International Journal of Herbal Medicine
Available online at www.florajournal.com

E-ISSN: 2321-2187
P-ISSN: 2394-0514
www.florajournal.com
IJHM 2022; 10(2): 20-25
Received: 09-01-2022
Accepted: 12-02-2022

Elham Mohammed Attia
Medicinal and Aromatic Plants Department, Desert Research Center, Cairo, Egypt

Wael Ismail Mohamed
Medicinal and Aromatic Plants Department, Desert Research Center, Cairo, Egypt

Emad Saleh Hamed
Medicinal and Aromatic Plants Department, Desert Research Center, Cairo, Egypt

Corresponding Author:
Elham Mohammed Attia
Medicinal and Aromatic Plants Department, Desert Research Center, Cairo, Egypt

Influence of some types of organic fertilizers on marjoram plant under Siwa Oasis conditions

Elham Mohammed Attia, Wael Ismail Mohamed and Emad Saleh Hamed

Abstract
In two successive seasons, 2018/2019 and 2019/2020, this experiment was conducted in sandy soil at Siwa Oasis, Egypt. The research was set to study the effect of some manure types on the yield of marjoram plants. The experiment involved applying four treatments (control, 24 m^3 sheep manure/hectare, 24 m^3 compost manure/hectare, and a combination of 12 m^3 sheep manure and 12 m^3 compost manure/hectare). The treatments were compared asa randomized complete block design. Results showed that all organic fertilizers significantly enhanced growth, herbage yield, and essential oil over control treatment. The soil amendment with sheep manure combined with compost manure was significantly superior to individual resources in improving growth and yield characteristics. The chief components of marjoram essential oil were cis-sabinene hydrate, 4-terpineol, α-terpinene, γ-terpinene, sabinene, and α-terpinolene. Different organic fertilizers greatly affected oil composition. Providing soil with sheep and compost manures gave rich oil in α and γ-terpinenes.

Keywords: Marjoram, organic fertilization, yield, essential oil composition

1. Introduction

Sweet marjoram (*Majorana hortensis* Moench., *Origanum majorana* L.) is an aromatic and medicinal perennial belonging to the Lamiaceae family. Marjoram leaves possess a beautiful fragrance. The used parts of marjoram are dried leaves, leaves extract, and essential oil. Marjoram had a common reputation as traditional medicine. A tea brewed from its leaves has an antispasmodic, sedative, and warming effect. It helps treat asthma, coughs, headaches, aids the digestive system, and tones the stomach. The essential oil of marjoram is well accepted in aromatherapy for insomniacs and used as an ingredient for body massage oils in general for relaxing. Also, it is used as a bath fragrance in warm baths and perfumery. The oil has many pharmacological activities in modern medicine, including antioxidant, antibacterial, antifungal, antiviral, antiprotozoal, cardioprotective, anti-platelet, antimetastatic, anti-inflammatory, and antitumor. Both leaves and essential oil are used in flavoring food products [1-5].

Marjoram originates throughout Mediterranean regions and is now cultivated in many parts of the world. Marjoram planting in Egypt dates back to 3000 BC. The Egyptian marjoram has a good reputation in outside markets for its high-quality aspects. In 2020, Egypt was ranked 9thwith the share in global marjoram export of 2.66%, with an export value of 100.57 M. The Egyptian government aims to increase the area of medicinal and aromatic plants in newly reclaimed lands, thus increasing production. Siwa Oasis in the Sahara desert inside the country is good land for cultivating medicinal and aromatic plants for irrigation water availability in that desert and the appropriate environmental conditions for the growth of such plants. The cultivation of marjoram was introduced to Siwa Oasis farmers a few years ago and succeeded. However, some problems are still related to the lack of information on agricultural treatments to produce the highest yield [6-11].

Sandy soil of Siwa Oasis is poor soil with inferior organic matter, poor nutrient elements, and does not hold water, which is reflected in low yield. Organic matter is the soul of the soil. The benefits of organic fertilization are improving the soil's physical, chemical, and biological properties. Therefore, raising the productivity of crops. The two organic fertilizers used at Siwa Oasis are sheep and compost manures. (i) Sheep manure is an essential source of organic fertilization; it has a high nitrogen content but a lower micronutrient ratio. Its quantity is also insufficient for agriculture expansion. (ii) Compost manure is manufactured by composting wastes from pruning palms and trimming olive trees. The Oasis has a large residue from palm and olives. It is prepared by composting residues from other crops. However, this compost quantity is sufficient for agriculture extension; it has a lower nitrogen percent than sheep manure [12-15].

The new investigations proved that soil amendments with two organic fertilizer types are better than a single resource [16-18]. So, our work aims to study the influence of some manure types such as sheep manure, compost manure, and the combination of two manures on marjoram to have the highest crude drug parameters.

2. Materials and Methods

The two seasons study was performed at a private farm in Khamisa Village, Siwa Oasis, Egypt, during 2018/2019 and 2019/2020. Soil samples were taken from a depth (0-30 cm) to analyze physical and chemical parameters (Tables 1 and 2). The chemical analysis of the underground irrigation water is also shown in Table (3). This work aimed to assess the influence of different manure types on the yield of marjoram. A randomized complete block design with three replications was used. The investigation included the subsequent treatments.

2.1 Treatments

- Control.
- Application of24 m^3 sheep manure/hectare.
- Application of24 m^3 compost manure/hectare.
- Application of12 m^3 sheep manure+12 m^3 compost manure/hectare as mixed manure.

2.2 Plant materials and procedures

One-year-old marjoram (*Majoranahortensis* Moench.) seedlings were obtained from the Ministry of Agriculture and Land Reclamation. All organic matter was added before planting with calcium superphosphate through soil preparation. The chemical analyses of sheep and compost manures are presented in Tables (4 and 5).For each season, the seedlings were cultivated in February under a drip irrigation system as the distances between seedlings were 30 cm and 75 cm between lines (44445 plants/hectare). Half dose of mineral fertilization of ammonium sulphate, calcium superphosphate, and potassium sulphate was conducted [19]. The herb was harvested5 cm above the soil surface at flowering, leaving several branches for regrowth. Five cuts were taken in April, June, September, November, and March in both seasons. Good agricultural practices were followed throughout the production and post-harvest steps. Manner of sampling ensured its representative of an entire lot of the raw material. L.S.D. test at 0.05 was used to compare the means of treatments [20].

2.3 Recorded data

At the time of each harvest, the following measurements were recorded:-

2.3.1Growth and yield parameters

Plant height (cm), fresh herb weight (g/plant), fresh herb yield (ton/hectare), dry herb weight (g/plant), and dry herb yield (ton/hectare).

2.3.2Quality parameters

2.3.2.1 Essential oil percentage

It was determined in the air-dried herb by hydro distillation [21].

2.3.2.2Essential oil yield per plant (ml)

Essential oil yield per plant (ml) = oil percentage × herb dry weight / 100

2.3.2.3 Essential oil yield per hectare (l)

Essential oil yield per hectare (l) = essential oil yield per plant × number of plants/hectare

2.3.2.4 Essential oil chemical constituents

Volatile oils of the second season (3rdcut) were analyzed using the Gas Chromatography-Mass Spectrometry instrument (GC/MS analysis) stands at the Laboratory of Medicinal and Aromatic Plants, National Research Center, Egypt, with the following specifications. Device: 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 TR-5MS column (30 m x 0.32 mm i.d., 0.25 μm film thickness). Analyses were conducted using helium as carrier gas at a flow rate of 1.3 ml/min at a split ratio of 1:10 and the following temperature program: 80°C for 1 min; rising at 4°C/min to 300°C and held for 1min. The injector and detector were held at 220 and 200°C, respectively. Diluted samples (1:10 hexane, v/v) of 1 μL of the mixtures were continuously injected. Mass spectra were obtained by electron ionization (EI) at 70 eV, using a spectral range of m/z 40-450. Identification of the compounds depended on both comparison of the retention times with those of authentic samples and computer matching against commercial and libraries mass spectra built up from pure substances [22-27].

Table 1: Physical analysis of the soil

Sand (%)	Silt (%)	Clay (%)	Soil texture
85.82	11.00	3.18	Sandy

Table 2: Chemical analysis of the soil

pH	E.C. (ppm)	O.M. (%)	Soluble anions (meq/l)				Soluble cations (meq/l)			
			CO_3^{--}	HCO_3^-	Cl^-	SO_4^{--}	Ca^{++}	Mg^{++}	Na^+	K^+
7.30	672.20	0.52	-	1.80	6.00	1.20	2.20	2.10	4.49	0.21

Table 3: Chemical analysis of the irrigation water

pH	E.C. (ppm)	Soluble anions (meq/l)				Soluble cations (meq/l)			
		CO_3^{--}	HCO_3^-	Cl^-	SO_4^{--}	Ca^{++}	Mg^{++}	Na^+	K^+
7.40	1997.00	-	1.56	19.49	13.06	4.80	3.87	25.00	0.44

Table 4: Chemical analysis of the sheep manure

pH	E.C. (ppm)	O.M. (%)	C/N ratio	N (%)	P (%)	K (%)	Fe (%)	Mn (mg/kg)	Zn (mg/kg)	Cu (mg/kg)
9.15	4902.00	44.00	18.00	1.59	0.24	1.91	0.43	105.00	26.70	12.80

Table 5: Chemical analysis of the compost manure

pH	E.C. (ppm)	O.M. (%)	C/N ratio	N (%)	P (%)	K (%)	Fe (%)	Mn (mg/kg)	Zn (mg/kg)	Cu (mg/kg)
8.80	2944.00	20.50	11.85	1.13	0.22	2.04	3.43	606.80	85.65	43.60

3. Results and Discussion

3.1 Growth and yield parameters

Data concerning the effect of different manures on the growth and yield of *Majorana hortensis* during the two seasons are presented in Tables (1-5) and illustrated in Figures (1-2).It was evident from the results that all organic fertilization types (sheep manure, compost manure, and their combination) added to the soil had marked effects on plant height, fresh and dry herb weights/plant, and fresh and dry herb yields/hectare than control. The significantly highest parameters resulted from the treatment of 12 m^3 sheep manure combined with 12 m^3 compost manure/hectare, followed by 24 m^3 sheep manure/hectare and then 24 m^3 compost manure/hectare.

The fresh weight/plant in the first cut recorded 43.87, 29.63, 25.83 g; in the second cut was 88.53, 58.38, 48.55 g; in the third cut was 97.33, 67.68, 56.68 g; in the fourth cut, these detections were 111.00, 72.33, 66.00 g; in the fifth cut was 138.54, 107.16, 84.22 g for sheep manure with compost, sheep manure, and compost manure, respectively. The dry weight/plant in the first cut was 21.44, 16.16, 13.50 g; for the second cut, this was 38.13, 25.81, 20.67 g; the third cut, this one was 43.58, 29.67, 26.00 g; in the fourth cut, it was 51.33, 34.00, 30.25 g; besides the fifth cut, these weights were 59.48, 39.50, 34.46 for sheep manure combined with compost, sheep manure, and compost manure, respectively. In contrast, the differences in plant height between control and compost manure treatments were non-significant in the first, second, and fourth cuts.

The fresh yield/hectare within the first cut was 1.95, 1.32, 1.15 ton; the second cut was 3.94, 2.60, 2.16 ton; the third cut showed 4.33, 3.01, 2.52 ton; the fourth cut presented 4.93, 3.22, 2.93 ton; the fifth cut offered 6.16, 4.76, 3.74 ton for mixed manure, sheep manure, and compost manure, correspondingly. The dry yield/hectare for the first cut was 0.95, 0.72, 0.60 ton; the second cut exhibited 1.70, 1.15, 0.92 ton; the third cut revealed 1.94, 1.32, 1.16 ton; in the fourth cut, it was 2.28, 1.51, 1.35 ton; furthermore, in the fifth cut, these weights were 2.64, 1.76, 1.53 for sheep manure joined with compost, sheep manure, and compost manure, individually. As well, the total yield per season took the same trend.

This promoting effect of organic fertilization on marjoram was in agreement with the literature [28-31]. They stated that applying different organic fertilizers increased plant height and herbs' fresh and dry weight more than unmannered plants. Also, our results were in harmony with the work of [32-33, 16]. They found that the plants' growth and yield were more excellent with mixed manure than with individual treatments.

Table 6: Effect of different manures on plant height (cm) (mean values of the two seasons)

Treatments	1st cut	2nd cut	3rd cut	4th cut	5th cut
Control	13.00	23.00	19.00	21.00	30.07
Sheep manure	15.33	27.33	23.00	25.33	35.83
Compost manure	14.00	25.67	22.00	23.30	32.50
Sheep manure+ compost manure	16.67	30.50	23.67	27.50	37.00
LSD 0.05	1.83	2.73	2.67	2.33	2.24

Table 7: Effect of different manureson fresh herb weight (g/plant) (mean values of the two seasons)

Treatments	1st cut	2nd cut	3rd cut	4th cut	5th cut
Control	19.67	36.33	45.42	52.33	64.67
Sheep manure	29.63	58.38	67.68	72.33	107.16
Compost manure	25.83	48.55	56.68	66.00	84.22
Sheep manure+ compost manure	43.87	88.53	97.33	111.00	138.54
LSD 0.05	5.44	7.87	10.99	12.51	17.32

Table 8: Effect of different manures on fresh herb yield (ton/hectare) (mean values of the two seasons)

Treatments	1st cut	2nd cut	3rd cut	4th cut	5th cut	Total
Control	0.87	1.62	2.02	2.33	2.87	9.71
Sheep manure	1.32	2.60	3.01	3.22	4.76	14.91
Compost manure	1.15	2.16	2.52	2.93	3.74	12.50
Sheep manure+ compost manure	1.95	3.94	4.33	4.93	6.16	21.31
LSD 0.05	0.24	0.35	0.48	0.56	0.77	2.05

Table 9: Effect of different manures on dry herb weight (g/plant) (mean values of the two seasons)

Treatments	1st cut	2nd cut	3rd cut	4th cut	5th cut
Control	10.33	17.50	20.33	24.33	29.00
Sheep manure	16.16	25.81	29.67	34.00	39.50
Compost manure	13.50	20.67	26.00	30.25	34.46
Sheep manure+ compost manure	21.44	38.13	43.58	51.33	59.48
LSD 0.05	3.01	2.46	2.25	2.33	3.60

Table 10: Effect of different manures on dry herb yield (ton/hectare) (mean values of the two seasons)

Treatments	1st cut	2nd cut	3rd cut	4th cut	5th cut	Total
Control	0.46	0.78	0.90	1.08	1.29	4.51
Sheep manure	0.72	1.15	1.32	1.51	1.76	6.46
Compost manure	0.60	0.92	1.16	1.35	1.53	5.56
Sheep manure+ compost manure	0.95	1.70	1.94	2.28	2.64	9.51
LSD 0.05	0.13	0.11	0.10	0.11	0.21	0.55

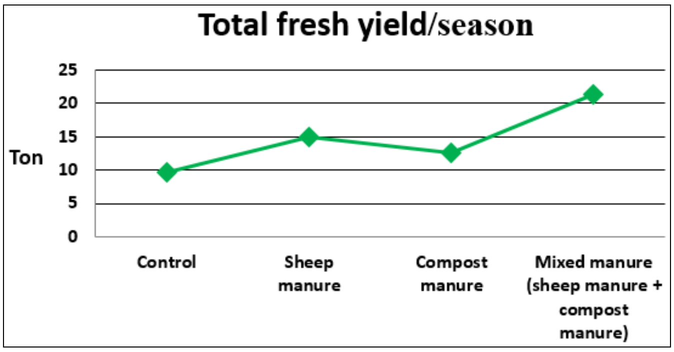

Fig 1: Effect of different manures on total fresh yield/season

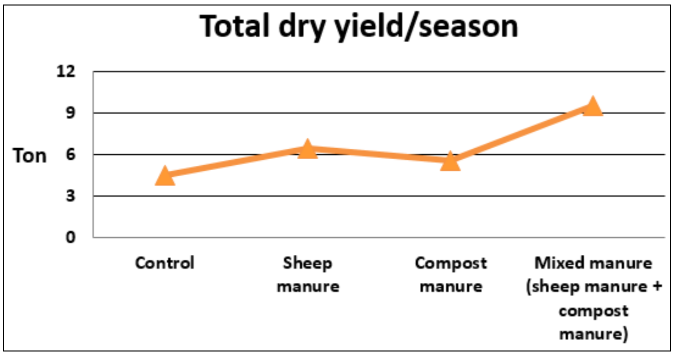

Fig 2: Effect of different manures on total dry yield/season

3.2 Quality parameters

Secondary metabolites of medicinal and aromatic plants have great importance [34-35].Essential oil is one of the leading factors determining the quality of marjoram. The data on essential oil are shown in Tables (6-9) and illustrated in Figure (3). It was clear that all organic fertilizers (sheep manure, compost manure, and mixed manure) had significant effects on oil percentage, oil yield per plant, and hectare than the control. The significantly maximum values were obtained by applying 12 m^3 sheep manure combined with 12 m^3 compost manure/hectare, followed by 24 m^3 sheep manure/hectare and then 24 m^3 compost manure/hectare.

Regarding essential oil percentage, the first cut results were 1.21, 1.04, 0.91%; the second cut data were 1.17, 1.05, 0.80%; the third cut means were 1.68, 1.49, 1.37%, obtained data of the fourth cut were 1.90, 1.63, 1.56%, and increments in the fifth cut were 1.30, 1.22, 1.14% for sheep manure plus compost, sheep manure, and compost manure, in that order.

These estimates meet the ISO standard, which mentioned that dried marjoram should have an agreeable aromatic flavor, and the oil percent should not be less than 0.70% [36]. As for essential oil yield per plant, the first cut produced 0.26, 0.17, 0.12 ml; the second cut gave 0.45, 0.27, 0.17 ml; the third cut gave 0.73, 0.44, 0.36 ml, the fourth cut values were 0.98, 0.55, 0.47 l, and the fifth cut limits were 0.77, 0.48, 0.39 ml for sheep manure plus compost, sheep manure, and compost manure, respectively. Also, the essential oil yield per hectare took the same trend.

The impact of organic manure on boosting oil accumulation coincided with [28-31] research. It also was in harmony with [33], who recommended that the thyme plants be fertilized with compost combined with sheep or chicken manure to take the highest yield.

As for essential oil composition, it was found that the source of organic manure had affected aroma compounds. The chief oil constituents of control plants contained cis-sabinene hydrate (42.26%), 4-terpineol (24.91%), sabinene (8.54%), and γ-terpinene (7.56%). The prevailing compounds in the sheep manure treatment werecis-sabinene hydrate (41.10%), 4-terpineol (28.70%), γ-terpinene (5.40%), and sabinene (5.39%).The abundant compounds in the oil of compost manure application wereα-terpinene (32.15%), γ-terpinene (19.60%), α-terpinolene (8.86%), sabinene (8.64%), and 4-terpineol (8.23%). The principal compounds for the combination of sheep and compost manures were α-terpinene (27.02%), γ-terpinene (19.87%), sabinene (13.19%), and α-phellandrene (8.98%).

However, supplying the soil with sheep and compost manures increased oil hydrocarbons, especially γ, α-terpinene contents. The two components have practical applications. Terpinene is one of the components responsible for the antioxidant activity of marjoram oil. Terpinene is responsible for the spicy taste, is often used as a flavoring, and has antimicrobial activities [37-38]. These results agreed with the findings obtained by [39], as they reported that the relative percentage of certain constituents of marjoram oil were affected by organic fertilization.

Table 6: Effect of different manures on essential oil percentage (mean values of the two seasons)

Treatments	1st cut	2nd cut	3rd cut	4th cut	5th cut
Control	0.79	0.70	1.13	1.48	1.05
Sheep manure	1.04	1.05	1.49	1.63	1.22
Compost manure	0.91	0.80	1.37	1.56	1.14
Sheep manure + compost manure	1.21	1.17	1.68	1.90	1.30
LSD 0.05	0.10	0.06	0.07	0.09	0.08

Table 7: Effect of different manures on essential oil yield/plant (ml) (mean values of the two seasons)

Treatments	1st cut	2nd cut	3rd cut	4th cut	5th cut
Control	0.08	0.12	0.23	0.36	0.31
Sheep manure	0.17	0.27	0.44	0.55	0.48
Compost manure	0.12	0.17	0.36	0.47	0.39
Sheep manure + compost manure	0.26	0.45	0.73	0.98	0.77
LSD 0.05	0.03	0.04	0.03	0.06	0.07

Table 8: Effect of different manureson essential oil yield/hectare (l) (mean values of the two seasons)

Treatments	1st cut	2nd cut	3rd cut	4th cut	5th cut	Total
Control	3.56	5.33	10.22	16.00	13.78	48.89
Sheep manure	7.56	12.00	19.56	24.45	21.33	84.9
Compostmanure	5.33	7.56	16.00	20.89	17.33	67.11
Sheep manure+compostmanure	11.56	20.00	32.45	43.56	34.22	141.79
LSD 0.05	1.33	1.56	1.30	2.58	3.17	7.63

Table 9: Chemical constituents (%) of essential oil samples

S. No	R.T.	Compound	Control	Sheep manure	Compost manure	Sheep Manure + compost manure
1	8.80	Thujene	0.49	0.30	0.34	0.73
2	9.11	α-pinene	0.82	0.45	0.39	0.81
3	10.59	Sabinene	8.54	5.39	8.64	13.19
4	10.86	2-α-pinene	0.38	0.26	-	0.19
5	11.16	α-myrcene	0.68	0.45	0.97	1.16
6	11.51	Camphenone, 6-	-	-	0.14	-
7	12.03	4-Ethyl-1,4-dimethyl-2-cyclohexen-1-ol	-	-	0.18	-
8	12.85	o-cymene	0.65	2.62	3.64	-
9	12.93	D-limonene	0.69	-	-	7.09
10	13.03	α-phellandrene	-	0.53	9.82	8.98
11	14.00	α-terpinene	4.63	2.74	32.15	27.02
12	14.21	γ-terpinene	7.56	5.40	19.60	19.87
13	15.44	α-terpinolene	1.12	0.83	8.86	5.79
14	15.76	Trans-4-methoxy thujane	-	0.21	-	-
15	16.10	Linalool	0.31	0.62	0.31	0.14
16	17.03	3-isopropenyl-5-methyl-1-cyclohexene	-	-	1.38	0.19
17	18.32	1-terpineol	0.74	2.11	-	-
18	20.16	4-terpineol	24.91	28.70	8.23	6.79
19	20.86	p-menth-1-en-8-ol	-	2.84	0.51	0.48
20	20.94	α-fenchyl alcohol	2.40	-	-	-
21	21.55	Isopulegol	0.15	0.17	-	-
22	22.96	Linalyl acetate	0.89	1.59	1.08	0.74
23	23.15	Cis-sabinene hydrate	42.26	41.10	0.82	4.60
24	25.40	Cis-sabinene hydrate acetate	0.17	0.20	0.21	-
25	30.86	Clovene	-	-	-	0.13
26	31.10	Trans-caryophyllene	1.40	2.25	1.88	1.47
27	34.48	Bicyclogermacrene	1.12	0.95	0.54	-
28	36.46	α-selinene	-	-	-	0.09
29	36.74	Elemene	-	-	-	0.40

30	38.18	(+) spathulenol	0.08	0.28	-	-
31	49.16	Bicyclo[2.2.2]octan-1-ol,4-phenyl-	-	-	0.13	-
32	49.23	Androst-5-en-3-ol-17-one,16,16-trimethylenedithio-	-	-	0.11	-
Total identified compounds			99.99	99.99	99.93	99.86
Total hydrocarbon compounds			28.08	25.01	88.72	87.59
Total oxygenated compounds			71.91	74.98	11.21	12.27

* RT= Retention Time

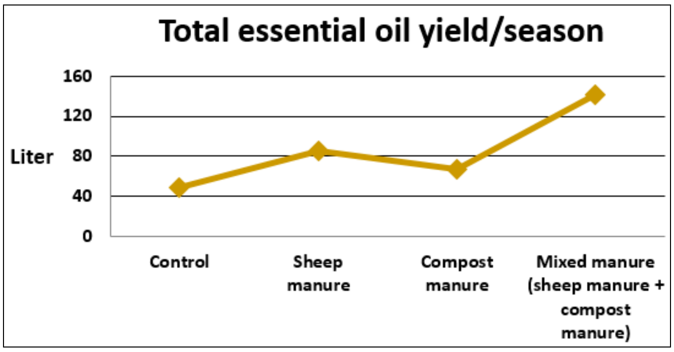

Fig 3: Effect of different manureson total oilyield/season

The present climate change problem causes plants' heat, salinity, and water stresses. The superiority of mixed manure may be due to alleviating some adverse environmental stresses more efficiently than classical manures, as will be discussed. Mixed manure enhances soil fauna community and improves microbial diversity. Increasing soil moisture conservation owing to their excellent physical characteristics thus reduces water stress. Mixed organic fertilizer increases soil structural stability resulting from high organic matter content and microbial activities. It enhances the nutrient use efficiency of added chemical fertilizers by reducing nutrient losses and improving nutrient availability to plants. Mixed manure also increases soil organic carbon, humic acid, macro, and microelements. Finally, obtaining the highest net income and investment ratio [40-42, 16-18].

4. Conclusion

The results revealed above showed that for producing the highest marjoram fresh and dry herb yields and essential oil yield at Siwa, farmers are advised to fertilize the field with 12 m^3 sheep manure plus 12 m^3 compost manure/hectare before cultivation.

5. References

1. Pleasant B. The Whole Herb: For Cooking, Crafts, Gardening, Health, and Other Joys of Life. Square One Publishers, Inc., 2004.
2. Sud RK, Kumar S. Herbs: Culinary, Medicinal, Aromatic (Secrets and Human Happiness). Scientific Publishers, 2004.
3. Bina F, Rahimi R. Sweet Marjoram: A review of ethnopharmacology, phytochemistry, and biological activities. Journal of Evidence-Based Integrative Medicine. 2017;22(1):175-185.
4. Choi HJ. Chemical constituents of essential oils possessing anti-influenza A/WS/33 virus activity. Osong Public Health Res Perspect. 2018;9(6):348-353.
5. Adina MM, Cyril MC. Natural Herbal Cures and Home Remedies. More in One eBook, 2020.
6. Downes K. Aromatherapy 101. Hay House, Inc, 2000.
7. Toaima WIM, Hamed ES. Productivity Evaluation for some imported Basil Varieties under Siwa Oasis Conditions. Middle East Journal of Agriculture Research. 2016;5(4):810-819.
8. Elansary HO. chemical diversity and antioxidant capacity of essential oils of marjoram in northwest Egypt. Journal of Essential Oil Bearing Plants. 2015;18(4):917-924.
9. Hamed ES, Toaima WIM, El-Shazly M. Effect of planting density and biofertilization on growth and productivity of *Cymbopogon citratus* (DC.) Stapf. (Lemongrass) plant under Siwa Oasis conditions. Journal of Medicinal Plants. 2017;5(2):195-203.
10. Hamed ES. Effect of biofertilization on Siwa Oasis mint (*Mentha spicata* L. CV. Siwa) plants. Journal of Medicinal Plants. 2018;6(3):24-33.
11. Tridge. https://www.tridge.com/intelligences/marjoram1/EG
12. Ghodia RHA. Productivity improvement of onion (*Allium cepa* L.) under Siwa Oasis conditions. Journal of Plant Production, Mansoura University. 2012;3(12):3037-3049. https://www.gardeningknowhow.com/composting/manures/manure-pros-cons.htm
13. Ebrahem MS, Sleem TEA, Ali SA, Abdel Hamid SA. The financial evaluation of the project of compost production in Siwa Oasis. Journal of Environmental Science. 2018;44(2):491-512.
14. Ashour MA, Belal RM. An economic study for the agricultural wastes recycling project in Siwa Oasis. Al-Azhar Journal of Agricultural Research. 2020;45(2):138-149.
15. El-Sodany ME, El-Maddah EI, Abd-Allah YAM. Evaluation of compost, farmyard manure and sheep manure using a three-factor computer model and its effect on some soil physical and hydrophysical properties and productivity of soils. 10th International Conference for Sustainable Agricultural Development 2-4 March 2020. Fayoum Journal of Agricultural Research and Development. 2020;34(1)(B):425-451.
16. Tabrika I, Azim K, Mayad E, Zaafrani M. Composting of tomato plant residues: improvement of composting process and compost quality by integration of sheep manure. Organic Agriculture. 2020;10:229-242.
17. Sun L, Wu J. Combined application of animal manure and straw benefit soil fauna community in dryland farming. Soil. 2021. https://soil.copernicus.org/preprints/soil-2021-132/soil-2021-132.pdf
18. Osman YAH, Abd El-Wahab MA. Production of medicinal and aromatic plants in New Lands. (In Arabic). Desert Research Center, Ministry of Agriculture, Cairo, 2003.
19. Snedecor GW, Cochran WG. Statistical Methods. The Iowa State Univ., Press, Ames, Iowa, 1982.
20. British Pharmacopoeia. Determination of Volatile Oil in Drugs. The Pharmaceutical Press, London, 1963.
21. Stenhagen E, Abrahamsson S, McLafferty FW. Registry of mass spectral data. 12th ed., Wiley & Sons, New York, 1974.
22. Massada Y. Analysis of essential oils by gas

chromatography and mass spectrometry. Illustrated, ed. Wiley & Sons, New York, 1976.
23. Jennings W, Shibamoto T. Qualitative analysis of flavor and fragrance volatiles by Glass capillary gas chromatograph. 1st ed., Academic Press, New York, 1980.
24. National Committee for Clinical Laboratory Standards. Performance standards for antimicrobial susceptibility testing. 29th ed., Clinical and Laboratory Standards Institute, Wayne, 2002.
25. Adams RP. Identification of essential oil components by gas chromatography/Quadrupole mass spectroscopy, 4thed. Allured Publishing Corporation, Illinois, 2007.
26. Babushok VI, Linstrom PJ, Zenkevich IG. Retention indices for frequently reported compounds of plant essential oils. Journal of Physical and Chemical Reference Data. 2011;40:043101-47.
27. Gharib FA, Moussa LA, Massoud ON. Effect of compost and bio-fertilizers on growth, yield and essential oil of sweet marjoram (*Majorana hortensis*) plant. International Journal of Agriculture & Biology. 2008;10:381-7.
28. Zaghloul RA, El-Husseiny TM, Hanafy EA, Rahal AGH, Abdelrahman HM. Effect of biofertilization and organic manuring on soil dehydrogenase activity, macronutrients and essential oil content of marjoram. Egyptian Journal of Microbiology. Special Issue."13th Conf. of Microbiol, 2010, 15-32.
29. Al-Fraihat AH, Al-dalain SYA, Al-Rawashdeh ZB, Abu-Darwish MS, Al-Tabbal JA. Effect of organic and biofertilizers on growth, herb yield and volatile oil of marjoram plant grown in Ajloun region, Jordan of Medicinal Plants Research. 2011;5(13):2822-2833.
30. Nikou S, Mirshekari B, Miandoab MP, Rashidi V, Ghorttapeh AH. Effects of organic, chemical and integrated nitrition systems on morpho-physiological traits of oregano (*Origanum vulgare* L.). Turkish Journal of Field Crops. 2019;24(1):70-80.
31. Jianming L, Pute W, Behboudianc MH, Zhonghongd W, Zhirong Z, Mortonc A. Response of muskmelon to cattle or sheep manure compost mixed with sandy soil. Journal of Organic Systems. 2008;3(2):40-50.
32. Ateia EM, Osman YAH, Meawad AEAH. Effect of organic fertilization on yield and active constituents of *Thymus vulgaris* L. under North Sinai conditions. Research Journal of Agriculture and Biological Sciences. 2009;5(4):555-565.
33. Badr SEA, Sakr DM, Mahfouz SA, Abdelfattah MS. Licorice (*Glycyrrhiza glabra* L.): Chemical composition and biological impacts. Research Journal of Pharmaceutical, Biological and Chemical Sciences. 2013;4(3):606-621.
34. Abdelfattah MS, Badr SEA, Lotfy SA, Attia GH, Aref AM, Abdel Moneim AE, *et al.* Rutin and selenium co-administration reverse 3-nitropropionic acid-induced neurochemical and molecular impairments in a mouse model of Huntington’s disease. Neurotoxicity Research. 2020;37(1):77-92.
35. ISO. 10620. https://standards.iteh.ai/catalog/standards/sist/3252f672-8744-4939-b782-42f13d3fe4a5/iso-10620-1995
36. Rudbäck J, Bergström MA, Börje A, Nilsson U, Karlberg AT. α-Terpinene, an antioxidant in tea tree oil, autoxidizes rapidly to skin allergens on air Exposure. Chemical Research in Toxicology. 2012;25(3):713-721.
37. Badee AZM, Moawad RK, ElNoketi MM, Gouda MM. Antioxidant and antimicrobial activities of marjoram (*Origanum majorana* L.) essential oil. Journal of Applied Sciences Research. 2013;9(2):1193-1201.
38. Edris AE, Shalaby A, Fadel HM. Effect of organic agriculture practices on the volatile aroma components of some essential oil plants growing in Egypt II: sweet marjoram (*Origanum majorana* L.) essential oil. Flavor and Fragrance Journal. 2003;18:345-351.
39. Bouajila K, Sanaa M. Effects of organic amendments on soil physico-chemical and biological properties. Journal of Materials and Environmental Science. 2011;2(1):485-490.
40. Bharath T, Vidyasagar GECH, Rao VP, Reddy SN, Madhavi A. Influence of organic manures integrated with inorganic fertilizer on soil properties after harvest of ctops in maize-groundnut crop sequence. Environment & Ecology. 2017;35(3):1759-1764.
41. Sun L, Sun Z, Hu J, Opoku-Kwanowaa Y, Wu J. Combined application of animal manure and stover enhance labile organic carbon and benefit the microbial community in dark brown soil. Archives of Agronomy and Soil Science. 2021. https://www.tandfonline.com/doi/full/10.1080/03650340.2021.2013472