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RESPONSE OF BARLEY TO NITROGEN FERTILIZATION, FOLIAR APPLICATION OF MICRONUTRIENTS MIXTURE AND CITRIC ACID UNDER CALCAREOUS SOIL

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ABSTRACT

A field trial was conducted at Nubaria Agricultural Research Station, El-Behira Governorate, Egypt, during two successive growing seasons 2012/2013 and 2013/2014. The aim was to study the effect of nitrogen fertilizer rates *i. e.* 15, 30, 45 and 60 kg N fed^{-1} and foliar spray by micronutrient mixture (Fe + Zn + Mn) at concentrations of 0, 133 and 200 ppm for each element and citric acid (0, 1000 and 1500 ppm) on barley cultivar Giza 2000. The rate of 60 kg N fed^{-1} gave the maximum values of plant height, leaf area/ main stem, number of days to 50% heading, spike length, crop growth rate (CGR) at the first (60-75) DAS and second (75-90 DAS) periods, number of spikes m^{-2}, number of kernels $spike^{-1}$, 1000-kernel weight as well as straw and grain yields, total chlorophyll of leaves at 75 DAS and protein content of grains. Whereas, insignificant differences were observed in grain yield between applying 45 and 60 kg N fed^{-1}. All growth traits, yield and its components as well as total chlorophyll of leaf and protein content of grains recorded the maximum values when barley plants were sprayed by 200 ppm of micronutrients mixture (Fe + Zn + Mn) for each element plus 1500 ppm citric acid (S_2) compared to other foliar spray treatments (S_0 and S_1). The interaction between nitrogen fertilizer rates and foliar spray of micronutrients mixture plus citric acid had a significant effect on all traits under study except the number of days to 50% heading. The maximum values of such traits were obtained when barley plants received 60 kg N fed^{-1} and foliar spray of 200 ppm (Fe + Zn + Mn) for each element plus 1500 ppm citric acid.

Key word: *Barley, nitrogen, micronutrients, citric acid.*

1. INTRODUCTION

In Egypt, barley (*Hordem vulgare* L.) is the main cereal crop grown in rainfed areas and new reclaimed lands. Barley is considered one of the most important cereal crops in the world being used for many purposes such as malting and brewing industry, animal feeding, bread making alone or by mixing with wheat flour in some places, some human food and beverages and many other uses. In Egypt, most of barley production areas are located where the adverse conditions exist such as poor soil. Nitrogen fertilization is a common agronomic practice that leads to improve barley productivity. In Egypt, new lands such as calcareous soils need more studies to determine macro and micro nutrient needs. Many researches have postulated the importance of nitrogen fertilization in improving growth, yield and yield components for barley crop. Dirienzo *et al.* (1991) reported that increasing nitrogen fertilizer rates *i. e.* 0, 40, 80 and 120 b N $acre^{-1}$ increased grain and straw yields as well as crude protein of barley grains. Megahed *et al.* (1999) reported that, adding nitrogen fertilizer *i. e.* 0, 107, 143 and 179 kg N ha^{-1} to barley plants (Giza 124), increased significantly plant height, biological yield, grain and straw yields by adding 179 kg N ha^{-1} while, heading date was significantly decreased. Megahed *et al.* (2001 b) indicated that plant height, spike length, number of spike/m^{-2}, number of kernels /spike, spike kernel weight, 1000-kernel weight, biological yield, grain and straw yields of barley significantly increased with increasing nitrogen levels up to 90 kg fed^{-1}. Roy and Singh (2006) noted that adding nitrogen fertelizer up to 90 kg N ha^{-1} significantly increased grain and straw yields. Zeidan (2007) stated that increasing nitrogen rates from 30 to 70 kg N fed^{-1} increased plant height, flag leaf area, the number of spike m^{-2}, 1000-kernels weight and grain yield as well as protein content

of barley grains. Abd El-Rahman *et al.* (2012) stated that, the maximum values of plant height and spike length were obtained when barley received 45 kg N fed^{-1}. In newly reclaimed calcareous soils micronutrients play a great role to improve barley production. Abdel-Hadi *et al.* (1990) found that applying Zn either to the soil or as a foliar spray led to a marked increase for wheat grain yield. El-Sayed and Abdel-Hadi (1991) found a significant increase in plant height, grain yield and harvest index for barley grown in sandy soil by spraying plants with micronutrient a mixture of Fe + Zn + Mn. El-Habbal *et al.* (1995), found that coating wheat grains with a mixture prepared from three individual chelating micronutrients each contained 12% of Fe, Mn and Zn gave the highest grain and straw yields. Anton *et al.* (1999), reported that, coating barley grains with a micronutrient mixture (Fe + Zn + Mn) significantly increased plant height, number of tillers m^{-2}, the number of spikes m^{-2}, spike length, spike kernels weight, 1000-kernel weight as well as straw, grain and biological yields fed^{-1}. Citric acid has a simulative effect on plant growth and development. Miernyk and Trelease (1981) found that citric acid is one of the organic acids presented in tricarboxylic acid cycle and synthesized either from acetyl-COA, glycine and α-ketoglutic, or malic acid conversion to citric acid.

The objective of this study was to investigate the effect of nitrogen fertilization and foliar spray with a micronutrient mixture (Fe + Zn + Mn) and citric acid on barley growth, yield and yield components as well as the total chlorophyll of leaves and protein content of grains under calcareous soil conditions.

2. MATERIALS AND METHODS

The present work was carried out at Nubaria Agricultural Research Station, El-Behira Governorate, Egypt, during 2012/2013 and 2013/2014 seasons. The aim was to study the effect of nitrogen fertilizer rates *i. e.* 15, 30, 45, and 60 kg N fed^{-1} and foliar spray with a micronutrients mixture of Fe + Zn + Mn at aconcentration of 0, 133 and 200 ppm for each element and citric acid (0, 1000 and 1500 ppm) on barley Giza 2000 cultivar. Citrin solution consists of 2% Fe, Zn and Mn for each element plus 15% citric acid was used. Citrin solution was supplied by the biofertilizer production unit, soils, water and environment Research Institute, Agric. Res. Center (ARC), Giza, Egypt. The experiment was laid out in a split plot design with four replicates. The main plots were occupied by nitrogen levels and sub-plots contained micronutrients mixture plus citric acid. Sub-plot area was 10.5 m^2 (3.5 x 3m), 15 rows, 20 cm apart and 3.5 long. Some physical and chemical properties of the experimental site shown in Table (1) and were done according to Ryan *et al.* (1996) The treatments were as follows:-

- Main plots (Nitrogen fertilization) were four rates of N 15, 30, 45 and 60 kg fed^{-1}.
- Sub-plots (micronutrients mixture + citric acid):- spray with water (S_0), spray with 133 ppm (Fe + Zn + Mn) for each elements plus 1000 ppm citric acid (S_1) and spray with 200 ppm (Fe + Zn + Mn) for each with elements plus 1500 ppm citric acid.

Table (1): Physical and chemical properties of the experimental site in both seasons.

Property	2012/2013	2013/2014
Particle size distribution		
sand %	51.4	27.54
Silt %	24.9	36.76
Clay %	23.7	24.67
Texture	Sandy clay loam	Sandy clay loam
PH	7.5	7.1
O. M% (Organic matter %)	0.21	0.18
$CaCo_3$	18.10	19.10
Available nutrients (mg kg^{-1})		
N	12.50	13.20
P	4.10	3.95
K	115.00	126.00
DTPA-extractable (mg kg^{-1})		
Fe	0.68	0.61
Zn	0.41	0.39
Mn	0.54	0.48

***Textural classes according to the triangular diagram.**
C.F. Soil and Water Research Institute, A. R. C., Egypt.

Giza 2000 cultivar was sown on 25/11/2012 and 16/11/2013 in the first and second seasons, respectively. All sub-plots received the recommended dose of P and K fertilization. 30 kg p_2o_5 fed^{-1} in the form of calcium super phosphate (15% p_2O_5) and 48 kg K_2O fed^{-1} in the form of potassium sulphate (48% K_2O) were added and incorporated into soil before sowing. Nitrogen fertilization treatments in the form of ammonium nitrate (33.5 % N) were added in two equal doses, the first at 21 days after sowing (DAS) and the second at 35 DAS. Foliar application of the micronutrient mixture and citric acid were sprayed two times, the first after 35 days from sowing (tillering stage) and the second after 50 days from sowing (before the heading stage), the volume of water was one liter/ plot, 0.5% wetting agent of 20 was used. Cultural practices were practiced according to the methods being adopted for growing barley in the locality.

2. I. Growth traits

Plant height (cm), spike length (cm), the number of days to 50% heading, crop growth rate (CGR) g /plant / week, leaf area / main stem (cm^2) were estimated for five plants by using leaf area meter at 75 DAS. For determining the crop growth rate (CGR), five plants were randomly taken from the outer rows of each sub-plots for the four replications. The sampling dates were 60, 75 and 90 DAS. Plants were separated into roots and shoots and then dried at 70 c◦ in a ventilated oven to a constant weight. The following formula was used to determine CGR according to Watson (1952) :

$CGR= (W_2 – W_1) / (t_2 – t_1)$

Where: $W_2 – W_1$= differences in dry mater accumulation between two successive samples in grams. $t_2 – t_1$= the number of days between two successive samples in week.

Leaf area/main stem in cm^2 was estimated for plants by using leaf area meter at 75 DAS.

2. 2. Yield and its components

Harvest took place at 20/5/2013 and 10/5/2014 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 number of kernels / spike and 1000-kernel weight (g). Number of spikes /m^2 was determined from one m^2 area in each sub-plot. In addition, plants in the central area ($4m^2$) of each sub-plot were harvested to determine straw yield (t fed^{-1}) and grain yield (ard fed^{-1}).

2. 3. Chemical traits

Total chlorophyll content of the leaves at 75 DAS was determined as a SPAD unit (Soil and Plant Analysis Department) of Minolta Co. This unit was transformed to mg m^{-2} as described by Monge and Bugbe (1992) as follows:- chl. = 80.05 + 10.4 (SPAD 502). Grain samples from the two growing seasons were subjected to chemical analysis to determine crude protein% in grains according to A. O. A. C. (1990).

The comparison of error mean squares between the two seasons for all traits was done by the help of Bartlett's test of homogeneity of variances (Snedecor and cochran, 1989) and found not significantly different.

Data of the two seasons were combined and statistically analyzed according to Steel and Torrie (1990). The discussion of the obtained results was carried out on the basis of the combined analysis values.

3. RESULTS AND DISCUSSION

3. 1. Growth traits

Results in Tables (2, 3 and 4) indicated that both nitrogen fertilization and foliar spray with micronutrients mixture plus citric acid had significant effects on plant height, leaf area / main stem, number of days to 50% heading, spike length as well as crop growth rate (CGR) at the first period (60-75 days) and the second one (75-90 days). It can be noticed that CGR values were higher in the first period than in the second period. Such decrease at the second period is mainly due to the fact that barley plants directed its effort to heading and grain formation. Results showed that increasing nitrogen fertilizer from 15 kg N fed^{-1} up to 60 kg N fed^{-1} increased gradually all growth traits under study. Abdo and El-Moselhy. (2004) explained such finding to be the function of nitrogen in plant metabolism *i. e.* as constituent of amino and nucleic acids, many cofactors and cellular compounds. It is worthy to mention that insignificant differences were observed between adding 45 kg N fed^{-1} and 60 kg N fed^{-1} for all growth traits under study, except the number of days to 50% heading. These results are in harmony with those obtained by Megahed (2003).

Concerning foliar spray of micronutrients mixture plus citric acid, data in Tables (2, 3 and 4) indicated that spraying plants by 200 ppm of (Fe + Zn + Mn) for each element plus 1500 ppm citric acid (S_2) significantly increased plant

Table (2): Plant height (cm) and leaf area/main stem (cm^2) of barley as affected by nitrogen fertilization and foliar spray by micronutrients mixture plus citric acid in 2012/2013, 2013/2014 and combined two seasons.

Treatments		Plant height			Leaf area/main stem (cm^2) at 75 DAS		
Nitrogen level kg N fed^{-1}	Micronutrients mixture + citric acid *(S)	2012/ 2013	2013/ 2014	Comb.	2012/ 2013	2013/ 2014	Comb.
15	S_0	61.25	65.50	63.38	96.82	97.19	97.01
	S_1	67.5	67.50	67.50	111.84	109.49	110.67
	S_2	72.25	72.50	72.38	116.82	114.34	115.58
Mean		**67.00**	**68.50**	**67.75**	**108.49**	**107.01**	**107.75**
30	S_0	67.75	68.75	68.25	112.31	109.20	110.76
	S_1	71.00	73.75	72.38	115.70	115.19	115.45
	S_2	70.25	75.75	73.00	129.65	127.54	128.60
Mean		**69.67**	**72.75**	**71.21**	**119.22**	**117.31**	**118.27**
45	S_0	76.50	79.00	77.75	126.39	124.59	125.49
	S_1	82.00	83.00	82.50	134.31	132.46	133.39
	S_2	85.75	88.25	87.00	141.01	139.23	140.12
Mean		**81.42**	**83.42**	**82.42**	**133.90**	**132.09**	**133.00**
60	S_0	77.75	73.75	75.75	127.58	125.31	126.45
	S_1	83.25	87.75	85.50	135.07	134.28	134.68
	S_2	85.75	89.25	87.50	146.23	143.43	144.83
Mean		**82.25**	**83.58**	**82.92**	**136.29**	**134.34**	**135.32**
General mean of micronutrients + citric acid	S_0	70.81	71.75	71.28	115.78	114.07	114.93
	S_1	75.94	78.00	76.97	124.23	122.86	123.55
	S_2	78.50	81.44	79.97	133.43	131.14	132.28
L. S. D at 0.05	N	1.82	1.73	1.15	10.45	10.70	6.87
	S	1.43	1.24	0.87	8.33	8.66	5.52
	N x S	2.86	2.49	1.74	20.72	22.72	14.12
C. V %		2.63	2.22	2.43	7.91	8.10	8.00

***** S_0= Spraying with water, $S_{1=}$ Spraying with 133 ppm (Fe+Zn+Mn) for each element + 1000 ppm citric acid and S_2 =Spraying with 200 ppm (Fe+Zn+Mn) for each element + 1500 ppm citric acid.

height, leaf area / main stem, number of days to 50% heading, spike length as well as CGR at citric acid (S_2) significantly increased plant height, leaf area / main stem, number of days to 50% heading, spike length as well as CGR at (60-75 days) and (75-90 days) periods. These results could be explained on the basis that micronutrients must be presented during vegetative stage to get the normal growth. Where, manganese regulates the oxidation reduction system of iron. Also, zinc plays an important role in tryptophan synthesis which is a precursor of IAA. In addition it was reported that the ratio between micronutrients in plant tissues was very important for the accumulation of many nutrients in plants (Osawa, 1973). also, Mourad (2006) reported that plant height of grain sorghum reached its maximum value when plants sprayed with 500 ppm of citric acid.

Regarding the interaction between nitrogen fertilization and foliar spray of micronutrients mixture plus citric acid, data in Tables (2, 3 and 4) show a significant effect on all growth traits except the number of days to 50% heading. The maximum values of plant height, leaf area/main stem, spike length as well as crop growth rate at (60-75 days) and (75-90 days) periods were obtained when barley plants received 60 kg N fed^{-1} and foliar application of 200 ppm (Fe + Zn + Mn) for each element plus 1500 ppm of citric acid.

3. 2. Yield and its components traits

Data in Tables (5, 6 and 7) showed that nitrogen fertilization had a significant effect on the number of spikes /m^2, number of kernels / spike, 1000-kernel weight as well as straw and grain yields. The highest values of such traits were scored from applying 60 kg N fed^{-1}. This

result could be attributed to the role of nitrogen on barley growth and yield components which in turn reflected on straw and grain yields/fed. These results are supported by those obtained by Roy and Singh (2006), Zeidan (2007) and Abd El-Rahman *et al.*(2012). It is worthy to mention that, insignificant differences were observed between adding 45 and 60 kg N fed^{-1} with respect to grain yield of barley. So, from the economic point of view and nitrogen fertilizer conservation, it is advisable to practice 45 kg N fed^{-1} under calcareous soils condition in Nubaria region.

As for the effect of foliar spray of micronutrient mixture plus citric acid (Tables 5, 6 and 7), the results indicated that, spraying 200 ppm (Fe + Zn + Mn) for each element plus 1500 ppm citric acid (S_2) on barley plants significantly increased number of spikes m^{-2}, the number of kernels $spike^{-1}$, 1000-kernel weight (g), straw yield (t fed^{-1}) and grain yield (ard fed^{-1}) compared with other foliar spray treatments (S_0 and S_1). In this connection, Anton *et al.* (1999) found that foliar spray of ascorbic and citric acids in combination with micronutrients mixture (Fe + Zn + Mn) on barley plants had a significant effect on plant height, the number of tillers m^{-2}, straw and biological yields fed^{-1}.

Concerning the interaction effect between nitrogen fertilization and foliar spray of micronutrients mixture plus citric acid, data in Tables (5, 6 and 7) showed that all yield and yield components traits under study recorded a significant effect. The maximum values of number of spikes m^{-2}, number of kernels $spike^{-1}$, 1000-kernel weight (g), straw yield (t fed^{-1}) and grain yield (ard fed^{-1}) were obtained when barley plants were treated by 60 kg N fed^{-1} and foliar spray with of 200 ppm (Fe + Zn + Mn) for each element plus 1500 ppm citric acid (S_2).

Table (3): Number of days to 50% heading and spike length (cm) of barley as affected by nitrogen fertilization and foliar spray by micronutrients mixture plus citric acid in 2012/2013, 2013/2014 and combined two seasons.

Treatments		Number of days to 50% heading			Spike length (cm)		
Nitrogen level kg N fed^{-1}	Micronutrients mixture + citric acid *(S)	2012/ 2013	2013/ 2014	Comb.	2012/ 2013	2013/ 2014	Comb.
15	S_0	83.25	82.75	83.00	5.22	5.33	5.28
	S_1	84.25	83.50	83.88	5.73	5.17	5.45
	S_2	84.75	85.25	85.00	5.96	6.19	6.08
Mean		**84.08**	**83.83**	**83.96**	**5.64**	**5.56**	**5.60**
30	S_0	85.00	84.75	84.88	6.23	6.26	6.25
	S_1	86.00	85.50	85.75	6.61	6.60	6.61
	S_2	86.25	86.50	86.38	6.81	6.92	6.87
Mean		**85.75**	**85.58**	**85.67**	**6.55**	**6.59**	**6.57**
45	S_0	86.75	86.75	86.75	7.24	7.22	7.23
	S_1	87.75	87.25	87.50	7.57	7.60	7.59
	S_2	88.25	87.75	88.00	7.83	7.58	7.71
Mean		**87.58**	**87.25**	**87.42**	**7.55**	**7.47**	**7.51**
60	S_0	88.50	88.50	88.50	6.68	6.99	6.84
	S_1	88.75	88.50	88.63	7.77	7.90	7.84
	S_2	89.00	88.75	88.88	8.34	8.06	8.20
Mean		**88.75**	**88.58**	**88.67**	**7.60**	**7.65**	**7.63**
General mean of micronutrients + citric acid	S_0	85.88	85.69	85.78	6.34	6.45	6.39
	S_1	86.69	86.19	86.72	6.92	6.95	6.94
	S_2	87.06	87.06	87.06	7.23	7.19	7.21
L. S. D at 0.05	**N**	0.84	0.80	0.53	0.23	0.22	0.15
	S	0.65	0.56	0.39	0.20	0.17	0.12
	N x S	N. S	N. S	N. S	0.36	0.31	0.22
C. V %		0.75	0.90	0.82	2.05	4.03	3.20

***** S_0= Spraying with water, $S_{1=}$ Spraying with 133 ppm (Fe+Zn+Mn) for each element + 1000 ppm citric acid and S_2 =Spraying with 200 ppm (Fe+Zn+Mn) for each element + 1500 ppm citric acid.

Table (4): Crop growth rate (CGR) g/plant/week at (60-75) and (75-90) DAS of barley as affected by nitrogen fertilization and foliar spray by micronutrients mixture plus citric acid in 2012/2013, 2013/2014 and combined two seasons.

Treatments		Crop growth rate (CGR) g/plant/week					
		(60-75) DAS			(75-90) DAS		
Nitrogen level kg N fed^{-1}	Micronutrients mixture + citric acid *(S)	2012/2013	2013/2014	Comb	2012/2013	2013/2014	Comb
15	S_0	0.97	0.71	0.84	0.49	0.46	0.48
	S_1	1.08	0.95	1.02	0.56	0.53	0.55
	S_2	1.10	1.05	1.08	0.59	0.58	0.57
Mean		**1.05**	**0.90**	**0.98**	**0.54**	**0.52**	**0.53**
30	S_0	1.04	0.84	0.94	0.54	0.53	0.54
	S_1	1.15	1.03	1.09	0.62	0.61	0.62
	S_2	1.17	1.10	1.14	0.64	0.62	0.63
Mean		**1.12**	**0.99**	**1.06**	**0.60**	**0.59**	**0.60**
45	S_0	1.09	1.02	1.06	0.60	0.59	0.60
	S_1	1.20	1.12	1.16	0.70	0.64	0.67
	S_2	1.23	1.13	1.18	0.71	0.68	0.70
Mean		**1.17**	**1.09**	**1.13**	**0.67**	**0.64**	**0.66**
60	S_0	1.18	1.09	1.14	0.63	0.60	0.62
	S_1	1.22	1.13	1.18	0.71	0.70	0.71
	S_2	1.24	1.14	1.19	0.72	0.74	0.73
Mean		**1.21**	**1.12**	**1.17**	**0.70**	**0.68**	**0.69**
General mean of micronutrients + citric acid	S_0	1.07	0.92	0.99	0.57	0.55	0.56
	S_1	1.16	1.06	1.11	0.65	0.62	0.64
	S_2	1.19	1.11	1.15	0.67	0.66	0.66
L. S. D at 0.05	**N**	0.10	0.11	0.07	0.08	0.09	0.06
	S	0.07	0.08	0.05	0.06	0.07	0.04
	N x S	0.17	0.20	0.12	0.15	0.18	0.11
C. V %		8.64	8.91	8.78	9.31	8.15	0.73

* S_0= Spraying with water, $S_{1=}$ Spraying with 133 ppm (Fe+Zn+Mn) for each element + 1000 ppm citric acid and S_2 =Spraying with 200 ppm (Fe+Zn+Mn) for each element + 1500 ppm citric acid

Table (5): Number of spikes/m^2 and number of kernels / spike of barley as affected by nitrogen fertilization and foliar spray by micronutrients mixture plus citric acid in 2012/2013, 2013/2014 and combined two seasons.

Treatments		Number of spikes/m^2			Number of kernels / spike		
Nitrogen level kg N fed^{-1}	Micronutrients mixture + citric acid *(S)	2012/2013	2013/2014	Comb.	2012/2013	2013/2014	Comb.
15	S_0	339.75	331.25	335.50	31.50	31.75	31.63
	S_1	350.00	338.00	344.00	34.50	34.00	34.25
	S_2	355.75	345.00	350.38	35.50	33.25	35.38
Mean		**348.50**	**338.08**	**343.30**	**33.83**	**33.75**	**33.75**
30	S_0	365.75	353.25	359.50	38.50	37.50	38.00
	S_1	373.25	359.75	366.50	40.50	40.75	40.63
	S_2	375.50	365.75	370.38	41.75	41.75	41.75
Mean		**371.50**	**359.42**	**365.45**	**40.25**	**40.00**	**40.13**
45	S_0	382.50	373.75	378.13	42.95	43.50	42.98
	S_1	386.00	373.85	379.87	45.91	46.50	46.08
	S_2	391.00	376.25	383.63	48.50	48.75	48.63
Mean		**386.50**	**374.58**	**380.54**	**45.79**	**46.00**	**45.89**
60	S_0	375.00	381.00	378.00	42.50	43.00	42.75
	S_1	386.00	389.25	387.62	44.50	45.75	45.13
	S_2	393.00	393.75	393.37	51.75	52.75	52.25
Mean		**384.67**	**388.00**	**386.33**	**46.25**	**47.63**	**46.71**
General mean of micronutrients + citric acid	S_0	365.75	359.81	362.78	38.86	38.81	38.84
	S_1	373.81	365.19	369.50	41.35	41.69	41.52
	S_2	378.81	370.06	374.43	44.38	44.63	44.50
L. S. D at 0.05	**N**	6.58	6.25	4.17	0.76	0.88	0.53
	S	5.17	4.91	3.28	0.63	0.66	0.42
	N x S	10.34	9.82	6.55	1.27	1.32	0.90
C. V %		11.06	11.34	11.06	2.11	2.19	2.15

***** S_0= Spraying with water, $S_{1=}$ Spraying with 133 ppm (Fe+Zn+Mn) for each element + 1000 ppm citric acid and S_2 =Spraying with 200 ppm (Fe+Zn+Mn) for each element + 1500 ppm citric acid.

Table (6): 1000-kernel weight (g) and Straw yield (T/fed) of barley as affected by nitrogen fertilization and foliar spray by micronutrients mixture plus citric acid in 2012/2013, 2013/2014 and combined two seasons.

Treatments			1000-kernel weight (g)			Straw yield (T/fad)		
Nitrogen level kg N fed^{-1}	Micronutrients mixture + citric acid *(S)		2012/ 2013	2013/ 2014	Comb.	2012/ 2013	2013/ 2014	Comb.
15	S_0		31.45	31.49	31.45	3.22	3.22	3.21
	S_1		34.45	34.55	34.50	3.34	3.35	3.34
	S_2		35.43	35.60	35.51	3.43	3.45	3.44
Mean			**33.78**	**33.85**	**33.82**	**3.33**	**3.34**	**3.33**
30	S_0		38.55	38.43	38.55	3.34	3.37	3.36
	S_1		39.85	39.85	39.85	3.53	3.56	3.55
	S_2		40.53	40.58	40.53	3.67	3.71	3.69
Mean			**39.64**	**39.64**	**39.64**	**3.51**	**3.55**	**3.53**
45	S_0		42.53	42.63	42.53	3.43	3.54	3.49
	S_1		45.05	45.13	45.05	3.77	3.81	3.79
	S_2		46.58	46.61	46.58	4.13	4.04	4.08
Mean			**44.72**	**44.70**	**44.76**	**3.78**	**3.80**	**3.79**
60	S_0		48.05	48.13	48.08	3.62	3.51	3.57
	S_1		48.95	48.83	48.95	3.16	4.17	4.17
	S_2		49.63	49.63	49.63	4.44	4.40	4.42
Mean			**48.87**	**48.88**	**48.51**	**4.08**	**4.02**	**4.05**
General mean of micronutrients + citric acid		S_0	40.14	40.14	40.14	3.40	3.41	3.41
		S_1	42.07	42.10	42.09	3.70	3.72	3.71
		S_2	43.04	43.08	43.08	3.92	3.90	3.90
L. S. D at 0.05		**N**	0.93	0.98	0.67	0.18	0.17	0.11
		S	0.76	0.66	0.46	0.14	0.13	0.09
		N x S	1.19	1.32	0.82	0.20	0.22	0.16
C. V %			2.85	2.87	2.86	11.30	12.35	11.90

***** S_0= Spraying with water, $S_{1=}$ Spraying with 133 ppm (Fe+Zn+Mn) for each element + 1000 ppm citric acid and S_2 =Spraying with 200 ppm (Fe+Zn+Mn) for each element + 1500 ppm citric acid.

Table (7): Grain yield (ard/fed) of barley as affected by nitrogen fertilization and foliar spray by micronutrients mixture plus citric acid in 2012/2013, 2013/2014 and combined two seasons.

Nitrogen level kg N fed^{-1}	Micronutrients mixture + citric acid *(S)		Grain yield (ard/fed)		
			2012/2013	**2013/2014**	**Comb.**
15		**S_0**	10.56	10.61	10.59
		S_1	10.69	10.71	10.70
		S_2	10.84	10.81	10.83
Mean			**10.70**	**10.71**	**10.71**
30		**S_0**	11.27	11.43	11.35
		S_1	11.56	11.71	11.64
		S_2	11.77	11.92	11.85
Mean			**11.53**	**11.69**	**11.61**
45		**S_0**	12.56	13.21	12.89
		S_1	13.70	13.78	13.74
		S_2	14.65	14.87	14.76
Mean			**13.64**	**13.95**	**13.80**
60		**S_0**	12.59	12.68	12.64
		S_1	13.78	13.84	13.81
		S_2	15.60	15.68	15.64
Mean			**13.99**	**14.07**	**14.03**
General mean of micronutrients + citric acid		**S_0**	11.75	11.98	11.87
		S_1	12.43	12.51	12.47
		S_2	13.22	13.32	13.27
L. S. D at 0.05		**N**	0.57	0.54	0.36
		S	0.45	0.43	0.29
		N x S	0.90	0.71	0.52
C. V %			11.27	11.84	11.59

***** S_0= Spraying with water, $S_{1=}$ Spraying with 133 ppm (Fe+Zn+Mn) for each element + 1000 ppm citric acid and S_2 =Spraying with 200 ppm (Fe+Zn+Mn) for each element + 1500 ppm citric acid.

3. 3. Chemical traits

3.3.1.Total chlorophyll of leaves

Results in Table (8) indicated that the total chlorophyll of leaves at 75 DAS increased significantly with increasing nitrogen rates gradually from 15 up to 60 kg N fed^{-1}. The maximum value for total chlorophyll of leaves was scored from adding 60 kg N fed^{-1}. Such results may be due to the fact that nitrogen plays an important role in chlorophyll synthesis. Similar results were found by Mourad (2006) on grain sorghum plants. Regarding the effect of foliar spray of micronutrient mixture in combination with citric acid, Table (8) showed that total chlorophyll of the leaves increased significantly when barley plants were sprayed with 200 ppm (Fe + Zn + Mn) for each element plus 1500 ppm citric acid (S_2). In this respect, Hanna *et al.* (2001) found that the total chlorophyll of wheat leaves was increased with spraying 500 or 100 ppm ascorbic acid compared with The control.

Concerning the interaction effect between nitrogen fertilization and foliar spray with micronutrients mixture plus citric acid on total chlorophyll of leaves, the results of Table (8) recorded a significant effect. The maximum value of such trait was scored when plants treated with 60 kg N fed^{-1} and foliar spray by 200 ppm (Fe + Zn + Mn) for each element plus 1500 ppm citric acid (S_2). In this respect, Mourad (2006) reported that the maximum value of total chlorophyll was gained when grain sorghum plants treated with 140 kg N fed^{-1} and sprayed with 500 ppm ascorbic acid plus 500 ppm citric acid.

Table (8): Total chlorophyll of leaves at 75 DAS (mg/ m^2) and protein % of grains of barley as affected by nitrogen fertilization and foliar spray by micronutrients mixture plus citric acid in 2012/2013, 2013/2014 and combined two seasons.

Nitrogen level kg N/fed^{-1}	Micronutrients mixture + citric acid *(S)	Total chlorophyll of leaves at 75 DAS (mg/m^2)			protein % in grains		
		2012/ 2013	2013/ 2014	Comb.	2012/ 2013	2013/ 2014	Comb.
15	S_0	379.83	375.93	377.88	8.30	8.21	8.26
	S_1	395.43	388.41	391.92	8.88	8.98	8.93
	S_2	425.33	403.08	414.21	9.02	8.97	9.00
Mean		**400.20**	**389.14**	**394.67**	**8.73**	**8.72**	**8.73**
30	S_0	394.13	389.71	391.92	9.16	9.04	9.10
	S_1	424.55	415.97	420.26	9.82	9.88	9.85
	S_2	445.09	434.43	439.76	10.38	10.21	10.30
Mean		**421.26**	**413.37**	**417.32**	**9.79**	**9.71**	**9.75**
45	S_0	398.29	387.21	392.75	10.14	10.23	10.19
	S_1	440.41	439.37	439.89	10.68	10.62	10.65
	S_2	473.03	463.55	468.29	11.49	11.38	11.44
Mean		**437.24**	**430.04**	**433.64**	**10.77**	**10.74**	**10.76**
60	S_0	432.61	419.61	426.11	10.02	10.21	10.12
	S_1	478.89	474.21	476.55	10.93	11.02	10.98
	S_2	494.23	480.45	487.34	12.14	12.08	12.11
Mean		**468.58**	**458.09**	**463.33**	**11.03**	**11.10**	**11.07**
General mean of micronutrients +citric acid	S_0	401.22	393.12	397.17	9.41	9.42	9.42
	S_1	434.82	429.49	432.16	10.08	10.13	10.10
	S_2	459.52	445.38	452.40	10.76	10.66	10.71
L. S. D at 0.05	N	7.62	7.24	4.83	0.47	0.45	0.30
	S	6.00	5.70	3.81	0.36	0.34	0.23
	N x S	11.98	11.38	7.59	0.73	0.66	0.45
C. V %		4.93	4.31	4.62	3.76	3.54	3.65

***** S_0= Spraying with water, $S_{1=}$ Spraying with 133 ppm (Fe+Zn+Mn) for each element + 1000 ppm citric acid and S_2 =Spraying with 200 ppm (Fe+Zn+Mn) for each element + 1500 ppm citric acid.

3.3.2. Protein content of grains

Data of Table (8) show that protein content in grains was increased gradually with raising nitrogen rate from 15 up 60 kg N fed^{-1}. Results indicated that treated barley by 60 kg N fed^{-1} significantly increased grain protein content, compared with the other three levels *i. e.* 15, 30 and 45 kg N fed^{-1}. Such results can be ascribed to the function of nitrogen in plant metabolism viz constituent of amino and nucleic acids, many cofactors and cellular compounds. Similar results were found by Zeidan (2007) and Abd El-Rahman *et al.* (2012).

Regarding the effect of foliar application with micronutrients mixture and citric acid, results in Table (8) recorded a significant effect on protein content of grains. The maximum value was scored when barley plants were sprayed with 200 ppm (Fe + Zn + Mn) for each element plus 1500 ppm citric acid (S_2) compared with S_0 and S_1. Such finding may be due to the role of micronutrients on enhancing the enzymes which help in protein formation process (Ghaly *et al.*, 1992). Anton and Bassiem (1998) reported that in peanut, the foliar spray of 500 ppm ascorbic acid recorded the highest value of protein % in seeds flowed by spraying 500 ppm citric acid.

The interaction effect between nitrogen fertilization and foliar spray with micronutrients mixture plus citric acid recorded a significant effect on protein content of grains. The maximum value of such traits was achieved when plants were treated with 60 kg N fed^{-1} and foliar spray by 200 ppm micronutrients mixture (Fe + Zn + Mn) for each element plus 1500 ppm citric acid. These results are in harmony with those reported by Anton *et al.*, (1999).

Conclusion

In the light of the present results, the maximum grain yield and protein content in grains of barley were obtained from plants treated by 60 kg N fed^{-1} and foliar spray with 200 ppm micronutrients mixture (Fe + Zn + Mn) for each element plus 1500 ppm citric acid. However, from the economic point of view and nitrogen fertilizer conservation it is advisable to practice 45 kg N fed^{-1} under calcareous soils condition in Nubaria region, due to insignificant differences in grain yield observed between adding 45 and 60 kg N fed^{-1}.

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استجابة الشعير للتسميد النتروجينى و الرش الورقى بمخلوط العناصر الصغرى وحامض الستريك تحت ظروف الأراضى الجيرية

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ملخص

اجريت تجربة حقلية بمحطة البحوث الزراعية بالنوبارية بمحافظة البحيرة بمصر لدراسة تاثير التسميد النتروجينى بمعدل 15 ، 30 ، 45 ، 60 كجم نتروجين/فدان و الرش الورقى بمخلوط العناصر الصغرى (حديد + زنك + منجنيز) بتركيز صفر، 133 ، 200 جزء فى المليون لكل عنصر و كذلك حمض الستريك بتركيز صفر ، 1000 ، 1500 جزء فى المليون على نبات الشعير. ويمكن تلخيص النتائج فيمايلى:- أدت اضافة 60 كجم نيتروجين / فدان للحصول على أعلى قيم لكل من طول النبات ، مساحة الأوراق / نبات ، عدد الأيام اللازمة حتى طرد 50 % من السنابل ، طول السنبلة ، معدل نمو المحصول (CGR) فى المرحلة الأولى و الثانية ، عدد السنابل/ م^2 ، عدد الحبوب فى السنبلة ، وزن الألف حبة وكذلك محصولى الحبوب و القش ، الكلورفيل الكلى للأوراق عند 75 يوم من الزراعة و محتوى الحبوب من البروتين. وقد لوحظ فرق غير معنوى بين اضافة 45 ، 60 كجم نيتروجين / فدان بالنسبة لمحصول الحبوب مما يوصى بأضافة 45 كجم نتيروجين للفدان من الناحية الأقتصادية. سجلت جميع صفات النمو و المحصول و مكوناتة وكذلك الكلورفيل الكلى للأوراق و محتوى الحبوب من البروتين تحت الدراسة أعلى قيمة عند رش نباتات الشعير ب 200 جزء فى المليون بمخلوط العناصر الصغرى (حديد + زنك + منجنيز) لكل عنصر بالأضافة إلى 1500 جزء فى المليون حمض الستريك مقارنة بمعاملات الرش الأخرى. كان تأثير التفاعل بين معاملات التسميد النتروجينى و الرش بمخلوط العناصر الصغرى وحمض الستريك معنوياً على جميع الصفات تحت الدراسة ماعدا صفة عدد الأيام اللازمة حتى طرد 50% من السنابل. و كانت أعلى قيمة لهذة الصفات عند تسميد الشعير ب 60 كجم نيتروجين / فدان و الرش الورقى ب200 جزء فى المليون بمخلوط العناصر الصغرى (حديد + زنك + منجنيز) لكل عنصر بالأضافة الى 1500 جزء فى المليون حمض الستريك.

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