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EFFECT OF POTASSIUM FERTILIZATION ON TWO *MENTHA* SPECIES

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ABSTRACT: A field experiment was carried out at Cairo Aromatic Farm found in Farafra Oasis (New Valley) through two growing seasons (2022 and 2023) to examine the impact of different levels of potassium sulfate (50% K_2O) fertilization (0.0, 45, 90 and 135 kg/fed K_2O/fed) on the vegetative growth characters (mean plant height, leaf area, number of plants per square meter and herb fresh and dry weights per cut as well as herb fresh and dry weights either per m^2 or per feddan) of two mint species (*Mentha spicata* & *Mentha piperita*). Data showed that all previous traits were significantly augmented with *Mentha spicata* than *Mentha piperita* in all cases. Also, such abovementioned parameters were increased with increasing potassium fertilization levels, where, 135 K_2O/fed produced the highest values in all cases. The interaction was significant for all studied parameters in all cases. It is advisable that the combination treatment between high level of potassium with *Mentha spicata* was the best in this regard.

Keywords: *Mentha spp*., spearmint, peppermint, nutrition, potassium, vegetative growth

INTRODUCTION

Mentha genus is a member of the Lamiaceae Family and comprises over 30 species. Plants within this family are known for being a valuable source of polyphenols, which may confer potent antioxidant properties.

Egypt has a long-standing tradition of cultivating mint, making it one of the most significant herbs in the country (Abd El-Wahab, 2009). *Mentha spp*. are commonly used in the form of tea for the treatment of stomach discomfort and chest-related ailments in home remedies. This herbal infusion is known to improve digestive processes and alleviate various disorders such as stomach pain, gastritis, dyspepsia, flatulence, enteritis, intestinal colic, gastric acidity, aerophagia, and spasms affecting the gallbladder, bile duct, and gastrointestinal tract (Abbaszadeh *et al*., 2009). *Mentha spicata* and *Mentha piperita* are members of this genus under our study.

Potassium plays a crucial role in plant metabolism by facilitating the production of carbohydrates, fats, and proteins, ultimately enhancing crop yield and quality. This essential mineral is vital for various physiological functions, including photosynthesis, transportation of photosynthates to different plant parts, maintenance of cell turgor, and activation of enzymes, particularly during overcast conditions (Marschner, 1995, Mengel and Kirkby, 2001 and Cakmak, 2005). Many researchers concluded that potassium fertilization enhanced growth on *Mentha spp.* such as Valmorbida and Boaro (2007), Nemeth *et al*. (2012), Hassani *et al*. (2015), Sheykholeslami *et al*. (2015), Chrysargyris *et al*. (2017) and Lothe *et al*. (2021).

So, this work aimed to determine the adequate potassium rate to get maximum yield especially under new reclaimed soils.

MATERIALS AND METHODS

The present field experiment was conducted over two consecutive growing seasons, specifically 2022 and 2023, at Cairo Aromatic Farm located in Farafra Oasis (New Valley). The primary objective of this study was to examine the impact of varying levels of potassium fertilization on the vegetative growth properties of two mint species, namely spearmint (*Mentha spicata*) and peppermint (*Mentha piperita*).

Plant material and Treatments:

The seedlings of both mint species (peppermint and spearmint) in the two seasons were obtained from Giza Seeds Company, Giza, 6th October, Egypt. Uniform seedlings of the two *Mentha* species were sown on February 25th in the two growing seasons in hills with 25 × 25 cm apart and between hills (16 plant/m^2). Each unit area was 1 m^2 (1 m width × 1 m length). So, each replicate was 2.5 m width × 6 m length and contains 2 main plots (1 m × 6 m) and 4 sub-plots (potassium treatments), 1 m × 4 m. To prevent seepage, a 0.5 m between main and sub-plots was left, under pivot irrigation system. Thus, the number of plants/fed was 64000 plants.

Two weeks before planting date, compost was added at 12 tons per fed during preparation of the soil for planting in the two experimental seasons in Cairo Aromatic Farm. Compost was obtained from Konoz company. Calcium triple phosphate (15.5% P_2O_5) was added at 200 kg/fed + 50 kg sulfur (98% S)/fed. Nitrogen was added at 150 kg ammonium sulphate (20.5% N)/fed (traditional dose under this region) at three equal doses (one week after potassium fertilization for each dose).

The potassium sulphate (K_2SO_4) fertilization treatments were used as a soil application at the rate of 0.0, 90, 180, and 270 kg/fed for both mint species were split into three equal doses with a 45-day interval, commencing on March 15th, then on May 1st, and finally on June 15th in both seasons. Mint harvesting was conducted three times with a 43-day interval, starting on April 27th, followed by June 13th, and lastly on July 28th in both seasons. The Physical and chemical properties of the used soil in Cairo Aromatic Farm, Farafra Oasis (New valley) were shown in Table (a), according to ICARDA (2013).

A randomized complete block design in a split plot with three replications was followed. Mint species (*spearmint* and *peppermint*) were arranged in the main plots (A), while four levels of potassium fertilization (0.0, 45, 90 and 135 units K_2O/fed) were occupied the sub-plots (B). Therefore, the interaction treatments (A × B) were 8 treatments.

Data recorded:

The recorded data of growth production were: plant length (cm), leaf area (cm^2), number of plants/m^2, herb fresh and dry weight (g/m^2/cut), total fresh weight of herbage (ton/fed/season) and total herbage dry weight (ton/fed/season).

Table a. Physical and chemical properties of the used soil before planting of mint during the two successive growing seasons of 2022 and 2023.

Soil Character	2022	2023	Soil Character	2022	2023
Physical properties			**Exchangeable nutrients**		
Sand (%)	77.13	75.28	**Ca^{++} (meq/l)**	6.51	6.45
Silt (%)	14.45	14.57	**Mg^{++} (meq/l)**	6.03	6.00
Clay (%)	8.42	10.15	**Na^{+} (meq/l)**	7.12	7.07
Soil texture	Sandy	Sandy	**K^{+} (meq/l)**	1.65	1.57
Chemical properties			**DTPA-Extractable nutrients**		
pH (1:2.5)	8.31	8.33	**Fe (ppm)**	0.35	0.33
E.C. (dS/m)	2.04	2.06	**Cu (ppm)**	0.07	0.06
O.M. (%)	0.03	0.04	**Zn (ppm)**	0.14	0.12
$CaCO_3$ (%)	9.98	10.06	**Mn (ppm)**	0.26	0.25

Statistical analysis:

The obtained data for all traits were tabulated and statistically analyzed according to MSTAT–C (1986) and LSD test was followed to compare between means of treatments.

RESULTS AND DISCUSSION

Regardless of the impact of all treatments, data presented in Tables (1 to 6) proved that all vegetative growth characteristics (plant height, number of plants per m^2, leaf area (cm^2), herb fresh and dry weights per plant per cut (g) were increased in both seasons in the third cut than either 2nd or 1st cut, except for plant height and leaf area, which were declined. This decline in such two parameters may be due to that plants development after the harvest did not reach the stage of height and leaf formation.

Changes in mean plant height, number of plants per m^2, leaf area (cm^2), herb fresh and dry weights per plant per cut and per season per feddan of the two species (*Mentha spicata* and *Mentha piperita*) depending on the levels of potassium fertilization were given in Tables (1 to 6). It was shown from the Tables that *Mentha spicata* was superior to *Mentha piperita* in all the abovementioned parameters in both seasons. The increase in fresh herbage reached 71.80 and 71.03% and dry mass (92.49 and 89.60%) over *Mentha piperita* in the first and second season, respectively. Such increase in all previous parameters due to the characteristics of *Mentha spp*. (Charles, 2013a and 2013b).

Data listed in the same Tables showed that increasing potassium rates from 90 to 270 kg potassium sulfate resulted in a significant increase for all previous traits. Therefore, the high level of K augmented the highest values. Such increase of fresh herb per feddan reached 58.19 and 59.40% and dry weight (58.35 and 59.38%) over control in the first and second seasons respectively, for 270 K_2SO_4 treatment.

Potassium is a crucial cation macronutrient that is required in significant amounts by plant cells, as it is integral to various physiological and biochemical

Table 1. Effect of potassium fertilization on mean of plant height (cm) of *Mentha spicata* and *Mentha piperita* during the three cuttings in both growing seasons (2022 and 2023).

Potassium fertilization treatments (kg/fed) (B)	*Mentha* species (A)					
	M. spicata	***M. piperita***	**Mean (B)**	***M. spicata***	***M. piperita***	**Mean (B)**
	First season (2022)			**Second season (2023)**		
			First cut			
Control (K_0)	29.17	28.20	28.69	29.75	29.05	29.40
K_1 (45 K_2O/fed)	31.40	30.87	31.14	32.12	31.82	31.97
K_2 (90 K_2O/fed)	35.47	32.60	34.04	36.42	33.68	35.05
K_3 (135 K_2O/fed)	40.33	37.93	39.13	41.54	39.26	40.40
Mean (A)	34.09	32.40	33.25	34.96	33.45	34.21
$LSD_{0.05}$	A: 1.65	B: 1.31	AB: 2.47	A: 1.50	B: 1.34	AB: 1.90
			Second cut			
Control (K_0)	25.60	24.20	24.90	26.14	24.97	25.56
K_1 (45 K_2O/fed)	32.30	28.87	30.59	33.05	29.88	31.47
K_2 (90 K_2O/fed)	34.60	31.67	33.14	35.54	32.69	34.12
K_3 (135 K_2O/fed)	37.07	34.83	35.95	38.22	36.05	37.14
Mean (A)	32.39	29.89	31.14	33.24	30.90	32.07
$LSD_{0.05}$	A: 1.42	B: 1.70	AB: 2.41	A: 1.46	B: 1.76	AB: 2.48
			Third cut			
Control (K_0)	24.87	23.27	24.07	25.41	24.01	24.71
K_1 (45 K_2O/fed)	27.93	26.47	27.20	28.58	27.35	27.97
K_2 (90 K_2O/fed)	32.77	29.10	30.94	33.66	30.10	31.88
K_3 (135 K_2O/fed)	35.13	32.93	34.03	36.29	34.07	35.18
Mean (A)	30.18	27.94	29.06	30.99	28.88	29.93
$LSD_{0.05}$	A: 1.20	B: 1.09	AB: 1.72	A: 1.24	B: 1.22	AB: 1.59

Table 2. Effect of potassium fertilization on leaf area (cm^2) of *Mentha spicata* and *Mentha piperita* during the three cuttings in both growing seasons (2022 and 2023).

Potassium fertilization treatments (kg/fed) (B)	*Mentha* species (A)					
	M. spicata	*M. piperita*	Mean (B)	*M. spicata*	*M. piperita*	Mean (B)
	First season (2022)			Second season (2023)		
			First cut			
Control (K_0)	4.04	3.44	3.74	4.05	3.45	3.75
K_1 (45 K_2O/fed)	4.52	3.92	4.22	4.53	3.93	4.23
K_2 (90 K_2O/fed)	4.88	4.45	4.67	4.89	4.46	4.68
K_3 (135 K_2O/fed)	6.04	4.96	5.50	6.06	4.97	5.52
Mean (A)	4.87	4.19	4.53	4.88	4.20	4.54
$LSD_{0.05}$	A: NS	B: 0.28	AB: 0.39	A: NS	B: 0.28	AB: 0.39
			Second cut			
Control (K_0)	3.64	3.24	3.44	3.65	3.25	3.45
K_1 (45 K_2O/fed)	4.36	3.72	4.04	4.37	3.73	4.05
K_2 (90 K_2O/fed)	4.76	4.11	4.44	4.78	4.12	4.45
K_3 (135 K_2O/fed)	5.84	4.88	5.36	5.87	4.89	5.38
Mean (A)	4.65	3.99	4.32	4.67	4.00	4.33
$LSD_{0.05}$	A: 0.29	B: 0.22	AB: 0.32	A: 0.29	B: 0.22	AB: 0.32
			Third cut			
Control (K_0)	3.48	3.03	3.26	3.49	3.04	3.27
K_1 (45 K_2O/fed)	4.16	3.52	3.84	4.17	3.53	3.85
K_2 (90 K_2O/fed)	4.33	4.08	4.21	4.35	4.09	4.22
K_3 (135 K_2O/fed)	5.58	4.57	5.08	5.61	4.58	5.10
Mean (A)	4.39	3.80	4.09	4.41	3.81	4.11
$LSD_{0.05}$	A: 0.0.38	B: 0.33	AB: 0.47	A: 0.38	B: 0.33	AB: 0.47

Table 3. Effect of potassium fertilization on number of plants/m^2 of *Mentha spicata* and *Mentha piperita* during the three cuttings in both growing seasons (2022 and 2023).

Potassium fertilization treatments (kg/fed) (B)	*Mentha* species (A)					
	M. spicata	*M. piperita*	Mean (B)	*M. spicata*	*M. piperita*	Mean (B)
	First season (2022)			Second season (2023)		
			First cut			
Control (K_0)	29.7	21.0	25.4	30.3	21.4	25.9
K_1 (45 K_2O/fed)	31.1	22.5	26.8	31.7	23.0	27.4
K_2 (90 K_2O/fed)	33.5	23.7	28.6	34.2	24.2	29.2
K_3 (135 K_2O/fed)	34.6	25.0	29.8	35.3	25.5	30.4
Mean (A)	32.2	23.1	27.6	32.9	23.5	28.2
$LSD_{0.05}$	A: 2.5	B: 1.4	AB: 2.0	A: 2.6	B: 1.5	AB: 2.1
			Second cut			
Control (K_0)	58.4	36.8	47.6	59.7	37.6	48.7
K_1 (45 K_2O/fed)	61.3	42.2	51.8	62.6	43.1	52.9
K_2 (90 K_2O/fed)	66.1	47.1	56.6	67.7	48.2	58.0
K_3 (135 K_2O/fed)	72.0	52.6	62.3	73.9	54.1	64.0
Mean (A)	64.5	44.7	54.6	66.0	45.8	55.9
$LSD_{0.05}$	A: 1.1	B: 0.7	AB: 1.1	A: 1.1	B: 0.8	AB: 1.1
			Third cut			
Control (K_0)	100.5	69.9	85.2	102.7	71.5	87.1
K_1 (45 K_2O/fed)	113.5	75.3	94.4	116.1	77.0	96.6
K_2 (90 K_2O/fed)	124.7	86.2	105.5	128.1	88.3	108.2
K_3 (135 K_2O/fed)	131.5	95.8	113.7	135.4	98.8	117.1
Mean (A)	117.6	81.8	99.7	120.6	83.9	102.2
$LSD_{0.05}$	A: 2.5	B: 0.7	AB: 1.0	A: 2.9	B: 0.7	AB: 1.0

Table 4. Effect of potassium fertilization herb fresh weight (g/m^2) of *Mentha spicata* and *Mentha piperita* during the three cuttings in both growing seasons (2022 and 2023).

Potassium fertilization treatments (kg/fed) (B)	*Mentha* species (A)					
	M. spicata	*M. piperita*	Mean (B)	*M. spicata*	*M. piperita*	Mean (B)
	First season (2022)			Second season (2023)		
			First cut			
Control (K_0)	244.84	156.24	200.54	250.24	159.52	204.88
K_1 (45 K_2O/fed)	263.54	173.74	218.64	269.68	177.58	223.63
K_2 (90 K_2O/fed)	332.14	207.04	269.59	340.9	211.82	276.36
K_3 (135 K_2O/fed)	404.02	231.86	317.94	415.94	239.62	327.78
Mean (A)	311.14	192.22	251.68	319.19	197.14	258.16
$LSD_{0.05}$	A: 30.76	B: 11.84	AB: 23.68	A: 31.54	B: 12.14	AB: 24.28
			Second cut			
Control (K_0)	568.68	302.34	435.51	580.8	309.06	444.93
K_1 (45 K_2O/fed)	630.68	355.2	492.94	644.18	363.46	503.82
K_2 (90 K_2O/fed)	704.32	432.46	568.39	721.58	443.44	582.51
K_3 (135 K_2O/fed)	885.3	517.26	701.28	909.72	532	720.86
Mean (A)	697.25	401.82	549.53	714.07	411.99	563.03
$LSD_{0.05}$	A: 27.54	B: 15.72	AB: 31.44	A: 28.10	B: 16.12	AB: 32.24
			Third cut			
Control (K_0)	1051.36	626.26	838.81	1074.9	640.3	857.60
K_1 (45 K_2O/fed)	1250.82	699.4	975.11	1280.22	715.84	998.03
K_2 (90 K_2O/fed)	1397.38	828.82	1113.10	1435.96	851.7	1143.83
K_3 (135 K_2O/fed)	1665.52	962.18	1313.85	1716.66	991.72	1354.19
Mean (A)	1341.27	779.17	1060.22	1376.94	799.89	1088.41
$LSD_{0.05}$	A: 23.30	B: 17.78	AB: 35.56	A: 23.96	B: 18.27	AB: 36.54

Table 5. Effect of potassium fertilization herb dry weight (g/m^2) of *Mentha spicata* and *Mentha piperita* during the three cuttings in both growing seasons (2022 and 2023).

Potassium fertilization treatments (kg/fed) (B)	*Mentha* species (A)					
	M. spicata	*M. piperita*	Mean (B)	*M. spicata*	*M. piperita*	Mean (B)
	First season (2022)			Second season (2023)		
			First cut			
Control (K_0)	44.08	25.00	34.54	45.54	26.16	35.85
K_1 (45 K_2O/fed)	47.44	27.80	37.62	49.08	29.12	39.10
K_2 (90 K_2O/fed)	59.78	33.12	46.45	62.04	34.74	48.39
K_3 (135 K_2O/fed)	72.72	37.10	54.91	75.70	39.30	57.50
Mean (A)	56.01	30.76	43.38	58.09	32.33	45.21
$LSD_{0.05}$	A: 5.42	B: 2.12	AB: 4.24	A: 5.64	B:2.20	AB: 4.40
			Second cut			
Control (K_0)	102.36	48.38	75.37	106.28	51.00	78.64
K_1 (45 K_2O/fed)	113.52	56.84	85.18	117.88	59.98	88.93
K_2 (90 K_2O/fed)	126.78	69.20	97.99	132.04	73.16	102.60
K_3 (135 K_2O/fed)	159.36	82.76	121.06	166.48	87.78	127.13
Mean (A)	125.51	64.30	94.90	130.67	67.98	99.33
$LSD_{0.05}$	A: 4.98	B: 2.76	AB: 3.92	A: 5.16	B: 2.88	AB: 4.08
			Third cut			
Control (K_0)	189.24	100.20	144.72	197.78	106.28	152.03
K_1 (45 K_2O/fed)	225.14	111.90	168.52	235.56	118.82	177.19
K_2 (90 K_2O/fed)	251.54	132.62	192.08	264.22	141.38	202.80
K_3 (135 K_2O/fed)	299.80	153.94	226.87	315.86	164.62	240.24
Mean (A)	241.43	124.67	183.05	253.36	132.78	193.07
$LSD_{0.05}$	A: 3.90	B: 4.48	AB: 6.34	A: 4.12	B: 4.72	AB: 6.68

Table 6. Effect of potassium fertilization total fresh and dry weights of herbage (ton/fed/season) of *Mentha spicata* and *Mentha piperita* in both growing seasons (2022 and 2023).

Potassium fertilization treatments (kg/fed) (B)	*Mentha* species (A)					
	M. spicata	***M. piperita***	**Mean (B)**	***M. spicata***	***M. piperita***	**Mean (B)**
	First season (2022)			**Second season (2023)**		
	Total fresh weight of herbage (ton/fed/season)					
Control (K_0)	7.460	4.340	5.900	7.624	4.436	6.030
K_1 (45 K_2O/fed)	8.580	4.914	6.747	8.776	5.028	6.902
K_2 (90 K_2O/fed)	9.736	5.874	7.805	9.994	6.028	8.011
K_3 (135 K_2O/fed)	11.820	6.846	9.333	12.170	7.054	9.612
Mean (A)	9.399	5.494	7.446	9.641	5.637	7.639
$LSD_{0.05}$	A: 0.114	B: 0.162	AB: 0.228	A: 0.116	B: 0.166	AB: 0.234
	Total dry weight of herbage (ton/fed/season)					
Control (K_0)	1.342	0.694	1.018	1.398	0.734	1.066
K_1 (45 K_2O/fed)	1.544	0.786	1.165	1.610	0.832	1.221
K_2 (90 K_2O/fed)	1.752	0.940	1.346	1.834	0.998	1.416
K_3 (135 K_2O/fed)	2.128	1.096	1.612	2.232	1.166	1.699
Mean (A)	1.692	0.879	1.285	1.769	0.933	1.351
$LSD_{0.05}$	A: 0.018	B: 0.028	AB: 0.040	A: 0.018	B: 0.030	AB: 0.042

processes, including the regulation of cell osmotic balance and the activation of enzymes, as noted by Marschner (1995) and Mengel and Kirkby (2001).

In accordance with our results were those findings of Jeliazkova *et al*. (1999), Nemeth *et al*. (2012), Hassani *et al*. (2015) and Sheykholeslami *et al*. (2015) on *Mentha piperita*; Chrysargyris *et al*. (2017) on *Mentha spicata*; and Lothe *et al*. (2021) on *Mentha arvensis*.

In all cases, the combination effect between *Mentha spp*. and potassium fertilization levels was significant for all studied parameters. The heaviest fresh herbage yield per feddan (11.820 and 12.170 ton) was achieved from *Mentha spicata* fertilized with 270 kg K_2SO_4. Also, for *Mentha piperita*, the heaviest fresh weight (6.846 and 7.054 ton) was obtained with 270 kg K_2SO_4. It is interesting to indicate that the response of *Mentha* to potassium fertilization was depending on the species, similarly, were the findings of Zheljazkov and Margina (1996) on mint.

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تأثير التسميد البوتاسي على نوعين من النعناع

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أجريت تجربة حقلية بمزرعة شركة القاهرة للبذور والنباتات الطبية والعطرية بواحة الفرافرة (الوادي الجديد) خلال موسمين زراعيين (٢٠٢٢ و٢٠٢٣) لدراسة تأثير مستويات مختلفة من التسميد البوتاسي (الكنترول، ٤٥، ٩٠ و١٣٥ وحدة بوتاسيوم) على صفات النمو الخضري (متوسط ارتفاع النبات، مساحة الورقة، عدد النباتات لكل متر مربع ووزن العشب الطازج والجاف/م٢/حشة وكذلك وزن العشب الطازج والجاف للفدان/موسم) لنوعي النعناع تحت الدراسة (النعناع البلدي والنعناع الفلفلي). أظهرت البيانات أن جميع الصفات السابقة زادت بشكل ملحوظ مع النعناع البلدي عن النعناع الفلفلي في جميع

الحالات. كما زادت هذه الصفات المذكورة أعلاه مع زيادة مستوى التسميد بالبوتاسيوم، حيث أنتج ٢٧٠ كجم سلفات بوتاسيوم أعلى القيم في جميع الحالات. كان التفاعل معنويا لجميع المعايير المدروسة في جميع الحالات. ومن المثير للاهتمام أن المعاملة المركبة بين المستوى العالي من البوتاسيوم مع النعناع البلدي كانت الأفضل في هذا الصدد.