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EFFECT OF SOWING DATES AND FOLIAR SPRAYING WITH MORINGA LEAF EXTRACT, SEAWEED EXTRACT AND POTASSIUM SULPHATE FERTILIZER ON GROWTH, YIELD AND CHEMICAL COMPOSITION OF SWEET FENNEL (*Foeniculum vulgare* Mill*)* PLANT

El - Shoura, A. M.[1]; A.S. Dapor[2] and G.F. Masoud[2]

[1]Cross Pollinated Vegetables Research Department, Horticulture Research Institute, ARC, Giza, **Egypt.**
[2]Medical and Aromatic Plants Research Department, Horticulture Research Institute, ARC, Giza, **Egypt.**

[*]**Corresponding author:** dalaaagri@yahoo.com **Received:** 25 Sept. 2019 **; Accepted:** 30 Oct. 2019

ABSTRACT: Climate change and population growth are the two most important challengers faced by today. So that, two field experiments were carried out at the Horticulture Research Farm of El- Baramoon, Dakahlia Governorate, Egypt, during the two winter seasons of 2017/2018 and 2018/2019 to evaluate the response of sweet fennel to foliar application with moringa leaf extract, seaweed extract and potassium sulphate levels in addition to control treatment under two sowing dates, i.e., 15th October and 15th November. The best results were recorded when sweet fennel seeds were sown on 15th October compared with sowing 15th November in the both tested seasons. Also, foliar spraying with seaweed, moringa leaf extracts and potassium sulphate improved vegetative growth, i.e., plant height; number of leaves and branches per plant and fresh and dry weight per plant as well as yield component, i.e., bulb length; bulb diameter; bulb thickness; seed yield, i.e., number of umbels per plant, weight of seeds per plant and weight of seeds per feddan and essential oil traits than sprayed with tap water (control) during the two seasons. The interaction between sowing dates 15th October and spraying with seaweed extract at 2 g / l resulted in higher values of studied traits in sweet fennel. Thus, we provide the evidence for sowing sweet fennel on the early date (15th October) then spraying the plants with seaweed extract at 1 and / or 2 g / l to produce higher vegetative growth, seed yield and essential oil traits in sweet fennel (*Foeniculum vulgare* Mill).

Key words: Sweet fennel, sowing dates, moringa leaf extract, seaweed, growth, yield, essential oil

INTRODUCTION

Sweet fennel (*Foeniculum vulgare* Mill) that belongs to the family *Apiaceae* is one of the important vegetables, medical and aromatic plants, which are an annual, biennial or perennial aromatic herb, depending on the variety, **(El-Bassiony *et al.*, 2014)**. It is native to Asia, Europe and North Africa Mediterranean Region, **(Abd El- Wahab and Mehasen, 2009)**. The essential oil of sweet fennel is used to flavor different foods and in industries. It contains phytochemical flavonoid, lipids, proteins, hormones and essential oil. Recently, the world focused his attention to reduce environmental pollution and human health effects, by reducing the use of chemical and synthetic fertilizers in crops production especially vegetables which are eaten fresh using natural substitution **(FAO, 2001).**

Changes in climate parameters lead to change in sowing date and consequently the performance of the crop. In addition to crop management, the physical environment has profound influence on growth of sweet fennel plants. Many author's studied that impact of sowing dates on growth of sweet fennel plants, **Baruah, (2004), Abd El- Wahab and Mehasen (2009) and Abou El-Magd *et al.*, (2010)** showed that fennel seeds should be sown from 15th September to 1st October for higher vegetative growth. On coriander, **Meena *et al.*, (2015)** reported that sowing dates clearly reduced growth of different Apiaceae plants and changed in essential oil yield and quality.

Likewise, natural growth stimulating materials safeties to the environment were used for incrementing the production and the quality of plants **(Shahzad *et al.*, 2013 and El-Sayed *et al.*, 2014).** Moringa is an important plant of Moringaceae family having immensely allelopathic potential. Moringa is known as a vital plant due to its many uses and rich in essential vitamin E, amino acids, proteins, minerals, cytokinins, phenolics, zeatin and many other compounds. Moringa has several uses in agriculture and medical sciences, as reported by **Mahmood *et al.*, (2010); Abdalla, (2014); Rady *et al.*, (2015) and El- Gamal and Ahmed (2016).** Secondary metabolites isolated from *Moringa oleifera* promote the plant growth and defense mechanisms against biotic stress. Furthermore, on pepper plant, **Abou El-Nour and Ewais (2017)** found that the maximum values of vegetative growth, yield and quality traits were obtained with moringa leaf extract foliar spray.

Seaweeds gaining more importance as a natural growth stimulator, which enhances plant growth at various levels of plant. Seaweed extracts have proven to activate the health and growth of plants due to contains appreciable quantities of N, P, K, Zn, Mn, Mg, Fe and etc…., and contains natural plant growth compounds as auxins, cytokinins and gibberlins **(Crouch and Van Stand, 1993 and Sandepogu, 2018)**. The using of seaweed extracts products improves seeds germination, seedling development and increase plant tolerance to environmental stress. Seaweed has been also reported to produce beneficial effects on Global artichoke **(Saif El-Deen *et al.*, 2014)**, sweet fennel **(El-Bassiony *et al.*, 2014)**, fennel **(Mostafa, 2015)**, Dill **(El- Gamal and Ahmed, 2016)** and sweet fennel **(Eisa, 2016)**.

Potassium is an important macro-elements and the most abundant cation in higher plants and has been the target of some researchers mainly because it is essential for enzyme activation and yet others fulfill a structural role in stabilizing proteins and plays an important role in many essential processes such as, photosynthesis, synthesis of protein, phloem transport, maintenance of the osmotic potential of cells in addition to cell extension and walls thickness and stability as indicated by **Marschner, (1995)** and **Cherel, (2004).** It also, helps in many physiological processes and uptake of other nutrient elements on sweet fennel, **Sadanandan *et al.*, 2002; Abou El-Magd *et al.*, (2010) and Shahein *et al.*, (2013)** on lettuce. **El-Bassiony, (2006)** on onion **and Kalid and Shedeed (2015)** on *Nigella sativa* L. they reported that vegetative growth parameters and yield and its component tended to increase with increasing potassium levels. **Shafeek *et al.*, (2018)** noticed that, sprinkle pea with potassium markedly increased vegetative growth, yield and quality. However, **El-Tohamy *et al.*, (2011)** found that, foliar spraying of potassium improved the growth, yield and its components of vegetables.

The study aimed to study the effects of sowing date and foliar spraying with moringa leaf extract, seaweeds extract and potassium sulphate for improving yield and quality characters of sweet fennel bulbs.

MATERIAL AND METHODS

Two field experiments were carried out at Horticulture Research Farm of El- Baramoon, Dakahlia Governorate, Egypt, (+7 m altitude, 30º11 - latitude and 28º26 - longitude), during two successive winter seasons of 2017/2018 and 2018/2019 to evaluate the effect of sowing date and foliar spraying with moringa leaf extract, seaweed extract and potassium sulphate on growth, yield and chemical composition of sweet fennel (*Foeniculum vulgare* Mill.) plant.

Some physical and chemical properties of the experimental soil at the depth 0-30 cm are showed in Table (1) according to **Black, (1982).**

Table 1. Some physical and chemical properties of the experiment soil during 2017/2018 and 2018/2019 seasons

Physical properties	Value		Chemical properties	Value	
	2017/2018	2018/2019		2017/2018	2018/2019
Sand %	27.2	27.5	pH value	8.1	7.6
Silt %	31.5	31.4	EC dS m^{-1}	0.9	0.8
Clay %	41.3	41.1	Total N %	0.03	0.04
Soil texture class	Clay loam	Clay loam	Available P (ppm)	11.3	11.5
CaCo3	3.12	3.2	Available K (ppm)	306	298
Organic matter %	1.4	1.2			

The experimental design was split – plot with three replicates in both growing seasons. Plot area was 13.5 m^2, containing five rows and the seeds were sown in hill on 25 cm spacing between plants and the spacing between two rows were 60 cm. This experiment included 14 treatments which were the

combinations between two sowing dates and 7 treatments. The main plots were assigned for different sowing dates, i.e., 15th October and 15th November and foliar spraying treatments were randomly arranged in sub plots. The prevailing weather conditions during the two growing seasons of sweet fennel in 2017/2018 and 2018/2019 at Dakahlya Governorate are presented in Table 2.

Table 2. The maximum, minimum and average air temperature of Dakahlya Governorate during 2017/2018 and 2018/2019 seasons

		October 2017	November 2017	December 2017	January 2018	February 2018	March 2018	April 2018	May 2018
First season	**Max**	28.93	25.24	23.36	20.77	22.81	24.49	33.72	38.11
	Min	9.41	9.69	10.93	7.23	11.92	15.87	18.52	20.18
	Avg	19.19	17.40	17.81	14.64	15.11	18.63	20.22	25.69
Second season		**October 2018**	**November 2018**	**December 2018**	**January 2019**	**February 2019**	**March 2019**	**April 2019**	**May 2019**
	Max	30.13	24.48	22.94	18.90	19.69	24.92	31.12	35.01
	Min	19.85	14.55	11.32	9.46	10.33	8.35	12.42	13.80
	Avg	24.60	19.01	16.26	13.30	15.69	16.36	18.81	18.86

*Source: Meteorological data from Central Laboratory for Agriculture Climate, Agricultural Research Center, Ministry of Agriculture and Land Reclamation, Egypt.

Different foliar spraying treatments were as follows:

1- Control (sprayed with tap water).
2- Foliar spraying with solution:

-Moringa leaf extract at 1 and 2 g /litter preparing according to **Culver *et al.*, (2012).** It contains appreciable quantities of N 2.89 %, P 0.19 %, K 1.96%, Fe 0.07%, Zn 0.01%, Ca 2.68%, Si 1.58%, IAA 6.31 mg/litter, protein 192 mg/g, carbohydrate 481mg/g, phenols 0.72, flavoids 33.6, GA_3 0.09 mg/l, cytokinin 14.8 mg/l .

- Seaweed extract (Algifret) at 1 and 2 g / litter, prepared as powder of *Ascophullum nodosum* and biological fertilizer, contains appreciable quantities of macro nutrients (N 1%, P 3%, K 2.5 %, Ca 0.17 %, Mg 0.43% and S 2.2 %), micro nutrients (Fe 50 ppm, Zn 0.99 ppm, B 3.87 ppm, Cu 4 ppm and Mn10 ppm), phytohoromones, vitamins and amino acids. It was obtained from Sidasa Egypt for fertilizers, pesticides and chemical company, Cairo, Egypt. - Potassium sulphate potassium fertilizer at 5 and 7.5 g / litter.

These treatments were applied at 30 and 45 days after sowing. Agriculture practices, such as cultivation, fertilization and irrigation, etc. were applied as commonly recommended in the commercial sweet fennel production. Harvesting was carried out at 110 and 120 days after transplanting in the two seasons.

Data recorded:

A random sample of five plants was taken from each plot at 120 days after sowing in both seasons of the study to record the growth parameters as follows:

1- Vegetative growth characteristics

Plant height (cm), number of leaves per plant, number of branches per plant, fresh weight of leaves (g) per plant, fresh weight of bulbs (g) per plant, total fresh weight of plant (g), dry weight of leaves (g) per plant, dry weight of bulbs (g) per plant, total dry weight of plant (g), bulb length (cm), bulb diameter (cm) and bulb thickness (cm),

2- Yield and its components

Sample five plants were randomly taken from each treatment to estimate the following traits, i.e., total soluble solids (TSS), bulb yield per feddan (ton), number of umbels per plant, weight of seeds per plant (g) and weight of seeds per feddan (kg).

3- Chemical analysis

Samples of herbs were oven dried at 70° C, then fine grounded and wet digested were prepared to determine nitrogen, phosphorus and potassium according to A.O.A.C. (1990). Essential oil constituents were carried out using Gas chromatography instrument, Laboratory of Medical and Aromatic Plants Research Section, HRI. Egypt.

Statistical analysis

Data of the two seasons were subjected to statistical analysis as a split- plot design using Co-stat statistical software of variances, and the comparison among means of the different treatment was measured by Gomez and Gomez (1984). The individual comparisons between the obtained values were carried out using LSD at 0.05 levels to compare the means.

RESULTS AND DISCUSSION

1- Vegetative growth characters

Effect of sowing dates

Results in Tables (3 - 6) showed that there were significant differences between sowing dates on 15th October and 15th November on all studied

vegetative growth traits during 2017/2018 and 2018/ 2019 seasons. Sowing sweet fennel seeds on 15th October recorded the highest values for plant height, number of leaves per plant and number of branches per plant for the two seasons. It could be attributed to the period of vegetative growth stage which became short and resulted in significant decreases in vegetative growth traits. The same results were obtained by El- Gamal and Ahmed, (2016) on dill. The same tables showed that significant differences between the sowing dates on 15th October. Sowing date on 15th October recorded the maximum values for fresh and dry weight of leaves, bulb and total of sweet fennel plants. Also, the same table showed that sowing dates affected significantly bulb thickness. The maximum values of these traits were registered when seed of sweet fennel sowed early on 15th October .There were no significant differences between two sowing dates with bulb length, bulb diameter and dry weight of bulbs.

Table 3. Effect of sowing dates, moringa leaf extract, seaweed extract and potassium sulphate and their interactions on plant height, number of leaves and number of branches of sweet fennel plants at 120 days after sowing during 2017 / 2018 and 2018 / 2019 seasons

Treatments		Plant height (cm)		No. of leaves / plant		No. of branches /plant	
		2017 / 2018	2018 / 2019	2017 / 2018	2018 / 2019	2017 / 2018	2018 / 2019
Sowing dates							
15th October		111.24	115.38	13.05	14.43	7.71	8.19
15th November		101.62	106.48	11.86	12.81	6.67	7.33
LSD 5%		1.47	0.89	2.16	1.34	0.89	1.22
Foliar spraying							
Control		69.83	74.00	8.83	9.00	5.17	5.33
MLE_1 at 1 g/L		128.00	136.00	12.17	15.17	7.83	8.17
MLE_2 at 2 g/L		139.67	145.33	14.00	16.00	8.00	8.83
SW_1 at 1 g/L		110.00	114.50	16.00	16.83	8.00	8.83
SW_2 at 2 g/L		121.67	126.33	17.17	18.67	8.5	9.33
K_1 at 5 g/L		86.67	89.50	9.5	9.5	6.33	6.67
K_2 at 7.5 g/L		89.17	90.83	9.5	10.17	6.83	7.17
LSD 5 %		3.58	3.42	1.49	1.47	0.91	0.67
Interaction							
15th October	**Control**	72.67	76.67	9.00	10.00	5.33	5.33
	MLE_1 at 1 g/L	134.00	142.33	12.00	16.67	8.00	8.33
	MLE_2 at 2 g/L	146.33	148.33	15.00	17.67	8.00	8.67
	SW_1 at 1 g/L	119.00	126.00	16.67	17.33	8.33	9.33
	SW_2 at 2 g/L	126.67	131.00	18.33	19.00	9.00	9.67
	K_1 at 5 g/L	88.33	81.00	11.00	10.00	7.33	7.67
	K_2 at 7.5g/L	91.67	92.33	9.33	10.33	8.00	8.33
15th November	**Control**	67.00	71.33	8.67	9.00	5.00	5.33
	MLE_1 at 1 g/L	122.00	129.67	12.33	13.67	7.67	8.00
	MLE_2 at 2 g/L	133.00	142.33	13.00	14.33	8.00	9.00
	SW_1 at 1 g/L	101.00	103.00	15.33	16.33	7.67	8.33
	SW_2 at 2 g/L	116.67	121.67	16.00	18.33	8.00	9.00
	K_1 at 5 g/L	85.00	88.00	8.00	8.00	5.33	5.67
	K_2 at 7.5 g/L	86.67	89.33	9.67	10.00	5.67	6.00
LSD 5 %		5.07	4.84	2.11	2.09	1.30	0.94

MLE: moringa leaf extract, SW: seaweed extract and K: potassium sulphate.

Effect of foliar application

Regarding the influence of spraying with moringa leaf extract, seaweed extract and potassium on vegetative growth characters of sweet fennel, the vegetative growth of sweet fennel responded positively to level of moringa leaf extract. Using moringa leaf extract at 1 or 2 g/l increased plant height. However, using 2 g/l was better of plant height in both seasons as compared with the other treatments. These results are in agreement with those obtained by **Prabhu *et al.*, (2010)** on sacred basil and **Abdalla, (2014)** on rocket plants. The same table illustrated that foliar spraying of moringa lead extract or seaweed improved markedly the

vegetative growth. Generally, the obtained data indicated that the foliar spraying of seaweed extract at 1 or 2 g/l increased significantly number of leaves and number of branches as comparison between the other treatments in the two seasons. Seaweed was superior in comparison to moringa lead extract and potassium levels and recorded the highest values of number of leaves and number of branches for both tested seasons respectively. Moringa leaf extract at 2 g / l recorded means closely near to those of seaweed foliar spraying. On the other hand, the highest plant height in the first and second season was recorded by moringa leaf extract. One of possible reasons for this acceleration of plant height with moringa leaf extract is the enriched content of nitrogen, calcium, proteins and growth promoting hormones **(Moyo *et al.*, 2011).**

Data in Tables (4 and 5) revealed that fresh and dry weight of leaves; bulb and total plant were significantly increased by foliar spraying with seaweed extract treatment at 2 g/l compared with foliar spray with moringa leaf extract and potassium sulphate levels in both seasons, the lowest amount of all traits found by control treatment. The stimulating effect of seaweed extract on growth traits might be attributed to its important action on improving cell division because it contain greatest amount of nutrient elements (N, P, K, B , Fe, Cu and Mg), vitamins and antioxidants**.** These results were in accordance with those reported by **Abd El-Mawgoud *et al.*, (2010)** on watermelon; **Abou El-Yazied *et al.*, (2012**) on snap bean; **Eisa, (2016)** on sweet fennel and **Sandepogu, (2018)** on spinach and lettuce.

As for treatments, spraying with seaweed extract at 1 or 2 g/l recorded the highest values of bulb dimensions (length, diameter and thickness), followed by moringa leaf extract at 1 or 2 g / l of sweet fennel plants in the two seasons. Moreover, the maximum values of bulb dimensions were obtained from spraying with seaweed extract at 2 g/l compared with other treatments in both seasons. Similar results on the effects of seaweed extract on garlic plant were noticed by **Tarek and Hassan (2014).**

Effect of the interaction

Respecting the interactions between sowing date and different concentration of foliar spraying treatments, it is pronounced from tables (3 – 6) that there are significant differences between different treatments. The highest values of plant height were noticed when sweet fennel plants cultivated on 15th October and sprayed with moringa leaf extract at 1 or 2 g/l. Also, the results showed that the highest values of number of leaves and number of branches per plant were obtained when spraying with seaweed followed by moringa leaf extract and potassium sulphate levels under the same sowing date on 15th October. The beneficial effect of seaweed extract application is as a result of many components that may work synergistically at different concentration **(Fornes *et al*., 2002)**.

Interaction between sowing dates and foliar spraying treatments, the results in Tables (4 and 5) revealed that significant differences between different treatments in two seasons were recorded. Generally, the highest values of leaves fresh and dry weight per plant in two seasons were obtained when cultivated on 15th October with spraying with seaweed extract at 2 g / l. The maximum total fresh weight was recorded when sweet fennel seeds cultivated on 15th October and sprayed with seaweed extract at 2 g / l. The lower of fresh weight of leaves per plant, bulb and total fresh weight of plant produced from late sowing dates could be due to high temperature. In the same time, the maximum dry weight of leaves (132.20 and 134.07g), (70.74 and 72.98 g) dry weight of bulb and (202.94 and 207.05g) for total dry weight per plant. Similar results obtained by **El- Gamal and Ahmed (2016)** on dill. Also, Table (6) present the interaction between sowing dates and foliar spraying treatments resulted in highly significant in bulb dimensions (length, diameter and thickness) of sweet fennel plants in both seasons. Seaweed extract at 1 or 2 g / l and early planting date on 15th October recorded the highest amount of bulb (length, diameter and thickness).

On the other hand, late sowing dates (15th November) and spraying with tap water treatment recorded the lowest values of the same traits. Interaction between the first date and spraying with seaweed extract at 2 g / l produced the maximum value of bulb length, bulb diameter and bulb thickness in both seasons. In the same time, interaction between sowing date on 15th November and spraying with seaweed extract at 2 g/l recorded (12.21 and 12.79 cm), (13.86 and 13.91cm) and (8.39 and 8.60 cm) for the same traits in the two tested seasons, respectively, the better efficiency of seaweed extract might be due to the increase in vegetative growth. Data in Table (2) illustrated that, the obtained data may be due to the environmental circumstances became suitable and optimal for having vegetative growth attributes and consequently gave higher number of umbels per plant and weight of seeds per plant in earlier dates of sowing. These results were in accordance with those of Ayub et al., (2008) and Mostafa, (2015) on fennel and El- Gamal and Ahmed (2016) on dill.

Table 4. Effect of sowing dates, moringa leaf extract, seaweed extract and potassium sulphate and their interactions on fresh weight of leaves and bulbs and total fresh weight (g) of sweet fennel plants at 120days after sowing during 2017 / 2018 and 2018 / 2019 seasons

Treatments		Fresh weight of leaves / plant (g)		Fresh weight of bulb / plant (g)		Total fresh weight / plant (g)	
		2017 / 2018	2018 / 2019	2017 / 2018	2018 / 2019	2017 / 2018	2018 / 2019
Sowing dates							
15th October		591.38	590.67	461.48	468.52	1052.76	1059.00
15th November		569.52	575.05	438.43	452.90	1007.95	1027.67
LSD 5%		3.38	6.06	11.31	12.00	13.51	2.95
Foliar spraying							
Control		343.83	339.50	334.17	386.00	678.00	725.50
MLE1 at 1 g/L		613.67	605.00	421.67	424.00	10.35.00	1028.50
MLE2 at 2 g/L		621.50	622.50	449.83	443.33	1071.33	1065.83
SW1 at 1 g/L		702.67	720.83	499.17	487.33	1201.83	1208.67
SW2 at 2 g/L		730.67	741.00	512.83	510.67	1243.50	1251.50
K1 at 5 g/L		518.67	522.33	457.83	468.33	976.50	990.67
K2 at 7.5 g/L		532.17	528.83	474.17	505.33	1006.33	1033.67
LSD 5 %		11.47	9.18	15.44	7.81	17.08	9.70
Interaction							
15th October	**Control**	348.00	346.00	350.00	390.33	698.00	736.33
	MLE1 at 1 g/L	619.00	600.00	433.33	432.00	1051.67	1031.00
	MLE2 at 2 g/L	634.67	636.67	458.33	450.00	1083.00	1086.67
	SW1 at 1 g/L	710.33	723.33	508.33	497.33	1218.67	1220.67
	SW2 at 2 g/L	745.00	745.67	523.67	514.67	1268.67	1260.00
	K1 at 5 g/L	526.67	529.67	471.67	485.33	998.33	1015.00
	K 2 at 7.5 g/L	556.00	553.33	485.00	510.00	1041.00	1063.33
15th November	**Control**	339.67	333.00	318.33	381.67	658.00	714.67
	MLE1 at 1 g/L	608.33	610.00	410.00	416.00	1018.33	1026.00
	MLE2 at 2 g/L	608.33	608.33	441.33	436.67	1049.67	1045.00
	SW1 at 1 g/L	695.00	718.33	490.00	477.33	1185.00	1195.67
	SW2 at 2 g/L	716.33	736.33	502.00	506.67	1218.33	1243.00
	K1 at 5 g/L	510.67	515.00	444.00	451.33	954.67	966.33
	K2 at 7.5 g/L	508.33	504.33	463.33	500.67	971.67	1003.00
LSD 5 %		16.22	12.98	21.83	11.05	24.15	13.72

MLE: moringa leaf extract, SW: seaweed extract and K: potassium sulphate.

Table 5. Effect of sowing dates, moringa leaf extract, seaweed extract and potassium sulphate and their interactions on dry weight of leaves and bulbs of sweet fennel plants at 120 days after sowing during 2017 / 2018 and 2018 / 2019 seasons

Treatments		Dry weight of leaves / plant (g)		Dry weight of bulbs / plant (g)		Total dry weight / plant (g)	
		2017 /2018	2018 / 2019	2017 / 2018	2018 / 2019	2017 / 2018	2018 / 2019
Sowing dates							
15th October		87.83	90.64	57.67	59.97	145.68	150.60
15th November		78.61	86.48	56.34	59.01	134.96	145.51
LSD 5 %		0.69	0.38	NS	NS	1.19	1.54
Foliar spraying							
Control		50.10	56.35	39.71	41.62	89.87	97.78
MLE$_1$ at 1 g/L		82.89	84.59	58.16	60.38	140.54	145.06
MLE$_2$ at 2 g/L		79.01	84.836	58.84	61.44	139.01	146.27
SW$_1$ at 1 g/L		109.75	123.51	63.91	66.20	173.66	189.71
SW$_2$ at 2 g/L		126.68	132.99	69.62	72.44	196.32	205.43
K$_1$ at 5 g/L		66.18	65.02	53.40	56.71	119.53	121.56
K$_2$ at 7.5 g/L		67.93	72.61	55.39	57.64	123.32	130.58
LSD 5 %		3.57	2.00	1.94	0.58	3.96	2.30
Interaction							
15th October	**Control**	51.45	57.58	40.34	42.14	91.79	99.39
	MLE$_1$ at 1 g/L	84.55	86.15	58.48	60.53	142.03	146.68
	MLE$_2$ at 2 g/L	85.91	88.49	58.25	62.08	146.49	150.57
	SW$_1$ at 1 g/L	120.80	124.74	65.48	67.02	186.28	191.77
	SW$_2$ at 2 g/L	132.20	134.07	70.74	72.98	202.94	207.05
	K$_1$ at 5 g/L	68.63	68.58	54.34	57.02	122.97	125.26
	K$_2$ at 7.5 g/L	71.24	74.84	56.05	58.01	127.28	133.52
15th November	**Control**	48.76	55.11	39.03	41.09	87.95	96.18
	MLE$_1$ at 1 g/L	81.23	83.03	57.82	60.22	139.05	143.43
	MLE$_2$ at 2 g/L	72.10	81.16	59.44	60.80	131.54	141.97
	SW$_1$ at 1 g/L	98.69	122.28	62.34	65.38	161.03	187.66
	SW$_2$ at 2 g/L	121.16	131.91	68.49	71.89	189.69	203.80
	K$_1$ at 5 g/L	63.73	61.47	52.47	56.40	116.09	117.87
	K$_2$ at 7.5 g/L	64.61	70.36	54.74	57.28	119.35	127.64
LSD 5 %		5.05	2.83	2.75	0.82	5.60	3.25

MLE: moringa leaf extract, SW: seaweed extract and K: potassium sulphate.

Table 6. Effect of sowing dates, moringa leaf extract, seaweed extract and potassium sulphate and their interactions on bulb length (cm), bulb diameter (cm) and bulb thickness (cm) of sweet fennel plants at 120 days after sowing during 2017 / 2018 and 2018 / 2019 seasons

Treatments		Bulb length (cm)		Bulb diameter (cm)		Bulb thickness (cm)	
		2017 / 2018	2018 / 2019	2017 / 2018	2018 / 2019	2017 / 2018	2018 / 2019
Sowing dates							
15th October		10.36	10.11	12.94	12.61	7.71	7.77
15thNovember		9.92	10.07	12.92	12.45	7.59	7.20
LSD 5 %		NS	NS	NS	NS	0.09	0.10
Foliar spraying							
Control		7.57	7.60	10.06	10.17	6.16	6.24
MLE_1 at 1 g/L		10.45	10.67	12.87	12.57	7.94	7.90
MLE_2 at 2 g/L		9.81	10.25	13.76	12.72	8.10	8.16
SW_1 at 1 g/L		12.54	12.14	14.84	14.76	8.31	8.52
SW_2 at 2 g/L		12.73	12.16	14.57	14.64	8.48	8.65
K_1 at 5 g/L		8.78	9.04	11.70	11.66	7.26	7.33
K_2 at 7.5 g/L		9.08	8.80	12.72	11.19	7.31	7.37
LSD 5 %		0.73	0.31	0.41	0.46	0.12	0.08
Interaction							
15th October	**Control**	7.57	7.54	10.6	10.32	6.15	6.22
	MLE_1 at 1g/L	10.82	10.88	12.94	12.58	8.03	7.99
	MLE_2 at 2g/L	10.43	10.20	13.61	12.90	8.15	8.16
	SW_1 at 1 g/L	12.66	12.06	14.54	14.55	8.43	8.63
	SW_2 at 2g/L	12.85	12.17	14.85	14.80	8.57	8.69
	K_1 at 5 g/L	8.98	9.07	11.60	11.46	7.31	7.39
	K_2 at 7.5 g/L	9.18	8.88	12.54	11.65	7.35	7.34
15th November	**Control**	7.57	7.65	9.76	10.02	6.16	6.25
	MLE_1 at 1g/L	9.19	10.30	14.60	14.71	7.84	7.82
	MLE_2 at 2g/L	10.07	10.46	14.84	14.74	8.06	8.16
	SW_1 at 1 g/L	12.23	12.21	13.91	12.23	8.18	8.42
	SW_2 at 2g/L	12.79	12.15	12.81	12.86	8.39	8.60
	K_1 at 5 g/L	8.59	9.01	11.80	11.86	7.21	7.27
	K_2 at 7.5 g/L	8.98	8.71	12.89	10.72	7.26	7.40
LSD 5 %		1.04	0.45	0.58	0.66	0.17	0.11

MLE: moringa leaf extract, SW: seaweed extract and K: potassium sulphate.

2- Yield and its components

Effect of sowing dates

Table (7) indicated that sowing dates affected significantly bulb yield traits, the maximum values of these traits were recorded when sweet fennel seeds were sowed on 15th October followed by sowing date on 15th November. There were no significant differences between two sowing dates with respect to TSS %. The most influent treatment and led to the highest significant values of (7.36 and 7.39 %) and (12.31and 12.49 ton) for these traits in the two seasons. Also, the obtained data in same table showed that significant differences between early and late sowing date, sowing sweet fennel seeds on 15th October showed increased of, number of umbels per plant, weight of seeds per plant and weight of seeds per feddan traits in both tested seasons. First sowing date showed the highest significant values of, number of umbels per plant, weight of seeds per plant and weight of seeds per feddan traits. These results are agreement with results, **(Ayub *et al.*, 2008 and Salama *et al.*, 2015)** on sweet fennel; they elucidate the 15th October dates of fennel had higher number of bulb yield per feddan, number of umbels per plant, weight of seeds per plant and weight of seeds per feddan.

Effect of foliar application

Also, Table 7 showed significant differences between foliar spraying treatments in both tested seasons. Potassium sulphate level uses were the bitter treatment in increasing of TSS % which led to their increment at plot level. With plant as foliar spraying with potassium sulphate application gave (8.01 and 8.03 %) and (8.06 and 8.06%) at 5 and 7.5 g / l, respectively. While, moringa leaf extract recorded (7.24 and 7.27%) and (7.27 and 7.30%), while seaweed extract recorded (7.82 and 7.86%) and (7.89 and 7.96) at 1 and 2 g / l, respectively while, control treatment gave (5.18 and 5.30 %) in the two seasons, respectively. Also, from the data recorded in Table (7) it is evident that foliar spraying of moringa leaf or seaweed extracts significantly increased bulb yield per feddan over control. Seaweed extract spray was the bitter treatment in increasing number of bulb yield per feddan and gave (13.67 and 13.70 ton) at 2 g / l, while, moringa leaf extract recorded (11.82 and 12.00 ton) at 2 g/l in both seasons, respectively. Foliar spraying with moringa leaf extract, seaweed extract and potassium levels improved above mentioned traits with superiority of seaweed extract compared with moringa leaf extract, potassium levels and control. The maximum values were recorded by seaweed extract at 2 g / l for number of umbels per plant, weight of seeds per plant and weight of seeds per feddan in the both seasons, respectively. While, moringa leaf extract at 2 g / l recorded (24.33 and 25.00), (27.89 and 28.26 g) and (743.62 and 753.45 kg) compared to control for the same above traits. These results are in agreement with those of **Mostafa, (2015)** on fennel; **Hassan, (2015)** on dill and **Eisa, (2016)** on sweet fennel.

Effect of the interaction

Respecting the interaction, between sowing dates and foliar spraying treatments, the results in Table (7) illustrated that there were significant differences between treatments. Foliar spraying with potassium sulphate at 5, 7.5 g / l on 15th October recorded the maximum values of these traits followed by seaweed extract in the same planting date, while second sowing date (15th November) recorded the lowest value with potassium sulphate levels at 5, 7.5 g / l, respectively. Interaction between first sowing date and spraying with potassium sulphate at 7.5 g / l showed the maximum value for TSS % and bulb yield per feddan of sweet fennel in both seasons, respectively. Also, the results in Table (7) elucidate highly significant variations between different treatments. Early sowing date on 15th October with foliar spraying with seaweed extract at 2 g/l recorded the maximum values of above traits followed by spraying with seaweed on 15th November for the same traits, in the same time, spraying with moringa leaf extract ranked secondly. Respecting the interaction, the studied combination between first sowing dates and seaweed extract foliar treatment showed highest record for number of umbels per plant, weight of seeds per plant and weight of seeds per feddan in both seasons, respectively. While, the interaction between second sowing date and foliar spray with seaweed extract cleared lowest record for the same trait in both seasons. Generally, to economic view, must be selecting suitable sowing dates on15th October and spraying with seaweed extract at 1 or 2 g /l twice during the growing season to increase TSS, bulb yield and weight of seeds per plant.

Table 7. Effect of sowing dates, moringa leaf extract, seaweed extract and potassium sulphate and their interactions on TSS, number of umbels/ plant, weight of seeds / plant (g) and feddan (kg) of sweet fennel plants at 120days after sowing during 2017 / 2018 and 2018 / 2019 seasons.

Treatments		TSS (%)		Bulb yield (ton)/ fed.		No. umbels / plant		Weight of seeds/ plant (g)		Weight of seeds/ fed. (kg)	
		2017 / 2018	2018 / 2019	2017 / 2018	2018 / 2019	2017/ 2018	2018/ 2019	2017/ 2018	2018/ 2019	2017 / 2018	2018 / 2019
Sowing dates											
15th October		7.36	7.39	13.31	13.49	25.76	26.00	28.19	26.94	698.43	718.44
15th November		7.35	7.41	11.69	12.08	23.90	22.57	25.76	25.86	681.77	689.46
LSD 5 %		NS	NS	0.30	0.22	0.70	1.22	1.06	0.15	16.42	4.13
Foliar spraying											
Control		5.18	5.30	8.91	10.29	18.00	19.00	17.47	19.66	524.25	535.85
MLE_1 at 1 g/L		7.24	7.27	11.25	11.31	24.17	24.00	26.98	27.59	719.40	735.71
MLE_2 at 2 g/L		7.27	7.30	11.82	12.00	24.33	25.00	27.89	28.26	743.62	753.45
SW_1 at 1 g/L		7.82	7.86	13.31	13.00	26.17	24.83	28.77	29.14	767.36	776.88
SW_2 at 2 g/L		7.89	7.96	13.67	13.70	28.33	27.83	29.47	29.67	785.76	791.00
K_1 at 5 g/L		8.01	8.03	12.21	12.49	23.67	24.83	24.55	25.06	654.78	668.21
K_2 at 7.5 g/L		8.06	8.08	12.65	13.62	24.17	25.50	24.71	25.43	658.90	678.16
LSD 5 %		0.16	0.06	0.41	0.20	1.42	0.92	0.58	0.71	22.14	19.01
Interaction											
15th October	**Control**	5.22	5.28	9.33	10.41	19.67	20.00	19.41	20.30	517.59	541.23
	MLE_1 at 1 g/L	7.25	7.27	11.56	11.52	25.00	25.67	27.20	27.80	725.23	741.40
	MLE_2 at 2 g/L	7.27	7.29	12.22	12.00	25.33	26.67	28.23	28.77	752.69	767.27
	SW_1 at 1g/L	7.82	7.85	13.56	13.26	26.67	27.33	28.90	29.77	770.73	793.70
	SW_2 at 2g/L	7.91	7.93	13.96	13.72	29.00	30.00	29.68	30.41	791.45	810.91
	K_1 at 5 g/L	8.00	8.02	12.58	12.94	23.67	26.00	24.74	25.60	659.89	682.65
	K_2 at 7.5g/L	8.04	8.07	12.93	13.60	24.00	26.33	25.18	25.95	671.49	691.89
15thNovember	**Control**	5.13	5.31	8.49	10.18	18.33	16.00	19.53	19.02	520.79	507.28
	MLE_1 at 1g/L	7.22	7.24	10.93	11.09	23.33	22.33	26.77	27.38	713.58	730.02
	MLE_2 at 2 g/L	7.26	7.33	11.77	11.64	24.33	23.33	27.55	27.74	734.56	739.63
	SW_1 at 1g/L	7.83	7.90	13.07	12.73	25.67	22.33	28.65	28.50	763.98	760.07
	SW_2 at 2g/L	7.88	7.99	13.38	13.51	27.67	25.67	29.25	28.92	780.07	771.10
	K_1 at 5 g/L	8.02	8.03	11.84	12.03	23.67	23.67	24.37	24.52	649.76	653.76
	K_2 at 7.5g/L	8.08	8.06	12.36	13.35	24.33	24.67	24.24	24.91	646.30	664.43
LSD 5 %		0.22	0.12	0.58	0.29	2.01	12.36	0.82	1.00	31.30	26.89

MLE: moringa leaf extract, SW: seaweed extract and K: potassium sulphate.

3- Essential oil determination

Effect of sowing dates

Data in Table (8) showed that the essential oil %, essential oil content / plant (ml) and essential oil / feddan (liter) of sweet fennel plants were significantly affected by the two sowing dates and other treatments during the two seasons. The maximum values were noticed when plants sown on 15th October comparison to plant sown on 15th November in the two seasons , except essential oil content in the 2nd season.

Effect of foliar application

As for foliar spraying treatments, the results Table (8) cleared those significant differences in essential oil %, essential oil content / plant (ml) and essential oil / feddan (liter) of sweet fennel plants when comparison to the control. The maximum values resulted from plants sprayed with seaweed extract treatment, followed by moringa leaf extract treatment in the two seasons and the maximum values of essential oil %, (1.21 and 1.22 %), (0.331 and 0.345 ml) for essential oil content /plant and essential oil / feddan (9.524 and 9.684 ml) appeared at 2 g / l in the two tested seasons respectively, followed by moringa leaf extract foliar spray. The results are in harmony with those obtained by **Abo El-Yazied *et al.*, (2012)** on snap bean and **Mostafa, (2015)** on fennel plants.

Effect of the interaction

Respecting the interaction, Table (8) illustrated that significant influence between sowing dates and other foliar spraying treatments on essential oil %, essential oil content / plant (ml) and essential oil / feddan (liter) in the two seasons. Best interaction treatment was from the combination between sowing date on 15th October and spraying with Seaweed extract at 2 g / l in both seasons, the maximum values of essential oil %, essential oil content / plant and essential oil / feddan at 2 g / l in the two seasons respectively, followed by moringa leaf extract foliar spray. The lower essential oil from sowing on 15th November dates may be due to high temperature during development period. This result was agreement with previous finding by **Mirshekari *et al.*, (2011)** on cumin; **Hassan (2015) & El- Gamal and Ahmed** on dill and **Eisa (2016)** on sweet fennel.

4- N, P and K percentage

Effect of sowing dates

The results in Table (9) illustrated that, sowing dates induced variable N, P and K percentages and gave the highest of N, P and K % were recorded from plants sowing on 15th October followed by sowing date on 15th November, except P content in the 1st season. The highest value content of N, P and K % were (1.68 and 1.69 %), (0.38 and 0.39%) and (0.41 and 0.45%) in the two seasons, respectively. while, the lowest values of the percentage of N, P and K which reduced by delaying in planting sowing date in the two seasons, respectively. This trend agrees with that of **Ayub *et al.*, (2008)** on fennel and **El- Gamal and Ahmed (2016)** on dill.

Effect of foliar application

Data in the same Table, illustrated that foliar spraying of moringa leaf extract significantly affected percentage of nitrogen, phosphorus and potassium in leaves of sweet fennel plants. The highest amount of nitrogen, phosphorus and potassium were obtained from the plants sprayed with moringa leaf extract in both seasons. The increment of nitrogen, phosphorus and potassium percentage might be attributed to organic and mineral elements constituents of moringa leaf extract. On dill, **Hassan, (2015)** found that spraying with seaweed extract increased of phosphorus and potassium percentages. **Carigie, (2011)** suggested that seaweed extract elicit abiotic stress tolerance in plants and impart stress tolerance. These results were agreement with previous finding by **Abou El-Yazied *et al.*, (2012)** on snap bean and **El- Gamal and Ahmed (2016)** on dill.

Effect of the interaction

The results in Table (9) show clearly that, the differences between all interactions were significant in the two growing seasons. The reactiveness between sowing date on 15th October and spraying with moringa leaf extract recorded the highest N percentage. While, interaction between sowing date on 15th October and spraying with Seaweed extract recorded the highest P percentage while interaction between sowing date on15th October and spraying with potassium sulphate at 7.5 g / l recorded the maximum values of potassium percentage. The favorable effects of moringa leaf extract may be due to its content of specific plant pigments with demonstrated potent antioxidant properties and contains highly nutritional potentialities of several macro elements as N, P and K. **Abdalla, (2014)** elucidate that foliar application with moringa leaf extract increased rocket (N, P and K %). This result confirmed with the finding of **Zhang and Ervin (2008) and El- Gamal and Ahmed (2016)** on dill.

Table 8. Effect of sowing dates, moringa leaf extract, seaweed extract and potassium sulphate and their interactions on essential oil percentage, essential oil content per plant and essential oil yield per feddan of sweet fennel at 120days after sowing during 2017 / 2018 and 2018 / 2019 seasons.

Treatments		Essential oil (%)		Essential oil content / Plant (ml)		Essential oil yield / fed. (liter)	
		2017 /2018	2018 / 2019	2017 /2018	2018 / 2019	2017 /2018	2018/ 2019
Sowing dates							
15th October		1.13	1.16	0.298	0.306	7.955	8.273
15th November		1.10	1.14	0.286	0.298	7.628	7.935
LSD 5 %		0.01	0.01	0.008	NS	0.220	0.216
Foliar spraying							
Control		1.02	1.02	0.200	0.201	5.311	5.356
MLE1 at 1 g/L		1.12	1.14	0.302	0.313	8.062	8.346
MLE2 at 2 g/L		1.11	1.16	0.311	0.329	8.284	8.760
SW1 at 1 g/L		1.13	1.15	0.326	0.319	8.711	8.951
SW2 at 2 g/L		1.21	1.22	0.357	0.363	9.524	9.684
K1 at 5 g/L		1.11	1.16	0.272	0.292	7.244	7.693
K 2 at 7.5 g/L		1.12	1.17	0.278	0.298	7.404	7.938
LSD 5 %		1.01	0.02	0.007	0.017	0.188	0.270
Interaction							
15th October	**Control**	1.05	1.03	0.203	0.208	5.413	5.556
	MLE1 at 1 g/L	1.12	1.14	0.308	0.318	8.222	8.471
	MLE2 at 2 g/L	1.13	1.16	0.319	0.334	8.507	8.906
	SW1 at 1 g/L	1.15	1.16	0.331	0.345	8.835	9.209
	SW2 at 2 g/L	1.23	1.25	0.365	0.379	9.742	10.106
	K1 at 5 g/L	1.12	1.13	0.276	0.296	7.360	7.733
	K2 at 7.5 g/L	1.14	1.15	0.285	0.297	7.609	7.929
15thNovember	**Control**	1.00	1.02	0.195	0.193	5.209	5.155
	MLE1 at 1 g/L	1.10	1.13	0.296	0.308	7.902	8.222
	MLE2 at 2 g/L	1.11	1.15	0.302	0.323	8.062	8.613
	SW1 at 1 g/L	1.12	1.14	0.322	0.326	8.586	8.693
	SW2 at 2 g/L	1.19	1.21	0.349	0.347	9.306	9.262
	K1 at 5 g/L	1.10	1.17	0.267	0.287	7.128	7.653
	K2 at 7.5 g/L	1.11	1.20	0.270	0.298	7.199	7.946
LSD 5 %		0.02	0.02	0.010	0.024	0.267	0.381

MLE: moringa leaf extract, SW: seaweed extract and K: potassium sulphate.

Table 9. Effect of sowing dates, moringa leaf extract, seaweed extract and potassium sulphate and their interactions on N, P and K percentage / dried herb of sweet fennel plants at 120 days after sowing during 2017/2018 and 2018/ 2019 seasons.

Treatments		N %		P %		K %.	
		2017 /2018	2018 / 2019	2017 /2018	2018 / 2019	2017 /2018	2018 / 2019
Sowing dates							
15th October		1.68	1.69	0.38	0.39	2.43	2.45
15th November		1.62	1.63	0.36	0.36	2.40	2.41
LSD 5 %		0.02	0.04	NS	0.01	0.02	0.009
Foliar spraying							
Control		1.42	1.44	0.29	0.27	2.28	2.24
MLE1 at 1 g/L		1.85	1.89	0.34	0.35	2.34	2.31
MLE2 at 2 g/L		1.93	1.90	0.42	0.42	2.37	2.38
SW1 at 1 g/L		1.77	1.70	0.43	0.47	2.46	2.40
SW2 at 2g/L		1.82	1.85	0.52	0.47	2.49	2.46
K1 at 5 g/L		1.47	1.44	0.33	0.32	2.55	2.49
K2 at 7.5g/L		1.51	1.52	0.35	0.39	2.61	2.57
LSD 5 %		0.03	0.02	0.02	0.02	0.01	0.01
Interaction							
15th October	**Control**	1.36	1.47	0.29	0.28	2.28	2.24
	MLE1 at 1 g/L	1.82	1.86	0.35	0.35	2.35	2.32
	MLE2 at2 g/L	1.91	1.95	0.41	0.43	2.39	2.38
	SW1 at 1 g/L	1.60	1.67	0.48	0.43	2.47	2.40
	SW2 at 2 g/L	1.77	1.78	0.50	0.48	2.50	2.47
	K1 at 5 g/L	1.44	1.43	0.34	0.31	2.57	2.50
	K2 at 7.5 g/L	1.50	1.50	0.36	0.40	2.63	2.58
15thNovember	**Control**	1.48	1.41	0.28	0.26	2.27	2.23
	MLE1 at 1 g/L	1.87	1.83	0.32	0.35	2.33	2.30
	MLE2 at 2 g/L	1.96	1.87	0.39	0.40	2.35	2.38
	SW1 at 1 g/L	1.66	1.84	0.45	0.43	2.45	2.39
	SW2 at 2 g/L	1.87	1.83	0.50	0.47	2.47	2.45
	K1 at 5 g/L	1.50	1.46	0.32	0.32	2.53	2.48
	K2 at 7.5 g/L	1.51	1.53	0.34	0.37	2.59	2.57
LSD 5 %		0.04	0.03	0.03	0.03	0.02	0.02

MLE: moringa leaf extract, SW: seaweed extract and K: potassium sulphate.

CONCLUSION

As a conclusion, it could be recommended that, sowing sweet fennel plants on 15th October and spraying with bio-stimulants such as seaweed extract at 2 g / l and/or moringa leaf extract at 2 g / l twice to produce best yield, seed yield and essential oil.

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