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EFFECT OF MAGNESIUM FERTILIZATION ON GROWTH, YIELD, CHEMICAL COMPOSITION AND ESSENTIAL OILS OF SOME NEW CULTIVARS OF PARSLEY UNDER SINAI CONDITIONS

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Two field experiments were carried out during 2014/2015 and 2015/2016 seasons to evaluate the effect of different levels of magnesium sulphate (0, 25, 50 and 75 kg/feddan) on growth, yield, chemical composition, essential oils and their constituents of three curly parsley cultivars (Petra, Krausa and Bravour) under South Sinai conditions (Ras Sudr). Results showed that Krausa cultivar surpassed the two others cultivars in stem/leaves per plant, plant fresh weights per square meter, plant fresh yield per feddan, chlorophyll a, carotenoids, nitrogen, magnesium contents and fractions for essential oils responsible on the preferred parsley aroma. On the other hand, Petra cultivar showed the superiority in plant dry weight, chlorophyll b, total chlorophyll, phosphorus, potassium content, essential oil and total oil yield. Magnesium sulphate at 75 kg/feddan resulted in the best values of the studied characters. The highest growth and yield values were obtained with Krausa cultivar and 75 kg magnesium sulphate per treatment, while, the Petra cultivar with 75 kg per feddan gave the highest content of essential oil under salt stress.

Keywords: Parsley, fresh weight, dry weight, pigments, mineral contents, salt stress

Parsley (*Petroselinum crispum* Mill.) is a biennial herb belonging to the family of Apiaceae (Umbelliferae). This herb is commercially cultivated as an annual vegetable for its aromatic fresh, dry leaves (Bailey and Bailey, 1976) and essential oils (Abd El-Wahab and Mehasen, 2009). Parsley fruit contains 3-6% essential oil, the main component of the oil is myristicin and apiol in Krausa and Bravour cultivars, while in Petra cultivar is β-phellandrene, germacrene, α- and β-pinene (Robert, 1995; Kurt, 1999 and Wanda, 2001). Parsley is a very rich source of vitamin C and E, carotene, thiamin, riboflavin and organic minerals (Wills et al., 1986 and Kołota, 2011). Parsley plant is a useful herb for building bones and teeth because it is a great store of potassium (Yanardag et al., 2003). Generally, it is useful in cases of cystitis, menstrual, indigestion, a diuretic, and the secretion of bile from the liver, also it dissolves the accumulated fats and natural laxative, increases the vitality and activity of the body. As for the syrup has a large force to ease the pain of the kidneys and remover of gallstones and soothing for colic colon and stomach (Kreydiyyeh and Usta, 2002), as well as it removes muscle pain. In Egypt, curly parsley cultivation began in the early last decade, as several European varieties were imported in order to meet the export specifications in terms of the quality and the color of fresh and dry leaves, as well as the storage ability of fresh leaves (Pereira et al., 2015 and Moustafa et al., 2016). The most popular imported varieties in the Egyptian market were common or curled-leaf parsley such as Bravour, Petra and Krausa cultivars.

Magnesium (Mg) is considered a macro-element and plays an important role in plant nutrition process. This element is necessary for performance of the main physiological functions: it participates in a photosynthesis process as a constituent of a chlorophyll molecule; it is an important agent in the process of phosphorus transport within the plant; it takes part in the synthesis of sugars and transport of starch, as well as in several other physiological and biochemical processes (Roemheld and Kirkby, 2007). Magnesium deficiency in plants can be occurred not only by the low level of readily available magnesium content in soil, but also the competition with cations Ca^{+2} in calcareous soils and Na^{+} in saline soils, that can also prevent the uptake of magnesium by plants (Mengel and Kirkby, 2001 and Shaul, 2002). Moreover, the uptake of magnesium by plants depends also on the ratio of the levels of exchange cations: calcium, magnesium, potassium, sodium and ammonium (Loide, 2004). Plants grown in the soils with low magnesium content levels (sandy soils are generally low in magnesium) accumulate less of this element; in such cases magnesium fertilization is very efficient (Mayland and Wilkinson, 1989). The magnesium fertilization plays an important role in increase of productivity, crop protection and green color that is one of the required quality specifications (Rengel and Robinson, 1989; Marschner et al., 1991; Rehm et al., 1994; Malakouti and Tehrani, 1999; El-Fouly et al., 2002; Piagentini et al., 2002 and Hao and Papadopoulos, 2004).

The aim of this study was to investigate the effect of magnesium sulphate on growth, yield, chemical composition, essential oil and its constituents of three curly parsley cultivars (Petra, Krausa and Bravour) under South Sinai (Ras Sudr) conditions.

MATERIALS AND METHODS

The current experiment was conducted under field conditions at the Experimental Farm, Desert Research Center, Ras Sudr, South Sinai Governorate, Egypt, during two successive seasons (2014/2015 and 2015/2016). The soil characteristics of the experimental field are shown in table (1). Soils were analyzed according to the methods described by Black et al. (1982) and Jackson (1973). The experiment was irrigated by saline water pumped from a well (4500 ppm). The drip irrigation method was used in the experiment. The analysis of irrigation water is given in table (2).

Table (1). Mechanical and chemical properties of the experimental soil.

Depth (cm)	pH	EC ($mS\cdot cm^{-1}$)	$CaCO_3$ (%)	Silt (%)	Sand (%)	Clay (%)	Class texture
0-30	7.8	8.71	57.05	7.95	80.28	10.59	Sandy
30-60	7.4	7.98	52.11	7.52	85.78	6.27	Loam
	Soluble anions ($mg\cdot 100g^{-1}$)				**Soluble cations ($mg\cdot 100g^{-1}$)**		
	CO_3^{-2}	HCO_3^-	SO_4^{-2}	Cl^-	Ca^{+2}	Mg^{+2}	Na^+	K^+
0-30	0.00	99	2812	2266	762	329	1350	76
30-60	0.00	58	3123	1813	614	261	1511	3.8

Table (2). Chemical analysis of the irrigation water.

pH	EC ($mS\cdot cm^{-1}$)	Soluble anions ($mg\cdot dm^{-3}$)				Soluble cations ($mg\cdot dm^{-3}$)		
		CO_3^{-2}	HCO^{-3}	SO_4^{-2}	Cl^-	Ca^{2+}/Mg^{2+}	Na^+	K^+
8.7	7.04	0.00	125	1395	1717	41.35	916	2.7

Seeds of the two curly parsley cultivars; *Petroselinum crispum* var. Petra and *Petroselinum crispum* var. Krausa, were imported from the Netherlands by Bejo Zaden Co., while *Petroselinum crispum* var. Bravour was imported from Germany Enza Zaden Co.

Seeds were sown on October 1^{st} and 5^{th} of first and second seasons, respectively. The distances were 60 and 35 cm between rows and dripper, respectively. After 3 weeks from germination, the plants were thinned as two plants per hill; the distances were 15 cm among hills at a rate of 2 hills per dripper. The final number of plants in feddan was 80000 plants. The experiment was designed as a split plot design with three replications, each replicate contained twelve plots, the main plots devoted the three cultivars (Moskrul 2-Petra, Moskrul 2-Krausa and Bravour), while the sub plots were occupied with four magnesium sulphate rates (0, 25, 50 and 75 kg/feddan), which added once as soil addition before sowing. All agricultural practices suitable for parsley cultivation and production were followed according to the instructions of the Egyptian Ministry of Agriculture.

Three cuttings were carried out from the plants after 65, 95 and 125 days from seeding date. In each cut, many data were recorded, i.e., plant stems/leaves percent, fresh weight (kg/m^2), dry weight (g/m^2), total yield of fresh and dry weight (ton/feddan), and essential oil content (%), which was determined according to British Pharmacopoeia (1963). The extracted essential oil was dehydrated over anhydrous sodium sulphate and stored at freezer till used for gas chromatography – mass spectrometry (GC-MS).

Essential oil samples, which were extracted from all parsley genotypes were analyzed using gas chromatography-mass spectrometry instrument stands at the Department of Medicinal and Aromatic Plants Research, National Research Center, Egypt with the following specifications: Instrument: a TRACE GC Ultra Gas Chromatographs (THERMO Scientific Corp., USA), coupled with a THERMO mass spectrometer detector (ISQ Single Quadrupole Mass Spectrometer). The GC-MS system was equipped with a TG-WAX MS column (30 m x 0.25 mm i.d., 0.25 µm film thickness). Analyses were carried out using helium as the carrier gas at a flow rate of 1.0 ml/min and a split ratio of 1:10 using the following temperature program: 40^o C for 1 min; rising at 4 to 160°C/min and held for 6 min; rising at 6 to 210°C /min and held for 1min. The injector and detector were held at 210°C. Diluted samples (1:10 hexane, v/v) of 0.2 µl of the mixtures were routinely injected. Mass spectra were obtained by electron ionization (EI) at 70 eV, using a spectral range of m/z 40-450. Most of the ingredients were identified using mass spectra (authentic chemicals, Wiley spectral library collection and NSIT library).

The photosynthetic pigments (chlorophyll a, chlorophyll b and carotenoids) were determined at the third cut according to the acetone (80%) incubation method described by Metzner et al. (1965). The pigments content was spectrophotometrically measured using a UV visible spectrophotometer (Optizen Pop, Mecasys - Korea). The chlorophyll content was calculated as mg/g FW following the equations cited in Dere et al. (1998):

Chlorophyll a = 11.75 A662 - 2.350 A645

Chlorophyll b = 18.61 A645 - 3.960 A662

Carotenoids = 1000 A470 - 2.270 Chlorophyll a - 81.4 Chlorophyll b/227

Samples of air dry herb were digested for elements determination using the method of Piper (1947). Nitrogen % was determined by the modified microkejldahl method as described by Jackson (1973). Phosphorus % was determined according to Olsen and Sommers (1982) method. Potassium % was determined using flame photometericlly as described by Dewis and Freitas (1970). Magnesium was estimated by the versenate titration method as described by Jackson (1967).

All data were analyzed statistically following the analysis of variance (ANOVA) and the mean differences were adjusted with Duncan's test at a 0.05 level of significance (Steel, 1960), using the statistical computer package program, COSTAT.

RESULTS

1. Growth and Yield Characters

Data in tables (3 and 4) emphasized that there was a substantial variability among the three parsley cultivars in their growth and yield characters (plant stems/leaves, fresh weigh and total fresh yield) in the three cuts under application of magnesium at different rates and their interaction during both growing seasons. The results showed that Krausa cultivar had the superiority for increasing all growth and yield characters, except herb dry weight during the two growing seasons. Petra cultivar showed the superiority for increasing dry weight and total dry weight yield, followed by Krausa and Bravour cultivars, respectively.

Concerning, magnesium application, the most effective treatment for enhancing the plant stems/leaves, plant fresh and dry weights per square meter in almost three cuts, as well as total fresh and dry yield per feddan gave the highest values with magnesium level (75 kg/feddan), while the lowest values were recorded by no magnesium application (control), during both seasons. The differences among treatments were significant during the two seasons. These results are in accordance with those obtained by Khalid et al. (2009).

As for the interaction effect between cultivars and magnesium levels, data presented in table (3) cleared that the highest values of plant stems/leaves, plant fresh weights per square meter in three cuts and total fresh weight yield per feddan were obtained from Krausa cultivar with the highest magnesium level (75 kg/feddan). On the contrary, the lowest values were recorded by Bravour cultivar with no magnesium application treatment. These results were significant in both growing seasons and agree with those stated by El-Wahab and Mohamed (2007). The Petra cultivar combined with 75 kg magnesium/feddan resulted in increasing the values of plant dry weights per square meter in three cuts and total dry yield per feddan more than other treatments (Table 4). However, the lowest values were observed by Bravour cultivar combined with no magnesium application (control) in the two growing seasons. There were significant differences among treatments in both seasons, except plant dry weight per square meter in the second and first cuts in the first and second seasons, respectively. These results are in agreement with those obtained by El-Wahab and Mohamed (2007) on Ajowan, as well as Abd El-Wahab and Mehasen (2009) on two curly parsley varieties.

Table (3). Effect of magnesium fertilization on plant stems/leaves, fresh weight and total fresh yield of three parsley cultivars (Petra, Krausa and Bravour) during 2014/2015 and 2015/2016 seasons.

Treatments		2014/2015					2015/2016				
		Plant stems /leaves (%)	Fresh weight (kg/m^2)			Total fresh yield (ton/fed)	Plant stems /leaves (%)	Fresh weight (kg/m^2)			Total fresh yield (ton/fed)
Cultivars	Mg levels (kg/fed)		1st cut	2nd cut	3rd cut			1st cut	2nd cut	3rd cut	
Petra	0	35.80	0.305	0.414	0.429	4.59	38.22	0.294	0.388	0.412	4.38
	25	37.58	0.380	0.518	0.547	5.78	38.73	0.368	0.458	0.506	5.33
	50	42.04	0.424	0.672	0.742	7.35	40.69	0.393	0.582	0.614	6.35
	75	48.06	0.575	0.702	0.796	8.29	43.36	0.530	0.654	0.710	7.58
Mean		40.87	0.421	0.577	0.628	6.50	40.25	0.396	0.521	0.561	5.91
Krausa	0	45.01	0.314	0.455	0.474	4.97	44.15	0.310	0.439	0.506	5.02
	25	57.79	0.442	0.616	0.668	6.91	49.13	0.408	0.589	0.618	6.46
	50	60.14	0.539	0.703	0.768	8.04	53.91	0.497	0.648	0.650	7.18
	75	60.26	0.619	0.770	0.870	9.03	57.62	0.594	0.710	0.730	8.14
Mean		55.80	0.478	0.636	0.695	7.24	51.20	0.452	0.597	0.626	6.70
Bravour	0	33.42	0.212	0.283	0.351	3.39	31.40	0.200	0.263	0.320	3.13
	25	36.83	0.287	0.330	0.370	3.95	37.61	0.293	0.286	0.345	3.69
	50	44.73	0.380	0.489	0.502	5.48	45.71	0.368	0.408	0.436	4.85
	75	45.08	0.441	0.575	0.592	6.43	45.63	0.427	0.507	0.569	6.01
Mean		40.02	0.330	0.419	0.454	4.81	40.09	0.322	0.366	0.417	4.42
Over all means of Mg	0	38.08	0.277	0.384	0.418	4.32	37.92	0.268	0.363	0.413	4.18
	25	44.07	0.370	0.488	0.528	5.54	41.82	0.356	0.444	0.490	5.16
	50	48.97	0.448	0.621	0.671	6.96	46.77	0.419	0.546	0.566	6.13
	75	51.13	0.545	0.682	0.753	7.92	48.87	0.517	0.624	0.670	7.24
L.S.D. at 5%	Cultivars	5.95	0.020	0.024	0.035	0.21	1.96	0.019	0.027	0.019	0.12
	Mg level	2.84	0.030	0.024	0.021	0.21	2.80	0.022	0.030	0.023	0.14
	Interaction	4.91	0.049	0.038	0.034	0.36	4.84	0.034	0.049	0.038	0.25

Table (4). Effect of magnesium fertilization on dry weights and total dry weight of three parsley cultivars (Petra, Krausa and Bravour) during 2014/ 2015 and 2015/2016 seasons.

Treatments		2014/2015				2015/2016			
		Dry weight (g/m^2)			Total dry yield (ton/fed)	Dry weight (g/m^2)			Total dry yield (ton/fed)
Cultivars	Mg levels (kg/fed)	1st cut	2nd cut	3rd cut		1st cut	2nd cut	3rd cut	
Petra	0	61.07	82.80	85.73	0.92	58.87	77.60	82.47	0.88
	25	75.93	103.53	109.33	1.16	73.53	91.67	101.20	1.07
	50	84.73	134.40	148.40	1.47	78.53	116.40	122.73	1.27
	75	115.00	140.47	159.13	1.66	105.93	130.80	142.07	1.52
Mean		84.18	115.30	125.65	1.30	79.22	104.12	112.12	1.18
Krausa	0	52.33	75.83	78.94	0.83	51.61	73.11	84.39	0.84
	25	73.67	102.67	111.39	1.15	68.00	98.22	102.94	1.08
	50	89.83	117.11	128.06	1.34	82.78	108.06	108.28	1.20
	75	103.11	128.28	145.00	1.51	99.00	118.33	121.72	1.36
Mean		79.74	105.97	115.85	1.21	75.35	99.43	104.33	1.12
Bravour	0	35.39	47.17	58.50	0.56	33.33	43.78	53.28	0.52
	25	47.89	55.00	61.67	0.66	48.78	47.61	57.56	0.62
	50	63.33	81.50	83.67	0.91	61.33	68.06	72.61	0.81
	75	73.56	95.78	98.72	1.07	71.22	84.50	94.78	1.00
Mean		55.04	69.86	75.64	0.80	53.67	60.99	69.56	0.74
Over all means of Mg	0	49.60	68.60	74.39	0.77	47.94	64.83	73.38	0.74
	25	65.83	87.07	94.13	0.99	63.44	79.17	87.23	0.92
	50	79.30	111.00	120.04	1.24	74.21	97.50	101.21	1.09
	75	97.22	121.51	134.29	1.41	92.05	111.21	119.52	1.29
L.S.D. at 5%	Cultivars	3.88	6.50	7.86	0.04	3.53	8.56	3.42	0.02
	Mg level	5.28	5.64	4.71	0.04	5.22	5.56	4.61	0.05
	Interaction	9.15	NS	8.15	0.06	NS	9.63	7.99	NS

2. Photosynthetic Pigments

Leaf content of chlorophylls a, b, total chlorophylls and carotenoids was determined and the data are presented in table (5). Results indicate a significant difference among the three cultivars in both seasons. The Krausa cultivar recorded the highest values of chlorophyll a and carotenoids, whereas the Petra cultivar recorded the highest values of chlorophyll b and total chlorophyll in the two seasons. The lowest values of chlorophyll a and total chlorophyll were obtained from Bravour cultivar, but the Krausa and Petra cultivars gave the lowest values of chlorophyll b and carotenoids, respectively in both seasons. Magnesium application significantly increased photosynthetic pigments (chlorophyll a and b as well as total chlorophyll and carotenoids). The effect being more pronounced with the highest levels of magnesium sulphate (Table 5). The combined effect of cultivars and magnesium levels increased the total pigments content of parsley plant (Table 5). The highest content of chlorophyll a and carotenoids were obtained by Krausa cultivar with the highest magnesium level (75 kg/feddan), while the highest content of chlorophyll b, and total chlorophylls were obtained from Petra cultivar with no addition of magnesium during the two seasons. However, the significance was detected only at chlorophyll b and carotenoids in both seasons. These results are in agreement with those reported by Dorenstouter et al. (1985), Piagentini et al. (2002) and Hao and Papadopoulos (2004). Khalid et al. (2009) on thyme indicated that application of $MgSO_4$ produced a significant increase in accumulation of photosynthetic pigments (Chl a, Chl b and total carotenoids).

3. Nutrients Content

Data presented in table (6) indicated that there were significant differences among tested cultivars in the content of nitrogen, phosphorus, potassium and magnesium during both seasons. The highest values of N and Mg were obtained from Krausa cultivar, whereas Petra cultivar gave the highest K content in both seasons and P content in the first season. On the other hand, the lowest contents of N, Mg (in both seasons) and K (in the first season) were noticed with Bravour cultivar, while the lowest content of P (in both seasons) and K (in the second season) were obtained with Krausa cultivar.

Magnesium levels had significant effects on all studied nutrients content of parsley cultivars. In general, there were gradual increments in N, P, K and Mg contents with increasing the magnesium levels. These results are in agreement with those of El-Wahab and Mohamed (2007), Fajemilehin et al. (2008) and Khalid et al. (2009), who reported that nutrients content (N, P, K and Mg) of plant showed enhanced response to magnesium application.

Table (5). Effect of magnesium fertilization on Chlorophyll a, b, total chlorophyll and carotenoids of three parsley cultivars (Petra, Krausa and Bravour) during 2014/2015 and 2015/2016 seasons.

Treatments		2014/2015				2015/2016			
		Chl a	Chl b	Total Chl	Carotenoids	Chl a	Chl b	Total Chl	Carotenoids
Cultivars	Mg levels (kg/fed)	(mg/g fresh weight)							
Petra	0	2.76	0.77	3.54	1.28	2.83	0.72	3.55	1.22
	25	2.82	0.84	3.66	1.42	2.94	0.80	3.74	1.40
	50	2.99	1.20	4.18	1.55	3.07	1.10	4.17	1.51
	75	3.11	1.33	4.43	1.64	3.25	1.27	4.52	1.73
Mean		2.92	1.03	3.95	1.47	3.03	0.97	4.00	1.47
Krausa	0	2.84	0.67	3.51	1.32	2.89	0.61	3.51	1.30
	25	2.94	0.81	3.74	1.45	3.07	0.76	3.82	1.52
	50	3.02	1.01	4.03	1.67	3.29	0.91	4.20	1.73
	75	3.20	1.16	4.36	1.82	3.38	1.06	4.44	1.91
Mean		3.00	0.91	3.91	1.57	3.16	0.84	3.99	1.61
Bravour	0	2.61	0.74	3.35	1.27	2.48	0.76	3.24	1.23
	25	2.73	0.82	3.56	1.45	2.68	0.88	3.56	1.42
	50	2.92	0.96	3.88	1.56	2.85	1.01	3.86	1.54
	75	3.07	1.11	4.17	1.75	3.00	1.21	4.21	1.72
Mean		2.83	0.91	3.74	1.51	2.75	0.97	3.72	1.48
Over all means of Mg	0	2.74	0.73	3.46	1.29	2.74	0.70	3.43	1.25
	25	2.83	0.82	3.65	1.44	2.90	0.81	3.71	1.44
	50	2.97	1.06	4.03	1.59	3.07	1.01	4.08	1.59
	75	3.12	1.20	4.32	1.74	3.21	1.18	4.39	1.79
L.S.D. at 5%	Cultivars	0.06	0.03	0.17	0.04	0.04	0.04	0.11	0.03
	Mg level	0.09	0.02	0.13	0.03	0.05	0.02	0.12	0.02
	Interaction	NS	0.04	NS	0.05	NS	0.04	NS	0.03

Table (6). Effect of magnesium fertilization on N, P, K and Mg contents of three parsley cultivars (Petra, Krausa and Bravour) during 2014/2015 and 2015/2016 seasons.

Treatments		2014/2015				2015/2016			
Cultivars	Mg levels (kg/fed)	N (%)	P (mg/100 g)	K (%)	Mg (mg/100 g)	N (%)	P (mg/100 g)	K (%)	Mg (mg/100 g)
Petra	0	1.62	41.09	2.56	26.05	1.53	39.39	2.47	23.52
	25	1.79	44.86	2.95	31.85	1.64	43.27	2.90	30.92
	50	1.88	50.31	3.26	40.49	1.76	45.67	3.17	38.02
	75	2.25	51.42	3.76	40.79	1.87	49.98	3.88	40.08
Mean		1.89	46.92	3.13	34.80	1.70	44.58	3.11	33.13
Krausa	0	1.65	36.45	2.47	34.88	1.69	38.40	2.31	32.00
	25	1.81	40.47	2.74	42.57	1.74	42.24	2.61	38.93
	50	2.01	44.86	2.96	48.06	1.91	46.15	2.85	42.25
	75	2.32	48.06	3.24	49.57	2.16	48.86	2.95	45.84
Mean		1.95	42.46	2.85	43.77	1.87	43.91	2.68	39.75
Bravour	0	1.30	37.98	2.26	24.03	1.34	38.70	2.38	23.93
	25	1.52	42.26	2.50	29.66	1.50	43.01	2.63	30.26
	50	1.81	45.92	2.72	38.33	1.78	46.28	2.83	37.30
	75	2.02	49.88	2.90	39.57	1.86	50.74	3.01	39.25
Mean		1.66	44.01	2.60	32.90	1.62	44.68	2.71	32.69
Over all means of Mg	0	1.53	38.51	2.43	28.32	1.52	38.83	2.39	26.48
	25	1.71	42.53	2.73	34.69	1.63	42.84	2.71	33.37
	50	1.90	47.03	2.98	42.29	1.82	46.03	2.95	39.19
	75	2.20	49.79	3.30	43.31	1.97	49.86	3.28	41.72
L.S.D. at 5%	Cultivars	0.08	1.23	0.06	0.74	0.11	0.35	0.17	0.68
	Mg level	0.09	1.19	0.12	0.75	0.07	0.47	0.14	0.64
	Interaction	NS	NS	0.20	1.30	NS	0.81	0.25	1.11

Regarding the effect of the interaction between cultivars and magnesium levels on nutrients content, the statistical analysis indicated that there were significant differences among all treatments, except nitrogen content in both seasons and phosphorus content in the first season. The highest values of nitrogen and magnesium content were observed in Krausa cultivar received 75 kg magnesium sulphate/feddan., while the highest values of phosphorus and potassium contents were obtained with Petra cultivar with 75 kg magnesium sulphate/feddan, in the two growing seasons.

4. Essential Oil Content

Similar to the aforementioned characteristics, estimation of essential oil content revealed remarkable differences among the three cultivars. This was noticeable in the three cuts along the both seasons. Table (7) showed that Petra cultivar contained higher essential oil content when compare with Bravour cultivar, followed by Krausa cultivar in the two seasons. Petra cultivar gave the highest total oil yield, 32.84 and 29.43 liter per feddan in the first and second season, respectively. While, Bravour cultivar recorded the lowest values of total oil yield, 22.32 and 20.77 liter per feddan in first and second season, respectively. Influence of magnesium treatments cleared significant increase in essential oil of all cuts, as well as total oil yield. Essential oil in three cuts and total oil yield increased with the increasing in magnesium levels and attained the highest values with addition of 75 kg magnesium sulphate per feddan. Referring to the interaction effect among the three cultivars and magnesium levels, the maximum values of essential oil content and total oil yield were obtained from Petra cultivar plants received 75 kg magnesium sulphate per feddan during the two seasons. The results were significant, except first cut in both seasons. These results were in harmony with those obtained by British Pharmacopoeia (1963), Wanda (2001), Dordas (2009), Khalid et al. (2009) and Aziz et al. (2013).

5. Essential Oil Constituents

The essential oil composition varies according to cultivars and magnesium application and was characterized by high percentage of hydrocarbon compounds ranged from 64.18 to 74.68%. β –phellandrene was identified as the major compound in different treatments ranging from 36.62 to 44.82%. Myrictein, the second main component, ranged from 17.19 to 26.16%, followed by apiol, which ranged from 5.66 to 8.75%. Data in table (8) showed that Krausa cultivar combiend with 75 kg magnesium/feddan gave the most abundant fractions responsible for the preferred parsley aroma including Myrictein (25.17%), also the highest percent ages of apiol (6.33%) and α-terpinene (3.76%) as compare to others cultivars. However, Petra cultivar was higher in ß-phyllandrene (43.39%), which had the highest percentage (6.094%) of β-pinene, and the highest percent ages of germacrene (5.36%), whereas Bravour cultivar also proved successful in the

Table (7). Effect of magnesium fertilization on essential oil content of three parsley cultivars (Petra, Krausa and Bravour) during 2014/2015 and 2015/2016 seasons.

Treatments		2014/2015					2015/2016				
		Essential oil (%)					Essential oil (%)				
Cultivars	Mg levels (kg/fed)	1st cut	2nd cut	3rd cut	Mean	Total oil yield (L/fed)	1st cut	2nd cut	3rd cut	Mean	Total oil yield (L/fed)
Petra	0	0.49	0.44	0.41	0.45	20.65	0.48	0.42	0.38	0.43	18.83
	25	0.51	0.46	0.47	0.48	27.74	0.51	0.45	0.47	0.48	25.58
	50	0.53	0.5	0.52	0.52	38.22	0.53	0.48	0.52	0.51	32.38
	75	0.56	0.52	0.55	0.54	44.77	0.56	0.51	0.55	0.54	40.93
Mean		0.52	0.48	0.49		32.84	0.52	0.47	0.48		29.43
Krausa	0	0.37	0.32	0.36	0.35	17.39	0.37	0.31	0.34	0.34	17.07
	25	0.39	0.35	0.36	0.37	25.57	0.39	0.35	0.36	0.37	32.90
	50	0.40	0.36	0.39	0.38	30.55	0.40	0.36	0.39	0.38	27.28
	75	0.41	0.37	0.40	0.39	35.22	0.42	0.37	0.40	0.40	32.56
Mean		0.39	0.35	0.38		27.18	0.40	0.35	0.37		27.45
Bravour	0	0.45	0.41	0.40	0.42	14.24	0.45	0.40	0.41	0.42	13.15
	25	0.46	0.43	0.46	0.45	17.77	0.48	0.42	0.46	0.45	16.60
	50	0.49	0.45	0.47	0.47	25.76	0.50	0.45	0.48	0.48	23.28
	75	0.51	0.46	0.50	0.49	31.51	0.52	0.48	0.50	0.50	30.05
Mean		0.48	0.44	0.46		22.32	0.49	0.44	0.46		20.77
Over all means of Mg	0	0.44	0.39	0.39	0.41	17.42	0.43	0.38	0.38	0.40	16.35
	25	0.46	0.41	0.43	o.43	23.69	0.46	0.41	0.43	0.43	25.03
	50	0.48	0.44	0.46	0.46	31.51	0.48	0.43	0.46	o.46	27.65
	75	0.50	0.45	0.49	0.48	37.17	0.50	0.46	0.48	0.48	34.51
L.S.D. at 5%	Cultivars	0.01	0.02	0.01	0.01	1.97	0.01	0.01	0.01	0.01	0.30
	Mg level	0.01	0.01	0.01	0.01	1.98	0.01	0.01	0.01	0.01	0.50
	Interaction	NS	0.01	0.01	NS	3.43	NS	0.01	0.01	NS	0.86

production of higher value of apiol (8.06%), myrictein (25.17%), β–phellandrene (40.22%) and limonene (3.19%). There is no significant difference for the use of the high level of magnesium on the main components of the oil in the three cultivars. Khalid et al. (2009) found that application of $MgSO_4$ increased the main components of essential oil of thyme.

Table (8). Effect of magnesium fertilization on essential oil constituents of three parsley cultivars (Petra, Krausa and Bravour) during 2014/2015 and 2015/2016 seasons.

	Compounds	**Content (µg /µL) in six accessions**					
		Petra (control)	**Krausa (control)**	**Bravour (control)**	**Petra Mg levels (75 kg/fed)**	**Krausa Mg levels (75 kg/fed)**	**Bravour Mg levels (75 kg/fed)**
1	**α-Pinene**	5.21	6.23	6.15	5.24	6.33	5.75
2	**Myrcene**	2.71	3.14	2.73	2.71	3.22	2.35
3	**β- Pinene**	5.68	4.88	4.11	5.26	4.61	4.18
4	**β -Phellandrene**	44.82	36.62	38.34	43.39	37.42	40.22
5	**β -Cymene**	2.57	2.52	2.87	2.48	2.03	2.34
6	**Limonene**	2.21	2.17	3.17	3.21	2.18	3.19
7	**α- Terpinene**	3.11	4.05	3.11	2.89	3.76	3.18
8	**P-Cymene**	2.22	1.73	1.51	2.65	1.91	2.22
9	**1,3,8 P-Menthatriene**	0.85	0.51	0.85	0.31	0.38	0.51
10	**Germacrene**	5.30	2.33	3.64	5.36	2.81	1.73
11	**Myrictein**	18.14	26.16	23.16	17.19	25.17	24.14
12	**Apiol**	5.66	5.85	8.75	7.93	6.12	8.06
Total identified compounds		98.48	96.19	98.39	98.62	95.94	97.87
Total hydrocarbons compounds		74.68	64.18	66.48	73.50	64.65	65.67
Total oxygenated compounds		23.80	32.01	31.91	25.12	31.29	32.20

DISCUSSION

Parsley cultivars are grown mainly as a herb for consumption of the fresh and dried leaves, which are famous to use as flavoring in many food products due to its powerful aromatic odour (Simon and Quinn, 1988; Aziz et al., 2013 and Sabry et al., 2013). In addition, the essential oils originated from the herb and the seeds are used as flavors, mainly as fragrances in perfumery (Osińska et al., 2012), cosmetic and pharmaceutical industries to produce spice essential oil and drugs (Lopez et al., 1999). These facts are important to keep in mind during the evaluation of new cultivars in a certain area and under specific conditions. The differences among cultivars effect on parsley are due to differences in genetic characters. Therefore, the current study was managed to assess the rendering of three cultivars newly introduced to Ras Sudr, South Sinai Governorate under the application of magnesium with different levels. Results showed considerable differences in the productivity of all cultivars. Krausa cultivar surpassed than other cultivars, followed by Petra cultivar descendingly by Bravour cultivar in terms of plant stems/leaves and plant fresh weight per square meter and total fresh weight yield**.** On the other hand, Petra cultivar gave the heaviest dry weight per plant and the highest essential oil, followed dissentingly by Bravour cultivar while, Krausa cultivar showed the lowest values during both seasons**.**

Bravour cultivar accumulated the highest pigments content when treated with magnesium at level of 75 kg/feddan. This can be interpreted by the role of chlorophyll in photosynthesis, as well as magnesium function. Mg^{+2} is the coordinating metal ion in the chlorophyll molecule, and in plants where the ion is in high supply, about 6% of the total Mg^{+2} is bound to chlorophyll (Heenan and Campbell, 1981; Scott and Robson, 1990a; Scott and Robson, 1990b and Marschner, 1995). Thylakoid stacking is stabilised by Mg^{+2} and is important for the efficiency of photosynthesis, allowing phase transitions to occur (Fork, 1986). Mg^{+2} is probably taken up into chloroplasts to the greatest extent during the light-induced development from proplastid to chloroplast or etioplast to chloroplast. At these times, the synthesis of chlorophyll and the biogenesis of the thylakoid membrane stacks absolutely require the divalent cation (Gregory, 1989 and Lu et al., 1995).

Two major classes of the enzymes that interact with Mg^{+2} in the tissues during the light stage can be identified (Black and Cowan, 1995). Firstly, enzymes in the glycolytic pathway most often interact with two atoms of Mg^{+2}. The first atom is as an allosteric modulator of the enzymes' activity, while the second forms part of the active site and is directly involved in the catalytic reaction. The second class of enzymes includes those where the Mg^{2+} is complex to nucleotide di- and tri-phosphates (ADP and ATP), and the chemical change involves phosphoryl transfer. Mg^{+2} may also serve in a structural maintenance role in these enzymes (e.g. enolase) (Ebel and Guenther, 1980).

These findings were in agreement with those obtained by Osińska et al. (2012) and Karklelienė et al. (2014). Influence of genotype on accumulation of carotenoids and chlorophylls in parsley leaves was also demonstrated by Novac (2011). Application of magnesium at different levels revealed significant effect on growth parameters of parsley cultivars and the effect became more pronounced during the first and the third cuts. Applying magnesium at 75 kg/feddan induced the highest results in all cultivars, in terms of fresh weight, dry weight, essential oil content and leaf pigments content. In accordance with these results, Osińska et al. (2012) reported that plants receiving magnesium might have been helped in terms of vigorous root growth, formation of chlorophyll, resulting in higher photosynthesis and protein content, which might have resulted in better growth and higher dry matter production. Chlorophyll and other natural dyes are important in production of parsley for determining the appearance of both raw material and its biological value (Piagentini et al., 2002). Importance of magnesium is clear for chlorophyll formation and photosynthesis and it is important in the enzyme systems and respiration of plants (Tariq et al., 2004). Positive effect of magnesium on plant growth is attributed to its role in photosynthesis, as a carrier of phosphorus, improvement of nutrient uptake, sugar synthesis and starch translocation (Gregory, 1989; Marschner, 1995 and Laing et al., 2000). Improvement of plant growth in response to magnesium application was demonstrated previously by Upadhyay and Patra (2011) and Abou El-Nour and Shaaban (2012).

It could be concluded that productivity and quality of parsley depended significantly on the cultivar and application of magnesium. Petra cultivar showed noticeable superiority in the plant stems/leaves and plant fresh weight per square meter and total fresh weight yield per feddan, whereas Krausa cultivar showed its superiority in the dry weight per plant and the highest essential oil content under the experimental conditions. Improvement of growth and characteristics, as well as photosynthetic pigments, nutrients content and essential oil content were possible with using application of magnesium at 75 kg/feddan.

CONCLUSION

The three curled cultivars (Petra, Krausa and Bravour), when treated with magnesium at levels of 75 kg/feddan., showed very acceptable vegetative growth, high yield of fresh and dry leaves and essential oil. The essential oil composition contains components responsible for cancer curing (anticancer compounds) and other diseases curing chemical compounds as aforementioned discussed. Moreover, some of these foreign cultivars contained the parsley preferred flavor compounds. These cultivars with these characteristics may enrich parsley cultivation and production in the South Sinai under saline conditions and enhance fresh and dry parsley products suitable for exportation.

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تأثير التسميد بالماغنسيوم على النمو والمحصول والتركيب الكيميائي والزيوت الطيارة لبعض أصناف البقدونس الجديدة تحت ظروف سيناء

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أجريت الدراسة في موسمين متتالين هما ٢٠١٥/٢٠١٤ و٢٠١٥/ ٢٠١٦ بمزرعة محطة بحوث رأس سدر التابعة لمركز بحوث الصحراء، مصر، بهدف دراسة تأثير التسميد بالماغنسيوم (سلفات ماغنسيوم) بمعدلات ٠، ٢٥، ٥٠ و ٧٥ كجم/فدان إضافة أرضية على النمو، المحصول، التركيب الكيميائي والزيوت الطيارة لثلاثة أصناف من البقدونس المجعد (بترا، كروزا وبريڤور). أظهرت النتائج تفوق الصنف كروزا على الصنفين الأخرين في صفات نسبة السيقان/الأوراق على النبات، الوزن الطازج للنباتات/م٢، المحصول الطازج الكلي للفدان، كلوروفيل أ، الكاروتين ومحتوى النبات من النيتروجين، الماغنسيوم والمواد المميزة لرائحة البقدونس، بينما تفوق الصنف بترا في صفات الوزن الجاف للنباتات/م٢، المحصول الجاف الكلي للفدان، كلوروفيل ب، الكلوروفيل الكلي ومحتوى النبات من الفوسفور والبوتاسيوم وكذلك محتوى النبات من الزيت العطرى. كما أسفرت النتائج أن المستوى العالي من الماغنسيوم (٧٥ كجم/فدان) أدى إلى زيادة معنوية في جميع الصفات المدروسة، لكن لم يكن هناك إختلاف معنوي بين مستويات التسميد بالماغنسيوم على مكونات الزيت العطري في الثلاثة أصناف. بذلك أمكن الحصول على أفضل نمو خضري ومحصول كلي للفدان من زراعة الصنف كروزا مع إضافة ٧٥ كجم سلفات ماغنسيوم/فدان، بينما أمكن الحصول على أعلى محتوى من الزيت العطري من زراعة الصنف بترا مع إضافة ٧٥ كجم سلفات ماغنسيوم للفدان.