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Article

Effect of harvest dates, mycorrhiza, and some biostimulants on some vegetative growth properties and yield of volatile oil for sweet scented geranium plant (*Pelargonium graveolens* L.Herit.)

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ABSTRACT

The experiment was carried out in one of the fields of Research Station B in the College of Agricultural Engineering Sciences / University of Baghdad - Al-Jadiriya on the fragrant plant for the spring season 2021 in order to study the effect of harvest date, mycorrhiza, bio-stimulants and the interaction among them on some characteristics of vegetative growth and the essential oil yield of sweet-scented geranium plants. The experiment used a randomized complete block design (RCBD) with a split-plot design with three replications. The experiment included three factors, as the factor of harvest dates represents the main panels with two harvest dates, which are 60 and 90 after planting and symbolized by H1 and H2. In contrast, the secondary panels include the treatment of the mycorrhizal fungal vaccine by two treatments, namely, not adding the mycorrhizal fungal vaccine to the root system and adding it with symbols M1 and M2 As for the sub-secondary panels, the treatments include four stimulating factors: the measurement treatment and the spraying of the vegetative mass with the amino acid phenylalanine at a concentration of 300 mg l^{-1}. The treatment of spraying the foliage with moringa leaf extract at a concentration of 10 gm L^{-1} and the treatment of spraying the foliage with licorice root powder extract at a concentration of 10gm L⁻¹symbolized by B1, B2, B3, and B4 respectively. The results showed the superiority of the H2 treatment in most indicators of vegetative growth, as well as the increase in the percentages of each of the nutrients and volatile oil in the dried leaves and the volatile oil yield in the dried leaves. Treatment M2 significantly increased all vegetative growth characteristics as well as the percentages of nutrients and volatile oil in dried leaves and volatile oil yield in dried leaves. In contrast, treatment B3 showed an increase in the number of main branches, total number of leaves, total leaf area, fresh and dry weight of leaf yield in the plant and the content of The dried leaves of total chlorophyll as well as the percentages of nutrients and volatile oil in the dried leaves of the plant and the yield of volatile oil in the dried leaves. In contrast, treatment B2 had a significant effect in increasing the plant height rate, the number of main branches and the fresh weight of the leaves. It is one of the most prominent triple interaction treatments recorded. The largest increase in all the traits studied above is the triple interaction H2M2B3 treatment, which was characterized by an

increase in most vegetative growth characteristics, especially the wet and dry weight of leaves and the percentages of nutrients as well as the percentage of volatile oil and volatile oil yield in the leaves. The triple interaction treatment H2M2B4 was also characterized by its recording of Remarkable superiority in both plant height and leaf content of Total chlorophyll and potassium percentage.

Keywords: Sweet-scented geranium plant, Harvest date, Mycorrhizae, Biostimulants, vegetative growth, volatile oil.

INTRODUCTION

The production of secondary compounds in medicinal and aromatic plants is affected by several factors, including the harvest date of the plant [26], bio-fertilizers [14] and bio-stimulators [51]. The rose-scent plant is one of the important aromatic medicinal plants that enter the pharmaceutical and aromatic industries, especially perfumes and aromatherapy. It is scientifically known as Pelargonium graveolens L.'Herit of the Geraniaceae family [58]. The importance of the medicinal plant is due to its volatile oil, which is a complex mixture of volatile chemical compounds and includes many groups, the most important of which are turbines, which include geraniol, linalool, citronellal and the components of citronellyl formate and its esters, which generally constitute percent. 50 -70%, and this percentage makes up a large portion of the essential oils responsible for their fragrance [43]. Determining the correct harvest date for the sweet-scented geranium plant is very important to obtain the maximum productivity of the foliar yield and the essential oil with high quality [23]. The quantity and quality of the oil and the proportions of the active compounds that make up the sweet-scented geranium plant are affected by several factors, the most important of which are environmental conditions and composition. Genetics, plant physiology, and the distillation methods that affect the yield, components and composition of the oil, the age stage of leaf development, the number of harvest times, and the date and season of harvest [18]. Mosta explained [41] that sweet-scented geranium plants that were harvested four months after planting the seedlings gave the highest amount of the total yield of leaves and volatile oil compared to the plants whose leaves were harvested two months after planting the seedlings. After four months of planting, the total yield of the leaves of the plants that were harvested after four months of planting increased compared to the plants that were harvested after two months of being planted in the field, which gave a lower total leaf yield. However, the plants harvested two months after planting the seedlings were distinguished. The number of oil glands increased in plants. However, this relationship between the number of oil glands and the total vegetative yield was not significant, in addition to the fact that the oil glands were not filled with volatile oil and had very small sizes, which is due to the physiology of the plant. In recent years, the use of bio-fertilizers and bio-stimulants has increased in promoting the growth and production of crops and plants, including medicinal and aromatic plants, due to their therapeutic value and being one of the safe and environmentally friendly methods. Mycorrhizal fungus, which is added as a bio-fertilizer to the root of the plant, is known as one of the symbiotic fungi that infect the roots of fifty types of medicinal plants belonging to nineteen different plant families, including the geranium family. The mechanism of action of the mycorrhizal fungus lies in its formation of a symbiotic relationship with the roots of the host plant that infects it, which leads to an increase in the characteristics of vegetative growth and production and the accumulation of active substances in the plants it infects as a result of the increase in the root area of plants inoculated with the mycorrhizal fungus, causing an increase in the absorption of nutrients from the soil

and thus Sustainability of the ecosystem by finding new production strategies in the plant affected by this type of fungus that is necessary to sustain the management of the agricultural ecosystem by stimulating the accumulation of active substances in medicinal plants such as turbines such as volatile oils [28]. Research and studies have concluded that the relationship of mycorrhizal to the increase of terpene compounds comes from the fact that it works to supply the plant with nutrients [32] and on the other hand, it works to increase carbohydrates and sugars that may form the carbon structures of terpene compounds [64]. It works to cause an increase in the height of the plant, the total yield of leaves, the fresh and dry weight, and an increase in the percentage of nutrients such as nitrogen, potassium and phosphorous [52, 15, 49.] The investment of carbon significantly in the process of photosynthesis in leaves, and the second factor is that the mycorrhizal fungus improves the nutritional process of the host plant by supplying the plant with water and nutrients necessary for its growth, including phosphorous [36]. Natural extracts are a good source of bio-stimulants, so they are used as bio-stimulants for both agricultural and horticultural crops to improve growth, public health and plant vitality, as well as increase plant resistance to pathogens due to their content of compounds, amino acids, plant hormones, proteins and nutrients that increase the productivity of the plant and the accumulation of active substances in it. By increasing both the absorption of elements and the plant's tolerance to abiotic stresses, and given what has been mentioned, the best application for the use of natural extracts is in the form of an extract that is sprayed on the foliar mass instead of adding it to the soil because it works to increase the characteristics of vegetative growth and nutrients as well as the quantity and quality of secondary compounds In the plant [20]. [40] concluded that the treatment of the rose-scent plant by foliar spraying with the amino acid phenylalanine at a concentration of 100 mg/L gave the highest plant height and an increase in the fresh and dry weight, the number of main and secondary branches of the plant, the percentage of the total volatile oil, the volatile oil yield and the total protein. The amino acid phenylalanine may have a role in the mechanics of phytochemicals of the Pelargonium graveolens through its effect on the metabolism of terpenes, volatile oils, protein and endogenous hormones. [54] showed that using an aqueous extract of Moringa leaves as a spray on the shoots of sweet-scented geranium plants at a concentration of 6 gm L⁻¹ led to an increase in both vegetative growth characteristics compared to untreated plants. Geranium (*Pelargonium zonale* L.) with aqueous extract of licorice roots at a concentration of 3 gm L⁻¹ led to an increase in the total chlorophyll content of the leaves, the number of total branches, the leaf area and the dry weight of the vegetative group compared to the control treatment, which recorded a decrease in the same characteristics. The reason was attributed to the fact that the aqueous extract contained root powder. The licorice plant contains mevalonic acid, the initiator of the biosynthesis of gibberellin, which increases the incidence of division and cell elongation, which is positively reflected in the growth of the plant and the improvement of its vegetative and floral characteristics [1] as well as the elements included in the composition of the extract, which had an effective role in activating the work of enzymes, division and elongation of cells building proteins and increasing the manufacture of nutrients that helped in the growth of plant tissues, which was reflected in giving the largest amount of flowers [12]. Therefore, this study aimed to show the effect of harvest dates, mycorrhizal biofertilizer and spraying with bio-stimulants on vegetative growth characteristics, volatile oil yield and its percentage in sweet-scented geranium plants to determine the best date for harvesting fragrant plants under the conditions of Baghdad region with the highest percentage of volatile oil and its yield in leaves.

MATERIALS AND RESEARCH METHODS

The experiment was conducted in research station B at the College of Agricultural Engineering Sciences / University of Baghdad - Al-Jadiriya on the sweet-scented geranium plant for the period from 2/4/2021 to 1/8/2021 in order to study the effect of harvest date, mycorrhizal, bio-stimulants and the interaction between them on vegetative and root growth indicators and yield The essential oil of Pelargonium graveolens L.Herit. The field was plowed, smoothed and divided into 3 terraces. The distance between one terrace and another was 1 m, and the width of the meers was 1 m. The planting distances between the plant and the last were 40 cm. The field was provided with a network of T-tape drip tubes. The experiment included three factors:

The first factor is the date of harvest. Harvesting date: It was denoted by the symbol H, which included the main parameters in the main plot. It consisted of two dates for harvest, and according to what Gebremeskel and Woldetsadik [27] found, the best dates for harvesting the sweet-scented geranium plant according to the weather conditions of the Islamic Republic of Iran are harvest dates 90 and 120 days after the transfer of seedlings, as some modifications were made to the harvest dates following the weather in Iraq due to the high at temperatures above 40 C˚ during the growing season and to maintain the amount of volatile oil in the plant, the harvest periods were two dates, as follows:

1. The date of the first harvest, symbolized by H1, was on 15/6/2021, 60 days after planting. Note that the process of harvesting the fragrant plant took place when the plant reached the stage of maturity, which was inferred when the flowering rate of plants reached more than 50%, according to what was mentioned by Gebremeskel and Woldetsadik [27], knowing that the harvesting process took place in the early morning and according to what was mentioned before cylindrical [4].
2. The date of the second harvest, which H2 symbolizes, was on 7/14/2021, that is, 90 days after planting.

The second factor is the mycorrhizal fungus vaccine: It included two treatments, which are both the addition and non-addition of the bio-fertilizer *Glomus mosseae*, which was randomly distributed under the main treatments (Subplot) and symbolized by the symbol M as shown below:

- M1: treatment without the addition of mycorrhizal vaccine.
- M2: Treatment of adding mycorrhizal vaccine.

100g added. Plant-¹, according to Amiri et al. [13], from the bio-mycorrhizal vaccine to the seedling planting room with the addition of 250 g of sterilized peat moss according to the method mentioned by [10]. It was loaded on soil containing small pieces of the roots of maize plants infected with mycorrhiza.

The Third Factor: Bio-stimulators: The third factor included the use of four spray treatments on the paper total of the stimuli, which were randomly distributed under the sub-plot (sub-sub plot), which was symbolized by the symbol B, by four sprays. It was stated by [16] and as illustrated by the following transactions:

- B1: Measurement treatment (Control) and the foliar mass were sprayed with distilled water only.
- B2: Spraying treatment with the amino acid phenylalanine at 300 mg Ī¹. According to the findings of [39].
- B3: Spray treatment with powdered extract of dried Moringa leaves at a concentration of 10 gm Ī¹. The dried moringa leaf extract was prepared according to the method described in [25]
- B4: Spraying treatment with dried licorice root powder extract at 10 gm Ī.¹ The extract of licorice root powder was prepared according to the method described by [5] and the concentration recommended by [11]

The stimuli treatments were randomly distributed, thus resulting in 48 experimental units (2 x 2 x 4 x 3), each experimental unit containing eight plants. The measured data were taken, and the results were statistically analyzed according to the design mentioned above using the statistical program version 7-Genstat according to the analysis method of variance 5% [2, 3].

Planting seedlings

A drip irrigation system moistened the land before planting the seedlings. Then, it was irrigated immediately after planting the first date and the second date. The seedlings prepared in advance for the plant were planted on both sides of the terrace by 8 plants per treatment, and the distance between one plant and another was 40 cm. The agricultural service operations were carried out similarly for all transactions.

Field environment					
Average number of hours of sunshine QF	Relative humidity%	Minimum temperature C°	Maximum temperature C°	Days	**Month**
9	22.63	14.01	30.6	1	**April**
	23.37	14.97	31.78	2	
	30.09	21.22	38.76	3	
11.3	29.93	21.42	38.29	1	**May**
	33.19	22.9	42.01	2	
	33.02	23.06	41.72	3	
12.1	29.63	22.9	42.15	1	**June**
	32.60	24.65	40.6	2	
	36.82	25.12	46.51	3	
12.5	36.89	25.79	46.19	1	**July**
	34.51	27.86	46.94	2	

Table 1. Maximum and minimum temperatures (◦C), relative humidity (%) and average number of hours of sunshine for the agricultural field * (1) represents the average of the first ten days of the month. * (2) represents the average of the second ten days of the month. * (3) represents the average of ten to eleven days, the third of the month according to the Gregorian calendar. ** The maximum and minimum temperatures, relative humidity and solar brightness of the field were obtained from the Ministry of Transport and Communications / Meteorological Department in Baghdad for 2021 for station 650.

Characteristics of vegetative growth:

Five plants were randomly selected from the middle of the planting line to measure the characteristics of vegetative growth, and after the completion of the biostimulant spraying treatments and according to the harvest dates that were determined when the treatments entered the flowering stage by 50%, then the rate was calculated

Average plant height (cm):

The length of the plant was measured by measuring tape from the soil surface to the top of the plant at the start of entry for each harvest date for each plant of the selected experimental unit and divided by the number of measured plants.

Average number of main branches per plant (prime branch of a plant):

The number of main branches of each plant of the selected experimental unit was calculated and divided by the number of plants measured.

Average number of total leaves per plant (leaf¹):

The number of leaves for each plant of the measured experimental unit was calculated after the start of the harvest dates and the average was calculated.

Average total leaf area of the plant (dm² plant-1):

Ten leaves were randomly selected for each of the five selected plants, starting from the bottom to its top, and the average area of one leaf was calculated and then multiplied by the number of leaves per plant. [57] Then calculate the result according to the following equation:

$$\text{Average area of one sheet } (cm^2) = (\text{The total leaf area of a plant} / \text{The total leaf area of a plant}) \times \text{number of leaves per plant} \quad (1)$$

Average dry weight of the vegetative complex in a plant (gm plant ¹):

The shoots were dried at the temperature of a ventilated room after they were placed on sheets of cardboard with the process of stirring the samples from time to time until complete dryness and stability of the weight. The dry weight of each plant of the measured experimental unit was calculated, and the average was extracted.

Average area of one leaf per plant (cm^2 $plant^{-1}$):

Ten leaves were randomly selected for each of the five selected plants, starting from the bottom to its top, and the average area of one leaf was calculated using a scanner using the Digimizer program downloaded on a Dell computer and then extracted the average [6].

Determination of total chlorophyll content in fresh leaves (mg. 100gm^{-1} fresh wt):

The total chlorophyll content of fresh leaves was determined according to the method described by Goodwin [30].

Average wet weight of leaf yield per plant (gm plant-1):

After the leaves were separated from the branches and stems, and after each harvest date, the soft leaves were weighed Only for each plant of the experimental unit measured and averaged.

Average dry weight of leaf yield per plant (gm plant-1):

After the leaves were separated from the branches and stems and after each harvest date, the leaves were dried by placing them on sheets of cardboard in ventilated rooms and then turning them over continuously until the weight was stable and the average was calculated

Estimation of the nutrients in the leaves:

The fourth leaf was taken from the developing apex of the main stem of five randomly selected plants from each experimental unit. The leaves were washed with distilled water to remove dirt and dust, then placed on a clip to get rid of the suspended water, then spread on cardboard and dried in a room at a temperature between 25-30 ° C. Container on a vacuum with continuous stirring until the stability of the weight, then crushed and placed in plastic bags Sealed and kept in a dry place. The wet digestion process was carried out by taking 0.2 g of the plant sample and digesting it using sulfuric and perchloric acid in a ratio of 3:5. According to the method proposed by Cresser and Parson [19] and after completing the digestion process, the following elements were estimated:

Determination of Nitrogen in Leaves:

Estimate total nitrogen according to the method described by [33].

Determination of Phosphorous in Leaves:

It was estimated using ammonium molybdate blue modified by [35] after adjusting the degree of reaction of the used solutions using paratrophenol dye as a guide and then measuring it by spectrophotometer at wavelength 882 [47].

Determination of Potassium in Leaves:

It was estimated according to the method of flame photometer [63].

Determination of the percentage of volatile oil (%):

The oil was extracted using the water distillation method mentioned by cylinder [4] with some modifications. Then, the oil was collected for each treatment and kept in opaque bottles with a tight-fitting lid and kept in the refrigerator at a temperature of 4° C ˚ until the tests were conducted. The volatile oil percentage was estimated according to the equation mentioned before [31].

Percentage of volatile oil = weight of the resulting oil (gm) / weight of the plant sample (gm) x 100 (2)

Estimation of the yield of volatile oil in a plant (gm.plant^{-1}):

According to the following equation:

The yield of volatile oil (gm) = the percentage of volatile oil x the yield of the plant from dry leaves (3)

RESULTS AND DISCUSSION

Average plant height (cm):

The results of Table 2 indicate a significant effect of the two harvest dates on the plant height rate, as treatment H2 was significantly superior to treatment H1 by giving it the highest rate of plant height that, reached 51.62 and 50.32 cm, respectively. Also, treatment M2 showed significantly superior to treatment M1, which recorded 53.67 and 48.27 cm, respectively. Treatment B2 and treatment B4 were significantly superior by recording the highest plant height of 51.92 and 51.67 cm, respectively, compared to control treatment B1, which had a plant height of 49.47 cm. The binary interaction between the two harvest dates and the Mycobacterium tuberculosis (H×M) vaccine showed no significant differences in the above trait. The binary interaction treatment also significantly affected the treatments of the two harvest dates and the treatments (H×B) in this trait, as the interaction H2B2 treatment was recorded. The highest plant height was 52.67 cm, while H1B3, H1B1 and H2B1 recorded the lowest at 49.67, 49.60 and 49.33 cm, respectively. The binary interaction treatments between the mycorrhizal inoculum and the stimulating treatments ((M×B) showed significant superiority, whereby M2B4, M2B3 and M2B2 recorded the highest plant height rate of 55.50, 54.67 and 54.00 cm, respectively. In contrast, both The two-interference treatment M1B4 and treatment without the addition of mycorrhizal and spraying with distilled water M1B1 and M1B3 treatment had the lowest values, reaching 48.43, 47.83 and 47.00 cm, respectively. The results of the triple interaction between the study factors, the date of harvest, the mycorrhizal vaccine and the stimulation treatments (H×M×B) indicated a significant superiority in plant height, where the treatment H2M2B4 recorded the highest plant height of 57.67 cm compared to treatment H1M1B1 and treatment H1M1B4 and treatment H2M1B4 and treatment H2M1B3B1 and treatment H2M1B3B1 Each recorded the lowest plant height of 48.53, 48.33 and 47.33, 46.67 cm, respectively.

H*M		B				M	H
		B4	B3	B2	B1		
48.30		48.33	46.67	49.67	48.53	M1	H1
52.33		53.33	52.67	52.67	50.67	M2	
48.25		47.33	47.33	50.00	48.33	M1	H2
55.00		57.67	56.67	55.33	50.33	M2	
N.S.	LSD H*M	1.77				LSD H*M*B	
		51.67	50.83	51.92	49.47	Average B	
		0.62				LSD B	
H*B							
Average H		B4	B3	B2	B1	H	
50.32		50.83	49.67	51.17	49.60	H1	
51.62		52.50	52.00	52.67	49.33	H2	
1.14	LSD H	0.98				LSD H*B	
M *B							
Average M		B4	B3	B2	B1	M	
48.27		47.83	47.00	49.83	48.43	M1	
53.67		55.50	54.67	54.00	50.50	M2	
1.62	LSD M	1.60				LSD M*B	

Table 2. Effect of harvest date, mycorrhiza and some bio-stimulants on the rate of plant height (cm). H = date of harvest, M = mycorrhizal vaccine, B = stimulus factors. H1 = the date of the first harvest H2 = the date of the second harvest M1 = without adding the mycorrhizal vaccine M2 = adding the mycorrhizal vaccine B1 = spraying distilled water (measuring treatment) B2 = spraying phenylalanine acid B3 = spraying moringa leaf extract B4 = spraying licorice root extract powder.

Average Number of Main Branches in a Plant (Primary Branch-1):

The results of Table 3 showed no significant effect of the date of harvest H on the average number of main branches. The M2 treatment also showed a significant superiority to the M1 treatment, which recorded 2.250 and 1.792 main branches-1, respectively. Both treatments B2 and B3 were significantly superior by recording the highest average number of main branches in the plant, which amounted to 2.167, 2.167 main branches. Plant-1, respectively, compared to treatment B1, which recorded a significant decrease in the number of main branches, amounting to 1.667 main branches of Plant-1. The bilateral interaction between the two harvest dates and the Mycobacterium tuberculosis vaccine (H×M) and the bilateral interaction between the treatments of the harvest dates and the (H×B) treatments did not show. In contrast, the bilateral interaction between the mycobacterial vaccine treatments and the treatments ((M×B) showed a significant superiority. The M2B3 treatment recorded the highest rate of the number of main branches in the plant, reaching 2.667 the main branches of Plant-1, while the binary interaction M1B1 treatment recorded the lowest rate of 1.333 main branches of Plant-1. The results of the tripartite interaction between the study factors, the date of harvest, the mycorrhizal vaccine, and the stimulating factors H×M×B) showed that there were no significant differences in the characteristics of the average number of main branches.

H*M		B				M	H
		B4	B3	B2	B1		
1.833		2.333	1.667	2.000	1.333	M1	H1
2.250		2.000	2.667	2.333	2.000	M2	
1.750		2.000	1.667	2.000	1.333	M1	H2
2.250		2.000	2.667	2.333	2.000	M2	
N.S.	LSD H*M	N.S.				LSD H*M*B	
		2.083	2.167	2.167	1.667	Average B	
		0.378				LSD B	
H*B							
Average H		B4	B3	B2	B1	H	
2.042		2.167	2.167	2.167	1.667	H1	
2.000		2.000	2.167	2.167	1.667	H2	
N.S.	LSD H	N.S.				LSD H*B	
M *B							
Average M		B4	B3	B2	B1	M	
1.792		2.167	1.667	2.000	1.333	M1	
2.250		2.000	2.667	2.333	2.000	M2	
0.306	LSD M	0.513				LSD M*B	

Table 3. Effect of harvest date, mycorrhizae and some biostimulants on the average number of main branches of the fragrant plant (prime branch^{-1}). H = date of harvest, M = mycorrhizal vaccine, B = stimulus factors. H1 = the date of the first harvest H2 = the date of the second harvest M1 = without adding the mycorrhizal vaccine M2 = adding the mycorrhizal vaccine B1 = spraying distilled water (measuring treatment) B2 = spraying phenylalanine acid B3 = spraying moringa leaf extract B4 = spraying licorice root extract powder

Average number of total leaves per plant (leaves ⁻¹):

The results of Table 4 showed that there was a significant effect of the two harvest dates H on the average number of leaves per plant, as the H1 treatment recorded the highest average of the total number of leaves per plant, which amounted to 370.0 leaves^{-1} compared to the H2 treatment, which recorded the lowest rate of the total number of leaves per plant, which amounted to 357.1 leaves^{-1}. Treatment M2 showed a significant superiority over treatment M1 as the average number of total leaves per plant was 374.3 leaves^{-1}, compared to treatment M1, which recorded a significant decrease in the number of leaves, which amounted to 352.8 leaf^{-1}. In contrast, treatment B3 excelled by registering the highest rate of total number of leaves per plant. 384.8leaves^{-1} respectively compared to control treatment B1, which recorded a significant decrease in the total number of leaves, reaching 332.1 leaves^{-1}. The bilateral interaction between the two harvest dates and the Mycobacterium tuberculosis (H×M) vaccine did not show any significant differences, and the bilateral interaction treatment between the treatments of the two harvest dates and the stimulation treatments (H×B) also did not show any significant differences. In contrast, the bilateral interaction treatments showed between the two treatments. The mycorrhizal fungal vaccine and stimulation treatments (M×B) were significantly superior, as the M2B3 treatment recorded the highest number of leaves per plant, amounting to 411.7 leaves^{-1}. In contrast, M1B1 treatment recorded the lowest rate of 327.0 leaves^{-1}. The results of the triple interaction between the study factors, the date of harvest, the mycorrhizal inoculum, and the stimulation treatments (H×M×B) showed no significant difference in the characteristic of the average number of total leaves of the plant.

H*M		B				M	H
		B4	B3	B2	B1		
360.7		365.3	366.0	376.3	335.0	M1	H1
379.3		392.3	419.3	366.0	339.7	M2	
345.0		356.7	349.7	354.7	319.0	M1	H2
369.3		387.0	404.0	351.3	334.7	M2	
N.S.	LSD H*M	N.S.				LSD H*M*B	
		375.3	384.8	362.1	332.1	Average B	
		4.8				LSD B	
H*B							
AverageH		B4	B3	B2	B1	H	
370.0		378.8	392.7	371.2	337.3	H1	
357.1		371.8	376.8	353.0	326.8	H2	
9.8	LSD H	N.S				LSD H*B	
M *B							
Average M		B4	B3	B2	B1	M	
352.8		361.0	357.8	365.5	327.0	M1	
374.3		389.7	411.7	358.7	337.2	M2	
2.8	LSD M	6.2				LSD M*B	

Table 4. Effect of harvest date, mycorrhiza and some biostimulants on the average number of Leaves total in the plant (leaves^{-1}). H = harvest time, M = mycorrhizal infection, B = stimulus factors. H1 = first harvest date H2 = second harvest date M1 = without adding mycorrhizal vaccine M2 = adding mycorrhizal vaccine B1 = spraying distilled water (measuring treatment) B2 = spraying phenylalanine acid B3 = spraying moringa leaf extract B4 = spraying extract of root extract powder licorice

Average leaf area (dm² plant⁻¹):

The results of Table 5 showed that there was a significant effect of the harvest date H on the average leaf area, as treatment H2 recorded the highest leaf area per plant, amounting to 48.76 dm2 plant-1 compared to treatment H1, which recorded the lowest leaf area per plant amounted to 46.67 dm2 plant-1. The M2 treatment also showed a significant superiority over the M1 treatment, as the leaf area per plant was 51.46 dm2 plant-1 compared to the M2 treatment, which recorded the lowest area of 43.97 dm2 plant-1. Treatment B3 was superior by recording the highest leaf area per plant, 58.23 dm2 plant-1. Compared to control treatment B1, which recorded the lowest leaf area of a plant, which was 33.79 dm2 plant-1. The bilateral interaction between the two harvest dates and the mycorrhizal vaccine (H×M) did not show any significant differences, and the bilateral interaction treatment between the treatments of the mycorrhizal vaccine and the stimulation treatments (M×B) also did not show any significant differences. In contrast, the bilateral interaction treatments between the harvest dates showed. The stimulation treatments (H×B) were significantly superior, where the treatment H2B3 recorded the highest leaf area of the plant, amounting to 59.03 dm2 plant-1. In contrast, the dual interaction treatment H1B1 recorded the lowest leaf area of 33.79 dm2 plant-1. The results of the triple interaction between the study factors also showed. The date of harvest and addition of mycorrhizae and stimulus factors (H×M×B)) showed that there was no significant difference in the leaf area characteristic of the plant.

H*M		B				M	H
		B4	B3	B2	B1		
43.10		47.77	53.42	40.56	30.63	M1	H1
50.24		53.50	61.43	48.44	37.57	M2	
44.84		49.53	55.13	43.97	30.74	M1	H2
52.68		58.37	62.93	53.20	36.23	M2	
N.S	LSD H*M	N.S				LSD H*M*B	
		52.29	58.23	46.54	33.79	AverageB	
		1.18				LSD B	
H*B							
H Average		B4	B3	B2	B1	H	
46.67		50.63	57.43	44.50	34.10	H1	
48.76		53.95	59.03	48.58	33.48	H2	
1.23	LSD H	1.56				LSD H*B	
M *B							
AverageM		B4	B3	B2	B1	M	
43.97		48.65	54.28	42.27	30.69	M1	
51.46		55.93	62.18	50.82	36.90	M2	
0.97	LSD M	N.S				LSD M*B	

Table 5. Effect of harvest date, mycorrhiza and some biostimulants on the foliage of fragrant plant (dm² plant⁻¹).H = harvest time, M = mycorrhizal infection, B = stimulus factors. H1 = first harvest date H2 = second harvest date M1 = without adding mycorrhizal vaccine M2 = adding mycorrhizal vaccine B1 = spraying distilled water (measuring treatment) B2 = spraying phenylalanine acid B3 = spraying Moringa leaf extract B4 = spraying Licorice root extract powder.

Total chlorophyll content of leaves (mg100g fresh weight):

The results of Table 6 showed a significant effect of the date of harvest on the leaf content of total chlorophyll, as treatment H2 recorded the highest content of total chlorophyll, amounting to 10.04 mg 100 g-1 fresh weight compared to treatment H1, which recorded the lowest content of total chlorophyll amounted to 9.14 mg. g⁻¹. The M2 treatment also showed a significant superiority over the M1 treatment, as the total chlorophyll content of the plant was 10.39 mg 100 g-1 fresh weight compared to the M2 treatment, which recorded the lowest total chlorophyll content in the leaves was 8.79 mg 100 g-1 fresh weight. Whereas, treatment B3 excelled by recording the highest total chlorophyll content of 11.04 mg 100 gm-1 fresh weight compared to control treatment B1, which recorded the lowest total chlorophyll content in leaves of 7.12 mg. 100gm-1 soft weight. The binary interaction between the two harvesting dates and the Mycorrihzae vaccine (H×M) showed no significant differences in the traits studied above. The two interaction treatments between harvest dates and stimulation treatments (H×B) showed significant superiority, where the treatment H2B4 recorded the highest content of total chlorophyll in the leaves, amounted to 11.57 mg 100 g-1 fresh weight compared to the dual interaction treatment H1B1, which gave the lowest content of total chlorophyll in the leaves. It reached 6.67 mg.100gm-1 fresh weight. The dual interaction treatment showed significant differences between the mycorrhizal vaccine treatments and the stimulus treatments (M×B) for the same characteristic above, as both the treatment of the two interactions, M2B3 and M2B4, were characterized by giving them the highest total chlorophyll content in Leaves were 11.55, 11.34 mg 100 g-1 fresh weight compared to M1B1 treatment, which recorded the lowest total chlorophyll content in leaves was 6.15 mg 100 g-1 fresh weight leaves. The results of the triple interaction between the study factors, the date of harvest, the mycorrhizal

vaccine and the stimulation treatments (H×M×B) showed a significant difference in the characteristic of the total chlorophyll content of the leaves. Soft compared to treatment H1M1B1, which recorded the lowest content of total chlorophyll in leaves, which was 5.60 mg 100 g-1 fresh weight.

H*M		B				M	H
		B4	B3	B2	B1		
8.39		9.51	10.80	7.64	5.60	M1	**H1**
9.89		10.12	11.46	10.24	7.74	M2	
9.19		10.58	10.27	9.19	6.70	M1	**H2**
10.89		12.56	11.63	10.93	8.45	M2	
N.S.	LSD H*M	0.72				**LSD H*M*B**	
		10.69	11.04	9.50	7.12	**Average B**	
		0.34				**LSD B**	
H*B							
Average H		B4	B3	B2	B1	**H**	
9.14		9.82	11.13	8.94	6.67	**H1**	
10.04		11.57	10.95	10.06	7.57	**H2**	
0.76	LSD H	0.60				**LSD H*B**	
M *B							
Average M		B4	B3	B2	B1	**M**	
8.79		10.05	10.53	8.42	6.15	**M1**	
10.39		11.34	11.55	10.59	8.09	**M2**	
0.24	LSD M	0.45				**LSD M*B**	

Table 6. Effect of harvest date, mycorrhiza and some bio-stimulants on the total chlorophyll content of fragrant plants (mg 100 g⁻¹ fresh weight) on leaves. H = date of harvest, M = mycorrhizal vaccine, B = stimulus factors. H1 = date of the first harvest H2 = date of the second harvest M1 = without adding mycorrhizal vaccine M2 = adding mycorrhizal vaccine B1 = spraying distilled water (measuring treatment) B2 = spraying phenylalanine acid B3 = spraying moringa leaf extract B4 = spraying Licorice root extract powder.

Average fresh weight of leaves (gm plant$^{-1)}$:

The results of Table 7 showed that there was a significant effect of the two harvest dates on the average fresh weight of leaves, as treatment H2 recorded the highest fresh weight of leaf yield, amounted to 550.4 gm plant¹- compared to treatment H1, which recorded the lowest fresh weight of leaf yield amounted to 492.2 gm plant-1. Treatment M2 showed a significant superiority to treatment M1, as the fresh weight of the leaf yield plant-1 was 539.6 gm plant-1 compared to treatment M1, which recorded the lowest fresh weight of leaf yield, amounted to 492.2 gm plant-1. While both treatment B2 and treatment B3 excelled by recording the highest fresh weight of plant-1. Leaves reached 547.3 and 541.8 gm plant-1, respectively, compared to control treatment B1, which recorded the lowest fresh weight for leaf yield of 462.2 gm plant-1. The bilateral interaction between the two harvesting dates and the mycobacterium tuberculosis (H×M) vaccine showed significant differences in the abovementioned trait. The treatment H2M2 was superior by giving it the highest weight of fresh leaves, which reached 569.6 gm plant-1, compared to the treatment H1M1, which amounted to 453.2 gm plant-1. In contrast, the dual interaction treatments between harvest dates and stimulation treatments ((H×B)) showed significant superiority in the same trait studied above. Whereas the treatment H2B3 excelled by registering the highest fresh weight of leaves that

reached 602.3 gm plant-1 compared to treatment H1B1, 449.2 gm plant-1. In contrast, the dual interaction treatment between mycorrhizal pollen and stimulus (M×B) treatments showed significant differences for the same above trait, as each From treatment M2B3 and M2B2 treatment by giving it the highest fresh weight of leaf yield amounted to 568.2 and 567.2 gm plant-1 compared to treatment M1B1 which recorded the lowest fresh weight of leaf yield amounted to 443.7 gm plant-1. The results of the tripartite interaction between the study factors showed the date of harvest, mycorrhizae and stimulation treatments (H×M×B), there was a significant difference in the characteristic of the fresh weight of the leaves yield, as the H2M2B3 treatment excelled by registering the highest fresh weight of the leaves yield amounted to 632 gm plant-1 compared to the treatment H1M1B1, which recorded the lowest Fresh weight of leaf yield was 418.7 gm plant-1 for fragrant plant.

H*M		B				M	H
		B4	B3	B2	B1		
453.2		449.6	457.0	487.4	418.7	M1	**H1**
509.6		489.8	505.7	563.0	479.7	M2	
531.1		515.7	572.6	567.5	468.7	M1	**H2**
569.6		593.3	632.0	571.4	481.8	M2	
14.9	LSD H*M	29.7				**LSD H*M*B**	
		541.8	541.8	547.3	462.2	**AverageB**	
		15.8				**LSD B**	
H*B							
AverageH		B4	B3	B2	B1	**H**	
481.4		469.7	481.3	525.2	449.2	**H1**	
550.4		554.5	602.3	569.5	475.3	**H2**	
17.4	LSD H	21.0				**LSD H*B**	
M *B							
AverageM		B4	B3	B2	B1	**M**	
492.2		482.7	514.8	527.5	443.7	**M1**	
539.6		541.6	568.9	567.2	480.8	**M2**	
12.4	LSD M	21.2				**LSD M*B**	

Table 7. Effect of harvest date, mycorrhiza and some bio-stimulants on average Fresh weight of leaf yield of fragrant plant (gm plant⁻¹). H = date of harvest, M = mycorrhizal vaccine, B = stimulus factors. H1 = date of the first harvest H2 = date of the second harvest M1 = without adding mycorrhizal vaccine M2 = adding mycorrhizal vaccine B1 = spraying distilled water (measuring treatment) B2 = spraying phenylalanine acid B3 = spraying moringa leaf extract B4 = spraying Licorice root extract powder.

Average dry weight of leaf yield (g plant⁻¹):

Table 8 showed a significant effect of the harvest date H on the dry weight rate for leaf yield. Treatment H2 recorded the highest dry weight of leaf yield, amounting to 96.6 gm plant-1, compared to treatment H1, which recorded the lowest dry weight of leaf yield, amounted to 90.4 gm plant-1. Treatment M2 also showed a significant superiority over treatment M1, as the dry weight of the leaf yield of the plant was 96.9 gm plant-1 and 91.2 gm plant-1, respectively. While treatment B3 excelled by registering the highest dry weight of leaf yield of 104.3 gm. Plant-1 compared to control treatment B1, which recorded the lowest dry weight of leaf yield, 84.6 gm, Plant-1. The binary interaction between the two harvesting dates and the Mycobacterium tuberculosis (H×M) vaccine showed significant differences in the abovementioned trait. The H1M1 treatment showed the highest dry weight of leaf yield, amounting to 115.1 gm plant-1, compared to the treatment

with the lowest dry weight of 78.3 gm plant-1. In contrast, the binary interaction treatments between harvest dates and stimulation treatments (H×B) showed a significant superiority in the same studied trait. Above, the treatment H2B3 was superior by giving it the highest dry weight of the leaves yield, which amounted to 105.4 gm plant-1, compared to treatment H1B1, which recorded the lowest dry weight of leaves, 83.3 gm plant-1. The treatment showed the binary interaction between the mycorrhizal pollen treatments and the stimulation treatments (M×M). B) Significant differences for the same trait above, as each of the M2B3 treatments was characterized by giving it the highest dry weight of the leaves, amounted to 110 gm plant-1 compared to the treatment M1B1, which recorded the lowest dry weight of leaves was 81.5 gm plant-1. The results of the triple interaction between the study factors showed the date of harvest, mycorrhiza and stimulation treatments (H×M×B)), and there was a significant difference in the dry weight characteristic of the leaves, as the treatment H2M2B3 excelled by registering the highest dry weight of the leaves yield to 115.1 g. Plant-1 compared to treatment H1M1B1, which recorded the lowest dry weight of the leaves yield was 78.3 g, Plant-1.

H*M		**B**				**M**	**H**
		B4	B3	B2	B1		
88.8		86.8	101.6	88.3	78.3	M1	**H1**
93.5		88.2	104.9	92.7	88.2	M2	
91.1		86.1	95.7	98.1	84.6	M1	**H2**
102.8		101.2	115.1	107.5	87.4	M2	
0.40	LSD H*M	0.58				**LSD H*M*B**	
		90.6	104.3	96.6	84.6	**AverageB**	
		0.29				**LSD B**	
H*B							
AverageH		B4	B3	B2	B1	**H**	
91.2		87.5	103.3	90.5	83.3	**H1**	
96.9		93.7	105.4	102.8	86	**H2**	
0.51	LSD H	0.45				**LSD H*B**	
M *B							
AverageM		B4	B3	B2	B1	**M**	
89.9		86.5	98.7	93.2	81.5	**M1**	
98.2		94.7	110	100.1	87.8	**M2**	
0.24	LSD M	0.39				**LSD M*B**	

Table 8. Modified effect of harvest date, mycorrhizal and some biostimulants Dry weight of the yield of leaves of the plant (g plant^{-1}). H = date of harvest, M = mycorrhizal vaccine, B = stimulus factors. H1 = date of the first harvest H2 = date of the second harvest M1 = without adding mycorrhizal vaccine M2 = adding mycorrhizal vaccine B1 = spraying distilled water (measuring treatment) B2 = spraying phenylalanine acid B3 = spraying moringa leaf extract B4 = spraying Licorice root extract powder.

Determination of the percentage of nitrogen in the leaves of a plant (%)

The results of Table 9 showed a significant effect of the date of harvest H on the percentage of nitrogen in the leaves, as the H2 treatment recorded the highest percentage of nitrogen in the leaves, amounted to 0.54% compared to the H2 treatment, which recorded the lowest percentage of nitrogen in the leaves amounted to 0.47%. Treatment M2 also showed a significant superiority to treatment M1, as the percentage of nitrogen in the leaves was 0.55% compared to treatment M1, which recorded the lowest percentage of nitrogen elements, amounted to 0.55. Treatment B3 excelled by recording the highest percentage of nitrogen in leaves, which

amounted to 0.58% compared to treatment. The B1 comparison, which recorded the lowest percentage of nitrogen in the leaves, was 0.43%. The binary interaction between the two harvest dates and the Mycobacterium tuberculosis (H×M) vaccine showed significant differences in the same trait studied above. Treatment H2M2 showed the highest percentage of nitrogen elements, amounting to 0.58%, compared to treatment H1M1, which recorded the lowest percentage of nitrogen elements in the content of dried leaves of fragrant plants, amounted to 0.42%. The treatment of the binary interaction between the mycorrhizal pollen and stimulation treatments (M×B) showed differences Significant for the same trait above, as M2B3 treatment was distinguished by recording the highest percentage of nitrogen element amounting to 0.64% compared to treatment M1B1, which recorded the lowest percentage of nitrogen element in leaves amounted to 0.41%. In contrast, the two interactions between harvest dates and stimulation treatments (H×B) showed significant superiority in the same trait studied above. Treatment H2B3 was superior by recording the highest percentage of nitrogen elements in leaves, amounting to 0.60%, compared to treatment H1B1, which recorded the lowest percentage of nitrogen elements in leaves, amounted to 0.39%. The results of the triple interaction between the study factors, the date of harvest, mycorrhiza and stimulus factors (H×M×B), showed a significant difference in the percentage of nitrogen element in the leaves of the fragrant plant. Treatment H2M2B3 outperformed by recording the highest percentage of nitrogen elements, amounting to 0.65%, compared to treatment H1M1B1, which recorded the lowest percentage of nitrogen elements in the leaves of fragrant plants, amounted to 0.37%.

H*M		B				M	H
		B4	B3	B2	B1		
0.42		0.41	0.47	0.44	0.37	M1	**H1**
0.52		0.48	0.63	0.56	0.41	M2	
0.51		0.49	0.55	0.54	0.45	M1	**H2**
0.58		0.56	0.65	0.61	0.50	M2	
0.014	LSDH*M	0.017				**LSD H*M*B**	
		0.49	0.58	0.54	0.43	**AverageB**	
		0.007				**LSD B**	
H*B							
AverageH		B4	B3	B2	B1	**H**	
0.47		0.45	0.55	0.50	0.39	**H1**	
0.54		0.53	0.60	0.57	0.48	**H2**	
0.005	LSD H	0.009				**LSD H*B**	
M *B							
Average M		B4	B3	B2	B1	**M**	
0.47		0.45	0.51	0.49	0.41	**M1**	
0.55		0.52	0.64	0.58	0.46	**M2**	
0.014	LSD M	0.015				**LSD M*B**	

Table 9. Effect of harvest date, mycorrhiza and some bio-stimulants. Estimating the ratio of the percentage of nitrogen in plant leaves (%). H = date of harvest, M = mycorrhizal vaccine, B = stimulus factors. H1 = date of the first harvest H2 = date of the second harvest M1 = without adding mycorrhizal vaccine M2 = adding mycorrhizal vaccine B1 = spraying distilled water (measuring treatment) B2 = spraying phenylalanine acid B3 = spraying moringa leaf extract B4 = spraying Licorice root extract powder.

Determination of the percentage of phosphorous in the leaves of a plant (%):

The results of Table 10 showed a significant effect of the date of harvest H on the percentage of phosphorous in leaves, as treatment H2 recorded the highest percentage of phosphorous element in leaves, which amounted to 0.43% compared to treatment H1, which recorded the lowest percentage of phosphorous element that amounted to 0.38%. Treatment M2 also showed a significant superiority to treatment M1, as the percentage of a phosphorous element in the leaves was 0.47% compared to treatment M1, which recorded the lowest percentage of phosphorous elements, amounted to 0.33%. In comparison, treatment B3 excelled by recording the highest percentage of phosphorous elements in leaves, which amounted to 0.47%, compared to treatment B1, which recorded the lowest percentage of phosphorous in leaves, which was 0.30%. The binary interaction between the two harvesting dates and the mycorrhizal infection (H×M) showed significant differences in the same trait studied above. Treatment H2M2 showed the highest percentage of phosphorous content of leaves, amounting to 0.49%, compared to treatment H1M1, which recorded the lowest percentage of phosphorous elements in the leaves content of the fragrant plant, amounted to 0.29%. In contrast, the bilateral interaction between harvest dates and stimulation factors (H×) showed B Significant superiority in the same trait studied above, as the treatment H2B3 was superior by recording the highest percentage of phosphorous content in leaves that amounted to 0.50% compared to treatment H1B1, which recorded the lowest percentage of phosphorous element in leaves that was 0.30%. The mycorrhizal and stimulus treatments (M×B) were significant differences for the same trait above, as the M2B3 treatment excelled by registering the highest percentage of phosphorous content in the leaves, amounted to 0.57% compared to the M1B1 treatment, which recorded the lowest percentage of phosphorous element in the leaves amounted to 0.29%. The results of the triple interaction between the study factors, the date of harvest, mycorrhiza and stimulus factors (H×M×B) showed a significant difference in the percentage of phosphorous element in the leaves of the fragrant plant. The treatment H2M2B3 outperformed by recording the highest percentage of phosphorous elements, which amounted to 0.58%, compared to treatment H1M1B1, which recorded the lowest percentage of phosphorous elements in the leaves of the fragrant plant, which amounted to 0.25%.

Determination of the percentage of potassium in the leaves of a plant (%):

The results of Table 11 showed a significant effect of the date of the harvest H on the percentage of potassium in the leaves, as the H2 treatment was superior to the percentage of potassium in the leaves and the treatment H1, which recorded 0.80 and 0.73% respectively on the percentage of potassium in the dried leaves. In contrast, the treatment showed M2 was significantly superior to treatment M1, as the potassium percentage in the leaves was 0.82% compared to treatment M1, which recorded the lowest percentage of potassium in the leaves, which was 0.67%.

H*M		B				M	H
		B4	B3	B2	B1		
0.29		0.27	0.34	0.31	0.25	M1	H1
0.46		0.43	0.55	0.49	0.36	M2	
0.38		0.36	0.42	0.40	0.33	M1	H2
0.49		0.47	0.58	0.51	0.41	M2	
0.009	LSDH*M	0.014				LSD H*M*B	
		0.38	0.47	0.43	0.34	AverageB	
		0.007				LSD B	
H*B							
AverageH		B4	B3	B2	B1	H	
0.38		0.35	0.45	0.40	0.30	H1	
0.43		0.42	0.50	0.45	0.37	H2	
0.011	LSD H	0.010				LSD H*B	
M *B							
AverageM		B4	B3	B2	B1	M	
0.33		0.32	0.38	0.35	0.29	M1	
0.47		0.45	0.57	0.50	0.38	M2	
0.005	LSD M	0.009				LSD M*B	

Table 10. Effect of harvest date, mycorrhiza and some bio-stimulants. Estimating the ratio of the percentage of phosphorous in plant leaves (%). H = date of harvest, M = mycorrhizal vaccine, B = stimulus factors. H1 = date of the first harvest H2 = date of the second harvest M1 = without adding mycorrhizal vaccine M2 = adding mycorrhizal vaccine B1 = spraying distilled water (measuring treatment) B2 = spraying phenylalanine acid B3 = spraying moringa leaf extract B4 = spraying Licorice root extract powder.

Treatment B3 excelled by recording the highest percentage of potassium in the leaves, which amounted to 0.80%, compared to treatment B1, which recorded the lowest percentage of potassium in leaves, 0.67%. The binary interaction between the two harvest dates and the Mycobacterium tuberculosis (H×M) vaccine showed significant differences in the same trait studied above. Whereas both treatment H1M2 and treatment H2M2 showed the highest percentage of potassium content in leaves, which amounted to 0.82% and 0.82%, respectively. Both treatment H2M1 and treatment H1M1 showed the lowest potassium percentage in the leaves content of fragrant plants, which reached 0.67% and 0.66%, respectively. The binary interaction treatments between harvest dates and stimulation treatments (H×B) recorded a significant superiority in the same trait studied above. Treatment H1B3 excelled by registering the highest percentage of potassium content in leaves, amounting to 0.82%, compared to treatment H2B1 and treatment H1B1, which recorded the lowest percentage. The percentages of potassium in the leaves were 0.68 and 0.66%. The binary interaction treatment between the mycorrhizal inoculum treatments and the stimulus treatments (M×B) showed significant differences for the same trait above, as both treatment M2B3 and M2B4 recorded the highest percentage in the leaves content from potassium was 0.89 and 0.86%, respectively, while the M1B1 treatment recorded the lowest percentage of potassium in the leaves and was 0.62%. The results of the triple interaction between the study factors, the date of harvest, mycorrhiza and stimulus factors (H×M×B) showed a significant difference in the potassium percentage in the leaves of the fragrant plant. Whereas, both treatment H2M2B4 and treatment H2M2B3 outperformed by recording the highest percentage of potassium, which amounted to 0.93% and 0.92%, respectively, compared to treatment H1M1B4, treatment H2M1B1 and treatment H1M1B1, which all recorded the lowest percentage of potassium in the leaves of the plant, which reached 0.64%. 63% and 0.61%, respectively.

H*M		B				M	H
		B4	B3	B2	B1		
0.66		0.64	0.71	0.67	0.61	M1	H1
0.80		0.78	0.85	0.85	0.72	M2	
0.67		0.66	0.72	0.68	0.63	M1	H2
0.84		0.93	0.92	0.78	0.72	M2	
0.028	LSDH*M	0.039				LSD H*M*B	
		0.75	0.80	0.74	0.67	means B	
		0.018				LSD B	
H*B							
means H		B4	B3	B2	B1	H	
0.73		0.71	0.78	0.76	0.66	H1	
0.80		0.79	0.82	0.73	0.68	H2	
0.024	LSD H	0.025				LSD H*B	
M *B							
means M		B4	B3	B2	B1	M	
0.67		0.65	0.72	0.67	0.62	M1	
0.82		0.86	0.89	0.81	0.72	M2	
0.027	LSD M	0.031				LSD M*B	

Table 11. Effect of harvest date, mycorrhiza and some bio-stimulants, percentage estimation Potassium in plant leaves (%). H = date of harvest, M = mycorrhizal vaccine, B = stimulus factors. H1 = date of the first harvest H2 = date of the second harvest M1 = without adding mycorrhizal vaccine M2 = adding mycorrhizal vaccine B1 = spraying distilled water (measuring treatment) B2 = spraying phenylalanine acid B3 = spraying moringa leaf extract B4 = spraying Licorice root extract powder.

Determination of the percentage of volatile oil in the dried leaves of the plant (%)

The results of Table 12 showed a significant effect of the date of harvest H on the percentage of volatile oil in the dried leaves, as the date of the second harvest H2 exceeded in recording the highest percentage of volatile oil in the dry leaves amounted to 1.04% compared to the date of the first harvest H1, which recorded the lowest percentage of volatile oil amounted to 0.75%; While treatment M2 showed a significant superiority to treatment M1, as the percentage of volatile oil in the dry leaves was 1% compared to treatment M1, which recorded the lowest percentage of leaves content of volatile oil amounted to 0.79%. Treatment B3 excelled by recording the highest percentage of volatile oil in The dry leaves, amounting to 0.99%, compared to the control treatment B1, which recorded the lowest percentage of volatile oil in the dry leaves, amounting to 0.81%. The binary interaction between the two harvest dates and the Mycobacterium tuberculosis (H×M) vaccine showed significant differences in the same trait studied above. The H2M2 treatment showed the highest percentage of the dry leaves content of the volatile oil, amounting to 1.17%, while the H1M1 treatment recorded the lowest percentage of the volatile oil in the dried leaves of the fragrant plant, amounted to 0.67%, Whereas, the binary interaction treatments between harvest dates and stimulation treatments (H×B) showed a significant superiority in the same trait studied above. The H1B3 treatment excelled by recording the highest percentage of volatile oil in the dried leaves, amounting to 1.14%, compared to each of the treatments H1B1, which recorded the lowest percentage. The percentage of volatile oil in the leaves was 0.66%. The binary interaction treatment between the mycorrhizal vaccine and the stimulus (M×B) treatments showed significant differences for the same trait above, as the M2B3 treatment recorded the highest percentage in the leaves content of the volatile oil, and it was 1.11%. In contrast, the M1B1 treatment recorded the lowest percentage of the volatile oil in the dried leaves. 0.72%. The results of the

triple interaction between the study factors, the date of harvest, mycorrhiza and stimulus factors (H×M×B)) showed a significant difference in the percentage of volatile oil in the dried leaves of the fragrant plant. The treatment H2M2B3 outperformed by recording the highest percentage of volatile oil, amounting to 1.27%, compared to treatment H1M1B1, which recorded the lowest percentage of volatile oil in the dried leaves of the fragrant plant, reaching 0.61%.

H*M		B				M	H
		B4	B3	B2	B1		
0.67		0.65	0.72	0.69	0.61	M1	H1
0.83		0.79	0.95	0.89	0.71	M2	
0.92		0.89	1.01	0.95	0.84	M1	H2
1.17		1.13	1.27	1.20	1.06	M2	
0.019	LSDH*M	0.018				LSD H*M*B	
		0.86	0.99	0.93	0.81	AverageB	
		0.006				LSD B	
H*B							
AverageH		B4	B3	B2	B1	H	
0.75		0.72	0.83	0.79	0.66	H1	
1.04		1.01	1.14	1.08	0.95	H2	
0.024	LSD H	0.018				LSD H*B	
M *B							
AverageM		B4	B3	B2	B1	M	
0.79		0.77	0.86	0.82	0.72	M1	
1.00		0.96	1.11	1.05	0.89	M2	
0.009	LSD M	0.010				LSD M*B	

Table 12. Effect of harvest date, mycorrhiza and some bio-stimulants, percentage estimation of the volatile oil in the dried leaves of the plant (%). H = date of harvest, M = mycorrhizal vaccine, B = stimulus factors. H1 = date of the first harvest H2 = date of the second harvest M1 = without adding mycorrhizal vaccine M2 = adding mycorrhizal vaccine B1 = spraying distilled water (measuring treatment) B2 = spraying phenylalanine acid B3 = spraying moringa leaf extract B4 = spraying Licorice root extract powder.

Determination of the volatile oil yield in the dried leaves of the plant (g plant⁻¹):

The results of Table 13 showed a significant effect of the date of harvest H on the characteristic of the volatile oil yield in the dried leaves of a plant, as treatment H2 excelled in recording the highest yield of volatile oil in the dried leaves of the plant amounted to 0.95 g of plant⁻¹ compared to treatment H1, which recorded the lowest yield of volatile oil of the plant amounted to 0.75 g Plant⁻¹. In contrast, treatment M2 showed a significant superiority to treatment M1, as the yield of volatile oil in the plant was 0.97 gm plant⁻¹ compared to treatment M1, which recorded the lowest yield of volatile oil of the plant was 0.75 g plant⁻¹. In contrast, treatment B3 excelled by recording the highest yield of volatile oil in the plant, which reached 1.02 gm plant⁻¹ compared to control treatment B1, which recorded the lowest yield of volatile oil in the plant, which was 0.68 g plant⁻¹. The binary interaction between the two harvest dates and the Mycobacterium tuberculosis (H×M) vaccine showed significant differences in the same trait studied above. The H2M2 treatment showed the highest yield of the volatile oil in the plant, which amounted to 1.07 gm plant⁻¹, while the H1M1 treatment recorded the lowest yield of the volatile oil of the plant, which amounted to 0.63 gm plant⁻¹. The dual interaction treatments between harvest dates and stimulation treatments (H×B) showed significant superiority in the same

trait studied above, as the H2B3 treatment excelled by registering the highest yield of volatile oil in the plant, which amounted to 1.14 g of plant^{-1} compared to the treatment H1B1, which recorded the lowest yield of The volatile oil in the plant was 0.57 g plant^{-1}. The dual interaction treatment between the mycorrhizal vaccine and the stimulus (M×B) treatments showed significant differences for the same trait above, as the M2B3 treatment recorded the highest yield of volatile oil in the plant. It was 1.16 gm of the plant, while the M1B1 treatment recorded the lowest yield of volatile oil, and it was 0.59 plant clouds^{-1}. The results of the tripartite interaction between the study factors, the date of harvest, mycorrhizal, and stimulus factors (H×M×B)) showed a significant difference in the yield of volatile oil in the plant. The treatment H2M2B3 was superior by recording the highest yield of volatile oil, amounting to 1.22 gm plant^{-1} compared to treatment H1M1B1, which recorded the lowest yield of volatile oil in the plant, reaching 0.52 g plant^{-1}.

H*M		B				M	H
		B4	B3	B2	B1		
0.63		0.59	0.73	0.68	0.52	M1	H1
0.87		0.80	1.09	0.96	0.62	M2	
0.83		0.77	1.06	0.84	0.66	M1	H2
1.07		0.99	1.22	1.12	0.94	M2	
0.011	LSDH*M	0.027				LSD H*M*B	
		0.79	1.02	0.90	0.68	means B	
		0.015				LSD B	
H*B							
means H		B4	B3	B2	B1	H	
0.75		0.70	0.91	0.82	0.57	H1	
0.95		0.88	1.14	0.98	0.80	H2	
0.007	LSD H	0.019				LSD H*B	
M *B							
means M		B4	B3	B2	B1	M	
0.73		0.68	0.89	0.76	0.59	M1	
0.97		0.90	1.16	1.04	0.78	M2	
0.011	LSD M	0.020				LSD M*B	

Table 13. Effect of harvest date, mycorrhiza, and some bio-stimulants on yield estimation of the volatile oil in the dried leaves of the plant (g plant^{-1}). H = date of harvest, M = mycorrhizal vaccine, B = stimulus factors. H1 = date of the first harvest H2 = date of the second harvest M1 = without adding mycorrhizal vaccine M2 = adding mycorrhizal vaccine B1 = spraying distilled water (measuring treatment) B2 = spraying phenylalanine acid B3 = spraying moringa leaf extract B4 = spraying Licorice root extract powder.

DISCUSSION

From the results presented in Table (2-13), the moral effect of the study's parameters on most of the vegetative growth indicators, the percentage of volatile oil yield and the oil yield in the leaves of the fragrant plant in this study is evident. Determining the correct harvest time for sweet-scented geranium plants is crucial for obtaining maximum yield from foliar yield and high-quality essential oil [23]. The sweet-scented geranium plant is one of the long-day plants, as the leaf area and greenness of the leaves increase in the long day, which leads to an increase in the dry mass as a result of the increase in the vegetative total content of total chlorophyll [24]. The growth of the vegetative group of sweet-scented geranium plants increases in the hot, sunny weather [23, 45]. A group of factors affect the yield of the

volatile oil and its components, which include the environmental, genetic and physiological conditions of plants and the method of distillation [61, 18]. The planted seed, planting date, altitude and depression above sea level are other factors that affect the yield of volatile oil and its percentage in the leaves of the sweet-scented geranium plant [62]. The volatile oil yield of the fragrant plant is mostly affected by the high yield of the foliar yield, and it is little affected by the volatile oil content in the leaves. The reason is attributed to the fact that the foliar yield and the accumulation of volatile oil concentration fluctuate independently for each of them [42]. Therefore, the resulting increase in most of the vegetative growth rates at the time of the second harvest (H2) (Table 2-8) may be due to the positive effect of maximum and minimum temperatures, relative humidity, average number of hours of sunshine and the relationship between them, which may have been optimal for plant growth until the date of its second harvest, H2. Under the conditions of Baghdad / Al-Jadriya region (Table 1), as well as the longevity of the plant in the field until harvest on the second date, which may have a moral effect that gave plants with high heights and leaves that were characterized by large leaf area due to the small number of total leaves formed on the plants that were Harvested during the second harvest time (Table 4 and 5). As for the increase in the total chlorophyll content of the leaves, this is due to the increase in the process of nutrient absorption and concentration in the leaves during the second harvest, which led to an increase in the total and dry weight of the leaves (Table 7-8), which confirms this The results that were reached at the date of the second harvest of this study include an increase in the average leaf area of leaves and an increase in the ratios of nitrogen, phosphorous and potassium in the leaves The dried leaves of the fragrant plant (Table 9-11) recorded the highest percentage of volatile oil and oil yield in the dried leaves of sweet-scented geranium plant [12, 13]. As for the reason for the superiority of the treatment of the second harvest date H2 by recording the highest percentage of volatile oil and volatile oil yield in the dried leaves, it is because the sweet-scented geranium plant is one of the long-day plants, as the long day worked to cause an increase in the leaf area and greenness of the leaves (Table 5 and 6), which led There was an increase in the dry mass (Table 8) as a result of the increase in the total vegetative content of total chlorophyll (Table 6), which was positively reflected on the yield of leaves from the volatile oil and the percentage of volatile oil [23, 45]. The results obtained in this study are consistent with what was found: [23, 45, 24, 41]. As for the superiority of the treatment of adding Mycorrhizae M2 pollen in all vegetative growth characteristics, estimation of elements and yield of volatile oil in dried leaves and their percentage in this study (Table 2-13), it may be attributed to the strong enhancement caused by the fungus G. mosseae to the root system of the sweet-scented geranium plant as a result of its colonization of the area. The root system was strongly stimulated, which resulted in a remarkable balance between the root system and the vegetative parts, as the Mycorrhizal fungus G.mosseae increased the readiness of nutrients and the absorption of water and nutrients necessary for growth due to its release of Siderophores compounds, which are produced in iron deficiency conditions by the Mycorrhizal fungus. It works to improve the growth of the plant through its ability to search for iron in the environment in which the roots of the plant grow, as well as its work on the readiness of the elements in the area near the root cells [17, 53], which was positively reflected in improving growth and increasing biomass production sweet-scented geranium plant and its leaf content of nutrients [28], in addition to the fact that plants treated with mycorrhizal fungal inoculum recorded an increase in the rate of photosynthesis [65]. This was reflected in the increase in the number of leaves in this study (Table 4), which was at the expense of the average area of one leaf in the plant whose roots were not treated with the Mycorrhizal vaccine M1 (Table 5). The results that were reached in this study are in agreement with those of [15, 46, and 29].

The increase caused by spraying with Moringa leaves extracts B3 in most of the characteristics of vegetative growth. The estimation of nutrients in the leaves is due to the nutritional effect of Moringa leaves extract as a result of it containing micro and macronutrients, amino acids and vitamins that the plant needs for its growth [60], which led to an increase in the ability to grow The plant and most indicators of vegetative growth as a result of increased absorption of nutrients, which confirms the results reached when estimating nutrients (Table 9-11), as well as its work as a foliar fertilizer in addition to its other roles represented by its hormonal effect, which is one of the main reasons for effective bio-stimulation in groups The plant contains hormones necessary for growth such as cytokinins, auxins and abscisic acid. Moringa aqueous extract is an excellent source of biologically active compounds such as micro and macro elements (calcium, phosphorous, potassium, sulfur, iron, sodium), amino acids, phenols, flavonoids, vitamins (A, B1, B2, B3, C, E), sugars and antioxidants. Oxidation, soluble sugars, thiamine, riboflavin, nicotinic acid, ascorbic acid, and carotene. In addition to that, Moringa aqueous extract is characterized by being rich in plant hormones such as indole-3-acetic acid (IAA), gibberellin (GA3) and zeatin (9), which act as growth hormones, especially zeatin, and sufficient quantities It is one of the necessary nutrients with the appropriate proportion that moringa extract contains to cause an increase in the characteristics of vegetative growth and the yield from volatile oil, its percentage, components and the productivity of many plants [22] and this was confirmed by the results that were reached in each of Table 3-13; as well as The aqueous moringa extract has a major role in improving the proportion of volatile oil, as it causes a significant increase in photosynthetic pigments, and this was confirmed by the results obtained in this study. Study (Table 6) It also causes the accumulation of total sugars and promotes cell division and elongation and chlorophyll biosynthesis, so it can be considered a useful nutrient or foliar fertilizer that helps plants to overcome the harmful effects of environmental stress that were prevalent during the second harvest time (Table 1), which was reflected on The increase in the percentage of volatile oil and volatile oil yield in the dried leaves of sweet-scented geranium plant in this study (Table 12 and 13). The results agreed with what was found by [66 and 54]. The resulting increase when treated by spraying the shoots with phenylalanine B2 in the characteristics of plant height rate, number of main branches and fresh weight of leaves (Table 2, 5 and 7) is due to the amino acid phenylalanine, which is a source of nitrogen, as it plays a key physiological role in plant growth and development [34]. As well as being the initiator of various antioxidants such as salicylate, flavonoids, anthocyanins and tannins, all of which protect plants from various environmental stresses that affect the processes of plant growth and development. Biosynthesis of gibberellin [48]. Amino acids, including phenylalanine, act as building blocks for proteins that can contribute to a number of additional functions, such as regulating metabolism, transporting, and storing nitrogen [21]. Also, spraying with phenylalanine on the shoot results in a significant increase in the rate of plant height, the number of main branches, and the fresh weight of the plant leaves. It also has a vital effect in the interaction of plant stress during signaling processes [38], and phenylalanine has a role in the mechanics of phytochemicals of the Pelargonium graveolens plant through its effect on the metabolism of terpenes, volatile oils, protein and endogenous hormones [40]. The results reached when spraying the shoots with phenylalanine B2 agree with the findings of [59, 56, and 55]. Numerous studies, experiments and scientific research have proven that foliar spraying with licorice root extract stimulates and improves vegetative and flowering growth and the content and components of horticultural and medicinal aromatic plants from primary and secondary metabolic compounds quantitatively and qualitatively [7, 44, 8]. The licorice plant is a nutritious plant as well as containing many secondary compounds and compounds similar to gibberellins and amino acids [7]. This explains

the superiority of spraying treatment with licorice root extract powder B4 in the rate of plant height (Table 4) because the aqueous extract of licorice root powder contains mevalonic acid, the initiator of the biosynthesis of gibberellin hormone, which increases the incidence of division and cell elongation, which is positively reflected on plant growth and improving its qualities. Vegetative and floral [1], as well as the elements included in the composition of the extract, had an effective role in activating the work of enzymes, division and elongation of cells, building proteins and increasing the manufacture of nutrients that helped in the growth of plant tissues while increasing the storage of materials in the leaves [12]. The results obtained in this study agree with those of [44, 37].

CONCLUSIONS

The superiority of the H2 treatment in most indicators of vegetative growth, as well as an increase in the percentages of nutrients in the dried leaves and the percentage of volatile oil and volatile oil yield in the dried leaves

The M2 treatment significantly increased all vegetative growth characteristics and the percentages of nutrients in the dried leaves, the percentage of volatile oil and the volatile oil yield in the dried leaves.

Treatment B3 showed an increase in the number of main branches, the total number of leaves, the total leaf area, the fresh and dry weight of the yield of leaves in the plant and the content of dried leaves of total chlorophyll as well as the percentages of nutrients in the dried leaves of the plant, the percentage of volatile oil and volatile oil yield in the dried leaves While the B2 treatment had a significant effect in increasing the plant height rate, the number of main branches and the fresh weight of the leaves.

The treatment of the triple interaction H2M2B3 was superior in causing an increase in the characteristics of the wet and dry weight of leaves and the percentages of nutrients, as well as the percentage of volatile oil and volatile oil yield in leaves. The treatment of the triple interaction H2M2B4 was also distinguished by recording a remarkable superiority in the characteristics of plant height, leaf content of total chlorophyll and percentage of potassium.

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