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RESPONSE OF BARLEY PLANTS TO MAGNESIUM FERTILIZATION UNDER SANDY SOILS CONDITION

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ABSTRACT: *Magnesium is an important element in plant nutrition. So this study was carried out as pot experiment in greenhouse at Experimental Farm, Faculty of Agriculture, Minufiya University, Shibin El-Kom, Egypt with barley plants (Hordeum vulgare L.) variety Giza 123 grown on the loamy sand soils to assess the plants response to magnesium fertilizers applications during winter growth season 2013/ 2014. Three surface soil samples (0 - 30 cm) represented three loamy sand soils of Egypt varied widely in their physical and chemical properties and also in their contents of available macronutrients were chosen. Soil samples were collected from Wheat Farm, Village 6, El-Nubariya City - Beheira Governorate (soil 1, characterized with low EC and available Mg); West Abd El-Haleem Mahmoud Village - Beheira Governorate (soil 2, characterized with low nutrients) and Ahmed Oraby Society, South line 4 - Cairo Governorate (soil 3, characterized with high EC and $CaCO_3$). These soils were analyzed for some physical and chemical properties and also for their contents of available nutrients and different forms of Mg. Magnesium fertilizers were added in three sources, i.e., magnesium oxide " MgO" (48.2 % Mg), magnesium nitrate " $Mg(NO_3)_2$ " (9.6 % Mg and 18.9 % N) and magnesium sulphate " $MgSO_4 . 7H_2O$ " (20.0 % Mg and 14.0 % S) at application rates of 0, 10, 20 and 30 mg Mg / kg soil. The experiment was carried out in complete randomized block design with three replicates.*

The obtained data showed that, increasing added rates of Mg fertilizers were associated by a significant increases of plant height (cm) and both fresh and dry matter yields (g pot^{-1}) of barley plants, where the highest values of these three parameters and its relative changes "RC" as a percent of control values were found in the plants fertilized with $Mg(NO_3)_2$ followed by $MgSO_4$ treatments for all soils. At the same treatments of Mg , the highest values of the fresh and dry weight were found in the plants grown on soil 2, while the lowest values were found in the plants grown on soil 1. Agronomical efficiency "AE" (mg / mg) of the used three Mg fertilizers at different application rates were varied from Mg source to another and also from soil to another. The highest values of AE associated with the treatments of $Mg(NO_3)_2$, especially at low application rates. In the three soils, N, P, K and Mg concentration (%), uptake (mg pot^{-1}) and relative changes (%) increased with the increase of added Mg. The high content of these nutrients and their RI associated with the treatments of $Mg(NO_3)_2$ followed by $MgSO_4$ treatments. Except N content, the highest values of P, K and Mg concentration and uptake were found in the plants grown on soil 2 and the lowest values were found in the plants grown on soil 1. The obtained data concluded that, sandy soils of Egypt must be fertilized with Mg, especially in NO_3 or SO_4 forms to improve its productivity.

Key words: *Loamy sand soil, Magnesium, Growth parameters, Nutrients uptake and Barley plants.*

INTRODUCTION

Food scarcity and continuous loss of agricultural lands are issues of global concern. The government of Egypt adopted policies aimed at self-sufficiency in food production, e. g. extension of cultivated areas and increasing the production of the existing agricultural land. The principal purpose was and still is to overcome Egypt's overwhelmingly unfavorable population to agricultural land ratio. The cultivation of newly reclaimed sandy and calcareous soils has become an unavoidable necessity for increasing our agricultural production to meet the over-growing demand for food. These soils are poor in their nutrients content including magnesium. Sandy soils in Egypt represents more than 70 % of total area. Most of these soils may be reclaimed with low costs compared with other desert soils. Also, these soils are more suitable to many economical cultivations such as wheat, barley and corn. In addition, such soils are located within or near to the Valley of Nile River (FAO, 2006).

Moreover, magnesium is related to the group secondary essential macronutrients and involved in many metabolic processes in the plants. Whereas, it's only mineral constituent of the chlorophyll molecule and located at its center. So, chlorophyll formation accounts for about 15 - 20 % of the total Mg content of plants (Basak, 2006 and Cakmak and Yazici, 2010). However, chlorotic or necrotic spots spread over the leaves indicate its deficiency of Mg. In this concern, Mg deficiency in most Egyptian soils was reported by many investigator such as (Abou Aziz *et al.,* 2000 ; El-Metwally *et al.*, 2010 and Abou El-Nour and Shaaban, 2012). On the other hand, Mg ionic form (Mg^{++}) adhered to the colloidal particles in the soil and its available to be taken up by the plant roots. According to El-Fouly *et al.* (2010), available Mg decreases in the period 1998 - 2006 reached about 80 % from the available Mg in 1998. So, intensive agriculture used high rates of potassium and ammonium fertilizers and neglecting of Mg-fertilization led to Mg-unavailability which became a limiting growth factor.

Barley (*Hordeum vulgare L.*) is one of the most important cereal crops in the world, being used for many purposes such as molting, brewing industry, animal feeding, bread making as it is or by mixing with wheat flour in some places, some food and beverages.

Thereafter, this pot experiment was carried out to study the response of barley plants grown on loamy sand soils which varied widely in their properties to Mg fertilization.

MATERIALS AND METHODS

Pot experiment was conducted during winter growth season 2013 / 2014 in the greenhouse at Experimental Farm, Faculty of Agriculture, Minufiya University, Shibin El-Kom, Egypt with barley plants (*Hordeum vulgare L.*) variety Giza 123 grown on loamy sand soils to study the effect of different soil applications (sources and rates) of magnesium fertilization on plant growth parameters and its mineral composition.

Surface soil samples (0-30 cm depth) were collected separately from three different locations of Egypt which varied widely in their physical and chemical properties and also in their contents of available macronutrients. These locations are:- Wheat Farm, Village 6, El-Nubariya City - Beheira Governorate (soil 1, characterized with low EC and available Mg); West Abd El-Haleem Mahmoud Village - Beheira Governorate (soil 2, characterized with low nutrients) and Ahmed Oraby Society, South line 4 - Cairo Governorate (soil 3, characterized with high EC and $CaCO_3$). These samples were air - dried, ground, good mixed, sieved through a 2 mm sieve and analyzed for some physical and chemical properties and also the contents of available some macronutrients according to the methods described by Cottenie *et al.* (1982); Page *et al.* (1982) and Klute (1986). The obtained data were recorded in Tables (1 to 3). Magnesium fertilizers were added in three sources, i.e., magnesium oxide " MgO" (48.2 % Mg); magnesium nitrate " $Mg(NO_3)_2$ " (9.6 % Mg and 18.9 % N) and magnesium sulphate " $MgSO_4 . 7H_2O$ " (20.0 % Mg and 14.0 % S) at application rates of 0, 10, 20 and 30 mg Mg / kg soil.

The experimental units were 108 plastic pots, including 3 sources of Mg fertilizers x 4 rates of each form x 3 loamy sand soils x 3 replicates. Plastic pots of 20 cm depth and 25 cm diameter were used in this study. The experiment was carried out in completely randomize block design (CRBD) with three replicates. Fifteen seeds of barley plants were sown at 1st of December, 2013 in pots contained 7.0 kg loamy sand soil (36 pots of each soil). After 12 days of sowing, plants

Table (1) : Some physical properties of the used soils.

Soil No.	Location	Governorate	Particles size distribution (%)				Texture grade	Saturation percent (SP)
			Coarse sand	Fine sand	Silt	Clay		
1	Wheat Farm, Village 6, El-Nubariya City	Beheira	7.9	64.1	17.2	10.8	Loamy sand	26
2	West Abd El- Haleem Mahmoud Village	Beheira	5.7	74.3	11.6	8.4	Loamy sand	22
3	Ahmed Oraby Society, South line 4	Cairo	8.2	62.8	18.3	10.7	Loamy sand	26

Table (2) : Some chemical properties of the used soils.

Soil No.	pH 1:2.5 (soil : water susp.)	EC* dSm^{-1}	Soluble ions** (meq l^{-1})								OM ($g\ kg^{-1}$)	$CaCO_3$ ($g\ kg^{-1}$)	CEC ($cmol_c\ kg^{-1}$)
			Cations				Anions						
			Na^+	K^+	Ca^{2+}	Mg^{2+}	Cl^-	$CO_3^=$	HCO_3^-	$SO_4^=$			
1	7.75	0.83	5.05	0.60	2.56	0.134	3.84	--	1.10	3.40	6.2	18.0	4.87
2	7.70	2.08	7.65	1.40	11.16	0.638	14.54	--	1.51	4.80	2.2	30.4	6.12
3	7.70	12.73	90.52	5.64	29.06	2.102	77.26	--	2.06	48.00	9.4	89.6	7.64

EC* in soil paste extract , Soluble ions** in the soil paste extract , $SO_4^=$ was calculated by difference.

Table (3) : The content (mg kg^{-1}) of some available macronutrients and different Mg forms and its percentage of total Mg of the used soils.

Soil No.	Available N (mg kg^{-1})	Available P (mg kg^{-1})	Available K (mg kg^{-1})	Total Mg (mg kg^{-1})	Soluble Mg		Available Mg		Exchangeable Mg		Fixed Mg	
					(mg kg^{-1})	(%) of total Mg	(mg kg^{-1})	(%) of total Mg	(mg kg^{-1})	(%) of total Mg	(mg kg^{-1})	(%) of total Mg
1	10.21	5.15	120.32	762.7	6.2	0.813	34.2	4.48	28.0	3.67	728.5	95.5
2	8.34	3.85	107.30	3088.3	34.8	1.127	149.4	4.84	114.6	3.71	2938.9	95.2
3	29.33	8.71	131.54	5265.7	97.0	1.842	397.4	7.55	300.4	5.71	4868.3	92.5

were thinned to 10 plants. The moisture content was always kept at field capacity of each soil during the growth period. Before sowing, every pot received 1.4 g super mono-phosphate (15.5 % P_2O_5). After thinning directly, every pot received 1.05 g urea (46% N) and 0.45 g potassium sulphate (48 % K_2O) as basic fertilization. Magnesium treatments for each soil were added after 20 days of sowing at rates of 0, 10, 20 and 30 mg Mg / kg soil as follows:-

- Control plants received no magnesium fertilizers.
- 0.07 g Mg pot^{-1} equal 50 kg $fed.^{-1}$ $MgSO_4 . 7H_2O$ (20 % Mg and 14 % S).
- 0.14 g Mg pot^{-1} equal 100 kg $fed.^{-1}$ $MgSO_4 . 7H_2O$ (20 % Mg and 14 % S).
- 0.21 g Mg pot^{-1} equal 150 kg $fed.^{-1}$ $MgSO_4 . 7H_2O$ (20 % Mg and 14 % S).
- 0.07 g Mg pot^{-1} equal 104 kg $fed.^{-1}$ $Mg(NO_3)_2$ (9.6 % Mg and 18.9 % N).
- 0.14 g Mg pot^{-1} equal 208 kg $fed.^{-1}$ $Mg(NO_3)_2$ (9.6 % Mg and 18.9 % N).
- 0.21 g Mg pot^{-1} equal 312 kg $fed.^{-1}$ $Mg(NO_3)_2$ (9.6 % Mg and 18.9 % N).
- 0.07 g Mg pot^{-1} equal 20.7 kg $fed.^{-1}$ Mg O (48.2 % Mg).
- 0.14 g Mg pot^{-1} equal 41.4 kg $fed.^{-1}$ Mg O (48.2 % Mg).
- 0.21 g Mg pot^{-1} equal 62.1 kg $fed.^{-1}$ Mg O (48.2 % Mg).

Plant harvested at 21^{th} of February, 2014 separately of each pot. Plant samples were measured for some growth parameters, i.e., plant height (cm) and shoot fresh (g pot^{-1}). All plant samples were washed with distilled water, air-dried and divided into two parts. The first part was dried at 105 °C to determined the dry matter (shoot dry yield as g pot^{-1}). Then the relative change of these growth parameters (plant height, fresh weight and dry weight) and agronomical efficiency (mg / mg Mg) for Mg fertilization treatments were calculated. On the other hand, the second part was oven-dried at 70 °C , weighted, ground and digested for chemical determinations according to Chapman and Pratt (1978). Nitrogen, P, K and Mg concentrations were determined in the digested plants according to the methods described by Cottenie *et al.* (1982). Then the nutrient uptake was accordingly calculated. The obtained data were exposed to proper statistical analysis of variance (ANOVA) by using Minitab computer program and least significant difference (L.S.D.) were calculated at level of 5 % (Barbara and Brain, 1994).

The relative change (RC) of barley plants (plant height, fresh and dry weight) was calculated as follows:-

RC = { (treated plants) - (untreated plants) / (untreated plants) }x 100.

The agronomical efficiency (AE) was calculated according to Sisworo *et al.* (1990) as follows :-

AE = { (dry matter yield of treated plants as mg / pot) - (dry matter yield of untreated plants as mg / pot) }/ added Mg as mg / pot.

RESULTS AND DISCUSSION

Growth Parameters :

Data presented in Table (4) show plant height (cm) and both fresh and dry weights (g pot^{-1}) of barley shoots in relation with Mg sources and rates. It was clearly that increasing the rates of Mg fertilizers increased significantly growth parameters, i.e. plant height, fresh and dry weights of barley plants. The rate of increases were varied between different Mg sources and rates. These increases show the enhanced effect of Mg on plant growth may be due to its important role on some biochemical processes and enzymes activity within plant tissues. Also Mg played a major role of chlorophyll formation by plant leaves. Positive effect of Mg on dry biomass accumulation and plant height can be attributed to its role in photosynthesis, as a carrier of phosphorus, improvement of nutrient uptake, sugar synthesis and starch translocation (Marschner, 2003 and Cakmak and Yazici, 2010). These data are in harmony with those obtained by Abou El-Nour and Shaaban (2012) ; El-Fouly *et al.* (2010) and El-Metwally *et al.* (2010).

Table (4): Plant height (cm), fresh and dry weight (g/pot) of barley plants grown in different soils as affected by sources and rates of Mg fertilizers.

Mg treatments \ Soil (A)		Soil 1			Soil 2			Soil 3		
Sources (B)	Rates (C) (mg/kg)	Plant height (cm)	Fresh weight (g/pot)	Dry weight (g/pot)	Plant height (cm)	Fresh weight (g/pot)	Dry weight (g/pot)	Plant height (cm)	Fresh weight (g/pot)	Dry weight (g/pot)
MgO	0	16.8	4.11	2.08	12.8	6.27	3.30	17.1	6.16	2.95
	10	22.7	4.65	2.18	17.9	6.38	3.65	19.0	7.04	3.51
	20	23.5	4.95	2.34	18.8	7.13	3.80	19.9	7.27	3.66
	30	25.9	5.84	2.40	20.1	7.61	3.93	20.8	8.10	3.75
Mean		22.2	4.89	2.25	17.4	6.85	3.67	19.2	7.14	3.47
$Mg(NO_3)_2$	0	16.8	4.11	2.08	12.8	6.27	3.30	17.1	6.16	2.95
	10	24.8	5.15	2.55	19.2	7.63	3.80	20.2	7.36	3.83
	20	26.9	5.98	2.86	20.3	8.69	4.17	23.5	7.76	3.98
	30	27.5	6.16	3.22	22.1	9.44	4.57	24.7	8.63	4.39
Mean		24.0	5.35	2.68	18.6	8.01	3.96	21.4	7.48	3.79
$MgSO_4$	0	16.8	4.11	2.08	12.8	6.27	3.30	17.1	6.16	2.95
	10	22.2	4.75	2.24	17.5	6.83	3.73	20.0	7.11	3.67
	20	24.8	5.31	2.66	19.6	7.27	4.12	20.9	7.61	3.90
	30	26.7	5.75	3.09	20.5	8.54	4.23	21.7	7.85	4.13
Mean		22.6	4.98	2.52	17.6	7.23	3.85	19.9	7.18	3.66

General mean

Growth parameters	A			B			C			
	Soil 1	Soil 2	Soil 3	MgO	$Mg(NO_3)_2$	$MgSO_4$	0	10	20	30
Plant height	22.93	17.87	20.17	19.60	21.32	20.03	15.56	20.38	22.02	23.33
Fresh weight	5.07	7.36	7.26	6.29	6.94	6.46	5.51	6.32	6.88	7.54
Dry weight	2.48	3.82	3.63	3.13	3.47	3.34	2.77	3.24	3.49	3.74

L.S.D. at 0.05

Growth parameters	A	B	C	AB	AC	BC	ABC
Plant height	0.044	0.044	0.051	0.076	0.088	0.088	0.152
Fresh weight	0.046	0.046	0.053	0.079	0.091	0.091	0.157
Dry weight	0.034	0.034	0.039	0.058	0.067	0.067	0.116

Data in Tables (4 and 5) showed that, all growth parameters under study, i.e., plant height (cm), fresh and dry weights increased significantly with the increase of added Mg fertilizers. These data also show that, in different soils under study, barley plants appeared high response to Mg fertilizers where the rate of this response varied from soil to another depending on soil physical and chemical properties and its content of different Mg forms, especially the content of available Mg. So, with different Mg treatments, the obtained values of relative changes "RC" of plant height take the order : soil 2 > soil 1 > soil 3, while these values with the fresh and dry weights were arranged as follows: soil 1 > soil 3 > soil 2 and soil 3 > soil 1 > soil 2, respectively.

In addition, the values of plant height, fresh and dry shoots of barley plants as presented in Tables (4 and 5) varied widely with the used sources of Mg fertilizers, where the highest values of these three parameters were found in the plants fertilized by Mg $(NO_3)_2$ followed by $MgSO_4$. This variation was attributed to added N and S as a main composition of Mg $(NO_3)_2$ and $MgSO_4$, where N and S as macronutrients play a major role on plant growth and many biochemical processes activity within different plant tissues (Marschner, 2003 and Basak, 2006).

Table (5): Relative changes (RC, %) of plant height, fresh and dry weight of barley plants grown in different soils as affected by sources and rates of Mg fertilizers.

Mg treatments \ Soil (A)		Soil 1			Soil 2			Soil 3		
		Relative changes (RC, %)								
Sources (B)	Rates (C) (mg/kg)	Plant height	Fresh weight	Dry weight	Plant height	Fresh weight	Dry weight	Plant height	Fresh weight	Dry weight
MgO	0	-	-	-	-	-	-	-	-	-
	10	35.12	13.14	4.81	39.84	1.72	10.61	11.11	14.29	18.98
	20	39.88	20.44	12.50	46.88	13.72	15.15	16.37	18.02	24.07
	30	54.17	42.09	15.38	57.03	21.37	19.09	21.64	31.49	27.12
Mean		43.06	25.22	10.90	47.92	12.27	14.95	16.37	21.27	23.39
$Mg(NO_3)_2$	0	-	-	-	-	-	-	-	-	-
	10	47.62	25.30	22.60	50.00	21.69	15.15	18.13	19.48	29.83
	20	60.12	45.50	37.50	58.59	38.60	26.36	37.43	25.97	34.92
	30	63.69	49.88	54.81	72.66	50.56	38.48	44.44	40.10	48.81
Mean		57.14	40.23	38.30	60.42	36.95	26.66	33.33	28.52	37.85
$MgSO_4$	0	-	-	-	-	-	-	-	-	-
	10	32.14	15.57	7.69	36.72	8.93	13.03	16.96	15.42	24.41
	20	47.62	29.20	27.88	53.13	15.95	24.85	22.22	23.54	32.20
	30	58.93	39.90	48.56	60.16	36.20	28.18	26.90	27.44	40.00
Mean		46.23	28.22	28.04	50.00	20.36	22.02	22.03	22.13	32.20

The calculated values of relative changes (RC,%) of the studied growth parameters in relation to the studied treatments were recorded in Table (5). These values showed that, the values of RC were positive and increased with the increase of added Mg in the three sources for all growth parameters under study in the three soils. The highest RC values for each growth parameters were found with the plants fertilized by Mg $(NO_3)_2$ and the lowest values were found in the plants fertilized by MgO for all growth parameters. The positive values of RC concluded that, loamy sand soils must be fertilized with Mg especially in the form of NO_3 or SO_4. These findings are in agreement with those obtained by Basak (2006) and El-Fouly *et al.* (2010).

Data presented in Table (6) showed the calculated values of agronomical efficiency (AE) of different Mg sources (mg / mg Mg) under different three soils. The highest AE values were found with the low rate of added Mg mostly, however these values were decreased with the increase of added Mg. These findings means that , low rates of added Mg have a high efficiency compared with that of high application rates. Also, these findings were found in the three soils and three sources of Mg fertilizers. Also, data showed that, at the same rate of added Mg in the three soils the high values of AE were found in the plants fertilized with Mg $(NO_3)_2$ followed by fertilized with $MgSO_4$. This trend was in harmony with the enhanced effect of NO_3 and SO_4 on plant growth. In addition, the values of AE varied widely from soil to another where the highest values of AE were found with the plants grown on soil 3 which characterized with high CEC and content of available Mg, while the lowest values were found in the plants grown on soil 1. These results are in agreement with those obtained by Badran *et al.* (2004) ; Basak (2006) and Abou El-Nour and Shaaban (2012).

Nitrogen (N) Content:

Data presented in Table (7) showed the concentration and uptake of N by shoots of barley plants as affected by both sources and rates of Mg. Both N concentration and uptake increased with the increase of added Mg in the three sources for all soils. These increases may be due to the enhanced effect of Mg on plant growth and activity rate of many biological processes and enzymes. The high N content was found in the plants fertilized with Mg $(NO_3)_2$, but the lowest one was found in the plants fertilized with MgO. Also, the plants grown on soil 3 which characterized by adequate content of N was higher in the concentration and uptake of N than that of the plants grown on soil 1 which characterized by deficiency of N. This trend was observed with the three sources of Mg and different application rates. These findings means that, Mg application have a clear effect on N concentration and uptake, where this effect depending on Mg source and its application rate and also on soil properties. These results are in agreement with those obtained by Bohri *et al.* (2000) ; Marschner (2003) and Abou El-Nour and Shaaban (2012).

Table (6) : Agronomical efficiency (AE, mg mg^{-1}) of barley plants grown in different soils as effected by Mg fertilizers .

Added rates (mg / kg)	Soil 1			Soil 2			Soil 3		
	MgO	Mg $(NO_3)_2$	$MgSO_4$	MgO	Mg $(NO_3)_2$	$MgSO_4$	MgO	Mg $(NO_3)_2$	$MgSO_4$
10	1.43	6.71	2.29	5.00	7.14	6.14	8.00	12.57	10.29
20	1.86	5.57	4.14	3.57	6.21	5.86	5.07	7.36	6.79
30	1.52	5.43	4.81	3.00	6.05	4.43	3.81	6.86	5.62
Mean	1.60	5.90	3.75	3.86	6.47	5.48	5.63	8.93	7.57

Table (7): Nitrogen concentration (%), uptake (mg/pot) and its relative change (RC, %) of barley plants grown in different soils as affected by sources and rates of Mg fertilizers.

Mg treatments / Soil (A)		Soil 1			Soil 2			Soil 3		
Sources (B)	Rates (C) (mg/kg)	Conc. (%)	Uptake (mg/pot)	RC (%)	Conc. (%)	Uptake (mg/pot)	RC (%)	Conc. (%)	Uptake (mg/pot)	RC (%)
MgO	0	0.19	3.95	-	0.20	6.60	-	0.22	6.49	-
	10	0.20	4.36	10.38	0.22	8.03	21.67	0.23	8.07	24.35
	20	0.22	5.15	30.38	0.24	9.12	38.18	0.25	9.15	40.99
	30	0.23	5.52	39.75	0.26	10.22	54.85	0.28	10.50	61.79
Mean		0.21	4.75	26.84	0.23	8.49	38.23	0.25	8.55	42.38
$Mg(NO_3)_2$	0	0.19	3.95	-	0.20	6.60	-	0.22	6.49	-
	10	0.23	5.87	48.61	0.24	9.12	38.18	0.26	9.96	53.47
	20	0.26	7.44	88.35	0.28	11.68	76.97	0.29	11.54	77.81
	30	0.28	9.02	128.38	0.29	13.25	100.76	0.31	13.61	109.71
Mean		0.24	6.57	88.44	0.25	10.16	71.97	0.27	10.40	80.33
$MgSO_4$	0	0.19	3.95	-	0.20	6.60	-	0.22	6.49	-
	10	0.21	4.70	18.99	0.23	8.58	30.00	0.25	9.18	41.45
	20	0.24	6.38	61.52	0.26	10.71	62.27	0.27	10.53	62.25
	30	0.25	7.73	95.70	0.27	11.42	73.03	0.29	11.98	84.59
Mean		0.22	5.69	58.74	0.24	9.33	55.10	0.26	9.55	62.76

General mean

N content	A			B			C			
	Soil 1	Soil 2	Soil 3	MgO	$Mg(NO_3)_2$	$MgSO_4$	0	10	20	30
Conc.	0.22	0.24	0.26	0.23	0.25	0.24	0.20	0.23	0.26	0.27
Uptake	5.67	9.33	9.50	7.26	9.04	8.19	5.68	7.54	9.08	10.36

L.S.D at 0.05

N content	A	B	C	AB	AC	BC	ABC
Conc.	0.005	0.005	0.005	0.008	0.009	0.009	0.016
Uptake	0.046	0.046	0.053	0.082	0.091	0.091	0.158

The calculated values of RC of N uptake as recorded in Table (7) showed that, RC values of N uptake by shoots of barley plants were positive for all Mg treatments in different soils, where these values were increased with the increase of added Mg. This means that, the high rates of added Mg have a high efficiency on N uptake by plants compared with low application rates. These findings were observed with the three Mg sources in the three soils. Also, the treatments of Mg $(NO_3)_2$ have a high RC values of N uptake compared with those found with either of $MgSO_4$ or MgO at different application rates in the three soils. With most Mg treatments, the plants grown on soil 3 gave a high RC values of N uptake, while soil 1 gave a low RC values. These findings were attributed to varied in soil properties and their contents of available

Mg. These results are in agreement with those found by Bohri *et al.* (2000) ; Marschner (2003) and Abou El-Nour and Shaaban (2012).

Phosphorus (P) Content:

Phosphorus concentration (%) and uptake (mg / pot) by shoots of barley plants in relation to Mg fertilization in the studied soils were investigated and the obtained data were recorded in Table (8). It showed that, P concentration and uptake were increased with the increase of added Mg rates for the three sources. The highest uptake of P were found in the plants fertilized with Mg $(NO_3)_2$, while the lowest values were found with $MgSO_4$ treatments. These findings were found in the three soils. Also, the highest P concentration (%) was found in the plants grown on soil 2, while the lowest one was found in the plants grown on soil 3. This trend is in harmony with $CaCO_3$ content in soils which played a major role in P transfers to unavailable form (Marschner, 2003). On the other hand, the high P uptake was found in the plants grown on soil 2 followed by that in the plants grown on soil 3. These findings were found with the three sources of Mg at different application rates. These results are in agreement with these obtained by Badran *et al.* (2004) and El-Metwally *et al.* (2010).

Data presented in Table (8) also showed, RC (%) values of P uptake by shoots of barley plants as affected by sources and application rates of Mg in soils. These data showed that, all values of RC were positive and increased with the increase of added Mg. The found values of RC of P uptake varied widely from source to anther and different soils. With different treatments of Mg, the plants grown on soil 3 have a highest RC value of P uptake and the lowest values were found in the plants grown on soil 1. This trend was related with the obtained dry matter of barley plants in the three soils under study. These findings are in agreement with those obtained by Bohri *et al.* (2000) and Abou El-Nour and Shaaban (2012).

Potassium (K) Content:

Data presented in Table (9) showed that, K concentration (%) and uptake (mg / pot) were greatly affected by sources and rates of Mg fertilizers in soils. Both K concentration and uptake by shoots of barley plants increased clearly with the increase of added Mg for three sources and the three soils, presumably due to the enhanced effect of added Mg on plant growth. At the same rate of added Mg and in the three soils, the highest content of K was found in the plants fertilized with Mg $(NO_3)_2$ and the lowest one was associated with the treatments of MgO. This is mainly attributed to the enhancement effect of N and S applied with Mg $(NO_3)_2$ and $MgSO_4$ on plant growth and activity rates of many bio-chemical processes within different plant tissues (Marschner, 2003). These results are in agreement with those obtained by Ding *et al.* (2006) and Fageria (2009). With all Mg treatments (sources and application rates), K concentration in shoots of barley plants grown on soil 3 were higher than those found in the plants grown on the two soils. This order is in harmony with the soil properties especially their content of available nutrients.

The calculated RC (%) values of K uptake by shoots of barley plants grown on three soils as affected by different sources and application rates of Mg fertilizers were recorded in Table (9). The obtained RC values of K uptake were positive in different soils and different sources of added Mg, where the values of RC of K uptake were increased with the increase added Mg. According to the found values of RC of K uptake , the tested Mg sources may be arranged as follows : Mg $(NO_3)_2$ > $MgSO_4$ > MgO. Also, with all Mg treatments, the plants grown on soil 3 gave a high values of RC of K uptake followed by the plants grown on soil 1.

Magnesium (Mg) Content:

The results of Mg concentration (%) and uptake (mg / pot) by shoots of barley plants grown under different soils in relation to the studied treatments of Mg fertilization were recorded in Table (10). These data showed that, increasing rates of added Mg for three sources under different soils were associated with clear increases of both Mg concentration and uptake. The high values of Mg content was associated with the treatments of Mg $(NO_3)_2$ followed by that found in the plants fertilized with $MgSO_4$. This trend means that, the presence of N and S in the growth media or in other words application N and S to growth media increased plant response to Mg. Also this trend means that application of N and S increased Mg fertilization efficiency. With all Mg treatments, the plants grown on soil 2 have a highest values of both Mg concentration and uptake, while the lowest values were found in the plants grown on soil 1. These results are in agreement with those obtained by Hardter *et al.* (2004) ; El-Metwally *et al.* (2010) and Mayland and Wilkinson (2012).

Table (8): Phosphorus concentration (%), uptake (mg/pot) and its relative change (RC, %) of barley plants grown in different soils as affected by sources and rates of Mg fertilizers.

Mg treatments \ Soil (A)		Soil 1			Soil 2			Soil 3		
Sources (B)	Rates (C) (mg/kg)	Conc. (%)	Uptake (mg/pot)	RC (%)	Conc. (%)	Uptake (mg/pot)	RC (%)	Conc. (%)	Uptake (mg/pot)	RC (%)
MgO	0	0.10	2.08	-	0.11	3.63	-	0.09	2.66	-
	10	0.13	2.83	36.06	0.16	5.84	60.88	0.12	4.21	58.27
	20	0.17	3.98	91.35	0.21	7.98	119.83	0.15	5.49	106.39
	30	0.21	5.04	142.31	0.24	9.43	159.78	0.18	6.75	153.76
Mean		0.15	3.48	89.91	0.18	6.72	113.50	0.14	4.78	106.14
$Mg(NO_3)_2$	0	0.10	2.08	-	0.11	3.63	-	0.09	2.66	-
	10	0.12	3.06	47.12	0.14	5.32	46.56	0.10	3.83	43.98
	20	0.15	4.29	106.25	0.19	7.92	118.18	0.14	5.57	109.40
	30	0.19	6.12	194.23	0.21	9.60	164.46	0.16	7.02	163.91
Mean		0.14	3.89	115.87	0.16	6.62	109.73	0.12	4.77	105.76
$MgSO_4$	0	0.10	2.08	-	0.11	3.63	-	0.09	2.66	-
	10	0.12	2.69	29.33	0.13	4.85	33.61	0.12	4.40	65.41
	20	0.16	4.26	104.81	0.18	7.42	104.41	0.14	5.46	105.26
	30	0.18	5.56	167.31	0.20	8.46	133.06	0.17	7.02	163.91
Mean		0.14	3.65	100.48	0.16	6.09	90.36	0.13	4.89	111.53

General mean										
P content	A			B			C			
	Soil 1	Soil 2	Soil 3	MgO	$Mg(NO_3)_2$	$MgSO_4$	0	10	20	30
Conc.	0.14	0.17	0.13	0.16	0.14	0.14	0.10	0.13	0.17	0.19
Uptake	3.67	6.47	4.81	4.99	5.09	4.87	2.79	4.11	5.81	7.22

L.S.D. at 0.05							
P content	A	B	C	AB	AC	BC	ABC
Conc.	0.005	0.005	0.005	0.008	0.009	0.009	0.016
Uptake	0.046	0.046	0.053	0.079	0.092	0.092	0.159

Table (9): Potassium concentration (%), uptake (mg/pot) and its relative change (RC, %) of barley plants grown in different soils as affected by sources and rates of Mg fertilizers.

Mg treatments \ Soil (A)		Soil 1			Soil 2			Soil 3		
Sources (B)	Rates (C) (mg/kg)	Conc. (%)	Uptake (mg/pot)	RC (%)	Conc. (%)	Uptake (mg/pot)	RC (%)	Conc. (%)	Uptake (mg/pot)	RC (%)
MgO	0	1.58	32.86	-	1.65	54.45	-	1.68	49.56	-
	10	1.63	35.53	8.13	1.67	60.96	11.96	1.71	60.02	21.11
	20	1.69	39.55	20.36	1.73	65.74	20.73	1.76	64.42	29.98
	30	1.71	41.04	24.89	1.74	68.38	25.58	1.78	66.75	34.69
Mean		1.65	37.25	17.79	1.70	62.38	19.42	1.73	60.19	28.59
$Mg(NO_3)_2$	0	1.58	32.86	-	1.65	54.45	-	1.68	49.56	-
	10	1.68	42.84	30.37	1.70	64.60	18.64	1.73	66.26	33.70
	20	1.74	49.76	51.43	1.77	73.81	35.56	1.81	72.04	45.36
	30	1.77	56.99	73.43	1.79	81.80	50.23	1.83	80.34	62.11
Mean		1.69	45.61	51.74	1.73	68.67	34.81	1.76	67.05	47.06
$MgSO_4$	0	1.58	32.86	-	1.65	54.45	-	1.68	49.56	-
	10	1.60	37.18	13.15	1.68	62.66	15.08	1.73	63.49	28.11
	20	1.71	45.49	38.44	1.75	72.10	32.42	1.79	69.81	40.86
	30	1.73	53.46	62.69	1.76	74.45	36.73	1.81	74.75	50.83
Mean		1.66	42.25	38.09	1.71	65.92	28.08	1.75	64.40	39.93

General mean

K content	A			B			C			
	Soil 1	Soil 2	Soil 3	MgO	$Mg(NO_3)_2$	$MgSO_4$	0	10	20	30
Conc.	1.66	1.71	1.75	1.69	1.73	1.71	1.64	1.68	1.75	1.77
Uptake	41.62	65.63	63.88	53.25	60.36	57.52	45.62	54.80	61.41	66.33

L.S.D. at 0.05

K content	A	B	C	AB	AC	BC	ABC
Conc.	0.0045	0.0045	0.005	0.008	0.009	0.009	0.016
Uptake	0.212	0.212	0.245	0.367	0.423	0.423	0.734

Table (10): Magnesium concentration (%), uptake (mg/pot) and its relative change (RC, %) of barley plants grown in different soils as affected by sources and rates of Mg fertilizers.

Mg treatments \ Soil (A)		Soil 1			Soil 2			Soil 3		
Sources (B)	Rates (C) (mg/kg)	Conc. (%)	Uptake (mg/pot)	RC (%)	Conc. (%)	Uptake (mg/pot)	RC (%)	Conc. (%)	Uptake (mg/pot)	RC (%)
MgO	0	0.64	13.31	-	0.70	23.10	-	0.60	17.70	-
	10	0.67	14.61	9.77	0.72	26.28	13.77	0.64	22.46	26.89
	20	0.69	16.15	21.34	0.77	29.26	26.67	0.68	24.89	40.62
	30	0.74	17.76	33.43	0.80	31.44	36.10	0.71	26.63	50.45
Mean		0.69	15.46	21.51	0.75	27.52	25.51	0.66	22.92	39.32
$Mg(NO_3)_2$	0	0.64	13.31	-	0.70	23.10	-	0.60	17.70	-
	10	0.74	18.87	41.77	0.78	29.64	28.31	0.69	26.43	49.32
	20	0.76	21.74	63.34	0.82	34.19	48.01	0.74	29.45	66.38
	30	0.79	25.44	91.13	0.85	38.85	68.18	0.77	33.80	90.96
Mean		0.73	19.84	65.41	0.79	31.45	48.17	0.70	26.85	68.89
$MgSO_4$	0	0.64	13.31	-	0.70	23.10	-	0.60	17.70	-
	10	0.71	15.90	19.46	0.77	28.72	24.33	0.67	24.59	38.93
	20	0.75	19.95	49.89	0.80	32.96	42.68	0.72	28.08	58.64
	30	0.77	23.79	78.74	0.84	35.53	53.81	0.74	30.56	72.66
Mean		0.72	18.24	49.36	0.78	30.08	40.27	0.68	25.23	56.74

General mean

Mg content	A			B			C			
	Soil 1	Soil 2	Soil 3	MgO	$Mg(NO_3)_2$	$MgSO_4$	0	10	20	30
Conc.	0.71	0.77	0.68	0.69	0.74	0.72	0.64	0.71	0.74	0.77
Uptake	17.84	29.68	24.99	21.96	26.04	24.51	18.03	23.05	26.29	29.31

L.S.D. at 0.05

Mg content	A	B	C	AB	AC	BC	ABC
Conc.	0.004	0.004	0.005	0.007	0.008	0.008	0.015
Uptake	0.246	0.246	0.285	0.426	0.493	0.493	0.853

The calculated RC (%) values of Mg uptake by barley plants in relation to Mg fertilization within different sources and different application rates for the three soils were listed in Table (10). With all treatments under study, all RC values of Mg uptake were positive and increased with the increase of added Mg. The highest RC values of Mg uptake were found in the plants fertilized with Mg $(NO_3)_2$ followed by $MgSO_4$ treatments. Also, at the same treatment of Mg, the highest RC values of Mg uptake were found in the plants grown on soil 3 , while the lowest values were found in the plants grown on soil 2.

Conclusion:

The obtained results from this study concluded that, Mg fertilizers must be added to sandy soils of Egypt, where the barley plants grown on these soils appeared to high response to Mg fertilization. Where, the response of barley plants to Mg fertilization was increases when Mg applied in nitrate and sulphate forms.

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إستجابة نباتات الشعير للتسميد بالمغنسيوم تحت ظروف الأراضي الرملية

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الملخص العربي

يعتبر المغنسيوم عنصر ضروري لنمو النباتات و لهذا أجريت هذه الدراسة كتجربة أصص بالمزرعة البحثية لكلية الزراعة – جامعة المنوفية بشبين الكوم خلال موسم شتاء ٢٠١٣ / ٢٠١٤. و ذلك لدراسة إستجابة نباتات الشعير لإضافة ثلاث صور مختلفة من أسمدة المغنسيوم (أكسيد المغنسيوم ٤٨,٢ ٪ مغ, نترات المغنسيوم ٩,٦ ٪ مغ + ١٨,٩٪ ن و كبريتات المغنسيوم ٢٠ ٪ مغ + ١٤ ٪ كب) بمعدلات إضافة صفر , ١٠ , ٢٠ و ٣٠ مجم مغ / كجم أرض. و ذلك تحت ظروف ثلاث أراضي ذات قوام طمي رملي و لكنها مختلفة في خواصها الطبيعية , الكيميائية و أيضاً محتواها من بعض المغذيات الكبري. لهذا جمعت ثلاث عينات من تلك الأراضي محل الدراسة كل علي حده من الطبقة السطحية (صفر – ٣٠ سم) من ثلاث مناطق مختلفة من مصر و هي : مزرعة القمح , القرية ٦ مدينة النوبارية – محافظة البحيرة (أرض رقم ١ و تتميز بإنخفاض الملوحة و المغنسيوم الميسر), غرب قرية عبد الحليم محمود – محافظة البحيرة (أرض رقم ٢ و تتميز بإنخفاض المغذيات) و جمعية أحمد عرابي – جنوب خط ٤ – محافظة القاهرة (أرض رقم ٣ و تتميز بإرتفاع الملوحة و كربونات الكالسيوم). و الأراضي الثلاث قدر فيها بعض الخواص الطبيعية و الكيميائية و أيضاً محتواها من بعض المغذيات الكبري و الصور المختلفة للمغنسيوم وأجريت التجربة في تصميم قطاع تام العشوائية بثلاث مكررات.

وأشارت النتائج المتحصل عليها إلي زيادة معنوية في كل من إرتفاع النبات (سم) و الوزنين الطازج و الجاف (جم / أصيص) لنبات الشعير مع زيادة معدل إضافة المغنسيوم و كانت أعلي القيم المتحصل عليها لهذه القياسات و كذلك قيم التغير النسبي لها كنسبة مئوية (٪) لقيم الكنترول موجوداً في النباتات المسمدة بنترات المغنسيوم تلاها في ذلك القيم الخاصة بمعاملات كبريتات المغنسيوم و ذلك في الأراضي الثلاثة محل الدراسة.

عند نفس معاملة المغنسيوم كانت أعلي القيم للوزنين الطازج و الجاف موجودة في النباتات النامية علي الأرض رقم ٢ , بينما كانت أقل هذه القيم موجودة في النباتات النامية علي الأرض رقم ١. و لقد إختلفت الكفاءة المحصولية (مجم/ مجم) لأسمدة المغنسيوم الثلاثة التي تحت الدراسة و ذلك عند معدلات الإضافة المختلفة , حيث إختلفت هذه القيم من سماد إلي آخر و كذلك من أرض إلي أخري. و كانت أعلي القيم المتحصل عليها للكفاءة المحصولية عند إضافة نترات المغنسيوم خاصة عند معدلات الإضافة المنخفضة. و في كل الأراضي تحت الدراسة , إزداد كل من التركيز (٪) و الممتص (مجم / أصيص) من كل من الفيتروجين, الفوسفور , البوتاسيوم و المغنسيوم و كذلك قيم التغير النسبي للممتص منها (٪) بزيادة المضاف من المغنسيوم. و كان أعلي محتوي من هذه المغذيات و كذلك التغيرات النسبية لها مصاحباً لمعاملات نترات المغنسيوم تلاها في ذلك معاملات كبريتات المغنسيوم. و بإستثناء محتوي النيتروجين, فإن أعلي محتوي (التركيز و الممتص) في كل من الفوسفور , البوتاسيوم و المغنسيوم وجد في النباتات النامية علي الأرض رقم ٢ , بينما أقل هذه القيم وجد في النباتات النامية علي الأرض رقم ١. و أخيراً بناءاً علي النتائج المتحصل عليها , توصي الدراسة بضرورة تسميد الأراضي الرملية في مصر بالمغنسيوم خاصة في صورة نترات أو كبريتات المغنسيوم و ذلك لزيادة و تحسين إنتاجيتها.