Kebili-3 (stress condition). However, the lowest values of the Zn and Mn content were recorded at Kebili-3, Sidi-Bou (normal) and Sabra (stress) for Zn and Mn, respectively. On fodder beet, Hussein (16) revealed that omitting of irrigation decreased the all nutrients concentration determined i.e., N, P, K, Fe, Zn and Mn in top and roots of fodder beet grown in new reclaimed soil. These effects may be due to the effect of moisture deficit on soil water and nutrients availability (30).

Table 3. Grain micronutrient content of barley as affected by drought stress

Barley varieties	Fe (ppm)		Zn (ppm)		Mn (ppm)	
	Normal	*Stress*	*Normal*	*Stress*	*Normal*	*Stress*
Giza 123	213	185	38.8	31.2	13.4	12.6
Giza 125	90	86	27.9	26.3	11.5	8.6
Giza 126	151	147	30.8	29.7	9.4	8.8
Giza 127	173	120	29.2	21.6	10.6	7.50
Giza 130	194	182	36.5	29.2	14.4	11.0
Giza 131	243	198	30.4	29.3	16.5	12.2
Giza 2000	339	232	50.7	35.3	15	12.3
El-Arich	248	193	39.9	28.3	11.9	8.6
Ksar	241	162	26.9	22.5	16.5	15.2
Kebili 1	232	224	31.4	27.8	16.6	14.4
Tozeur-2	172	161	31.8	29.8	18.2	11.3
Kebili 3	162	122	25.5	21.1	17.9	15.3
Kairaouan	290	203	30.0	21.1	15.7	12.6
Manel	268	234	27.7	26.5	16.5	13.5
Raihane	152	115	31.4	27.3	18.1	11.5
Sidi-Bou	160	148	33.2	29.6	10.5	9.21
Sabra	141	103	25.9	20.6	10.9	6.5
Tombari	162	116	45.6	32.4	16.7	11.6
Lemsi	198	99	27.2	21.7	10.7	6.70
Temacine	249	180	32.6	22.1	14.9	10.2
Ksar-Megrine	160	116	24.3	23.2	18.1	11.6
Techedrett	291	228	37.1	27.0	22.5	18.6
Saida	257	176	39.3	28.7	19	16.2
Sedi Mahdi	131	91.0	23.2	21.9	15.1	11.5
Ras El-Mouche	137	120	24.8	22.8	8.80	7.70
Naïlia	270	197	38.8	26.7	27.2	17.3
Adrar	158	111	36.4	24.8	7.81	3.6
Oussama	146	112	26.7	23.5	14.3	10.3
Amalou	92.1	78.6	19.6	18.1	8.2	7.4
Massine	167	145	19.9	18.3	5.42	4.4
Taffa	167	113	22.6	20.9	9.2	4.5
Firdaws	191	116	29.5	19.4	15.5	11.6
Amira	135	164	25.1	13.9	12.2	9.3
Tamellalet	114	98	27	23.4	6.4	6.3
Laanaceur	245	218	36.7	32.5	18.1	12.4
LSD 0.05	2.099	1.628	0.733	0.526	0.106	0.078

Also, it is clear the difference between highest and lowest value (Kairouan 290 ppm)/ Sabra (141) was 48.62% at Fe and Tombari (45.6) Kebili-3 (25.5) was 55.92% at Zn and at Mn was Tozeur-2 (18.2ppm)/Sidi-Bou (10.5) was 57.7%. Water deficit induced obviously effects on the concentration and content of minerals in cereal plants (4, 18). Inadequate supply of nutrients is a major reason for low yields per unit area (22). The supply of nutrients via plant roots might be affected under some soil and environmental conditions such as high pH, high lime content, soil compactness as well as inadequate or excessive irrigation water. Some micronutrients (Fe, Zn and Mn) were determined in the investigated Algerian varieties and presented in Table 3. Resulted data revealed that exposed barley plant to drought stress led to decrease micronutrients comparing with normal condition. The highest reduction in micronutrients (Fe, Zn and Mn) was found at Fe followed by Zn and Mn. Also, it is worthy to mention that the highest Fe, Zn and Mn values were recorded for Techedrett, wither under normal or drought stressed except Saida (normal) and Naïlia (stress). Also, data found that Naïlia, Sedi Mahdi, Temacine, Ras El-Mouche and Sedi Mahdi recorded the lowest studied micronutrients (Fe, Zn and Mn) under normal and stress condition, respectively. Regarding to the grain micronutrients contents of Morocco barley in Table 3, data revealed that, imposing the barley plants to stress progressively increased micronutrients values for Fe under most studied verities, while the opposite was true in case of Zn and Mn. Laanaceur, Firdaws barley varieties followed Oussama and Amira were highly accumulated for Fe under normal and drought stress conditions, respectively. Whereas, Adrar, was the less studied micronutrients accumulated one. The highest content of determined micronutrients under normal condition was recorded at Laanaceur (245 ppm Fe, 36.7 ppm Zn and 18.1 ppm Mn) and the lowest values recorded for Amalou (98 ppm Fe, 19.6 ppm Zn) and Massine 5.40 ppm Mn. However, under stress condition the highest and lowest values of Fe, Zn and Mn were recorded for Laanaceur and Amalou (218 and 78ppm), Laanaceur and Amira (32.5 and 13.9 ppm), Laanaceur and Massine (12.4 and 4.4 ppm) for Fe, Zn and Mn, respectively. El-Faham (9) on wheat, revealed that K content in grains increased when irrigation skipped at jointing and P by skipping at the same stage or at milk ripe stage. They added also, that water stress had a depressive effect on Fe, Mn and Zn contents in grains.

CONCLUSION

Significant differences were observed among the tested barley varieties across the two years for Macro and Micronutrient content of barley plant whether at heading or harvest stage under drought stress and none stress condition. Drought promoted reduction in nutrients content in some barley varieties whether were Egyptian, Tunisian, Algerian and Morocco varieties under water stress condition. The barley varieties submitted to drought showed decrease in nitrogen, phosphorus, iron, zinc, manganese this enhanced the nutrient imbalance in barley under drought stress conditions.

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Conflict of interest

All authors declare no conflict of interest in this paper.

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