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Effect of some Natural Compounds on Reducing the Effect of Saline Water Irrigation on Marjoram Plants

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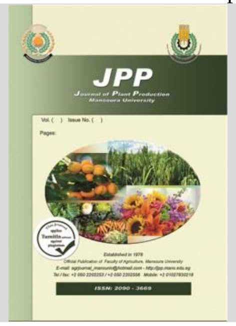

ABSTRACT

In order to examine the effect of FYM and putrescine K and P as natural rocks to reduce the harmful effect of salinity of irrigation water on sweet marjoram plants growth and oil production. Field experiment was achieved at new reclaimed sandy-loam soil located at Eastern Nile side in face of Beba district Beni Swief Governorate – Egypt; during two experimental seasons (2022 and 2023). The obtained results indicated that, under irrigation with saline water in new reclaimed sandy soil conditions, treated the sweet marjoram plants with FYM and putericin as well as potassium and phosphorus natural rocks significantly improved marjoram plant growth, mineral status and essential oil quantity and quality. The data also shows that, all combined treatments shows more effective than the individual application of each material.

Keywords: sweet marjoram, natural rocks, salinity, essential oil

INTRODUCTION

Majorana hortensis plant commonly known "sweet marjoram" is one of family Lamiaceae member. Cyprus and eastern Mediterranean countries considered as original zone of marjoram plant (Massoud *et al.*, 2009). Moreover , marjoram could propagated by cuttings and seeds (Shalan *et al.*, 2006; Abbassy *et al.*, 2009 and Massoud *et al.*, 2009). Marjoram plant distinguished by a sweet, spicy pleasant odor (Verma *et al.*, 2010). However, the Marjoram vegetative parts commonly used for extract the essential oil. It has a many pharmaceutical, medicine, perfumery antifungal, anticancer and antioxidant properties, as well as industries uses. Furthermore, Marjoram essential oil extensively use in food industry (as a spice, processed vegetables, baked goods, snack foods, soups and gravies (Mangaia & Ravi 2012).

Commercial Natural Phosphorus rocks (apatite) have theoretical P contents ≈ 15% (34% P_2O_5) it is also primary source of Mg and Fe and Ca (Marschner 1995).

Potassium Feldspar rock powder widely used as a potassium-fertilizers in different soil types (Ciceri *et al.*, 2019 and Liu, *et al.*, 2020). Studies on rock powders in agricultural fertilization as a source of K have been carried out, either in natural or after some solubilizing process (Ciceri *et al.*, 2019 and Liu, *et al.*, 2020). One of its most important features that it is available in large quantities and low-cost source of K (Liu, *et al.*, 2020). Potassium and Phosphorus rocks are a main source of K and P. However, in higher pH level soil, they are less readily available to plants absorption. The potential of using organic fertilizers (such as FMY) could be increased the solubility and absorption of these two cations through turn into insoluble phosphate and potassium in natural rocks to soluble forms (Schilling *et al.*, 1998).

Putrescine (butane-1,4-diamine) produced when amino acids decompose, it found in small amounts in living cells. Putrescine has multifaceted biochemical properties, and it has a several roles for under stressful conditions such as; salinity, cold or potassium deficiency stress. It has also play some fundamental roles in plant growth and predictability such as; it conceded as a starting point of the most common polyamines pathway in higher plants, cation balance, antioxidant activity, controlling cellular K^+ and Ca^{2+}, and mitochondria and chloroplasts bioenergetics and osmolyte or pH level regulator and also inhibit ethylene production. However, its role in salinity tolerances of medicine and aromatic plants remains poorly understood (Gonzalez-Hernandez *et al.*, 2022).

Reclaimed soil concern revolves around salinity, which negatively impacts plant growth and development, particularly in dry and semi-dry regions (Parihar et al., 2015) Plants with healthy soil have a higher probability of coping with abiotic stress conditions. Salt stress has been shown to disrupt several physiological processes leading to reduction in growth and yield, as well as oil quality (Mizrahi & Pasternak, 1985 and Parihar et al., 2015) The effects of salinity seem to depend on the plant species and cultivars, the stage of plant development, and agricultural processing and treatments (Marschner 1995, Grattan and Grieve 1999)

Consequently, the current investigation was aimed to exploitation of the relative advantage effect of FYM and natural compounds (Putrescine as well as natural potassium and phosphorus natural rocks) on decreasing the harmful effects of irrigation by using saline water on vegetative growth parameters, essential oil and essential oil quality of marjoram plants.

MATERIALS AND METHODS

The present investigation was carried out during two successive seasons 2022 and 2023 in privet farm located at new reclaimed land located at Eastern Nile side in face of Beba district, Beni Swief Governorate – Egypt where the soil texture was sandy loam. The farm irrigate

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through underground well water by using drip irrigation system.

Plant materials

Seeds of sweet marjoram plants were obtained from laboratory of medicinally and aromatically plant, Seds Agricultural Research Station Beni suef (Egypt) and sowed (in October 15th) on plastic boxes (50 cm width and 10 cm depth, filled with mixture of sand and clay soil. Then the boxes placed three weeks in greenhouse. When, the marjoram seedlings reached to the stage of 4-5 leaves and ≈10 cm in height the seedlings transplanted to the field. Moreover, seedlings were planted at 40 cm X 60 cm apart. The plants irrigated with normal underground water by using drip irrigation system. The Herbs harvested three times yearly, first cut in May 15th; second cut in early August and the third cut in October 15th, during both experimental seasons.

Treatments

During the present study, three materials were examined:

FYM (at 5 and 10 ton/fed.) were added in winter soil management (in January), natural potassium rock (400 kg/fed.) and natural phosphorus rock (300 kg/fed.) were added one time to the soil at in October during preparation the farm soil in the first season (just before seedlings transplanting) and in second week of October in the second season. While, putrescine at 10 µM (produced by Spezifkation auf Anfrage Company and distribution by El-Korma Company for chemical and seed disruption, Cairo – Egypt) was added three times yearly, as foliar application, the first one in early November and three weeks intervals.

Then, eleven treatments plus control (un-treated plants irrigated with the wells water) were achieved in this experiment. Each one was replicated three times.

Soil analysis

Composite samples of field soil and irrigation water were collected and physicochemical analyses were achieved (Lab. of soil & water analysis Fac. of Agric. Minia Univ.) according to Wilde *et al.,* (1985).

Table (1) shows the obtained data.

Table 1. Physical and chemical analysis of the soil and irrigation water.

Soil		Water	
Ingredients	**Values**	**Constituents**	**Values**
Sand	76 %	E.C (ms/cm)	4.1
Silt	10 %	Hardness	19.7
Clay	14 %	pH	7.41
Texture	Sandy	Ca (mg/L)	39.9
EC (m.mhos / cm / 25 ºC)	2.8	Mg (mg/L)	22.2
Organic matter %	0.35	K (mg/L)	6.02
pH Value(1 : 2.5 extract)	7.79	Na (mg/L)	97.1
N (mg/kg)	135	Alkalinity (mg/L)	182
Phosphorus (ppm)	7.71 ppm	Chlorides (mg/L)	121
Available Ca (meq/100g)	9.8	Nitrate (mg/L)	9.1
Available Mg (meq/100g)	1.43	Sulphates (mg/L)	53.1
Available K (meq/100g)	0.39	Boron (ppm)	
Available Na (meq/100g)	11.30	0.08	

Vegetative parameters:

-The height of plant (cm).

- Number of branches per plants.

-Herb fresh and dray weight were done by using sensitive balance (0.01cm accuracy).

-Determined leaves N, P and K contents samples of 30 adulate leaves (from each replicate) were picked at harvesting time, during the three cuts in both experimental seasons (Martin-Préval *et al.,* 1984**)**.

Leaves chemical analyses:

The leaves were washed with distillated water and dried at air and oven, then 0.5 g weight was digested using H_2SO_4 and H_2O_2 until a clear solution was obtained. A 100 ml volumetric flask was used to transport the digested solution. Following that, the contents of N, P, and K for each sample were determined as follows: Nitrogen was determined using modified microkejldahl methods (Walsh and Beaton, 1986)

Essential Oil extraction and analysis

Essential oil percentage of herb at the three achieved cuts were estimated according to the method described by British Pharmacopoeia (1963), sited in Ebaid (2011), to extract the essential oil, distilling 60 g of herb for 3 hours were achieved. Gas Chromatography (GC – Elite-62ms Column – 60 m x 0.25 mm I.D., 1.4 µm, Temp. -20 to 240 ºC) was also used for notify separation components and determination of essential oil composition in Fac. of Pharmacy Minia Univ., according to Marriott et al., (2001). The chemical compositions of essential oil presented in this work were obtained from the GC of first cut essential oil analysis only.

Statistical design and analysis of data

Complete randomized block design was used in the present investigation according to Snedecor and Cochran 1999). The obtained data were tabulated and statistically analysed by using MSTATC Program. Then, the comparisons between means were made by using new Least (New L.S.D) at p = 0.05, according to Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Plant height and branch numbers per plant:

Illustrated data in Table (2) shows the effect of farmyard manure (FYM), putrescine and natural rocks (K and P rocks) at different concentrations on height and number of branches per plant of sweet marjoram plant, during 2022 and 2023 seasons. It can be visually observed from the representative data that, during the two seasons increasing the FYM from 0.0 to 10 tons per feddan significantly enhanced both plant height and branches number per plant. Furthermore, treated marjoram plants with putericin at 10 µM or/and natural rocks (300kg P Rock + 400kg K rock) lead to significant increasing the two vegetative characters (height of plant and number of branches/plant).

In addition, the combined application of the three examined materials (FYM at 10 tons/fed., putrescine at 10 µM as well as K rock at 400kg/fed. and P Rock at 300kg/fed.) produced highest plant length and highest number of branches/plant in three cuts compared to using each material alone or untreated plants. On the opposite side, control treatment presents the lowest height of plant and lowest number of branches / plant. These findings were true in both experimental seasons.

Table 2. Effect of FYM, nature rocks and putrescine on plant height (cm) and number of branches / plant of marjoram plants, during 2022 and 2023 seasons.

Treatments	Plant height (cm)						Number of branches / plant					
	First Season(2022)			Second Season(2023)			First Season(2022)			Second Season(2023)		
	1st Cut	2nd Cut	3rd Cut	1st Cut	2nd Cut	3rd Cut	1st Cut	2nd Cut	3rd Cut	1st Cut	2nd Cut	3rd Cut
Control 0.0 ton FYM + 0.0 Nature Rocks + 0.0 Putrescine	19.5	20.2	18.1	18.2	19.3	18.7	10.3	12.4	13.2	12.1	13.9	14.0
0.0 ton FYM + 0.0 Nature Rocks + 10 µM Putrescine	20.1	22.5	19.9	21.3	24.4	20.2	12.9	14.7	14.4	13.6	15.2	15.4
0.0 ton FYM + (300kg P Rock + 400kg K rock) + 0.0 Putrescine	21.4	23.3	20.7	22.1	24.2	23.1	12.3	14.2	14.5	13.9	15.3	15.6
0.0 ton FYM + (300kg P Rock + 400kg K rock) + 10 µM Putrescine	22.1	25.3	20.9	23.6	27.4	23.1	12.6	14.6	14.9	14.9	15.9	16.6
5.0 ton FYM + 0.0 Nature Rocks + 0.0 Putrescine	22.1	24.6	19.7	25.5	32.1	24.7	12.5	14.2	14.0	14.8	14.4	16.2
5.0 ton FYM + 0.0 Nature Rocks + 10 µM Putrescine	26.6	31.3	24.4	31.1	39.5	28.3	14.2	14.9	15.3	16.7	17.1	17.3
5.0 ton FYM + (300kg P Rock + 400kg K rock) + 0.0 Putrescine	25.5	33.5	25.7	30.4	40.1	29.9	14.7	15.5	15.9	17.1	18.2	17.8
5.0 ton FYM + (300kg P Rock + 400kg K rock) + 10 µM Putrescine	31.8	39.7	28.9.6	33.7	44.2	30.3	15.2	16.8	17.9	17.6	17.9	18.2
10.0 ton FYM + 0.0 Nature Rocks + 0.0 Putrescine	39.8	40.7	31.7	32.9	41.8	30.6	15.9	16.4	16.8	17.7	18.5	19.0
10.0 ton FYM + 0.0 Nature Rocks + 10 µM Putrescine	41.2	51.1	37.8	41.8	49.7	39.7	16.8	17.6	18.4	17.9	19.1	19.2
10.0 ton FYM + (300kg P Rock + 400kg K rock) + 0.0 Putrescine	44.5	58.7	39.3	45.4	59.5	40.2	15.4	17.3	17.8	18.6	19.5	19.3
10.0 ton FYM + (300kg P Rock + 400kg K rock) + 10 µM Putrescine	51.6	62.3	41.7	53.7	66.4	43.2	17.6	18.7	19.5	18.9	19.6	19.9
New LSD at 5%	6.2	6.9	5.8	5.3	6.2	5.4	1.3	1.2	1.6	1.7	1.3	1.4

Herb fresh and dry weights

Gradual promotion on fresh and dry weights of sweet marjoram plants was observed as a result of treated the plants with FYM, putrescine and natural rocks (Table 3). It is clear from the same table that increasing the dose of FYM from 0.0 to 10 tons per was associated with significant and increment of the fresh and dry weights of marjoram herbs. This increment was parallel with increasing the dose of FYM from 0.0 tons to 10 tons per feddan.

Table 3. Effect of FYM, nature rocks and putrescine on herb fresh and dray weights (g) of marjoram plants, during 2022 and 2023 seasons.

Treatments	Herb fresh weight (g)						Herb dray weight (g)					
	First Season (2022)			Second Season (2023)			First Season (2022)			Second Season (2023)		
	1st Cut	2nd Cut	3rd Cut	1st Cut	2nd Cut	3rd Cut	1st Cut	2nd Cut	3rd Cut	1st Cut	2nd Cut	3rd Cut
Control 0.0 ton FYM + 0.0 Nature Rocks + 0.0 Putrescine	135.2	150.1	129.2	141.7	154.3	133.2	30.1	34.5	29.7	31.6	34.5	30.0
0.0 ton FYM + 0.0 Nature Rocks + 10 µM Putrescine	140.1	154.3	131.1	144.3	157.2	137.1	31.2	35.5	30.2	32.2	35.2	30.5
0.0 ton FYM + (300kg P Rock + 400kg K rock) + 0.0 Putrescine	142.5	155.5	133.2	151.3	165.5	139.9	32.8	35.8	30.6	33.8	37.1	31.2
0.0 ton FYM + (300kg P Rock + 400kg K rock) + 10 µM Putrescine	145.2	159.4	140.5	149.7	167.6	139.6	33.4	36.7	32.3	33.4	37.5	31.1
5.0 ton FYM + 0.0 Nature Rocks + 0.0 Putrescine	144.3	150.3	130.4	145.3	169.3	141.2	33.2	34.6	30.0	32.4	37.9	31.5
5.0 ton FYM + 0.0 Nature Rocks + 10 µM Putrescine	148.3	160.1	137.7	149.4	172.2	147.3	33.8	36.8	31.7	33.4	38.6	32.9
5.0 ton FYM + (300kg P Rock + 400kg K rock) + 0.0 Putrescine	147.3	152.2	140.3	151.1	177.3	151.3	33.9	35.0	32.3	33.7	39.8	33.8
5.0 ton FYM + (300kg P Rock + 400kg K rock) + 10 µM Putrescine	151.2	155.9	149.7	155.9	181.4	155.3	34.8	36.3	34.4	33.9	40.7	34.7
10.0 ton FYM + 0.0 Nature Rocks + 0.0 Putrescine	149.2	158.2	147.3	153.2	180.2	156.3	34.4	36.4	33.9	33.2	41.4	34.9
10.0 ton FYM + 0.0 Nature Rocks + 10 µM Putrescine	151.8	167.3	150.2	166.4	187.3	160.2	34.9	38.5	34.5	36.3	42.1	35.8
10.0 ton FYM + (300kg P Rock + 400kg K rock) + 0.0 Putrescine	155.3	183.4	165.7	167.3	188.9	164.7	35.7	42.2	37.1	36.5	42.4	36.9
10.0 ton FYM + (300kg P Rock + 400kg K rock) + 10 µM Putrescine	157.8	197.3	166.2	169.2	190.2	166.3	36.3	44.1	37.2	37.9	44.8	37.5
New LSD at 5%	7.2	6.6	8.3	8.7	7.2	8.3	1.9	2.1	1.7	1.8	2.2	1.7

In the same context, treated marjoram with putrescine or/and natural rocks (K & P rocks) significantly enhanced the both examined characters (fresh and dry weights) of marjoram plants, in both experimental seasons (2022 and 2023). The data also showed that, the combined application of the three examined materials (FYM, Putrescine and natural rocks) produced higher fresh and dray weights rather than using each material alone. Furthermore, application of the three examined materials (FYM at 10 tons/fed., putericin at 10 µM as well as K rock at 400kg/fed. and P Rock at 300kg/fed.) produced the highest fresh and dry weights of marjoram herb in three cuts compared to using each material alone or untreated plants. On the other hand, untreated marjoram plants produced the lowest weight of fresh and dry herb, these findings were taken the same trend in both experimental seasons.

The role of FYM, Putrescine and K & P natural rocks in elevated the harmful effects of salinity and/or improving marjoram or other medicinal and aromatic plants were mentioned by some authors such as Massoud *et al.*, (2009), Jelali *et al.*, (2011) and (Mangaia and Ravi 2012) on sweet marjoram plants**;** Gonzalez-Hernandez *et al.*, (2022) and Ali (2000) on reducing the harmful effects of salinity on aromatic & medicinal plants**,** and Parihar *et al.*, (2015).

Using FYM to improving vegetative growth parameters of aromatic and medicinal plants was well documented previously by certain authors. While, the role of putrescine in enhancing the vegetative parameters of marjoram plants can explained by its several justifications such as: It can increase plant resistance to salinity stress. it considered as a starting point of the most common polyamines pathway in higher plants cation balance, antioxidant activity, controlling cellular K+ and Ca^{2+}, mitochondria and chloroplasts bioenergetics as well as osmolyte or pH level regulator (Ali, 2000; Cui *et al.*, 2020; Jelali *et al.*, 2011 and Gonzalez-Hernandez *et al.*, 2022). On other hand, under sandy soil conditions, which the pH is higher than 7, large quantity of phosphorus and potassium will fixed in un-absorption form (Mengel, 1984; Mengel & Kirkaby, 1987; Marschner, 1995 and Kannaiyan, 2011). Then, treated the soil with potassium and phosphorus rocks may be logic to enhancing the absorption and assimilation of these elements by marjoram plants, these may by explained the significant improvement in vegetative growth of marjoram plants which obtained in the present study.

Plant mineral statues

Obtained data illustrated in Tables (4 and 5) shows the effect of treated sweet marjoram with FYM (at 0.0 5.0 and 10.0 tons/fed.), putrescine (at 10 µM) and k natural rock (at 400 kg/fed.) & P natural rocks (at 300 kg/fed.) either each one individually or in combination, on leaves NPK contents, during 2022 and 2023 seasons. The obtained data shows that, nitrogen, phosphorus and potassium of marjoram leaves were remarkably and significantly enhanced due treated the plants with the three examined materials, in the three cuts of plants in both seasons. The obtained data shows, however, that increasing the dose of FYM from 5 tons/feddan to 10 tons/feddan coincided with a significant and gradual increase in leaf contents from the three macronutrients (N, P, and K) rather than those of treated plants. On the same context, treated the plants with the potassium and phosphorus natural rocks caused a significant increase in leaves K and P contents. Also, treated the marjoram plants with putrescine at 10 µM were associated in significant enhancement in leaves NPK contents The three cuts during the two experimental seasons were true to these data. The obtained data also shows that the effect of those three materials on mineral content was more apparent in the second cuts plants than in the first or third cuts plants during the two seasons.

Regarding the treatments with the three examined materials, the plants treated with the combined application of the three materials (FYM, putrescine and natural rocks) present higher and significant contents of NPK in their leaves rather than using each material individually. Furthermore, the plant received the FYM at higher dose + putrescine (at 10 µM) + K rock (at 400 kg/fed. & P rock (300 kg/fed.) present the highest contents of nitrogen, potassium and phosphorus in their leaves, compared to the single application of each material or untreated plants. On the other side, control plants present the least nitrogen, potassium and phosphorus in their leaves. These findings were true in the three cuts during the two seasons.

The promotion of leaves contents in macro nutrients (N, P, K %) as a result of treated marjoram plants with FYM (at 0.0, 5.0 and 10.0 tons/fed.), putericin and natural rocks in the present investigation may be attributed to the following facts: organic fertilizers such FYM play an important role on enhancing soil physical and chemical properties, enhancing soil microorganisms population, increasing soluble mineral elements in in soil, produce some plant growth regulators in soil and decrease the pH in surrounded the root system. All these functions can lead to increasing the absorption of mineral nutrients by plants (Mengel 1984; Mengel & Kirkaby 1987 and Marschner, 1995). Under sandy soil conditions, which the pH is high, large quantity of phosphorus and potassium will fixed in un-absorption form (Mengel 1984; Mengel & Kirkaby, 1987; Marschner, 1995 and Kannaiyan, 2011). However, treated marjoram plants with potassium and phosphorus rocks can lead to increasing free K and P and these lead to increasing the absorption and stimulation of these elements. Putericin treatments can lead to increasing plant resistance to salinity stress. it considered as a starting point of the most common polyamines pathway in higher plants, cation balance, increasing antioxidant activity, controlling cellular K+ and Ca^{2+}, mitochondria and chloroplasts bioenergetics as well as osmolyte or pH level regulator (Ali, 2000; Cui *et al.*, 2020; Jelali *et al.*, 2011 and Gonzalez-Hernandez *et al.*, 2022).

Essential Oil %, yield of essential oil (ml/plant and L/feddan)

Data illustrated in Tables (5 and 6) shows the effect of treated marjoram plants with FYM (5 and 10 tons/fed.), putrescine (at 10 µM) and potassium natural rock (at 400 kg/fed.) & phosphorus natural rock (at 300 kg/fed.) on essential oil %, yield of essential (ml/plant) and oil yield (L /fed.) of marjoram plants, in the three cuts, during 2022 and 2023 seasons. It is clear that, treated marjoram plants with FYM, putrescine and potassium and phosphorus rocks significantly improved the essential oil percentage, essential oil yield (ml/plant and L /fed.), during the two experimental seasons. These data were true for the three cuts of marjoram plants. However, the concentrations of essential oil remains higher in the first cut plants and lower in the third cut plants.

Table 4. Effect of FYM, nature rocks and putrescine on nitrogen % and phosphorus % of marjoram adult leaves, during 2022 and 2023 seasons.

Treatments	Nitrogen %						Phosphorus %					
	First Season(2022)			Second Season(2023)			First Season(2022)			Second Season(2023)		
	1stCut	2ndCut	3rdCut	1stCut	2ndCut	3rdCut	1stCut	2ndCut	3rdCut	1stCut	2ndCut	3rdCut
Control 0.0 ton FYM + 0.0 Nature Rocks + 0.0 Putrescine	1.52	1.55	1.45	1.46	1.57	1.50	0.22	0.24	0.22	0.24	0.25	0.24
0.0 ton FYM + 0.0 Nature Rocks + 10 µM Putrescine	1.55	1.48	1.47	1.68	1.52	1.49	0.25	0.27	0.25	0.26	0.29	0.25
0.0 ton FYM + (300kg P Rock + 400kg K rock) + 0.0 Putrescine	1.44	1.47	1.48	1.47	1.52	1.51	0.24	0.33	0.25	0.30	0.35	0.28
0.0 ton FYM + (300kg P Rock + 400kg K rock) + 10 µM Putrescine	1.57	1.53	1.47	1.67	1.65	1.55	0.26	0.36	0.31	0.28	0.37	0.28
5.0 ton FYM + 0.0 Nature Rocks + 0.0 Putrescine	1.65	1.69	1.55	1.75	1.79	1.57	0.30	0.33	0.29	0.29	0.37	0.27
5.0 ton FYM + 0.0 Nature Rocks + 10 µM Putrescine	1.77	1.72	1.59	1.68	1.78	1.55	0.31	0.33	0.31	0.33	0.36	0.31
5.0 ton FYM + (300kg P Rock + 400kg K rock) + 0.0 Putrescine	1.86	1.73	1.58	1.85	1.88	1.65	0.33	0.38	0.35	0.30	0.38	0.30
5.0 ton FYM + (300kg P Rock + 400kg K rock) + 10 µM Putrescine	1.79	1.78	1.60	1.77	1.83	1.69	0.35	0.39	0.37	0.34	0.39	0.34
10.0 ton FYM + 0.0 Nature Rocks + 0.0 Putrescine	1.83	1.88	1.67	1.83	1.90	1.67	0.33	0.35	0.32	0.30	0.34	0.33
10.0 ton FYM + 0.0 Nature Rocks + 10 µM Putrescine	1.93	1.91	1.73	1.85	1.93	1.77	0.35	0.36	0.33	0.34	0.36	0.34
10.0 ton FYM + (300kg P Rock + 400kg K rock) + 0.0 Putrescine	1.79	1.96	1.75	1.92	2.00	1.79	0.36	0.37	0.36	0.37	0.39	0.36
10.0 ton FYM + (300kg P Rock + 400kg K rock) + 10 µM Putrescine	1.82	1.98	1.79	1.93	2.07	1.82	0.36	0.38	0.37	0.38	0.39	0.37
New LSD at 5%	0.13	0.17	0.12	0.12	0.13	0.14	0.02	0.02	0.03	0.02	0.03	0.03

Table 5. Effect of FYM, nature rocks and putrescine on potassium % and essential oil % of marjoram plant dry mater, during 2022 and 2023 seasons.

Treatments	Potassium %						Essential oil %					
	First Season (2022)			Second Season (2023)			First Season (2022)			Second Season (2023)		
	1stCut	2ndCut	3rdCut	1stCut	2ndCut	3rdCut	1stCut	2ndCut	3rdCut	1stCut	2ndCut	3rdCut
Control 0.0 ton FYM + 0.0 Nature Rocks + 0.0 Putrescine	1.33	1.43	1.32	1.23	1.33	1.29	0.5	0.5	0.4	0.5	0.4	0.4
0.0 ton FYM + 0.0 Nature Rocks + 10 µM Putrescine	1.40	1.44	1.40	1.49	1.51	1.53	0.8	0.7	0.6	1.2	0.8	0.7
0.0 ton FYM + (300kg P Rock + 400kg K rock) + 0.0 Putrescine	1.44	1.49	1.40	1.50	1.54	1.45	0.6	0.5	0.5	0.8	0.7	0.6
0.0 ton FYM + (300kg P Rock + 400kg K rock) + 10 µM Putrescine	1.49	1.55	1.44	1.50	1.62	1.42	1.0	0.8	0.6	1.1	0.8	0.7
5.0 ton FYM + 0.0 Nature Rocks + 0.0 Putrescine	1.44	1.44	1.41	1.51	1.67	1.40	0.7	0.6	0.6	0.9	0.8	0.7
5.0 ton FYM + 0.0 Nature Rocks + 10 µM Putrescine	1.47	1.62	1.42	1.62	1.69	1.51	1.0	0.8	0.7	1.1	1.0	0.8
5.0 ton FYM + (300kg P Rock + 400kg K rock) + 0.0 Putrescine	1.50	1.67	1.49	1.69	1.77	1.46	0.9	0.8	0.8	1.2	0.9	0.9
5.0 ton FYM + (300kg P Rock + 400kg K rock) + 10 µM Putrescine	1.53	1.69	1.53	1.72	1.88	1.59	0.9	0.9	0.8	1.3	1.0	0.9
10.0 ton FYM + 0.0 Nature Rocks + 0.0 Putrescine	1.51	1.66	1.50	1.66	1.74	1.50	1.0	0.9	0.7	1.2	0.8	0.7
10.0 ton FYM + 0.0 Nature Rocks + 10 µM Putrescine	1.55	1.71	1.59	1.69	1.82	1.53	1.2	1.0	0.8	1.5	1.1	0.9
10.0 ton FYM + (300kg P Rock + 400kg K rock) + 0.0 Putrescine	1.69	1.82	1.61	1.71	1.85	1.57	1.3	1.1	1.0	1.4	1.0	1.0
10.0 ton FYM + (300kg P Rock + 400kg K rock) + 10 µM Putrescine	1.72	1.82	1.64	1.81	1.86	1.69	1.3	1.2	1.2	1.5	1.1	1.2
New LSD at 5%	0.11	0.11	0.12	0.12	0.12	0.11	0.2	0.2	0.1	0.3	0.2	0.2

Table 6. Effect of FYM, nature rocks and putrescine on essential oil (ml/plant) and essential oil (L/fed.) of marjoram plants , during 2022 and 2023 seasons.

Treatments	Essential oil (ml/plant)						Essential oil (L / feddan)					
	First Season (2022)			Second Season (2023)			First Season (2022)			Second Season (2023)		
	1stCut	2ndCut	3rdCut	1stCut	2ndCut	3rdCut	1st Cut	2ndCut	3rdCut	1stCut	2nd Cut	3rdCut
Control 0.0 ton FYM + 0.0 Nature Rocks + 0.0 Putrescine	0.81	0.75	0.62	0.88	0.69	0.55	17.82	16.50	13.64	20.36	17.74	12.10
0.0 ton FYM + 0.0 Nature Rocks + 10 µM Putrescine	1.12	1.08	0.79	1.44	1.58	0.96	24.64	23.76	17.38	31.68	34.76	21.12
0.0 ton FYM + (300kg P Rock + 400kg K rock) + 0.0 Putrescine	0.86	0.78	0.67	1.21	1.32	0.84	18.92	17.16	14.74	26.62	29.04	18.48
0.0 ton FYM + (300kg P Rock + 400kg K rock) + 10 µM Putrescine	0.87	1.28	0.84	1.65	1.17	0.83	19.14	28.16	18.48	36.30	25.74	18.26
5.0 ton FYM + 0.0 Nature Rocks + 0.0 Putrescine	1.45	0.90	0.78	1.31	1.35	0.99	31.90	19.80	17.16	28.82	29.70	21.78
5.0 ton FYM + 0.0 Nature Rocks + 10 µM Putrescine	1.01	1.26	0.96	1.64	1.37	1.08	22.22	27.72	21.12	36.06	30.14	23.76
5.0 ton FYM + (300kg P Rock + 400kg K rock) + 0.0 Putrescine	1.32	1.28	1.12	1.71	1.60	1.41	29.04	28.16	24.64	37.62	35.20	31.02
5.0 ton FYM + (300kg P Rock + 400kg K rock) + 10 µM Putrescine	1.36	1.22	1.03	1.89	1.81	1.39	29.92	26.84	22.66	41.58	31.68	30.58
10.0 ton FYM + 0.0 Nature Rocks + 0.0 Putrescine	1.34	1.40	1.03	1.84	1.44	1.09	29.48	30.80	22.66	40.48	31.86	23.98
10.0 ton FYM + 0.0 Nature Rocks + 10 µM Putrescine	1.39	1.42	1.20	2.01	1.91	1.35	30.59	31.24	26.40	44.22	42.02	29.70
10.0 ton FYM + (300kg P Rock + 400kg K rock) + 0.0 Putrescine	1.69	1.57	1.32	2.21	1.88	1.50	37.18	34.54	29.04	48.62	41.36	33.00
10.0 ton FYM + (300kg P Rock + 400kg K rock) + 10 µM Putrescine	1.86	1.66	1.39	2.24	1.90	1.73	40.92	36.52	30.59	49.23	41.80	38.06
New LSD at 5%	0.10	0.12	0.11	0.13	0.10	0.11	2.21	2.02	2.11	2.15	2.14	2.01

Regarding the individual treatments of the three examined materials, all treatments were capable to significantly improve the percentage of oil and essential oil yield per plant or per feddan, compared to controle plants. However, increasing the dose of FYM (from 5 to 10 tons / feddan) significantly increased the essential oil percentage and essential oil yield (ml/ plant and L/feddan). In the three cuts during the two experimental seasons, using FYM and putrescine combinations shows more effective than using FYM and natural rocks combinations. However, using the three materials in combination shows more effective in increasing the oil % and oil yield (ml/plant and kg/fed.) rather than using each one alone. The data shows that the plants received FYM at 10 tons/feddan + putrescine at 10 µM + natural rocks produced the best essential oil percentage, yield of essential oil (ml/plant and L/feddan). In contrary, untreated marjoram plants produced the lowest oil % and lowest oil yield (ml/plant and L/feddan). These findings were true in the three plant cuts during the two experimental seasons.

The role of FYM, Putrescine and K & P natural rocks in reducing the harmful effects of salinity and/or improving marjoram essential oil as well as other medicinal and aromatic plants were supported by the results of other authors such as; Kandeel and Elwan (1991), Shalan et al., (2006), Gharib et al., (2008), Massoud et al., (2009), Jelali et al., (2011), Mangaia and Ravi (2012) on sweet marjoram plants and Gonzalez-Hernandez et al., (2022) and Ali (2000) on reducing the harmful effects of salinity stress on aromatic & medicinal plants.

Main compounds of essential oil

Data in Table (7) shows the major compounds of marjoram essential oil, of the first cut, as a result of gas chromatography separation of the three cuts during the two experimental seasons. The data shows that six main compounds called; 4-Terpinene, Ɣ-Terpinene, α-Terpinene, Terpinolene, α-Terpineol and β-Caryophyllene. It is clear that treated the plants with FYM, putericin and natural rocks significantly improved 4-Terpinene, Ɣ-Terpinene, α-Terpinene and β-Caryophyllene. While, all treatments failed to varying α-Terpinene and Terpinolene compounds significantly neither individually nor in combination treatments.

It is clear from the obtained results that increasing the dose of FYM from 5 tons/feddan to 10 tons/feddan individually or combined with putrescine at 10 µM and K natural rock (at 400 kg/fed.) and P natural rock (at 300 kg/fed.) significantly enhanced 4-Terpinene, Ɣ-Terpinene, α-Terpinene and β-Caryophyllene rather than untreated plants. However, all combined application of the three materials significantly increased all the four chemical compounds in marjoram essential oil rather than using each material alone. These findings were true for the three herb cuts in both experimental seasons. However, the marjoram plants treated with 10 tons/feddan combined with 10 µM putrescine and natural rocks (400kg/fed. K rock and 300 kg/fed. P rock) present the highest contents of the four main compounds of essential oil (4-Terpinene, Ɣ-Terpinene, α-Terpinene and β-Caryophyllene). In the contrary, untreated plants (control) present the lowest contents of these main four compounds of its essential oil. These data were true for the three cuts in the two experimental seasons.

Table 7. Effect of FYM, nature rocks and putrescine on essential oi composition of marjoram plants, during 2022 and 2023 seasons.

Treatments	Main ompounds of marjoram essential oil											
	4-Terpinene		ϒ-Terpinene		α-Terpinene		Terpinolene		α-Terpineol		B-Caryophyllene	
	2022	2023	2022	2023	2022	2023	2022	2023	2022	2023	2022	2023
Control 0.0 ton FYM + 0.0 Nature Rocks + 0.0 Putrescine	37.6	37.8	16.9	16.7	7.4	7.8	10.3	10.4	5.5	5.4	6.1	6.3
0.0 ton FYM + 0.0 Nature Rocks + 10 µM Putrescine	39.2	39.2	17.0	17.1	7.5	7.8	9.8	10.2	6.8	6.9	6.3	6.4
0.0 ton FYM + (300kg P Rock + 400kg K rock) + 0.0 Putrescine	38.1	38.4	17.8	17.5	7.6	7.8	10.1	10.4	5.7	6.2	6.3	6.6
0.0 ton FYM + (300kg P Rock + 400kg K rock) + 10 µM Putrescine	40.1	41.2	17.9	18.2	7.1	7.9	10.3	10.3	6.1	6.4	6.5	6.9
5.0 ton FYM + 0.0 Nature Rocks + 0.0 Putrescine	38.9	39.1	17.7	18.3	7.2	7.8	9.9	10.5	6.2	6.5	6.5	7.1
5.0 ton FYM + 0.0 Nature Rocks + 10 µM Putrescine	39.1	39.8	18.2	18.9	7.5	7.4	10.2	10.5	6.3	6.9	6.9	7.3
5.0 ton FYM + (300kg P Rock + 400kg K rock) + 0.0 Putrescine	41.2	42.8	18.9	18.9	7.4	7.7	10.2	10.4	6.6	7.2	6.9	7.4
5.0 ton FYM + (300kg P Rock + 400kg K rock) + 10 µM Putrescine	42.2	44.7	19.4	20.1	7.6	7.6	10.4	10.3	16.55	7.5	7.2	7.5
10.0 ton FYM + 0.0 Nature Rocks + 0.0 Putrescine	42.1	43.1	18.2	19.2	7.7	7.8	10.3	10.5	6.7	7.2	7.0	7.3
10.0 ton FYM + 0.0 Nature Rocks + 10 µM Putrescine	42.4	43.9	18.8	20.2	7.2	7.7	10.	10.6	6.8	7.6	7.3	7.6
10.0 ton FYM + (300kg P Rock + 400kg K rock) + 0.0 Putrescine	43.2	44.8	19.7	2.1	7.9	7.9	10.4	10.5	6.9	7.7	7.4	7.7
10.0 ton FYM + (300kg P Rock + 400kg K rock) + 10 µM Putrescine	44.1	45.3	21.9	22.7	7.9	8.0	10.6	10.5	7.1	7.8	7.6	7.8
New LSD at 5%	1.3	1.5	1.2	1.3	NS	NS	NS	NS	0.5	0.4	0.6	0.5

CONCLUSION

The obtained data during the present investigation declare that under irrigation with saline water in new reclaimed sandy soil conditions, treated the sweet marjoram plants with FYM, putrescine and potassium & phosphorus natural rocks significantly improved marjoram plant growth, mineral status and essential oil quantity and quality. The data also shows that, all combined treatments shows more effective than the individual application of each material.

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تأثير بعض المركبات الطبيعية في تقليل تأثير الري بالمياه المالحة على نباتات البردقوش

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الملخص

اجرى هذا البحث بهدف تأثير السماد البلدى وبعض الصخور الطبيعيه مثل البوتريسين والفسفور والبوتاسيوم لتقليل التأثير الضار لملوحه مياه الرى على نمو نباتات البردقوش الحلو وانتاج الزيت- أجريت تجربة حقلية على تربة طمييه رملية مستصلحة جديدة تقع على الجانب الشرقي من النيل مقابل منطقة ببا محافظة بني سويف – مصر خلال موسمى ٢٠٢٢ – ٢٠٢٣. أشارت النتائج المتحصل عليها إلى أنه معامله نباتات البردقوش الحلو بالسماد البلدى والبوتريسين وبعض الصخور الطبيعيه مثل الفسفور والبوتاسيوم تحت الري بالمياه المالحة في ظروف التربة الرملية المستصلحة الجديدة ادى الى تحسين معنوى لنباتلت البردقوش وكذللك محتوى المعادن وكميه وجوده الزيت الطيار وكان تأثير المعاملات مجمعه معا اكثر تأثيرا من استخدام كل منها منفردا.