

**EFFECT OF SOME COMMERCIAL BIOFERTILIZERS
ON GROWTH, SEED, VOLATILE OIL YIELD
AND CHEMICAL COMPOSITION OF
FOENICULUM VULGARE, MILL**

By

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ABSTRACT

This study was carried out at the Experimental Farm of Fac. Agric., Kafr El-Sheikh, Tanta University, during the two successive seasons of 1998/1999 and 1999/2000, to study the effect of some commercial biofertilizers (biogen, nitroben and serialen) on the vegetative growth, seed yield, volatile oil productivity, and chemical composition of *Foeniculum vulgare* Mill.

The field experiment received 10 m³/fed. organic manure for all treatments, before planting, biofertilizers were utilized at three different dates for each. The results can be summarized as follows:

- All biofertilizer treatments increased all studied parameters as plant height, number of leaves/plant, fresh and dry weight of vegetative parts/plant, number of branches/plant, number and weight of umbels/plant, fruits weight/plant and the weight of 100 fruits with significant differences over control in most cases. The best results were obtained from the treatments of serialen 2, biogen 2, biogen 3 and nitroben 3.
- The different commercial biofertilizers increased volatile oil % in the seeds, volatile oil yield/plant and /fed. The best treatment being serialen 2.
- The different commercial biofertilizers increased N, P and K% in the leaves over control with significant differences in most cases. The best results being for the treatments of Serialen 2 and nitroben 3 and serialen 3 in most cases both seasons.

INTRODUCTION

Biofertilizers are produced and practiced in different countries as well as in Egypt under different commercial names. They are either nitrogen fixers (Rhizobia, Azotobacter, Azospirillum and algae or phosphate solubilizing microorganisms (bacteria and mycorrhiza). Using these biofertilizers could supply plants with their requirements of nitrogen and phosphorus during their growth by cheap means, which in turn decreased the application of expensive mineral fertilizers and lead to significant decrease in the production costs of the different crops. Also, pollution rates in soil, water and air could be lowered as a result-of decreasing the applied chemical fertilizers. (Alaa El-Din, 1982).

Solubilization of mineral nutrients, synthesis of vitamins, amino acids, auxins and gibberellins, which stimulate plant growth, come as a result of inoculation with *Azotobacter* spp. (Sprent, 1990).

Foeniculaum vulgare Mill (fennel) Fam: Apiaceae (Umbelliferae) is a seed (fruit) aromatic plant. Its volatile oil has carminative and stimulant properties and spasmodic effects on smooth muscles of experimental animals *in vitro*, (Boulos, 1983).

Fennel volatile oil is used as carminative or flavoring agent in certain laxative preparations. The oil is used as a fragrant component in cosmetics, including soaps, detergents, creams, lotions and perfumes with the highest maximum use level of 0.4% for perfumes (Albert, 1980).

In general with using biofertilizers plant height, Number of leaves/plant, fresh and dry weights, herb, number of branches/plant, umbels number/plant, seed yield/hill, and/fed., N, P and K% of leaves, total carbohydrates %, volatile oil % volatile oil yield/hill and /feddan were increased as was reported by Kandeel et al. (2001) on *Foeniculum vulgare*.

Likewise, the results of El-Sawey et al. (1998) and Nofal et al. (2001) on *Ammi vismoga* who found that biofertilizers treatments increased growth parameters and the active constituents of fruits. Also, Rashed (2002) on *Anethum graveolens* L., *Coriandrum sativum* L. and *Petroselinum sativum* Mill found that biofertilizer treatments increased plant height, fresh and dry weights/plant and N, P and K % in the leaves.

This research, however, is an attempt to find out the best application time and suitable inoculation times of some commercial biofertilizer on the vegetative growth, chemical composition and volatile oil yield for *Foeniculum vulgare* (fennel).

MATERIALS AND METHODS

Two field experiments were carried out during the two successive seasons of 1998/1999 and 1999/2000, at the Experimental Farm of Fac. Agric., Kafr El-Sheikh, Tanta Univ. to study the effect of some commercial biofertilizers i.e. biogen, nitroben and serialen on the vegetative growth, seeds yield, volatile oil productivity, and chemical composition of *Foeniculuim vulgare*, Mill.

The plant seeds were supplied from the National Research Center, Dokki, Egypt. They were sown in a clay soil for the two seasons on November 15th in the first season and November 10th for the second one, in plots each of 1.50 × 2.0 m at the space of 40 × 50

cm as every plot contained 15 plants/plot and replicated 3 times in a completely randomized block design.

Before planting, organic manure as a compost at the rate of 10 m³/fed. was added for all treatments at the time of soil preparation.

The used commercial biofertilizers were biogen, nitroben, and serialen produced by Egyptian Ministry of Agriculture as the seeds were inoculated with either of them immediately before planting, except for control. Each commercial biofertilizers was added as inoculating the seeds or as side-dressing after 30 days from sowing and another treatment was repeated as a side-dressing after 30 and 60 days from planting.

Ten treatments were conducted as follows :

Control	:	received only organic fertilizer at 10 m ³ /fed.
Biogen	1	: seeds were inoculated with biogen immediately before planting at the recommended dose (400 gm/fed.).
Biogen	2	: inoculated seeds + side-dressing after 30 days from planting.
Biogen	3	: inoculated seeds + side-dressing after 30 and 60 days from planting.
Nitroben	1	: seeds were inoculated with nitroben immediately before planting at the recommended dose (400 gm/fed.).
Nitroben	2	: inoculated seeds + side-dressing after 30 days from planting.
Nitroben	3	: inoculated seeds + side-dressing after 30 and 60 days from planting.
Serialen	1	: seeds were inoculated with serialen immediately before planting at the recommended dose (400 gm/fed.).
Serialen	2	: inoculated seeds + side-dressing after 30 days from planting.
Serialen	3	: inoculated seeds + side-dressing after 30 and 60 days from planting.

The mean values of the treatment were compared by Duncan's multiple range test according to **Snedecor and Cochran (1967)**

The full blooming of fennel plants was on 1st March and 15th February in the first and second season, respectively as the following data were recorded

- 1- Plant height (cm)
- 2- No. of leaves/plant.
- 3- No. of branches/plant.
- 4- No. of umbels/plant.
- 5- Fresh and dry weights of vegetative parts/plant (g.).
- 6- Chemical composition of leaves (N, P and K%).

Ripe fruits of fennel were harvested on May 12th and April 28th for the two seasons, respectively.

At end of the growing season the following data were recorded after ripening of fruits.

- 7- Umbles weight/plant (g.)
- 8- Fruits weight/plant (g.)

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|------------------------------------|---|
| 9- Weight of 100 fruits (g.) | 10- Volatile oil percentage of seeds (fruits) |
| 11- Volatile oil yield/plant (ml.) | 12- Volatile oil yield/fed. (litre) |

The essential oil percentage in the dry ripe fruits was determined using a distillation apparatus.

For chemical analysis, leaves were oven dried at 70°C to a constant weight, then ground in the Willy mill to a fine powder, for the elements determination as 0.1 g of dry matter was used. Total nitrogen was estimated using micro-kjeldahl method according to Pregel (1945). Phosphorus was determined by using the method described by King (1951). Potassium was estimated by using the flame photometer according to the method described by Brown and Lilliland (1946).

For chemical analysis of the soil samples were taken before planting in the two seasons as determined the mechanical and chemical properties of the experimental soil according to Jackson (1967). The soil was of a clay texture with total N of 0.75-0.77 %, P (5.99-6.03 ppm) and K-exchangeable of (0.90-0.93%) in the two seasons.

RESULTS AND DISCUSSION

1. Effect of some commercial biofertilizer on vegetative growth, seeds and oil yield and chemical composition of fennel (*Foeniculum vulgare* (Mill)).

A. Vegetative growth :

Data of the effect of biogen, nitroben and serialen on plant height, number of leaves/plant, fresh and dry weight of aerial parts/plant for the two seasons are presented in Table (1)

1. Plant height :

Data in Table (1) showed that the used biofertilizers increased plant height over control treatment with significant differences in most cases during the two seasons.

The tallest plants resulted from the treatments of serialen 2 followed by biogen 3 in the first season, while in the second one the tallest plants were obtained from biogen 3 followed by serialen 2 treatment. Control treatment gave the shortest plants in two season. However, the differences between the other treatments of biofertilizer were non-significant during both seasons.

The stimulatory effect of inoculation with biofertilizer was observed and discussed by many workers on numerous plants as

Sharma *et al.* (1996) on *Acacia auriculiformis* who postulated that a significant increment was observed between various treatments of N₂-fixing symbionts and fertilizer for the height of field plants. Similar results were obtained by Hamed (2004) who found that application of biofertilizers increased plant height, number of branches per plant, fresh and dry weights of herb per plant and per feddan, essential oil %, essential oil yield per plant and per feddan and N, P, K % in the leaves of *Salvia officinalis* L and *Origanum syriacum* L. var. *aegyptiacum* Tack.

Table (1): Effect of some commercial biofertilizers on plant height, number of leaves/plant, fresh and dry weight of *Foeniculum vulgare* Mill herb during the two seasons of 1998/1999 and 1999/2000.

Treatments	1 st season				2 nd season			
	Plant height (cm)	No. of leaves/plant	Herb weight		Plant height (cm)	No. of leaves/plant	Herb weight	
			Fresh (g)	Dry (g)			Fresh (g)	Dry (g)
Control	99.50cd	8.63 c	56.75 d	11.66 d	952.2 c	8.89 b	58.07 f	8.05 e
Biogen 1	102.13 bcd	8.73 c	62.66 cd	11.88 d	104.78 bc	9.00 b	58.11 f	11.17 c
Biogen 2	106.33 abcd	10.73 ab	116.31 a	25.82 a	100.22 bc	11.00 ab	75.68 e	13.74 de
Biogen 3	112.50 ab	10.30 ab	96.03 b	20.48 bc	126.3 a	12.11 a	92.59 d	17.95 cd
Nitroben 1	103.67 abcd	9.20 bc	105.88 ab	21.62 bc	108.33 bc	9.89 ab	103.25 cd	19.12 bcd
Nitroben 2	110.50 abc	9.87 abc	97.57 b	19.81 c	114.22 ab	11.00 ab	117.99 bc	25.10 ab
Nitroben 3	101.00 cd	9.20 bc	116.66 a	24.32 ab	11.22 ab	10.89 ab	134.66 a	26.16 a
Serialen 1	99.63 cd	8.73 c	76.61 c	14.53 d	106.66 bc	100.00 ab	126.95 ab	25.44 ab
Serialen 2	114.67 a	11.73 a	106.22	21.38 bc	116.44 b	12.22 a	112.93 bc	20.20 bc
Serialen 3	106.00 abcd	11.63 a	101.23 ab	20.08 bc	105.11 bc	11.45 ab	111.24 bc	21.67 abc

Means having the same letters in the column are not significantly different at 5% level according to Duncan's Multiple Range Test.

2. Number of leaves/plant :

Data in Table (1) indicated that the majority of used commercial biofertilizer treatments gave more number of leaves/plant than control with significant differences in most cases for both seasons.

In the first season the highest number of leaves/plant resulted from the treatment of serialen 2 followed by serialen 3 then biogen 3 in a descending order, whereas nitroben at the different inoculation dates slightly increased number of leaves/plant with non significant difference over control in the two seasons except for the treatment of nitroben 2 in the first season only which significantly increased this value. In the second season the highest values resulted descendingly from the treatments of serialen 2, biogen 3, serialen 3, biogen 2 and nitroben 2.

Similar results were obtained by Reiad *et al.* (1987) on maize and Wange (1996) on *Daucus carota* who found that microbial inoculation of the seeds significantly increased number of leaves. The most effective microbial treatments tended to be microphos

(phosphate solubilizing bacteria), Azotobacter, Azospirillum, Azotobacter + Azospirillum and Azotobacter + Azospirillum + P solubilizing bacteria (microphos).

3. Fresh weight/plant :

It was evident from data in Table (1) that all treatments of commercial biofertilizers significantly increased fresh weight of *Foeniculum vulgare* herb in the two seasons.

The highest values were resulted from nitroben 3 and biogen 2 in the first season followed by serialen 2, nitroben 1 and serialen 3, while in the second one the highest values were recorded from nitroben 3 treatment followed by serialen 1, nitroben 2 then serialen 2, serialen 3 and nitroben 1. The lowest values were resulted from the treatment of biogen 1 for the two seasons.

These results are in agreement with those obtained by Hassouna et al. (1994) on *Medicago sativa* and Harridy and Amara (1997) on *Hibiscus sabdariffa* who stated that the plant growth showed generally a positive response especially with Rhizobium and Azotobacter. Rhizobium was the most effective bacteria in this respect.

4. Dry weight/plant :

Data in Table (1) revealed that, all used treatments of biofertilizers significantly increased the herbage dry weight/plant over control treatment in both seasons.

In the first season the heaviest dry weights resulted from the treatments of biogen 2 and nitroben 3 followed by nitroben 1, serialen 2, biogen 3 and serialen 3.

In the second season the heaviest dry weights resulted from the treatments of nitroben 3, serialen 1 and nitroben 2 followed by serialen 3, serialen 2 and nitroben 1. The stimulatory effect of inoculation with biofertilizers was observed and discussed by many workers on numerous plants as Reiad et al. (1987) on maize who found a significant increase in dry weight of leaves and shoots by using Azotobacter and by using mixture of biofertilizers. These results agree with those obtained by Maheshwari et al. (1988) on *Hyoscyamus niger*, and El-Naggar (1998) on *Polianthus tuberosa* L.

The superiority of biofertilizer treatments on plant height, number of leaves, fresh and dry weights/plant over control may be due to the fixed N by microorganisms as well as exerting vitamins, amino acids, cytokinins and gibberellins as growth regulators for the plants, (Subb Rao, 1981 and Sprent 1990).

5. Number of branches/plant :

Data of the effect of different inoculation treatments with some commercial biofertilizers are presented in Table (2) as showed that all treatments of commercial biofertilizers increased number of branches/plant over control treatment in the two seasons.

The highest augmentation of the number of branches/plant was resulted from the treatment of nitroben 3 in the first season, while in the second one was observed for serialen 2 treatment. Moreover, the values of number of branches/plant showed non significant differences between all used biofertilizer treatments in the first season

In the second season, a similar trend was observed for all used biofertilizers, which increased number of branches with non-significant differences between treatments except for serialen 2, which gave a significant increase in comparison to the other ones.

The lowest values of number of branches was obtained from the control in both seasons. This is in conformity with the results obtained by **Wange (1996)** on *Daucus carota* who reported that microbial inoculation of the seeds significantly increased number of buds as compared to the control treatment. The most effective microbial treatment tended to be microphos (phosphate solubilizing bacteria), Azotobacter, Azospirillum, Azotobacter + Azpspirillum and Azotobacter + Azospirillum + P solubilizing bacteria (microphos). In the same line **Mostafa (1997)** concluded that inoculation with Azotobacter raised number of branches for rape plant.

This result is in agreement with those obtained by **Bonito et al. (1995)** on *Zinnia elegans*, **El-Sawy (1998)** on *Ammi visnaga*, **Gupta et al. (1999)** on *Tagetes erecta* and **Rashed (2002)** on *Anethum geaveolens* L. and *Coriandum sativum* L. who found that NPK + biofertilizer treatments increased plant height, fresh and dry weights/plant and N, P and K% in the leaves

6. Number of umbels/plant :

It was clear from data in Table (2) that all treatments of biofertilizers increased number of umbels/plant over control with non-significant differences in most cases for the first season only.

The highest values of number of umbels/plant were obtained from the treatments of serialen 2 followed by biogen 2 in the first season and a similar trend was obtained in the second season, as the same treatments of serialen 2 followed by biogen 2 gave the highest values of number of umbels/plant. Nitroben 3 treatment increased number of umbels/plant without significant differences

between them for both seasons. These results are in conformity with those mentioned by Wange and Patil (1994) on *Polianthes tuberosa*, Sankaranayanan et al. (1995) on *Daucus carota* and El-Sawy et al. (1998) on *Ammi visnaga* who reported that inoculation with a mixture of Azotobacter and Azospirillum amendment with the full dose of rock phosphate and inorganic N-fertilizer in combination remarkably increased number of umbels/plant.

Table (2): Effect of some commercial biofertilizers on number of branches and number of umbels/plant of *Foeniculum vulgare* Mill during the two seasons of 1998/1999 and 1999/2000.

Treatments	1 st season		2 nd season	
	Branches No./plant	Umbels No./plant	Branches No./plant	Umbels No./plant
Control	2.07 b	7.89 b	2.22 b	9.07 c
Biogen 1	3.20 ab	9.00 b	3.33 b	12.33 bc
Biogen 2	3.40 ab	11.11 b	3.67 b	15.17 a
Biogen 3	4.53 ab	9.89 b	4.00 b	12.20 bc
Nitroben 1	3.97 ab	10.67 b	3.89 b	10.83 c
Nitroben 2	3.53 ab	9.78 b	3.89 b	12.00 c
Nitroben 3	5.20 a	9.22 b	4.00 b	11.50 c
Serialen 1	4.27 ab	11.67 b	4.62 b	10.33 c
Serialen 2	4.73 ab	13.22 a	4.78 a	15.50 a
Serialen 3	4.27 ab	12.55 b	4.44 b	14.33 b

Means having the same letters in the column are not significantly different at 5% level according to Duncan's Multiple Range Test.

B. Seed yield :

Data of the effect of some commercial biofertilizers on the umbels weight/plant, seeds weight/plant and weight of 100 fruits for *Foeniculum vulgare* Mill in the two seasons are presented in Table (3).

1. Weight of umbels/plant :

It was evident from data in Table (3) that all treatments of commercial biofertilizers significantly increased the weight of umbels/plant of *Foeniculum vulgare* over control in the two seasons.

In the first season the highest values were obtained from the treatments of serialen 2, nitroben 3 and serialen 3 followed by biogen 3, serialen 1 and biogen 2 while in the second one the heaviest umbles weight was obtained from the treatments of serialen 2, nitroben 3 and biogen 3 followed by nitroben 2, biogen 2 and nitroben 1. This is in confirmed with the results of, Kandeel et al. (2001) on *Foeniculum vulgare*, El-Sawy et al. (1986) on *Hyoscyamus muticus* L. who reported that the growth (seed yield) was considerably increased by dual inoculation with Azotobacter

and Azospirillum and organic amendment, likewise, the results of **El-Naggar and Mahmoud (1994)** on *Narcissus tazeta*, **Wang and Patil (1994)**, **El-Nagar (1998)** on *Polianthes tuberosa*, **El-Sawy et al. (1998)** and **Nofal et al. (2001)** on *Ammi visnaga*, who found that inoculation with Azotobacter and Azospirillum in the presence of the full dose of N, P and K (300 kg ammonium sulfate + 300 kg calcium superphosphate + 80 kg potassium sulfate per fedd.) raised the seeds yield per fed.

2. Fruits weight/plant :

Data in Table (3) showed that all treatments of biofertilizer increased the weight of fruits/plant over control with significant differences in most cases.

In the first season the highest values of fruits weight/plant were obtained from the treatments of serialen 2 followed by serialen 3 then nitroben 3 and biogen 3. In the second season the highest values were recorded from the treatments of serialen 2, nitroben 3, followed by nitroben 2, biogen 3 then biogen 2 and serialen 3.

These results may be attributed to the increase of the lateral shoots. These results agree with data obtained by **Kandeel et al. (2001)** on *Foeniculum vulgare* who found that inoculation with Azotobacter + Azospirillum in the presence of full dose of N, P and K (300 kg ammonium sulfate + 300 kg calcium superphosphate + 80 kg potassium sulfate per fedd.) increased the seeds yield per fed. **Maheshwari et al. (1991)** on *Cymbopogon martinii var motia* noticed that *Azotobacter chroococcum* alone enhanced herbage yield by 16% and when applied together with 80 kg N it increased yield by 29%. Likewise the results of **El-Naggar and Mahmoud (1994)** on *Narcissus tazeta*, **Wange and Patil (1994)** on *Polianthes tuberosa*, **Harridy and Amara (1997)** on *Hibiscus sabdariffa* and **Abd El-Fattah (1998)** on *Cynara scolymus*,

3. Weight of 100 fruits :

Data in Table (3) showed that, the weight of 100 fruits was increased using all commercial biofertilizers over control treatment with non-significant differences in most cases during the two seasons.

The highest values were resulted from serialen 3 for both seasons. Meanwhile the control treatment gave the lowest values of the two seasons. The previous results agreed with those obtained by, **El-Sawy et al. (1998)** on *Ammi visnaga* who found that inoculation with a mixture of Azotobater and Azospirillum amendment with the full dose of rock phosphate and inorganic N-

fertilizer inoculation remarkably increased weight of umbels and seeds.

Table (3): Effect of some commercial biofertilizer on the umbels weight/plant, fruits weight/plant and weight of 100 fruits of *Foeniculum vulgare* Mill during the two seasons of 1998/1999 and 1999/2000.

Treatments	1 st season			2 nd season		
	Weight of umbels/plant (g)	Fruits weight/plant (g)	Weight of 100 fruit (g)	Weight of umbels/plant (g)	Fruits weight/plant (g)	Weight of 100 fruit (g)
Control	12.27 dc	10.17 d	0.73 b	14.65 e	11.59 f	0.88 c
Biogen 1	16.38 bc	13.03 cd	0.89 ab	15.21 d	11.83 e	0.91 bc
Biogen 2	16.62 bc	14.57 c	0.89 ab	20.27 ab	17.03 bc	0.92 bc
Biogen 3	19.15 b	16.80 ab	1.01 ab	20.77 ab	17.40 bc	1.06 ab
Nitroben 1	13.74 de	10.35 d	0.74 b	18.53 bc	14.49 cd	0.92 bc
Nitroben 2	15.87 cd	12.32 cd	0.93 ab	20.28 ab	17.99 bc	0.99 b
Nitroben 3	22.60 ab	17.91 ab	0.93 ab	20.94 ab	18.08 ab	1.04 ab
Serialen 1	16.88 bc	12.66 cd	1.01 ab	17.72 cd	15.24 cd	1.06 ab
Serialen 2	23.32 a	18.61 a	1.00 ab	22.96 a	19.99 a	1.02 ab
Serialen 3	22.36 ab	18.09 ab	1.19 a	18.10 bc	15.90 cd	1.16 a

Means having the same letter in the column are not significantly different at 5% level according to Duncan's Multiple Range Test.

C. Volatile oil yield :

Data of the effect of some commercial biofertilizers on the volatile oil percentage, volatile oil yield/plant and /feddan in the two seasons are presented in Table (4).

1. Volatile oil percentage :

It was obvious from data in Table (4) that all treatments of biofertilizers increased the volatile oil percentage with significant difference in most cases over control in the first season. While in the second one most of the biofertilizer treatments augmented the volatile oil percentage with non-significant differences in the majority of treatments as compared to the control.

The highest values were observed for the treatments of serialen 2 followed by serialen 3, biogen 2 and serialen 1. On the other hand, in the second season the most pronounced effect resulted from the treatments of serialen 2 followed by nitroben 2, serialen 3, nitroben 3 and biogen 2, while the least values were recorded from the control treatment in the two seasons. These results agree with those obtained by Kandeel *et al.* (2001) on *Foeniculum vulgare* Mill, and Maheshwari *et al.* (1991 and 1995) on *Cymbopogon martinii var motia*, who found that the average oil

yield was raised by 21% with *Azospirillum chroococcum* alone and by 27% with *Azospirillum* + 80 kg N.

2. Volatile oil yield/plant :

Data in Table (4) showed that, all used biofertilizer treatments increased volatile oil yield/plant over control with significant differences in most cases during the two seasons.

In the first season the highest values of volatile oil were recorded for the treatment of serialen 2 followed by nitroben 3 and serialen 3 then biogen 3, respectively. The least values were recorded for the control plants during both seasons. In the second season the most pronounced effect resulted from the treatment of serialen 2 followed by nitroben 2 then nitroben 3. These findings are in agreement with those reported by Kandeel *et al.* (2001) on *Foeniculum vulgare* who found that the highest volatile oil yield/plant resulted from biofertilizer treatment with *Azotobacter* + *Azospirillum* in the presence of full dose of N, P and K (300 kg ammonium sulfate + 300 kg calcium superphosphate + 80 kg potassium sulfate/fed.). Also, Maheshwari *et al.* (1988) on *Cymbopogon martinii var motia*, stated that the highest essential oil yield was recorded from applying *Azotobacter* sp. at 2 kg/ha together with 20 kg N+20 kg P/ha under rainfed conditions in a shallow black soil.

Table (4): Effect of some commercial biofertilizer on volatile oil % and volatile oil yield per plant and per fed. of *Foeniculum vulgare* Mil during the two seasons of 1998/1999 and 1999/2000.

Treatments	1 st season			2 nd season		
	Volatile oil %	Volatile oil yield/plant (ml)	Volatile oil yield/fed. (L)	Volatile oil %	Volatile oil yield/plant (ml)	Volatile oil yield/fed. (L)
Control	0.80 d	0.08 cd	1.71 cd	0.84 c	0.10 de	2.11 de
Biogen 1	1.55 ab	0.20 bc	2.24 bc	1.25 de	0.14 cd	3.11 cd
Biogen 2	1.62 ab	0.23 bc	4.83 bc	1.50 cd	0.25 bc	5.36 bc
Biogen 3	1.43 bc	0.24 bc	5.06 bc	1.45 cd	0.25 bc	6.09 bc
Nitroben 1	1.44 bc	0.14 c	2.911 c	1.36 d	0.19 cd	4.13 cd
Nitroben 2	1.54 ab	0.19 bc	3.98 bc	1.60 b	0.28 ab	6.07 ab
Nitroben 3	1.52 ab	0.27 ab	6.09 ab	1.55 cd	0.28 ab	5.85 ab
Serialen 1	1.62 ab	0.20 bc	4.04 bc	1.49 cd	0.22 bc	4.76 bc
Serialen 2	1.77 a	0.32 a	6.72 a	1.80 a	0.36 a	7.56 a
Serialen 3	1.64 ab	0.27 ab	5.72 ab	1.57 b	0.24 bc	5.24 bc

Means having the same letters in the column are not significantly different at 5% level according to Duncan's Multiple Range Test.

3. Volatile oil yield/feddan :

It is clear from data in Table (4) that all used commercial biofertilizers increased the volatile oil yield/fed. over control with

significant differences in the majority of treatments during both seasons.

In the first season the highest values were recorded for the treatments of serialen 2 followed by nitroben 3 then serialen 3 and biogen 3.

In the second season the most pronounced effect resulted from the treatments of serialen 2 followed by biogen 3 and nitroben 2 then nitroben 3. However, the differences between the other treatments of biofertilizers were non-significant during both seasons. The least values were recorded for the control plants during both seasons. The previous results agreed with those obtained by Kandeel *et al.* (2001) on *Foeniculum vulgare* Mill who reported that the highest oil yield/fed. resulted from biofertilizer treatment with Azotobacter + Azospirillum in the presence of full dose of N, P and K (300 kg ammonium sulfate + 300 kg calcium superphosphate + 80 kg potassium sulfate/fed.).

D. Chemical composition :

The effect of commercial biofertilizers on nitrogen, phosphorus and potassium percentages of *Foeniculum vulgare* leaves in the two experimental seasons are presented in Table (5).

1. Nitrogen percentage :

Data in Table (5) cleared that all treatments of biofertilizers increased N % in the leaves with non-significant differences, over control treatment in both seasons.

In the first season the highest values of nitrogen percentage in the leaves were observed for the treatments of serialen 2 followed by nitroben 2 then biogen 3, while in the second one the highest values resulted from the treatments of serialen 2 followed by serialen 3 then biogen 2 and Serialen 1. These findings are in agreement with those reported by El-Sawy *et al.* (1998) on *Ammi visnaga* L. who reported that inoculation of seeds with a mixture of Azotobacter and Azospirillum with the full dose of rock phosphate and inorganic N-fertilizer remarkably increased production of chemical constituents. Nofal *et al.* (2001) stated that inoculation with Azotobacter and Azospirillum in the presence of full dose of N, P and K (300 kg ammonium sulfate/fed. + 300 kg calcium superphosphate + 80 kg potassium sulfate per fed.) gave the highest N % in *Ammi vsnaga* L. leaves.

2. Phosphorus percentage :

Data in Table (5) revealed that, phosphorus percentage was increased by using all commercial biofertilizers over control

treatment with significant differences in most cases during the two seasons.

Table (5): Effect of some commercial biofertilizers on N, P and K percentage in *Foeniculum vulgare* Mill leaves. during the two seasons of 1998/1999 and 1999/2000.

Treatments	1 st season			2 nd season		
	N	P	K	N	P	K
Control	1.45 e	0.08 c	3.04 c	2.20 bc	0.07 b	2.99 d
Biogen 1	2.87 bc	0.12 bc	4.33 bc	2.68 abc	0.13 ab	4.14 bcd
Biogen 2	2.16 d	0.11 bc	4.03 bc	3.20 abc	0.14 ab	3.89 bcd
Biogen 3	2.99 dc	0.11 bc	3.06 c	2.62 abc	0.12 ab	3.25 cd
Nitroben 1	2.71 bc	0.12 bc	3.23 c	2.97 c	0.11 ab	3.17 cd
Nitroben 2	3.01 ab	0.16ab	5.20 b	3.04 abc	0.14 ab	4.35 bcd
Nitroben 3	2.79 bc	0.15 ab	4.43 bc	2.91 abc	0.13 ab	4.03 bcd
Serialen 1	2.92 bc	0.15 ab	5.20 b	3.15 abc	0.15 ab	4.97 ab
Serialen 2	3.29 a	0.17 a	4.81 bc	3.77 a	0.18 a	4.47 bc
Serialen 3	2.76 bc	0.14 ab	5.31 a	3.40 ab	0.13 ab	5.80 a

Means having the same letters in the column are not significantly different at 5% level according to Duncan's Multiple Range Test.

The highest values of phosphorus percentage in the leaves were resulted from the treatments of serialen 2 followed by nitroben 2 then nitroben 3, serialen 1 and serialen 3 treatments in the first season, while in the second one the highest values were recorded from the treatments of serialen 2 followed by serialen 1 then biogen 2, nitroben 2 and serialen 3. The previous results agreed with those obtained by **Kandeel et al. (2001)** on *Foeniculum vulgare* who found that inoculation with Azotobacter + Azospirillum in the presents of full dose of N, P and K (300 kg ammonium sulfate + 300 kg calcium superphosphate + 80 kg potassium sulfate per fed.) increased the chemical constituents of the leaves, the full dose of N, P and K gave the highest N % in the leaves.

3. Potassium percentage :

Data in Table (5) showed that, potassium percentage in the leaves of *Foeniculum vulgare* Mill were increased by using all commercial biofertilizers over control treatment with significant differences in the most cases during two seasons.

The highest values were resulted from the treatments of serialen 3 followed by nitroben 2 then serialen 1 and serialen 2. On the other hand, in the second season the highest values were observed from the treatments of serialen 3 followed by serialen 1, serialen 2 and nitroben 2. These results are in harmony with those obtained by **Kandeel et al. (2001)** on *Foeniculum vulgare*, and **El-Sawy et al. (1998)** and **Nofal et al. (2001)** on *Ammi visnaga* L.

who reported that inoculation with *Azotobacter* and *Azospirillum* in the presence of full dose of N, P and K gave the highest K% in the leaves.

In fact the increase in N, P and K% in the leaves of *Foeniculum vulgare* may be due to more solubilizing minerals by microorganisms as well as fixing N by N-fixing bacteria, which in turn account on the N, P and K % in plant tissues. (Subb Rao, 1981 and Sprent, 1990).

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الملخص العربي

تأثير بعض الأسمدة الحيوية التجارية على النمو الخضري ومحصول البذرة
والزيت والتركيب الكيماوي لنبات الشمندر
يوسف قنديل، فردوس منبسي، مجدى خلف الله، وسام جاد
قسم البساتين - كلية الزراعة بكفر الشيخ - جامعة طنطا

أجرى هذا البحث بالمزرعة التجريبية بكلية الزراعة بكفر الشيخ - جامعة
طنطا خلال موسمي ١٩٩٩/٩٨م - ٢٠٠٠/٩٩م لدراسة تأثير الأسمدة الحيوية

التجارية مثل البيوجين والنتروبين والسيريايين على النمو الخضري ومحصول الزيت والتحليل الكيماوى لنبات الشمر.

وقد أضيف التسميد العضوى لكل القطع التجريبية بمعدل ٤٠٠ جم/فدان قبل واستخدام الأسمدة الحيوية بثلاث مستويات لكل سماد وكانت المعاملات المستخدمة كالآتى :

- الكنترول : سماد عضوى فقط بمعدل ٣١٠/فدان.
 بيوجين ١ : غمس البذرة فى البيوجين بمعدل ٤٠٠ جم/فدان قبل الزراعة مباشرة.
 بيوجين ٢ : غمس البذرة فى البيوجين قبل الزراعة ثم إضافته بجانب النبات بعد ٣٠ يوم من الزراعة.
 بيوجين ٣ : غمس البذرة فى البيوجين قبل الزراعة ثم إضافته بجانب النباتات بعد ٣٠ ، ٦٠ يوم من الزراعة.
 نتروبين ١ : غمس البذرة فى النتروبين بمعدل ٤٠٠ جم/فدان قبل الزراعة مباشرة.
 نتروبين ٢ : غمس البذرة فى النتروبين قبل الزراعة ثم إضافته بجانب النباتات بعد ٣٠ يوم من الزراعة.
 نتروبين ٣ : غمس البذرة فى النتروبين قبل الزراعة ثم إضافته بجانب النباتات بعد ٣٠ ، ٦٠ يوم من الزراعة.
 سيريايين ١ : غمس البذرة فى السيريايين بمعدل ٤٠٠ جم/فدان قبل الزراعة مباشرة.
 سيريايين ٢ : غمس البذرة فى السيريايين قبل الزراعة ثم إضافته بجانب النباتات بعد ٣٠ يوم من الزراعة.
 سيريايين ٣ : غمس البذرة فى السيريايين قبل الزراعة ثم إضافته بجانب النباتات بعد ٣٠ ، ٦٠ يوم من الزراعة.

ويمكن تلخيص النتائج المتحصل عليها فى الآتى :

- [١] أدت كل معاملات الأسمدة الحيوية الى زيادة كل القياسات مثل ارتفاع النبات وعدد الأوراق/نبات والوزن الطازج والجاف للعشب، عدد الأفرع وعدد النورات/نبات، وزن النورات والخيام/نبات، وزن ١٠٠ بذرة وكانت الزيادة معنوية فى معظم الحالات ونتجت أفضل القياسات من المعاملات سيرالين ٢، سيريايين ٣، بيوجين ٣، نتروبين ٣.
 [٢] إضافة الأسمدة الحيوية التجارية المختلفة زادت من النسبة المئوية للزيت الطيار فى الثمار ومحصول الزيت الطيار للنبات وللقدان وكانت أفضل النتائج المتحصل عليها من المعاملة سيريايين ٢.
 [٣] زادت الأسمدة الحيوية التجارية المستخدمة من النسبة المئوية للنيتروجين والفوسفور والبوتاسيوم فى الأوراق زيادة معنوية فى اغلب الحالات ولوحظت أفضل النتائج من المعاملات سيريايين ٢، نتروبين ٢ ثم سيريايين ٣ فى معظم الحالات خلال الموسمين.