Scientific J. Flowers & Ornamental Plants
www.ssfop.com/journal
ISSN: 2356-7864
doi: 10.21608/sjfop.2024.394483

EFFECT OF SOIL TYPE AND NITROGEN LEVELS ON GROWTH, YIELD AND CHEMICAL COMPOSITION OF *SALVIA OFFICINALIS* L.

S.M. Selim*, F.M.A. Matter*, Mahassen M.A. Sidky** and M.M. Sabra*,**
* Ornamental Horticulture Dept., Fac. Agric., Fayoum Univ., Fayoum, Egypt
** Medicinal and Aromatic Plants Res. Dept., Hort. Res. Inst., Agric. Res. Cent., Dokki, Cairo, Egypt

Scientific J. Flowers & Ornamental Plants, 11(3):127-150 (2024).

Received:
1/9/2024
Accepted:
23/9/2024

Corresponding author:
M.M. Sabra
mm3254@fayoum.edu.eg

ABSTRACT: The present study was conducted on *Salvia officinalis* L. plants throughout two successive seasons in 2020/2021 and 2021/2022 at a private farm in Fayoum Governorate, Egypt. The experiments aimed to find out the individual and the combined effects of nitrogen at three concentrations in the form of ammonium nitrate (33.5%N) at 0, 2 and 4 g/plant under two types of soils (clay and sandy soils) on vegetative growth, chemical composition and essential oil components of *salvia officinalis*. The results emphasized that using nitrogen fertilizer under two types of soils had significant response on all parameters in this study. Likewise, these treatments supported vegetative growth parameters, promoted chemical composition as well as, increased oil percentage and chemical constituents of essential oil, especially with using clay soil and high level of nitrogen (4 g/plant), the interaction between levels of nitrogen fertilizer improved all the studied parameters under clay soil.

Keywords: sage, clay, sand, nitrogen fertilizers

INTRODUCTION

In recent years the importance of medicinal and aromatic plants which form the essential active ingredient of many medicines and cosmetics was increased. Common sage (*Salvia officinalis* L.) is one of the important species of these aromatic plants. In Egypt, we have suitable climate conditions, abundance of employment, abundance of newly reclaimed lands and our special site so medicinal and aromatic plants production was expanded. In pharaonic Egypt, they used medicinal and aromatic plants for folk medicine instead of chemical medicinal preparations. Medicinal and aromatic plants are considered as essential economic products which has been recognized and detected in Egypt to cover the increasing demands of the local industries as well as, for export purpose (Abbas, 2011).

The growing demand for medicinal plants worldwide has made boosting their production a top priority. This aims to minimize the severe side effects associated with chemical therapies on human health while also enhancing economic benefits through the export of these products. As the need for active compounds from medicinal plants for pharmaceutical production and export continues to rise, the cultivation area dedicated to these plants has significantly increased. There are more than 150 species of medicinal plants in Egypt, grown in an area run to about 70 thousand feddans and the total exports of these crop products were more than 200 million Egyptian pounds (Kandeel, 2003). The Labiatae (Lamiaceae) family includes a large number of economically herbal plants (such as *Mentha sp., Marjoram sp., Salvia sp.* … etc.). Salvia genus includes about 700 species, one of which is *Salvia* *officinalis* (sage). It is a perennial herb indigenous to southern Europe, and now cultivated in temperature climate regions such as the Mediterranean sea region and, North Africa, America and Asia. The shoots are long spindle shaped with an erect woody stalk and straight branches. It grows to approximately 60 cm in height and has pale blue or purplish flowers. The leaves are elongated spear shaped with a soft velvety texture (Greenhalgh, 1992). Essential oils are produced from the Spanish sage (*lavandulifolia),* common or garden sage (*Salvia officinalis*) and clary sage (*S. sclarea*). Sage was considered as remedy for coughs and bad cold, it is included in gargles and mouth washes. The fresh leaves are used for whiten the teeth, while the dried ones are used cosmetically to restore the natural color to hair that is turning grey (Giannoulis *et al*., 2021 on *Salvia officinalis*). Sage has been used to treat various illnesses, such as respiratory infections, menstrual problems, and digestive issues. It is also believed to enhance memory and serves as a natural source of antioxidants. The essential oil of sage primarily consists of terpenes. In general, the growth and production of sage, including its morphological and chemical characteristics, are influenced by various environmental factors, such as drought and nutrient deficiencies.

Soil type plays a crucial role in determining key agronomic factors, such as water retention and nutrient availability. Additionally, it influences water infiltration, runoff, and movement within the soil. Sandy soils have low water retention capacity, leading to reduced fertility and, consequently, lower crop yields. On the other hand, clay soils have tiny particles that tightly hold water while restricting root penetration, which can negatively impact plant growth (Reinhardt *et al*., 2021b). The use of growing soil media and mineral fertilization are essential agricultural practices that have been shown to enhance plant growth and boost productivity. Gülser *et al*. (2010) clearly demonstrated that plant growth in soils with varying textures enhances soil physical properties, contributing to improved soil health and sustainability.

Shortage of nitrogen resulted in a decrease in plant photosynthesis in many plants. Photosynthetic capacity and total amount of leaf nitrogen per unit leaf area are usually correlated. Nitrogen occupies a main place in plant metabolic system and is the most important nutrient for plants to perform well. Nitrogen is also a key component of proteins, nucleic acids, and chlorophyll. The use of nitrogen fertilizer is important for improving the herb production.

This study aims to assess the performance of sage plants in terms of biomass yield and volatile oil production across different soil types (clay and sandy). Additionally, it seeks to evaluate the potential of using nitrogen-based chemical fertilizers within a sustainable production system.

MATERIALS AND METHODS

The experiment for this study was conducted at the private nursery in Fayoum Governorate, Egypt throughout two successive seasons (2020/2021 and 2021/2022). The purpose of experiment is to study the effect of nitrogen fertilization at two concentrations (2 and 4 g/plant) in the form of ammonium nitrate (33.5% N), in addition to the control (0 g/plant) on growth, chemical composition and essential oil of *Salvia officinalis* L. on two soil media (clay and sandy) The interaction effect between them was also studied.

Plant material:

Sage seeds were acquired from the Agricultural Research Centre, Giza, Egypt. Seeds were sowed at the end of November in seedling trays (7 × 12) then incubated in the greenhouse and received the normal agriculture practices until transplanting after 45 days of the two seasons into 25 cm diameter pots (one plant/pot) filled with clay or sandy soil.

The experiment focused on two factors, the first factor is soil media type namely clay and sandy soils. The second factor was the addition of nitrogen at two concentrations (2 and 4 g/plant) in the form of ammonium nitrate (33.5% N) as well as the control treatment (0 g/plant).

Soil media:

The clay and sandy soils were taken from Fayoum Governorate, Egypt. The analyses of some chemical and physical properties of the used medium were carried out according to Klute (1986) and Page *et al*. (1982) and are presented in Table (a).

Nitrogen fertilization:

Ammonium nitrate 33.5% was added to the plants at 0, 2 and 4 g/plant, each treatment was divided into two equal parts, the first one was applied after two weeks and the second after one month of transplanting. The plants received the normal agricultural practices to prevent fungal infection and insect infestations.

Harvesting:

In both seasons, sage plants were harvested two times, by cutting the aerial parts of each plant at 10 cm above the soil surface on 15th May (at the commencement of the flowering), and on 15th August. Four plants were randomly chosen from each experimental unit at cut, in both seasons.

Experimental design:

The experiment was set in a split-plot design with three replications (eight pots/replicate). The soil media types were the main plot, while the nitrogen was in the sub-plots.

Data recorded:

1. Vegetative growth characters:

Plant height (cm), number of branches per plant, herb fresh and dry weights/plant (g).

2. Chemical constituents:

a. Determination of carbohydrates in the herb:

The percentage of total carbohydrates was determined in the dry herb using the method described by Herbert *et al*. (1971). Five ml of 67% sulphuric acid were added to a known weight of the dry matter in a test tube. One hour later, the volume was completed to 100 ml with distilled water and the solution was filtered. One ml of the filtrate pipette into a test tube and an aqueous phenol solution 1 ml (5%) was added to the solution, followed by concentrated H_2SO_4 (5 ml) from a fast-delivering pipette. Measurements of the color intensity were taken using a Milton Roy colorimeter (model Spectronic 21 D) at

Table a. Some mechanicals and chemicals analysis of clay and sandy soil samples used for experiment.

Characters	1	2
Mechanical analysis:		
Clay %	56.80	5.00
Fine sand %	27.90	89.86
Silt %	13.40	6.09
Soil texture	Clay	Sandy
Chemical analysis:		
pH (at 25 °C)	7.80	8.90
EC ds/m (at 25 °C)	2.66	2.60
Organic matter (O.M) %	0.74	0.70
N (mg/kg)	73.22	55.50
P (mg/kg)	2.10	21.14
K (mg/kg)	0.54	0.89
Ca (meq)	7.00	1.50
Mg (meq)	9.30	0.42
Na (meq)	15.70	0.73
Cl (meq)	15.00	0.40
HCO_3 (meq)	3.50	1.30
SO_4 (meq)	15.80	0.98

490 nm and the content was calculated by the standard curve of glucose.

b. Determination of chlorophyll (a and b) and carotinoids in leaves:

The contents of chlorophylls (a and b) and carotenoids were determined according to the method described by Saric *et al.* (1976) where 0.5 g of fresh leaves of sage were macerated in 5 ml acetone for 48 hours in the dark. The filtration has been done using vacuum filtration through a centred glass funnel G_4. The residue was washed several times with acetone until the filtrate become colorless. Chlorophyll a and b was determined using the following equation:

Chlorophyll a = (9.784 × E660) - (0.99 × E640)

Chlorophyll b = (21.426 × E640) - (4.65 × E660)

Total carotenoids = (4.695 × E440) - (0.268 × (chl.+chl.b)

E= optical density at the wavelength indicated

c. Determination of N, P and K in the dry leaves:

The leaves were oven dried at 70 °C until a constant weight was obtained. The obtained dry matter was ground and 0.5 g of ground dry matter was digested using sulphuric acid and H_2O_2 and the wet digestion procedure was performed as follows: concentrated sulphuric acid (8 ml) was added to the dried sample and heated for 15 minutes and then H_2O_2 was added and heating was continued until a clear solution was obtained (Piper, 1947). Nitrogen determination was carried out using the modified micro-Kjedahl method, as described by Jackson (1967).

The phosphorus % was estimated calorimetrically according to the method of Murphy and Reily (1962).

While potassium (K) was determined by using an atomic absorption/Flame spectrophotometer (3300) according to Wilde *et al.* (1985).

3. Determination of essential oil percentage in the dry herb:

The essential oil percentage of each treatment of sage plants was determined in the air-dried herb using hydro-distillation method according to the British Pharmacopoeia (1983). The herb was placed in a flask of 1000 ml capacity and an amount of water (500 ml) was added. A proper essential oil trap and condenser were attached to the flask and enough water was added to fill the trap. The flask was placed on an electrically heated bath. The distillation continued for 2.5 hours after boiling until no further increase in the oil was observed, after finishing the distillation process the apparatus was left to be cooled and the essential oil percentage was estimated as follows:

Essential oil percentage=

$$\frac{\text{Essential oil vol.} \\ \text{(reading measured pipette)}}{\text{Weight of sample}} \times 100$$

4. Essential oil constituents (G.L.C analysis of the oil):

Essential oil constituents were analyzed using gas liquid chromatography (GLC) to determine the main constituents according to Heftmann (1967). The chromatograph apparatus was fitted with capillary column BPX-5,5% phenyl (reqiv) polysillphenylene-siloxan 30 m × 0.25 mm ID × 0.25µm film. Temperature program ramp increase with a rate of 80 °C/min from 70 to 200 °C. Flow rates of gases were nitrogen at 1 ml/min, hydrogen at 30 m/min and 330 ml/min for air. The detector and injector temperatures were 300 °C and 250 °C, respectively. The obtained chromatogram and report of GC analysis for each sample were analyzed to calculate the percentage of main components of essential oil. The area each peak was first calculated by an automatic integrator. The areas were then summed. The total area of peaks represented the whole sample. The percentage of each component was the ratio between its peak areas to the total peak area, multiplied by 100.

Statistical analysis.

Obtained data were subjected to the statistical analysis as a usual technique of analysis of variance (ANOVA) of the combined analysis in split-split plot design as mentioned by Gomez and Gomez (1984), using the least significant difference (L.S.D.) at 5% for comparison between means of the different treatments.

RESULTS AND DISCUSSION

Effects of soil type and nitrogen addition on vegetative growth of *Salvia officinalis* L. during 2020/2021 and 2021/2022 seasons:

1. Plant height (cm):

a. Effect of soil type and nitrogen addition:

The plants cultivated in clay and sand soil were affected by soil type, the plant height was increased in clay soil (64.43 and 62.93 cm) in the 1st and 2nd seasons, respectively, compared with sandy soil (45.99 and 44.92 cm) in the 1st and 2nd seasons, respectively (Table, 1). These results are in agreement with Badawy(1998) on tuberose, Barbara (2002) on *Solidago virgaaurea*, L., Abdel-Sattar *et al.* (2010) on tuberose, El-Nashar (2016) on calendula and Youssef *et al*. (2019) on *Swietenia mahagoni*.

Concerning the nitrogen addition treatments, it could be noticed that the highest values that affected plant height were nitrogen at 4 g/plant being 57.93 cm in the 1st season and 55.89 cm in the 2nd one compared to 0 and 2 g which were 51.84 and 52.0 cm for 0 g in the 1st and 2nd seasons, respectively, and 55.85 and 53.88 cm in the 1st and 2nd seasons respectively, for 2 g nitrogen addition (Table, 1).

These results are in agreement with Bagdat *et al*. (2017) and Sönmez and Bayram (2017) on *Ocimum basilicum*, Abdelkader *et al*. (2019) on *Cyperus esculentus*, Al-Sayed *et al*. (2019) on *Hibiscus sabdariffa*, Giannoulis *et al*. (2020) and Khaledigan *et al.* (2021) on *Ocimum basilicum*, and Katar *et al*. (2021) on *Salvia fruticosa* Mill.

b. Effect of the interaction between soil type and nitrogen addition:

Data presented in Table (2) revealed the interactions between soil type and nitrogen addition on the plant height (cm). It explained the tallest plants were obtained by clay soil plus nitrogen addition (4 g) being 67.93 and 64.63 cm while the relatively shortest plants were on sandy soil without nitrogen addition being 44.34 and 43.00 cm during the two seasons of study, respectively. Generally, the interaction of clay soil with different nitrogen levels addition was more effective on *Salvia officinalis* plant than the interaction of sandy soil with nitrogen addition during the two seasons of study. Similar results were achieved by Badawy (2015) on *Pimpinlla anisul* L., Ghoushchi *et al.* (2015) and Bagdat *et al.* (2017) on *Salvia officinalis*, Youssef *et al*. (2019) on *Swietenia mahagoni*, and Khaledigan *et al*. (2021) on *Ocimum basilicum* and *Satureja hortensis.*

2. Number of branches per plant:

a. Effect of soil type and nitrogen addition:

Considering the effect of clay and sand soil treatments on number of branches per plant, planting in the clay soil increased the number of branches per plant (7.50 and 5.35) in the 1st and 2nd seasons, respectively compared with sand soil (5.57 and 4.79) in the 1st and 2nd seasons, respectively (Table, 3).

Regarding the effect of nitrogen addition treatments on the number of branches per plant, it could be noticed that the highest values resulted by treating with 4 g nitrogen in the 1st season (7.71 g) and 2nd season (5.33 g) compared to 0 and 2 g levels.

These results are in agreement with those obtained by Badawy(1998) on tuberose, Abdel-Sattar *et al.* (2010) on tuberose, Sardoei and Rahbarian (2014) on some ornamental plants, El-Nashar (2016) on calendula plants, Badawy (2015) on *Pimpinlla anisul* L., Ghoushchi *et al.* (2015) and Bagdat *et al.* (2017) on *Salvia officinalis* and Khaledigan *et al*. (2021) on *Ocimum basilicum* and *Satureja hortensis*.

Table 1. Effects of soil type and nitrogen addition on the plant height (cm) of *Salvia officinalis* L. during 2020/2021 and 2021/2022.

Treatments		1st season		2nd season	
Soil type	**Cut No.**	**Plant height (cm)**	**Mean**	**Plant height (cm)**	**Mean**
Clay	**Cut 1**	59.50	64.43	60.43	62.93
	Cut 2	69.36		65.43	
Sandy	**Cut 1**	41.50	45.99	41.38	44.92
	Cut 2	50.48		48.46	
L.S.D at 5%			6.38		6.68
Nitrogen					
0 g	**Cut 1**	56.24	51.84	48.0	52.00
	Cut 2	46.35		56.0	
2 g	**Cut 1**	53.23	55.85	57.24	53.88
	Cut 2	58.24		49.34	
4 g	**Cut 1**	52.25	57.93	61.65	55.89
	Cut 2	62.89		49.37	
L.S.D at 5%			2.37		1.65

Table 2. Effects of the interactions between soil type and nitrogen addition on the plant height (cm) of *Salvia officinalis* L. during 2020/2021 and 2021/2022.

Treatments			1st season		2nd season	
Soil type	**Nitrogen**	**Cut No.**	**Plant height (cm)**	**Mean**	**Plant height (cm)**	**Mean**
Clay	**0 g**	**Cut 1**	56.23	59.25	57.01	61.01
		Cut 2	62.27		65.02	
	2 g	**Cut 1**	62.05	66.10	58.12	63.14
		Cut 2	70.15		68.16	
	4 g	**Cut 1**	65.91	67.93	61.60	64.63
		Cut 2	69.95		67.66	
Sandy	**0 g**	**Cut 1**	41.42	44.43	41.0	43.00
		Cut 2	47.45		45.0	
	2 g	**Cut 1**	40.55	45.60	40.59	44.63
		Cut 2	50.65		48.67	
	4 g	**Cut 1**	43.88	47.93	44.10	47.15
		Cut 2	51.98		50.20	
L.S.D at 5%				3.36		2.33

Table 3. Effects of soil type and nitrogen addition on the number of branches/plant of *Salvia officinalis* L. during 2020/2021 and 2021/2022.

Treatments		1st season		2nd season	
Soil type	**Cut No.**	**Number of branches/plant**	**Mean**	**Number of branches/plant**	**Mean**
Clay	**Cut 1**	5.47	7.50	2.32	5.35
	Cut 2	9.53		8.38	
Sandy	**Cut 1**	3.53	5.57	2.76	4.79
	Cut 2	7.61		6.83	
L.S.D at 5%			0.62		0.60
Nitrogen					
0 g	**Cut 1**	2.00	5.03	6.75	4.70
	Cut 2	8.06		2.65	
2 g	**Cut 1**	4.15	7.13	4.14	5.17
	Cut 2	10.11		6.20	
4 g	**Cut 1**	7.68	7.71	2.30	5.33
	Cut 2	8.73		8.36	
L.S.D at 5%			0.50		0.31

b. Effect of the interaction between soil type and nitrogen addition:

Data in Table (4) showed the effect of interactions between soil type and nitrogen addition on the number of branches per plant. The highest number of branches per plant was obtained by clay soil plus nitrogen addition at 4 g (8.81 and 5.56) during 2020/2021 and 2021/2022 seasons, respectively, but it was 6.12 and 4.92 in the two seasons in sandy soil. The lowest branch number per plant was 4.51 and 4.49 in sandy soil without nitrogen addition in the 1st season and 2nd season, respectively. These results are in agreement with Badawy (2015) on *Pimpinlla anisum* L., Ghoushchi *et al.* (2015) on *Salvia officinalis*, El-Nashar (2016) on calendula plants, Bagdat *et al.* (2017) on *Salvia officinalis* and Khaledigan *et al*. (2021) on *Ocimum basilicum* and *Satureja hortensis*.

3. Herb fresh weight/plant:

a. Effect of soil type and nitrogen addition:

Table (5) deals with the effect of soil type and nitrogen addition individually on the herb fresh weight. Planting sage plants on clay soil increased the herb fresh weight per plant (50.85 and 31.28 g) in the 1st and 2nd seasons, respectively compared with sand soil (26.82 and 30.70 g) in the 1st and 2nd seasons, respectively. These results are in agreement with those obtained by Magalhaes *et al*. (1995) on *Artemisia annual* plants, Gurumurthy and Sreenivasa (1996) on *Salvia officinalis* Badawy (1998) on tuberose, Barbara (2002) on *Salidago virgaaurea* L., Abdel-Sattar *et al.* (2010) on tuberose, El-Nashar (2016) on calendula, Youssef *et al*. (2019) on *Swietenia mahagoni* and Moghith *et al*. (2021) on *Salvia hispanica.*

Concerning the nitrogen addition treatments, it could be noticed that the highest values were obtained by nitrogen at 4 g in the 1st season (48.51 g) and 2nd season (51.82 g) compared to those treated with either 0 and 2 g which were 24.53 and 36.83 g in the 1st season and 43.46 and 49.83 g in the 2nd one. These results are in agreement with those obtained by Badawy (1998) on tuberose, Abdel-Sattar *et al.* (2010) on tuberose, Sardoei and Rahbarian (2014) on some ornamental plants, El-Nashar (2016) on calendula plants, Bagdat *et al.* (2017) and Sönmez and Bayram (2017) on *Salvia officinalis*, Abdelkader *et al*. (2017) on *Cyperus esculentus*, Al-Sayed *et al*. (2019) on *Hibiscus sabdariffa*, Giannoalis *et al*. (2020), Giannoulis *et al*. (2021) and Khaledigan *et al.* (2021) on *Salvia officinalis*, and Katar *et al*. (2021) on *Salvia fruticosa* Mill.

b. Effect of the interaction between soil type and nitrogen addition:

Data in Table (6) presented the interactions between soil type and nitrogen addition on the herb fresh weight per plant (g). The highest value was resulted from clay soil plus nitrogen addition at 4 g which was 62.69 and 68.49 g during 2020/2021 and 2021/2022 seasons, respectively. While this values was 31.12 and 33.88 g/plant in sandy soil. The data also showed that increasing nitrogen addition levels led to improving the productivity of sage plants. These results are in agreement with **Badawy (2015)** on *Pimpinlla anisum* L., **Ghoushchi *et al.* (2015) and Bagdat *et al.* (2017)** on *Salvia officinalis*, **Youssef *et al*. (2019)** on *Swietenia mahagoni*, **and Khaledigan *et al*. (2021)** on *Ocimum basilicum* and *Satureja hortensis.*

4. Herb dry weight per plant:

a. Effect of soil type and nitrogen addition:

Data in Table (7) shows the effect of soil type and nitrogen addition individually on the herb dry weight per plant. Clay and sand soil affect the herb dry weight per plant which were 47.51 and 44.71 g in clay soil in the 1st and 2nd seasons, respectively compared with sand soil (27.54 and 21.26 g) in the 1st and 2nd seasons, respectively.

Similar results were achieved by Magalhaes *et al*. (1995) on *Artemisia* annual plants, Gurumurthy and Sreenivasa (1996) on *Salvia officinalis*, Badawy (1998) on tuberose, Barbara (2002) on *Solidago virgaaurea* L., Abdel-Sattar *et al.* (2010) on tuberose, El-Nashar (2016) on calendula, Youssef *et al*. (2019) on *Swietenia mahagoni*

Table 4. Effects of the interactions between soil type and nitrogen addition on number of branches/plant of *Salvia officinalis* L. during 2020/2021 and 2021/2022.

Treatments			1st season		2nd season	
Soil type	Nitrogen	Cut No.	Number of branches/plant	Mean	Number of branches/plant	Mean
Clay	0 g	Cut 1	4.60	6.62	3.60	5.10
		Cut 2	8.64		7.14	
	2 g	Cut 1	5.90	8.13	3.53	5.55
		Cut 2	11.17		7.57	
	4 g	Cut 1	5.77	8.81	2.54	5.56
		Cut 2	11.85		8.58	
Sandy	0 g	Cut 1	3.49	4.51	2.43	4.49
		Cut 2	5.53		6.55	
	2 g	Cut 1	2.50	5.54	2.46	4.79
		Cut 2	8.58		6.82	
	4 g	Cut 1	3.09	6.12	2.90	4.92
		Cut 2	9.15		6.94	
L.S.D at 5%				0.71		0.44

Table 5. Effects of soil type and nitrogen addition on herb fresh weight/plant (g) of *Salvia officinalis* L. during 2020/2021 and 2021/2022.

Treatments		1st season		2nd season	
Soil type	Cut No.	Herb fresh weight/plant (g)	Mean	Herb fresh weight/plant (g)	Mean
Clay	Cut 1	45.80	50.85	27.24	31.28
	Cut 2	55.90		35.32	
Sandy	Cut 1	22.78	26.82	26.64	30.70
	Cut 2	30.86		34.76	
L.S.D at 5%			4.67		5.32
Nitrogen					
0 g	Cut 1	20.50	24.53	32.81	36.83
	Cut 2	28.56		40.85	
2 g	Cut 1	39.44	43.46	45.79	49.83
	Cut 2	47.48		53.87	
4 g	Cut 1	44.48	48.51	47.79	51.82
	Cut 2	52.54		55.85	
L.S.D at 5%			2.74		2.32

Table 6. Effects of the interactions between soil type and nitrogen addition on herb fresh weight/plant (g) of *Salvia officinalis* L. during 2020/2021 and 2021/2022.

Treatments			1st season		2nd season	
Soil type	Nitrogen	Cut No.	Herb fresh weight/plant (g)	Mean	Herb fresh weight/plant (g)	Mean
Clay	0 g	Cut 1	31.28	34.32	43.56	46.58
		Cut 2	37.35		49.60	
	2 g	Cut 1	54.69	58.73	62.75	65.77
		Cut 2	62.77		68.79	
	4 g	Cut 1	60.66	62.69	66.45	68.49
		Cut 2	64.72		70.53	
Sandy	0 g	Cut 1	14.90	17.93	24.07	27.08
		Cut 2	20.96		30.09	
	2 g	Cut 1	24.18	28.20	28.11	31.14
		Cut 2	32.22		34.17	
	4 g	Cut 1	29.10	31.12	29.84	33.88
		Cut 2	33.14		37.92	
L.S.D at 5%				3.87		4.75

Table 7. Effects of soil type and nitrogen addition on herb dry weight/plant (g) of *Salvia officinalis* L. during 2020/2021 and 2021/2022.

Treatments		1st season		2nd season	
Soil type	**Cut No.**	**Herb dry weight/plant (g)**	**Mean**	**Herb dry weight/plant (g)**	**Mean**
Clay	**Cut 1**	45.00	47.51	40.67	44.71
	Cut 2	50.01		48.75	
Sandy	**Cut 1**	22.49	27.54	17.26	21.28
	Cut 2	32.59		25.29	
L.S.D at 5%			2.99		4.77
Nitrogen					
0 g	**Cut 1**	22.12	26.16	16.21	19.23
	Cut 2	30.20		22.25	
2 g	**Cut 1**	40.93	42.95	33.78	36.79
	Cut 2	44.97		39.80	
4 g	**Cut 1**	45.19	47.22	39.90	42.94
	Cut 2	49.25		45.98	
L.S.D at 5%			2.66		3.59

and Moghith *et al*. (2021) on *Salvia hispanica*.

Concerning the nitrogen addition treatments, it could be noticed that the highest values of herb dry weight per plant were obtained by 4 g nitrogen level (47.22 and 42.94 g) in the 1st and 2nd seasons, respectively. compare to treated with 0 and 2 g nitrogen levels. Similar results were obtained by Bagdat *et al*. (2017), Sönmez and Bayram (2017), on *Salvia officinalis*, Abdelkader *et al*. (2017) on *Cyperus esculentus*, Al-Sayed *et al*. (2019) on *Hibiscus sabdariffa*, Giannoalis *et al*. (2020) and Giannoulis *et al*. (2021) on *Salvia officinalis*, Katar *et al*. (2021) on *Salvia fruticosa* Mill. and Khaledigan *et al*. (2021) on *Ocimum basilicum* and and *Satureja hortensis*. and Giannoulis *et al*. (2021) on *Salvia officinalis*.

b. Effect of the interaction between soil type and nitrogen addition:

Data in Table (8) presented the interactions between soil type and nitrogen addition on the herb dry weight per plant. The highest herb dry weight per plant was achieved in clay soil plus nitrogen addition at 4 g (69.13 and 51.48 g) during 2020/2021 and 2021/2022 seasons, respectively. It is known that sandy soil is poor in its nitrogen content, and this experiment showed that adding nitrogen led to an increase in the dry weight of sage plants from 15.43 by zero nitrogen level to 22.09 and 23.04 g by 2 and 4 g nitrogen levels per plant, respectively.

These results are in agreement with Badawy (2015) on *Pimpinlla anisum* L., Ghoushchi *et al.* (2015) and Bagdat *et al.* (2017) on *Salvia officinalis*, Youssef *et al*. (2019) on *Swietenia mahagoni*, and Khaledigan *et al*. (2021) on *Ocimum basilicum* and *Satureja hortensis.*

Effects of soil type and nitrogen addition and their interactions on chemical constituents of *Salvia officinalis* L. during 2020/2021 and 2021/2022 seasons:

1. Carbohydrates percentage:

a. Effects of soil type and nitrogen addition:

Data dealing with the effect of soil type and nitrogen addition individually on the carbohydrates percentage in the dried herb of *Salvia officinalis* L. during the both growing seasons were presented in Table (9). Using clay soil as a treatment for sage plants compared with sand soil significantly increased the carbohydrate contents (22.88% in the 1st season and 23.17% in the 2nd one). But it was 17.80 and 17.66% by sandy soil in the 1st and 2nd seasons, respectively. Similar results were reported by Bezzi (1987) on *Salvia officinalis* L., Rajeswara *et al.* (1990) on *Pelargonium graveolens* L., El-Sherbeiny

Table 8. Effects of the interactions between soil type and nitrogen addition on herb dry weight/plant (g) of *Salvia officinalis* L. during 2020/2021 and 2021/2022.

Treatments			1st season		2nd season	
Soil type	Nitrogen	Cut No.	Herb dry weight/plant (g)	Mean	Herb dry weight/plant (g)	Mean
Clay	0 g	Cut 1	28.70	31.74	21.24	26.26
		Cut 2	34.78		31.28	
	2 g	Cut 1	32.73	34.74	25.60	29.61
		Cut 2	36.75		33.62	
	4 g	Cut 1	68.11	69.13	50.46	51.48
		Cut 2	70.15		52.50	
Sandy	0 g	Cut 1	24.66	29.70	10.41	15.43
		Cut 2	34.74		20.45	
	2 g	Cut 1	32.10	36.20	20.90	22.05
		Cut 2	40.30		24.00	
	4 g	Cut 1	52.10	54.15	20.03	23.04
		Cut 2	56.20		26.05	
L.S.D at 5%				3.76		5.08

Table 9. Effects of soil type and nitrogen addition on carbohydrates percentage of *Salvia officinalis* L. during 2020/2021 and 2021/2022.

Treatments		1st season		2nd season	
Soil type	Cut No.	Carbohydrates (%)	Mean	Carbohydrates (%)	Mean
Clay	Cut 1	20.86	22.88	20.14	23.17
	Cut 2	24.90		26.20	
Sandy	Cut 1	14.77	17.80	13.62	17.66
	Cut 2	20.83		21.70	
L.S.D at 5%			1.10		1.10
Nitrogen					
0 g	Cut 1	18.40	18.56	16.88	18.92
	Cut 2	21.08		20.96	
2 g	Cut 1	15.50	20.55	15.60	20.65
	Cut 2	25.60		25.70	
4 g	Cut 1	19.38	21.42	17.64	21.67
	Cut 2	23.46		25.70	
L.S.D at 5%			0.345		0.568

et al. (1992) on *Pelargonium graveolens* L., Omidbaigi and Hornok (1992) on *Foeniculum vulgare* Mill, Rohricht *et al*. (1996) on *Salvia officinalis* L., Badawy (1998) on *Polianthes tuberosa*, Youssef *et al*. (2019) on *Swietenia mahagoni*, El-Fawakhry (2001) on tuberose, and Gaafar *et al*. (2021) on *Hibiscus sabdariffa*.

Concerning the nitrogen addition treatments, it could be noticed that the highest effective level was 4 g nitrogen in the 1st season (21.42%) and 2nd season (21.67%) compared to treating with 0 and 4 g levels. Similar results were cited by Badawy (1998) on tuberose, Abaas (2014), Sardoei and Rahbarian (2014) on some ornamental plants, El-Nashar (2016) on calendula plant, Abdelkader *et al*. (2017) on *Cyperus esculentus,* Sönmez and Bayram (2017) and Amer *et al*. (2019) on *Salvia officinalis,* Abdel-Sattar *et al.* (2010) on tuberose, Katar *et al*. (2021) on *Salvia fruticosa* Mill. and Khaledigan *et al*. (2021) on *Ocimum basilicum* and *Satureja hortensis*.

b. Effect of the interaction between soil type and nitrogen addition:

Data in Table (10) showed the interactions between soil type and nitrogen addition on carbohydrates percentage. The highest effect was clay soil plus nitrogen addition at 4 g (23.93 and 24.68% during two seasons of study, respectively), but the interaction between zero nitrogen level and sandy soil resulted in the lowest carbohydrate

Table 10. Effects of the interactions between soil type and nitrogen addition on carbohydrates percentage of *Salvia officinalis* L. during 2020/2021 and 2021/2022.

Treatments			1st season		2nd season	
Soil type	Nitrogen	Cut No.	Carbohydrates (%)	Mean	Carbohydrates (%)	Mean
Clay	0 g	Cut 1	19.60	21.64	17.54	21.57
		Cut 2	23.68		25.60	
	2 g	Cut 1	20.07	23.08	20.24	23.27
		Cut 2	26.09		26.30	
	4 g	Cut 1	19.90	23.93	20.66	24.68
		Cut 2	27.96		28.70	
Sandy	0 g	Cut 1	12.46	16.48	12.24	16.27
		Cut 2	20.50		20.30	
	2 g	Cut 1	14.00	17.02	16.02	18.04
		Cut 2	20.04		20.06	
	4 g	Cut 1	14.90	18.91	14.62	18.66
		Cut 2	22.92		22.70	
L.S.D at 5%				0.488		0.803

percentage (16.48 and 16.27% during two seasons of study, respectively). These results are in agreement with Badawy (2015) on *Pimpinlla anisul* L., Rohricht *et al*. (1996), Amber *et al.* (2008), EL-Sayed *et al.* (2009), Rioba *et al.* (2015), Ghoushchi *et al.* (2015), Bagdat *et al*. (2017) and Amer *et al*. (2019) on *Salvia officinalis,* Khaledigan *et al*. (2021) on *Ocimum basilicum* and *Satureja hortensis*, Gaafar *et al*. (2021) on *Hibiscus sabdariffa* L. and Heikal *et al*. (2015) on rosemary plants.

2. Carotenoids (mg/g):

a. Effects of soil type and nitrogen addition:

Data dealing with the effect of soil type and nitrogen addition individually on the carotenoids content during both 2020/2021 and 2021/2022 growing seasons were presented in Table (11). The effect of soil type on carotenoids content of sage plants was significant in the two seasons of study. Planting in clay increased carotenoids (0.59 and 0.58 mg/g) in the 1st and 2nd seasons, respectively compared with sandy soil (0.55 and 0.55 mg/g) in the 1st and 2nd seasons, respectively.

These results are in agreement with Bezzi (1987) on *Salvia officinalis* L., Rajeswara *et al.* (1990) on *pelargonium graveolens* L., Omidbaigi and Hornok (1992) on *Foeniculum vulgare* Mill., Rohricht *et al*. (1996) on *Salvia officinalis* L., Badawy (1998) on *Polianthes tuberosa*, Youssef *et al*. (2019) on *Swietenia mahagoni*, El-Fawakhry (2001) on tuberose, Moghith *et al*. (2021) on chia (*Salvia hispanica*) and Gaafar *et al*. (2021) on *Hibiscus sabdariffa* L.

Concerning the nitrogen addition treatment on carotenoids content of *Salvia officinalis* plants, it could be noticed that the highest values of carotenoids were obtained at nitrogen 4 g in the 1st season (0.63 mg/g) and 2nd season (0.60 mg/g) compared with that treated with (0 and 2 g).These results are in agreement with Abaas (2014) on *Salvia officinalis*, Abdelkader *et al*. (2017) on *Cyperus esculentus*, Sönmez and Amer Heba *et al*. (2019) on *Salvia officinalis,* Katar *et al*. (2021) on *Salvia fruticosa* Mill., and Khaledigan *et al*. (2021) on *Ocimum basilicum* and *Satureja hortensis*

b. Effect of the interaction between soil type and nitrogen addition:

Data in Table (12) presented the interactions between soil type and nitrogen addition on the carotenoids content. Clay soil plus nitrogen addition (4 g) produced the highest values (0.63 and 0.56 mg/g during the two seasons, respectively). In sand soil nitrogen addition improve the carotenoids content from 0.46 mg/g at zero level to 0.47 mg/g at 4 g level at the 1st season while this value raised from 0.56 to 0.55 mg/g at the same nitrogen levels in the 2nd one.

Table 11. Effects of soil type and nitrogen addition on carotenoids content (mg/g) of *Salvia officinalis* L. during 2020/2021 and 2021/2022.

Treatments		1st season		2nd season	
Soil type	**Cut No.**	**Carotenoids**	**Mean**	**Carotenoids**	**Mean**
Clay	**Cut 1**	0.54	0.59	0.56	0.58
	Cut 2	0.64		0.60	
Sandy	**Cut 1**	0.50	0.55	0.52	0.55
	Cut 2	0.60		0.58	
L.S.D at 5%			0.067		0.065
Nitrogen					
0 g	**Cut 1**	0.46	0.49	0.45	0.50
	Cut 2	0.52		0.55	
2 g	**Cut 1**	0.55	0.59	0.57	0.60
	Cut 2	0.63		0.63	
4 g	**Cut 1**	0.59	0.63	0.56	0.60
	Cut 2	0.67		0.64	
L.S.D at 5%			0.026		0.072

Table 12. Effects of the interactions between soil type and nitrogen addition on carotenoids content (mg/g) of *Salvia officinalis* L. during 2020/2021 and 2021/2022.

Treatments			1st season		2nd season	
Soil type	**Nitrogen**	**Cut No.**	**Carotenoids**	**Mean**	**Carotenoids**	**Mean**
Clay	**0 g**	**Cut 1**	0.61	0.63	0.51	0.56
		Cut 2	0.65		0.61	
	2 g	**Cut 1**	0.63	0.67	0.62	0.63
		Cut 2	0.71		0.64	
	4 g	**Cut 1**	0.67	0.71	0.60	0.64
		Cut 2	0.75		0.68	
Sandy	**0 g**	**Cut 1**	0.42	0.46	0.44	0.47
		Cut 2	0.50		0.50	
	2 g	**Cut 1**	0.50	0.51	0.48	0.53
		Cut 2	0.52		0.58	
	4 g	**Cut 1**	0.54	0.56	0.51	0.55
		Cut 2	0.58		0.59	
	L.S.D at 5%			0.036		0.102

These results are in agreement with Rohricht *et al*. (1996) on *Salvia officinalis*, Amber *et al.* (2008) on *Salvia officinalis*, Badawy (2015) on *Pimpinlla anisum* L., Heikal *et al*. (2015) on rosemary plants, Ghoushchi *et al.* (2015), Rioba *et al.* (2015), Bagdat *et al*. (2017) and Amer *et al*. (2019) on *Salvia officinalis,* Khaledigan *et al*. (2021) on *Ocimum basilicum* and *Satureja hortensis*, and Gaafar *et al*. (2021) on *Hibiscus sabdariffa* L.

3. Chlorophyll a (mg/g):

a. Effects of soil type and nitrogen addition:

The effect of soil type and nitrogen addition individually on chlorophyll a during the both growing seasons were presented in Table (13). Clay soil treatment increased the chlorophyll a in clay soil which was 0.73 mg/g in both seasons compared with sand soil (0.70 and 0.71 mg/g) in the 1st and 2nd seasons, respectively. Similar results were reported by Bezzi (1987) on *Salvia officinalis* L., Rajeswara *et al.* (1990) and El-Sherbeiny *et al*. (1992) on *Pelargonium graveolens* L., Omidbaigi and Hornok (1992) on *Foeniculum vulgare* Mill., Rohricht *et al*. (1996) on *Salvia officinalis* L., Moghith *et al*. (2021) on chia (*Salvia hispanica*) and Gaafar *et al*. (2021) on *Hibiscus sabdariffa* L.

Concerning the nitrogen addition treatments, it could be noticed that the highest values of chlorophyll a were obtained at 4 g

Table 13. Effects of soil type and nitrogen addition on chlorophyll a (mg/g) of *Salvia officinalis* L. during 2020/2021 and 2021/2022.

Treatments		1st season		2nd season	
Soil type	**Cut No.**	**Chlorophyll a**	**Mean**	**Chlorophyll a**	**Mean**
Clay	**Cut 1**	0.71	0.73	0.70	0.73
	Cut 2	0.75		0.76	
Sandy	**Cut 1**	0.65	0.70	0.68	0.71
	Cut 2	0.75		0.74	
L.S.D at 5%			0.109		0.129
Nitrogen					
0 g	**Cut 1**	0.55	0.59	0.62	0.60
	Cut 2	0.63		0.57	
2 g	**Cut 1**	0.76	0.73	0.72	0.74
	Cut 2	0.70		0.76	
4 g	**Cut 1**	0.82	0.81	0.80	0.82
	Cut 2	0.80		0.84	
L.S.D at 5%			0.026		0.035

nitrogen level which were 0.81 mg/g in the 1st season and 0.82 in the 2nd season compared to plants treated with 0 and 2 g. Similar results were reported by Abaas (2014), Sönmez and Bayram (2017) on *Salvia officinalis,* Abdelkader *et al*. (2017) on *Cyperus esculentus,* Amer *et al*. (2019) on *Salvia officinalis,* Katar *et al*. (2021) on *Salvia fruticosa* Mill. Khaledigan *et al*. (2021) on *Salvia officinalis.*

b. Effect of the interaction between soil type and nitrogen addition:

Data in Table (14) presented the interactions between soil type and nitrogen addition on the chlorophyll a. The highest value was obtained in clay soil plus nitrogen addition (4 g) as produced 0.83 and 0.84 mg/g during the two seasons of study, respectively. These results are in agreement with Rohricht *et al*. (1996) on *Salvia officinalis*, Amber *et al.* (2008) on *Ocimum basilcum*, Rioba *et al.* (2015) on *Salvia officinalis*, Ghoushchi *et al.* (2015) on *Salvia officinalis*, Badawy (2015) on *Pimpinlla anisum* L., Heikal *et al*. (2015) on rosemary plants, Bagdat *et al*. (2017) and Amer *et al*. (2019) on *Salvia officinalis*, Youssef *et al*. (2019) on *Swietenia mahagoni*, Khaledigan *et al*. (2021) on *Ocimum basilicum* and *Satureja hortensis* and Gaafar *et al*. (2021) on *Hibiscus sabdariffa* L.

4. Chlorophyll b (mg/g):

a. Effects of soil type and nitrogen addition:

The effect of soil type and nitrogen addition on chlorophyll b during both growing seasons of the study were presented in Table (15). The content of chlorophyll b in sage plants was increased in clay soil resulting 0.65 and 0.66 mg/g in the 1st and 2nd seasons, respectively compared with sandy soil which were 0.54 and 0.56 mg/g in the 1st and 2nd seasons, respectively. these results were in harmony with Bezzi (1987) on *Salvia officinalis* L., Rajeswara *et al.* (1990) on *Pelargonium graveolens* L., Omidbaigi and Hornok (1992) on *Foeniculum vulgare* Mill, El-Sherbeiny *et al*. (1992) on *Pelargonium graveolens* L., Gaafar *et al*. (2021) on *Hibiscus sabdariffa* L. and Moghith *et al*. (2021) on chia (*Salvia hispanica*).

Concerning the nitrogen addition treatments, it could be noticed that the highest values of chlorophyll b resulted from 4 g nitrogen (0.61 mg/g in the 1st season and 0.66 mg/g in the 2nd season) compared with treating with 0 or 4 g levels. Similar results were achieved by Abaas (2014) on *Salvia officinalis,* Sönmez and Bayram (2017) on *Salvia officinalis,* Amer *et al*. (2019) on *Salvia officinalis,* also by Abdelkader *et al*. (2017) on *Cyperus esculentus,* Katar *et al*. (2021) on *Salvia fruticosa* Mill., Khaledigan

Table 14. Effects of the interactions between soil type and nitrogen addition on chlorophyll a (mg/g) of *Salvia officinalis* L. during 2020/2021 and 2021/2022.

Treatments			1st season		2nd season	
Soil type	Nitrogen	Cut No.	Chlorophyll a	Mean	Chlorophyll a	Mean
Clay	0 g	Cut 1	0.72	0.76	0.72	0.76
		Cut 2	0.80		0.80	
	2 g	Cut 1	0.80	0.82	0.80	0.81
		Cut 2	0.84		0.82	
	4 g	Cut 1	0.80	0.83	0.80	0.84
		Cut 2	0.86		0.88	
Sandy	0 g	Cut 1	0.54	0.57	0.52	0.57
		Cut 2	0.60		0.62	
	2 g	Cut 1	0.65	0.70	0.60	0.61
		Cut 2	0.75		0.62	
	4 g	Cut 1	0.79	0.82	0.67	0.71
		Cut 2	0.85		0.75	
L.S.D at 5%				0.036		0.060

Table 15. Effects of soil type and nitrogen addition on chlorophyll b (mg/g) of *Salvia officinalis* L. during 2020/2021 and 2021/2022.

Treatments		1st season		2nd season	
Soil type	Cut No.	Chlorophyll b	Mean	Chlorophyll b	Mean
Clay	Cut 1	0.63	0.65	0.64	0.66
	Cut 2	0.67		0.68	
Sandy	Cut 1	0.50	0.54	0.53	0.56
	Cut 2	0.58		0.59	
L.S.D at 5%			0.043		0.056
Nitrogen					
0 g	Cut 1	0.56	0.58	0.50	0.55
	Cut 2	0.60		0.60	
2 g	Cut 1	0.55	0.58	0.66	0.63
	Cut 2	0.61		0.60	
4 g	Cut 1	0.60	0.61	0.62	0.66
	Cut 2	0.62		0.70	
L.S.D at 5%			0.038		0.046

et al. (2021) on *Ocimum basilicum* and *Satureja hortensis.*

b. Effect of the interaction between soil type and nitrogen addition:

Data in Table (16) presented the effect of interactions between soil type and nitrogen addition on the chlorophyll b content. The high value of chlorophyll b content resulted from clay soil plus 4 g nitrogen/plant (0.66 and 0.71 mg/g) during 2020/2021 and 2021/2022 seasons, respectively. Sandy soil and nitrogen addition at 4g showed relatively less effect than clay soil (0.57 and 0.61mg/g) during 2020/2021 and 2021/2022 seasons, respectively.

The interactions between the two soil types with 0 and 2 g/plant were less affected on chlorophyll b content in the two seasons. These results are in agreement with Rohricht *et al*. (1996) on *Salvia officinalis*, Amber *et al.* (2008) on *Ocimum basilcum*, Rioba *et al.* (2015) on *Salvia officinalis*, Ghoushchi *et al.* (2015) on *Salvia officinalis*, Badawy (2015) on *Pimpinlla anisum* L., Heikal *et al*. (2015) on rosemary plants, Bagdat *et al*. (2017) and Amer *et al*. (2019) on *Salvia officinalis,* Youssef *et al*. (2019) on *Swietenia mahagoni*, Khaledigan *et al*. (2021) on *Ocimum basilicum* and *Satureja hortensis* and Gaafar *et al*. (2021) on *Hibiscus sabdariffa* L.

Table 16. Effects of the interactions between soil type and nitrogen addition on chlorophyll b (mg/g) of *Salvia officinalis* L. during 2020/2021 and 2021/2022.

Treatments			1st season		2nd season	
Soil type	Nitrogen	Cut No.	Chlorophyll b	Mean	Chlorophyll b	Mean
Clay	0 g	Cut 1	0.60	31.74	0.61	26.26
		Cut 2	0.62		0.65	
	2 g	Cut 1	0.60	34.74	0.59	29.61
		Cut 2	0.70		0.71	
	4 g	Cut 1	0.64	69.13	0.69	51.48
		Cut 2	0.68		0.73	
Sandy	0 g	Cut 1	0.46	29.70	0.46	15.43
		Cut 2	0.54		0.50	
	2 g	Cut 1	0.53	36.20	0.60	22.05
		Cut 2	0.59		0.62	
	4 g	Cut 1	0.54	54.15	0.57	23.04
		Cut 2	0.60		0.65	
L.S.D at 5%				0.058		0.066

5. Nitrogen percentage:

a. Effects of soil type and nitrogen addition:

Data in Table (17) presented the effect of soil type and nitrogen addition individually on nitrogen percentage during 2020/21 and 2021/22 growing seasons. Using clay soil as a planting media increased nitrogen percentage (2.62 and 2.64%) in the 1st and 2nd seasons, respectively compared with using sandy soil (1.98 and 2.01%) in the 1st and 2nd seasons, respectively.

Similar results were obtained by Bezzi (1987) *Salvia officinalis* Rajeswara *et al.* (1990) on *Pelargonium graveolens* L., Omidbaigi and Hornok (1992) on *F. vulgare* Mill, El-Sherbeiny *et al*. (1992) on *P. graveolens* L., Rohricht *et al.* (1996) on *Salvia officinalis* L., Badawy (1998) on *Polianthes tuberosa*, El-Fawakhry (2001) on tuberose, Youssef *et al*. (2019) on *Swietenia mahagoni*, Moghith *et al*. (2021) on chia (*Salvia hispanica*) and Gaafar *et al*. (2021) on *Hibiscus sabdariffa* L.

Concerning the nitrogen addition treatments, it could be noticed that the highest values of nitrogen percentage resulted from 4 g of nitrogen addition per plant in the 1st season (2.54%) and 2nd season (2.61%) compared to untreated (0 addition) or 2 g addition level. Similar results were reported by Abaas (2014) on *Salvia officinalis*, Sönmez and Bayram (2017) on *Salvia officinalis,* Amer *et al*. (2019) on *Salvia officinalis,* Abdelkader *et al*. (2017) on *Cyperus esculentus*, Katar *et al*. (2021) on *Salvia fruticosa* Mill. and Khaledigan *et al*. (2021) on *Ocimum basilicum* and *Satureja hortensis.*

b. Effect of the interaction between soil type and nitrogen addition:

Data presented in Table (18) show the interactions between soil type and nitrogen addition on nitrogen percentage of *Salvia officinalis* L. The highest nitrogen percentage resulted from clay soil plus 4 g nitrogen (2.91 and 2.85%) compared with the sandy soil at the same nitrogen level (2.31 and 2.39%) during 2020/21 and 2021/22 seasons, respectively.

These results are in agreement with Rohricht *et al*. (1996) on *Salvia officinalis,* Amber *et al.* (2008) on *Ocimum basilcum,* Rioba *et al.* (2015) on *Salvia officinalis,* Ghoushchi *et al.* (2015) on *Salvia officinalis,* Badawy (2015) on *Pimpinlla anisum* L., Heikal *et al*. (2015) on rosemary plants, Bagdat *et al*. (2017) and Amer *et al*. (2019) on *Salvia officinalis*, Youssef *et al*. (2019) on *Swietenia mahagoni*, Khaledigan *et al*. (2021) on *Ocimum basilicum* and *Satureja hortensis* and Gaafar *et al*. (2021) on *Hibiscus sabdariffa* L.

Table 17. Effects of soil type and nitrogen addition on nitrogen percentage of *Salvia officinalis* L. during 2020/2021 and 2021/2022.

Treatments		1st season		2nd season	
Soil type	Cut No.	Nitrogen percentage	Mean	Nitrogen percentage	Mean
Clay	Cut 1	0.60	2.62	1.62	2.64
	Cut 2	4.64		3.66	
Sandy	Cut 1	0.97	1.98	1.00	2.01
	Cut 2	2.99		3.02	
L.S.D at 5%			0.169		0.511
Nitrogen					
0 g	Cut 1	1.00	2.00	1.00	2.02
	Cut 2	3.00		3.04	
2 g	Cut 1	1.33	2.36	1.35	2.36
	Cut 2	3.39		3.37	
4 g	Cut 1	1.51	2.54	1.58	2.61
	Cut 2	3.57		3.64	
L.S.D at 5%			0.095		0.240

Table 18. Effects of the interactions between soil type and nitrogen addition on nitrogen percentage of *Salvia officinalis* L. during 2020/2021 and 2021/2022.

Treatments			1st season		2nd season	
Soil type	Nitrogen	Cut No.	Nitrogen percentage	Mean	Nitrogen percentage	Mean
Clay	0 g	Cut 1	1.30	2.31	1.38	2.39
		Cut 2	3.32		3.40	
	2 g	Cut 1	1.69	2.71	1.60	2.63
		Cut 2	3.73		3.66	
	4 g	Cut 1	1.87	2.91	1.80	2.85
		Cut 2	3.95		3.90	
Sandy	0 g	Cut 1	0.71	1.73	0.60	1.62
		Cut 2	2.75		2.64	
	2 g	Cut 1	1.00	2.01	1.00	2.05
		Cut 2	3.01		3.09	
	4 g	Cut 1	1.30	2.31	1.21	2.23
		Cut 2	3.32		3.25	
L.S.D at 5%				0.339		0.134

6. Phosphorus percentage:

a. Effects of soil type and nitrogen addition:

Results established in Table (19) showed the effect of soil type and nitrogen addition on the phosphorus percentage during 2020/2021 and 2021/2022 growing seasons. Phosphorus percentage in sage plants in clay soil was high (0.52 and 0.42%) compared with sand soil (0.37 and 0.31%) in the 1st and 2nd seasons, respectively. This result was acceptable because the clay soil was high in nutrient elements than poor sand soil, a similar results were achieved by Bezzi (1987) on *Salvia officinalis*, Rajeswara *et al.* (1990) on *Pelargonium graveolens* L., Omidbaigi and Hornok (1992) on *F. vulgare* Mill, El-Sherbeiny *et al*. (1992) on *P. graveolens* L., Rohricht *et al.* (1996) on *Salvia officinalis* L., Badawy (1998) on *Polianthes tuberosa*, El-Fawakhry (2001) on tuberose, Youssef *et al*. (2019) on *Swietenia mahagoni* and Moghith *et al*. (2021) on chia (*Salvia hispanica*).

Concerning the nitrogen addition treatments, it could be noticed that the highest values of phosphorus percentage were obtained at 4 g nitrogen level in the 1st season (0.39%) and (0.37%) in the 2nd one compared with treating with 0 and 2 g nitrogen levels. Similar results were achieved by Abaas (2014) on *Salvia officinalis*, Sönmez and Bayram (2017) on *Salvia officinalis,* Amer *et al*. (2019) on *Salvia officinalis,* Abdelkader

Table 19. Effects of soil type and nitrogen addition on phosphorus percentage of *Salvia officinalis* L. during 2020/2021 and 2021/2022.

Treatments		1st season		2nd season	
Soil type	**Cut No.**	**Phosphorus percentage**	**Mean**	**Phosphorus percentage**	**Mean**
Clay	**Cut 1**	0.48	0.52	0.39	0.42
	Cut 2	0.56		0.45	
Sandy	**Cut 1**	0.34	0.37	0.27	0.31
	Cut 2	0.40		0.35	
L.S.D at 5%			0.029		0.044
Nitrogen					
0 g	**Cut 1**	0.30	0.27	0.33	0.34
	Cut 2	0.24		0.35	
2 g	**Cut 1**	0.30	0.33	0.31	0.34
	Cut 2	0.36		0.37	
4 g	**Cut 1**	0.38	0.39	0.34	0.37
	Cut 2	0.40		0.40	
L.S.D at 5%			0.392		0.384

et al. (2017) on *Cyperus esculentus*, Katar *et al*. (2021) on *Salvia fruticosa* Mill. and Khaledigan *et al*. (2021) on *Ocimum basilicum* and *Satureja hortensis.*

b. Effect of the interaction between soil type and nitrogen addition:

Data illustrated in Table (20), showed the effect of interactions between soil type and nitrogen addition on the phosphorus percentage of sage plants (*Salvia officinalis* L.). The highest values of phosphorus percentage resulted from clay soil plus 4 g nitrogen addition (0.54 and 0.43%) during the two seasons of study, respectively, while sandy soil resulted in low phosphorus percentage at the same nitrogen level (0.33% in both seasons).

These results are in agreement with Rohricht *et al*. (1996) on *Salvia officinalis*, Amber *et al.* (2008) on *Ocimum basilcum*, Rioba *et al.* (2015) on *Salvia officinalis*, Ghoushchi *et al.* (2015) on *Salvia officinalis*, Badawy (2015) on *Pimpinlla anisum* L., Heikal *et al*. (2015) on rosemary plants, Bagdat *et al*. (2017) and Amer *et al*. (2019) on *Salvia officinalis,* Youssef *et al*. (2019) on *Swietenia mahagoni*, Khaledigan *et al*. (2021) on *Ocimum basilicum* and *Satureja hortensis* and Gaafar *et al*. (2021) on *Hibiscus sabdariffa* L.

7. Potassium percentage:

a. Effects of soil type and nitrogen addition:

Data dealing with the individual effects of soil type and nitrogen addition on potassium percentage during both growing seasons were presented in Table (21). Planting sage plants (*Salvia officinalis* L.) on clay soil increased the potassium percentage which was 0.97 and 0.94% in the 1st and 2nd seasons, respectively. But sandy soil showed less potassium percentage (0.56 and 0.55%) in the 1st and 2nd seasons, respectively. Similar results were reported by Bezzi (1987) on *Salvia officinalis*, Rajeswara *et al.* (1990) on *Pelargonium graveolens* L., Omidbaigi and Hornok (1992) on *F. vulgare* Mill., El-Sherbeiny *et al*. (1992) on *P. graveolens* L., Rohricht *et al.* (1996) on *Salvia officinalis* L., Badawy (1998) on *Polianthes tuberosa*, El-Fawakhry (2001) on tuberose, Youssef *et al*. (2019) on *Swietenia mahagoni*, Moghith *et al*. (2021) on chia (*Salvia hispanica*) and Gaafar *et al*. (2021) on *Hibiscus sabdariffa* L.

Concerning the nitrogen addition treatments, it could be noticed that the highest effective nitrogen level on potassium percentage was 4 g/plant which produced 0.77% in the 1st season and 0.78 in the 2nd one compared with treating with 0 or 2 g/plant. Similar results were achieved by

Table 20. Effects of the interactions between soil type and nitrogen addition on phosphorus percentage of *Salvia officinalis* L. during 2020/2021 and 2021/2022.

Treatments			1st season		2nd season	
Soil type	**Nitrogen**	**Cut No.**	**Phosphorus percentage**	**Mean**	**Phosphorus percentage**	**Mean**
Clay	**0 g**	**Cut 1**	0.48	0.44	0.35	0.40
		Cut 2	0.40		0.45	
	2 g	**Cut 1**	0.46	0.48	0.39	0.42
		Cut 2	0.50		0.45	
	4 g	**Cut 1**	0.50	0.54	0.40	0.43
		Cut 2	0.58		0.46	
Sandy	**0 g**	**Cut 1**	0.26	0.29	0.25	0.29
		Cut 2	0.31		0.33	
	2 g	**Cut 1**	0.30	0.32	0.30	0.32
		Cut 2	0.34		0.34	
	4 g	**Cut 1**	0.31	0.33	0.30	0.33
		Cut 2	0.35		0.36	
L.S.D at 5%				0.058		0.039

Table 21. Effects of soil type and nitrogen addition on potassium percentage of *Salvia officinalis* L. during 2020/2021 and 2021/2022.

Treatments		1st season		2nd season	
Soil type	**Cut No.**	**Potassium percentage**	**Mean**	**Potassium percentage**	**Mean**
Clay	**Cut 1**	0.95	0.97	0.98	0.94
	Cut 2	0.99		0.90	
Sandy	**Cut 1**	0.54	0.56	0.50	0.55
	Cut 2	0.58		0.60	
L.S.D at 5%			0.130		0.060
Nitrogen					
0 g	**Cut 1**	0.68	0.72	16.88	18.92
	Cut 2	0.76		20.96	
2 g	**Cut 1**	0.69	0.72	15.60	20.65
	Cut 2	0.75		25.70	
4 g	**Cut 1**	0.75	0.77	17.64	21.67
	Cut 2	0.79		25.70	
L.S.D at 5%			0.024		0.040

Abaas (2014) on *Salvia officinalis*, Sönmez and Bayram (2017) on *Salvia officinalis*, Amer *et al*. (2019) on *Salvia officinalis*, Abdelkader *et al*. (2017) on *Cyperus esculentus*, Katar *et al*. (2021) on *Salvia fruticosa* Mill. and Khaledigan *et al*. (2021) on *Ocimum basilicum* and *Satureja hortensis.*

b. Effect of the interaction between soil type and nitrogen addition:

Data presented in Table (22), revealed the effect of interactions between soil type and nitrogen addition which significantly affected potassium content in *Salvia officinalis* L. The highest potassium percentage was on clay soil plus 4 g nitrogen which were 1.06 and 0.98% during two seasons, respectively. These results are in agreement with Rohricht *et al*. (1996) on *Salvia officinalis*, Amber *et al*. (2008) on *Ocimum basilcum*, Rioba *et al*. (2015) on *Salvia officinalis*, Ghoushchi *et al*. (2015) on *Salvia officinalis,* Badawy (2015) on *Pimpinlla anisum* L., Heikal *et al*. (2015) on rosemary plants, Bagdat *et al*. (2017) and Amer *et al*. (2019) on *Salvia officinalis*, Youssef *et al*. (2019) on *Swietenia mahagoni*, Khaledigan *et al*. (2021) on *Ocimum basilicum* and *Satureja hortensis* and Gaafar *et al*. (2021) on *Hibiscus sabdariffa* L.

8. Essential oil percentage:

a. Effects of soil type and nitrogen addition:

Data dealing with the individual effect of soil type and nitrogen addition on the essential oil percentage during 2020/2021 and

Table 22. Effects of the interactions between soil type and nitrogen addition on potassium percentage of *Salvia officinalis* L. during 2020/2021 and 2021/2022.

Treatments			1st season		2nd season	
Soil type	**Nitrogen**	**Cut No.**	**Potassium percentage**	**Mean**	**Potassium percentage**	**Mean**
Clay	0 g	Cut 1	0.87	0.91	0.86	0.89
		Cut 2	0.95		0.92	
	2 g	Cut 1	0.97	0.98	0.65	0.81
		Cut 2	0.99		0.97	
	4 g	Cut 1	0.10	1.06	0.97	0.98
		Cut 2	2.02		0.99	
Sandy	0 g	Cut 1	0.50	0.52	0.48	0.52
		Cut 2	0.54		0.56	
	2 g	Cut 1	0.51	0.56	0.52	0.56
		Cut 2	0.60		0.60	
	4 g	Cut 1	0.55	0.59	0.53	0.57
		Cut 2	0.63		0.61	
L.S.D at 5%				0.034		0.057

2021/2022 growing seasons were presented in Table (23). Clay soil increased the essential oil percentage resulting 1.65 and 1.71 in the 1st and 2nd seasons, respectively, compared with sandy soil (5.57 and 4.79%) in the 1st and 2nd seasons, respectively. Similar results were achieved by Bezzi (1987) on *Salvia officinalis*, Rajeswara *et al.* (1990) on *Pelargonium graveolens* L., Omidbaigi and Hornok (1992) on *F. vulgare* Mill., El-Sherbeiny *et al*. (1992) on *P. graveolens* L., Rohricht *et al.* (1996) on *Salvia officinalis* L., Badawy(1998) on *Polianthes tuberosa*, El-Fawakhry (2001) on tuberose, Youssef *et al*. (2019) on *Swietenia mahagoni* and Moghith *et al*. (2021) on chia (*Salvia hispanica*).

Regarding the nitrogen addition treatments, it could be noticed that the highest values of essential oil percentage were obtained at 4 g nitrogen level being 1.52% in the 1st season and 1.47% in the 2nd one compared with treating with 0 or 2 g nitrogen levels. Similar results were reported by Abaas (2014) on *Salvia officinalis*, Sönmez and Bayram (2017) on *Salvia officinalis*, Abdelkader *et al*. (2017) on *Cyperus esculentus*, Amer *et al*. (2019) on *Salvia officinalis,* Katar *et al*. (2021) on *Salvia fruticosa* Mill. and Khaledigan *et al*. (2021) on *Ocimum basilicum* and *Satureja hortensis*.

b. Effect of the interaction between soil type and nitrogen addition:

Data presented in Table (24) showed a significant effect of the interaction between soil type and nitrogen addition on essential oil percentage. The highest oil percentage was on the treatment of clay soil plus 4 g nitrogen addition (1.69 and 1.74%) during two seasons, respectively. Also, it can be noticed that nitrogen addition improved oil percentage on sandy soil. These results are in agreement with Rohricht *et al*. (1996) on *Salvia officinalis,* Amber *et al.* (2008) on *Ocimum basilcum,* Rioba *et al.* (2015) on *Salvia officinalis*, Ghoushchi *et al.* (2015) on *Salvia officinalis*, Badawy (2015) on *Pimpinlla anisum* L., Heikal *et al*. (2015) on rosemary plants, Bagdat *et al*. (2017) and Amer *et al*. (2019) on *Salvia officinalis,* Youssef *et al*. (2019) on *Swietenia mahagoni*, Khaledigan *et al*. (2021) on *Ocimum basilicum* and *Satureja hortensis* and Gaafar *et al*. (2021) on *Hibiscus sabdariffa* L.

9. Essential oil components:

Table (25) shows the different components separated and identified from sage herb oil samples produced from growing the plants in two soil types treated with nitrogen addition.

The obtained chromatograms revealed the presence of 17 components of which 12 components were identified by the retention times obtained from pure reference compounds. The identified components in herb sage oil are α-pinene, camphene, β-pinene, thujone, cineole, trpinene, linalool, methyl chavicol, linalyl acetate, camphor, borneol and eugenol. The relative percentage

Table 23. Effects of soil type and nitrogen addition on essential oil percentage of *Salvia officinalis* L. during 2020/2021 and 2021/2022.

Treatments		1st season		2nd season	
Soil type	**Cut No.**	**Essential oil percentage**	**Mean**	**Essential oil percentage**	**Mean**
Clay	**Cut 1**	0.60	1.65	0.67	1.71
	Cut 2	2.70		2.75	
Sandy	**Cut 1**	0.22	1.26	0.5	1.33
	Cut 2	2.30		2.15	
L.S.D at 5%			0.077		0.038
Nitrogen					
0 g	**Cut 1**	0.36	1.42	0.30	1.33
	Cut 2	2.48		2.36	
2 g	**Cut 1**	0.40	1.43	0.39	1.43
	Cut 2	2.46		2.47	
4 g	**Cut 1**	0.48	1.52	0.44	1.47
	Cut 2	2.56		2.50	
L.S.D at 5%			0.104		0.093

Table 24. Effects of the interactions between soil type and nitrogen addition on essential oil percentage of *Salvia officinalis* L. during 2020/2021 and 2021/2022.

Treatments			1st season		2nd season	
Soil type	**Nitrogen**	**Cut No.**	**Essential oil percentage**	**Mean**	**Essential oil percentage**	**Mean**
Clay	**0 g**	**Cut 1**	0.57	1.61	0.63	1.66
		Cut 2	2.65		2.69	
	2 g	**Cut 1**	0.60	1.65	0.70	1.74
		Cut 2	2.70		2.78	
	4 g	**Cut 1**	0.64	1.69	0.71	1.74
		Cut 2	2.74		2.77	
Sandy	**0 g**	**Cut 1**	0.15	1.20	0.98	0.99
		Cut 2	2.25		1.00	
	2 g	**Cut 1**	0.18	1.24	0.8	1.48
		Cut 2	2.30		2.16	
	4 g	**Cut 1**	0.32	1.34	0.17	1.20
		Cut 2	2.36		2.22	
L.S.D at 5%				0.147		0.132

Table 25. Effects of the interactions between soil type and nitrogen addition on essential oil components rcentages of *Salvia officinalis* during 2020/2021 and 2021/2022 seasons.

Soil type	N	α -pinene	Camphene	β-pinene	Thujone	Cineole	Trpinene	Linalool	Methyl chavicol	Linalyl acetate	Camphor	Borneol	Eugenol	Unknown
Clay	**2 g**	2.10	2.79	3.14	1.52	3.21	9.95	1.23	0.98	44.08	9.13	3.98	5.99	12.58
	4 g	2.15	2.97	3.01	1.66	3.86	11.03	1.30	1.03	44.91	11.05	4.54	6.07	13.46
Sandy	**2 g**	2.14	2.19	2.31	1.19	3.22	8.92	1.22	0.90	42.13	9.24	3.52	5.73	9.84
	4 g	1.91	2.27	2.91	1.33	3.87	10.60	2.28	0.98	34.70	11.01	4.30	6.00	26.62

areas indicating the effect of the different treatments on the composition of each sample will be demonstrated. The results showed that, clay soil + 4 g nitrogen addition level resulted in the greatest value of α -pinene, camphene, thujone, cineole, trpinene, linalool, methyl chavico, linalyl acetate, camphor, borneol and eugenol compared with other treatments.

REFERENCES

Abaas, I.S. (2014). Study of biometric and volatile oil quantity of sage plant (*Salvia officinalis* L.) as medicinal plant affected by nitrogen and phosphorus fertilizers. Inter. J. of Pharmacy and Pharmaceutical Sciences, 6(6):82-83.

AbdelKader, H.H.; El-Ghadban, E.A.; Ibrahim, Fatma R. and Ahmed, Manal A. (2019). Effect of some soil additives and mineral nitrogen fertilizer at different rates on vegetative growth, tuber yield and fixed oil of tiger nut (*Cyperus esculentus* L.) plants. J. Plant Production, Mansoura Univ., 8(1):39-48.

Abdel-Sattar, M.; Allam, Samira S. and Nabih, A. (2010). Response of *Polianthes tuberosa*, L. plant to different growing media and GA_3. Egypt. J. Bioticnol., 35:149-171.

Al- Sayed, H.M.; Hegab, S.A.; Youssef, M.A. and Khalafalla, M.Y. (2019). Integrated effect of inorganic and organic nitrogen sources on growth and yield of roselle (*Hibiscus sabdariffa* L.). Assiut J. Agric. Sci., 50(3):164-183.

Amber, H.; Arvind, K.; Promod, K. and Zalar, A. (2008). Effect on nitrogen levels on growth, herb yield and essential oil content of *Ocimum basilcum* (sweet basil). India J. Trop. Biodiversity, 15(2):140-143.

Amer, Heba M.; Salah, H.; Salem, S.S.; Mohamed, S.H. and Abd El-Fatah, Sally I. (2019). The growth, chemical composition and evaluation of antimicrobial activity of *Salvia officinalis* oil under partial substitution of mineral NPK fertilizer by bio-fertilizer. Middle East J. Agric., 8(2):457-468.

Badawy, O.E.F. (1998). Physiological and Anatomical Studies on Tuberose Bulbs. Ph.D. Thesis, Fac. Agric., Cairo Uni., Egypt, 321 p.

Badawy, Y.M. (2015). Studying the possibility of cultivating *Pimpinella anisum* L. plant under Sinai conditions by using chemical fertilization and mycorrhiza. Egyptian J. Desert Res., 65(2):215-232.

Bagdat, R.B.; Craker, L.E. and Yuksel, K. (2017). The effect of fertilization and mycorrhiza inoculation on yield variables and essential oil characteristics of *Salvia. officinalis* L. growing in the greenhouse and at the field. Indian J. Pharmac. Educ. and Res., 51(3):341-348.

Barbara, K. (2002). The effect of soil material and nitrogen fertilization on growth and development of (*Solidago virgaurea* L.). Folia Hort., 14(1):187-193.

Bezzi, A. (1987). A fertilizer trial of *Salvia officinalis* L. Forest Hort. Abst., 58:315-335.

British Pharmacopoeia (1983). Determination of Volatile Oils in Drugs. The Pharmaceutical Press, London, UK, 1210 p.

Daisley, G. (1982). The Illustrated Book of Herbs. American Nature Press, New York, USA, 128 p.

Devi, M.C. and Reddy, M.N. (2002). Phenolic acid metabolism of groundnut (*Arachis hypogea* L.) plants inoculated with VAM fungus and Rhizobium. Plant Growth Regul, 37:151-164.

El-Fawakhry, F.M. (2001). Studies on Some Factors Affecting Growth, Flowering and Bulb Productivity of *Polianthes tuberosa*, L. plant. Ph.D. Thesis, Fac. Agric., Kafr El-Sheikh, Tanta Univ., Egypt, 132 p.

El-Nashar, Y.I. (2016). Growth responses of calendula (*Calendula officinals* L.) to temperature regimes and different soil types. Alexandria Science Exchange Journal, 37(2):139 – 150.

El-Sherbeiny, S.E.; Aouleila, B.H. and Hussein, M.S. (1992). Influence of soil types on growth, oil and carbohydrate content of geranium cuttings. J. Physiological Sci., 16(1-2):151-161.

Gaafar, Doaa E.; Baka Z.A.M.; Abou-Dobara, M.I.; Shehata, Heba S. and El-Tapey, H.M.A. (2021). Microbial impact on growth and yield of *Hibiscus sabdariffa* L. on sandy soil fertility. Egypt. J. Soil. Sci., 61:259-274.

Ghoushchi, M.J., Abbaszadeh, B. and Oraei, M. (2015). Effects of chemical and biological fertilizers on growth, yield and essential oil of *Salvia officinalis*. Journal of Medicinal Plants and Byproducts, 1:31-37.

Giannoulis, K.D.; Skoufogianni, E. and Danalataos, N. G. (2021). Growth and productivity of *Salvia officinalis* L. under Mediterranean climatic conditions depends on biofertilizer, nitrogen fertilization, and sowing density. Industrial Crops and Products, 160:113 - 136.

Gomez, K.A. and Gomez, A.A. (1984). Statistical Procedures for Agricultural Research. John Wiley & Sons, New York, USA, 680 p.

Greenhalgh, P. (1979). The Market for Culinary Herbs. University of Wisconsin, Madison, USA, 170 p.

Gülser, C.; Candemir, F. and Demir, Z. (2010). Effect of Plant Growth on Some Physical Properties of Different Textured Soils. Proc. the International Soil Science Congress on Management of Natural Resources to Sustain Soil Health and Quality. Ondokuz Mayis Univ., Samsun, Turkey, May 26-28.

Gurumurthy, S.B. and Sreenivasa, M.N. (1998). Response of chilli to different inoculum levels of *Glomus macrocarpum* in two soil types of northern Karnataka. Karnataka J. Agric. Sci., 9(2):254-259.

Heftmann, E. (1967). Chromatography, 2nd Ed. Reinhold Publishing Corporation, 851 p.

Heikal, Amaal A.M. and Helmy, Samia S. (2015). Effect nitrogen fertilization and ascorbic acid on growth, essential oil and chemical composition of rosemary plant. Middle East Journal of Agriculture Research, 8(2):457-468.

Herbert, D.; Philipps, P.J. and Strange, R.E. (1971). Determination of total carbohydrates. Methods in Microbiology, 5:290-344.

Jackson, M.L. (1967). Soil Chemical Analysis. Prentice-Hall of India Pvt. Ltd., New Delhi, 498 p.

Kandeel, A.M. and Sharaf M.S. (2003). Productivity of *Majorana hortensis*, L. plants as influenced by the interaction between mineral and biological fertilization. J. Agric. Sci. Mansoura Univ., 28(2):1373-1389

Katar, D.; Katar, N. and Can, M. (2021). Agricultural and quality characteristics of sage (*Salvia fruticosa* Mill.) depending on nitrogen applications. J. Plant Nutrition, 45(10):1441-1449.

Khaledigan, N.; Weisany, W. and Schenk, P.M. (2021). Arbuscular mycorrhizae and rhizobacteria improve growth, nutritional status and essential oil production in *Ocimum basilicum* and *Satureja hortensis*. Industrial crops and products 160:113-163.

Klute, A. (1986). Methods of Soil Analysis, Part 1, Physical and Mineralogical Methods, 2nd Ed. American Society of Agronomy, Madison, Wisconsin, U.S.A., 1188 p

Magalhaes, P.; Raharinaivo, J. and Delabays, N. (1995). Effect of the amount and the type of nitrogen fertilization on the artemisinin production of *Artemisia annua* L. Revue Suisse De Viticulture, Arboriculture, Horticulture, 28(6):349-353.

Moghith, W.M.A.; Youssef, A.S.M.; Abd El-Wahab, M.A.; Mohamed, Y.F.Y. and Abou El-Ghait, Eman M. (2021). Effect of arbuscular mycorrhizal fungi and some phosphorus sources on growth, seeds yield, chemical compositions, oil productivity and fixed oil constituents of chia (*Salvia hispanica* L.) Plant. Ann. Agric. Sci. Moshtoher, 59:541 – 562.

Murphy, J. and Reily, J.P. (1962). A modified single method for determination of phosphorus in natural water. Anal. Chem. Acta., 27:31-36.

Omidbaigi, R. and Hornok, L. (1992). Effect of N fertilization on the production of fennel (*Foeniculum vulgare* Mill). Acta Hort., 306(30): 249 -252.

Page, A.L.; Miller, R.H. and Kenney, D.R. (1982). Methods of Soil Analysis, Part 2, 2nd ed. Amer. Soc. Agron. Wisconsin, USA., 1159 p.

Piper, C.S. (1947). Soil and Plant Analysis. The Univ. of Adelaide, Australia, 368 p.

Rajeswara, B.R.: Ashingh, K.; Battacharya, A. K. and Naovi, A.A. (1990). Effect of prilled urea and modified quality of gerainum (*Pelargonium graveolens* L.). Fertilizer Res., 23(2):81-85.

Reinhardt, J.; Hilgert, P. and Cossel, V.M. (2021). A review of industrial crop yield performances on unfavorable soil types. Agronomy, 11(12):1-31. https://doi.org/10.3390/agronomy11122382

Rioba, N.B.; Itulya, F. M.; Saidi, M.; Dudai, N. and Bernstein, N. (2015). Effects of nitrogen, phosphorus and irrigation frequency on essential oil content and composition of sage (*Salvia officinalis* L.). J. Appl. Research on Medicinal and Aromatic Plants, 2:21-29.

Rohricht, C.; Grunert, M. and Solf, M. (1996). The influence of graduated nitrogen fertilizer application on yield and quality of sage (*Salvia officialism* L.). Zeits Chrift Fur Arznei and Gewurzpflanzen, 1(3):117-122.

Sardoei, A.S. and Rahbarian, P. (2014). Effect of different media on growth indexes of ornamental plants under system mist. Euro. J. Exp. Bio., 4(2):361-365.

Saric, M.; Kastrori, R.; Curie, R.; Cupina T. and Gerie, I. (1976). Chlorophyll determination. Univ. Unoven Sadu Parktikum is fiziologizeBibjoke, Beagard, Hauncna, Anjig. 215. Curr. Sci., 5:23-25.

Sonmez, C. and Bayram, E. (2017). The influence of different water and nitrogen application on some yield parameters and antioxidant activity in sage (*Salvia officinalis L*.). Turk J. Field Crops, 22(1):96-103.

Wilde, S.A.; Corey, R.B.; Lyer, J. G. and Voight, G.K. (1985). Soil and plant Analysis for Tree Culture,3rd ed. Oxford and IBM Publishing Co., New Delhi, India, 217 p.

Youssef, N.M.; El Habba, E.; Abd El-Aziz, N.G.; Mazhar, A.A.; Sarhaan, A.M.Z. and Arafa, A.M.S. (2019). Influence of using NPK fertilizer on vegetative growth and nutrients content of *Swietenia mahagoni* (L.) Jacq. plants growing in different media types. Current Science International, 8:62-69.

تأثير نوع التربة والتسميد النيتروجيني على النمو الخضري والمحصول والتركيب الكيماوي لنبات المريمية

شكري محمود سليم*، فيصل محمود عبدالمجيد مطر*، محاسن عبدالغني صدقي**، محمد مخيمر صبرة دسوقى***

* قسم البساتين ، كلية الزراعة، جامعة الفيوم، الفيوم، مصر

** قسم بحوث النباتات الطبية والعطرية، معهد بحوث البساتين، مركز البحوث الزراعية، الدقي، القاهرة، مصر

هدفت التجارب إلى معرفة التأثيرات الفردية والجماعية للنيتروجين عند ثلاثة تركيزات على شكل نترات الأمونيوم (٣٣٫٥٪ ن) (صفر، ٢ و ٤ جم/نبات) تحت تأثير نوعين من التربة (الطينية والرملية) على النمو الخضري والتركيب الكيميائي ومكونات الزيت العطري لنبات المريمية. أكدت النتائج أن استخدام الأسمدة النتروجينية تحت نوعين من التربة كان له استجابة معنوية على جميع المتغيرات في هذه الدراسة. كما أدى ذلك إلى دعم مؤشرات النمو الخضري وتعزيز التركيب الكيميائي وزيادة نسبة الزيت والمكونات الكيميائية للزيت العطري، خاصة عند استخدام التربة الطينية ومستويات عالية من النيتروجين. بالإضافة إلى ذلك، فإن التفاعل بين مستويات الأسمدة النيتروجينية ونوع التربة أدى إلى تحسين جميع الصفات المدروسة، خاصة استخدام التسميد النتروجيني بمعدل ٤ جرام/نبات مع الزراعة في تربة طينية.