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Effect of organic and bio-fertilization treatments on Fennel plant under drip irrigation system in Bahria Oases.

I- Vegetative growth parameters and yield production

Abdou, M.A.H.[*], Helmy, T.A.[*], Salam, M. S.[*] and Hassan, A.A.[*]

[*]Horticultural department, Fac. of Agric., Minia Univ., Egypt.

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ABSTRACT

This experiment was carried out at the farm of Royal Herbs Company- Bahria Oases - Giza in a newly reclaimed desert land under the drip irrigation system during two successive seasons 2018/2019 and 2019/2020 with the aim of studying the effect of organic fertilizer (compost) and bio fertilization treatments (phosphorein – Effective microorganisms - Minia azoteine and their combinations) and the effect of their interaction on vegetative growth, yield and yield components.

The obtained results indicated that the application of compost was significantly increased vegetative growth parameters; plant height (cm), stem diameter (cm), number of main branches/plant, number of secondary branches/plant and herb dry weight/plant, as well as, fruit yield per plant (g) and fruit yield per fed. (kg).The best treatmernt was 20 ton compost.fed/

Similarly, vegetative and yield characters was significantly increased by all used six bio-fertilization treatments in comparison with control, Phosphorein + Effective microorganisms + Minia azotein treatment was more effective than other treatments.

The interaction between compost and bio-fertilization treatments was significant for all studied vegetative and yield parameters in both seasons. The best treatment was 20 ton/fed. compost with PHOS + EM + MA of bio-fertilizers in both seasons.

KEYWORDS: Compost, Bio-fertilization, (PHOS – EM – MA) and Fennel.

1. INTRODUCTION

Fennel (*Foeniculum vulgare*, Mill.) is a plant belonging to the Umbelliferae (Apiaceae) family; it is native to North Africa, Mediterranean Region, southern Europe and Asia (Abd El- Wahab and Mehasen, 2009). Medicinal and aromatic plants are important economic products which represent significant sources of economic revenue and foreign exchange and are among the most important agricultural export products. The Egyptian government in collaboration with the WHO seeks to protect fennel plants that serve as a source for pharmaceutical compounds and who might increase the export of these plants from Egypt to all over the world (Egypt Magazine, 2000).

The fruits of the plant are used in folk medicine as a diuretic, antispasmodic and stomachic, sedative, balsamic, cardiotonic, digestive, lactogogue and tonic properties and often added to purgatives to alleviate their tendency to cause gripe and improve their flavor and considered as a spice due to terpenoid compounds isolated from fruits volatile oil (Grieve, 1984 and Facciola, 1990).

The essential oil is used in cosmetics and pharmaceutical products (Lawrence, 1984 and Braun and Franz, 1990).

Organic manures are important for medicinal and aromatic plants to produce the best product in both quantity and quality and it is also very safe for human health and environment. This is made by recycling organic material as plant and animals waste and food scraps in a controlled process. Continuous usage of inorganic fertilizer affects soil structure. Hence, organic manures can serve as alternative to mineral fertilizers for improving soil structure (Dauda *et al*., 2008) and microbial biomass (Suresh *et al*., 2004).

Bio-fertilizers are considered to be low cost, eco-friendly and renewable sources of plant nutrients supplementing chemical fertilizers in sustainable agricultural system. This refers to microorganism, which increase crop growth through different mechanisms, i.e. biological nitrogen fixation, phosphate-dissolving, growth promoting or

hormonal substances, increasing availability of soil nutrients (Hedge *et al*., 1999).

Therefore, the aim of the present work was to study the effect of compost and bio-fertilization treatments, as well as, their interactions on vegetative growth, yield and yield components of fennel (*Foeniculum vulgare,* Mill.) plants.

2. MATERIALS AND METHODS

The present study was carried out for two seasons (2018/2019 and 2019/2020) at Bahria Oases (Gizza) – in Royal Herbs farm.

The fruits of fennel (*Foeniculum vulgare,* Mill.) plants were obtained from Royal Herbs company, Gizza, Shabramant. The experiment was arranged in a randomized complete block design in a split plot design with three replicates. The main plot (A) included four levels of compost, (0, 10,15 and 20 ton/fed.) while seven treatments of bio-fertilization Phosphorein (PHOS), Effective microorganisms (EM), Minia azotein (MA), (PHOS + EM), (PHOS + MA), (PHOS + EM + MA) and control treatments occupied the sub-plots (B).

Therefore, the interaction treatments (A*B) were 28 treatments. Fennel was sown in October 21st in the two growth seasons in plots. Each plot consists of 4 m width x 7 m length and it contains 7 terraces (2 line/terrace) with 1 m separation to prevent water seepage from each plot to adjacent plot. Planting rate was 5 kg seeds/fed. in hills with 50 cm apart between hills. Therefore, each experimental unit contained 224 plants (which were thinned into two plants per hill). Thus, the number of plants/fed. was 32,000 plants. Two weeks before planting date, compost was added during preparation of the soil for planting in the two experimental seasons of the Royal Herbs Farm. The physical and chemical analysis of the used soil in both seasons were determined according to **Page *et al*. (1982)** and shown in Table (1).

Table 1. Physical and chemical properties of the used soil.

Soil character	Values	Soil character	Values
Chemical properties:		**Available nutrients:**	
pH 1:2.5	7.80	Ca^{++} (ppm)	116.69
E.C. (dS/m)	0.77	Mg^{++} (ppm)	3.77
O.M.	0.13	Na^{+} (ppm)	35.50
$CaCO_3$	3.35	K^{+} (ppm)	15.56
Exchangeable nutrients:		**Physical properties:**	
Ca^{++} **(mg/100 g soil)**	3.5	Sand (%)	93.70
Mg^{++} **(mg/100 g soil)**	2.5	Silt (%)	3.85
Na^{+} **(mg/100 g soil)**	0.8	Clay (%)	2.45
K^{+} **(mg/100 g soil)**	0.2	Soil type	Sandy

Fresh and active bio-fertilizers, Minia azotein and effective microorganisms E.M. (containing N-fixing bacteria) and Phosphorein (containing phosphate dissolving bacteria) were obtained from the Laboratory of Bio-fertilizers, Department of Genetic, Fac. of Agric., Minia University. Bio-fertilizers were applied three times to the soil beside the plants at the rate of 50 cm^3/hill (1 ml=10^7 cells of bacteria). The first dose; for Phosphorein, Effective microorganism and Minia azotein was added 40 days from sowing date, 20 days interval between the three doses and then plants were irrigated immediately.

The Compost was obtained from El-Sharqia company. The physical and chemical properties of the used compost are shown in Table (2).

Table (2): Physical and chemical properties of the used compost:

Properties	First season	Second season
Organic matter (%)	15.00	13.80
Humidity (%)	7.90	9.00
Ca (ppm)	1405.10	1295.00
Mg (ppm)	46.60	47.40
Na (ppm)	644.00	613.00
K (ppm)	476.20	485.10
P (ppm)	4.30	4.70
E.C. (dS/m)	6.21	6.65
pH	8.10	7.97

The sub plot treatments (B) were as follows: **b_1**, Control; **b_2**, Phosphorien; **b_3**, Effective microorganism; **b_4**, Minia azotein; **b_5**, biofertilizers (Phosphorien + Effective microorganism); **b_6**, biofertilizers (Phosphorien + Minia Azotein); **b_7**, biofertilizers (Phosphorien + Effective microorganism + Minia azotein).

2.1. The following data were recorded at the harvesting time:

2.1.1. Vegetative growth parameters:

plant height (cm), stem diameter (cm), number of main branches/plant, number of secondary branches/plant and herb dry weight/plant (g).

2.1.2. Fruit yield per plant (g) and fruit yield per fed. (kg).

2.2. Statistical analysis:

All obtained data in the first and second seasons were tabulated and statistically analyzed according to **MSTAT-C (1986)** and the L.S.D. test at 5% was followed to compare between the means.

3. RESULTS AND DISCUSSIONS

3.1. Vegetative growth parameters:

Data presented in Tables (3, 4 and 5) revealed that the plant parameters of fennel (plant height, stem diameter, number of main branches/plant, number of secondary branches/plant and herb dry weight/plant) were significantly increased due to the fertilizing plants with the three levels of compost in comparison with untreated treatment in the first and second seasons. The most effective level was 20 ton/fed. followed by 15 ton/fed. then 10 ton/fed.

The increment in fennel growth obtained in the present study as a results of application of organic manure was also found by many authors on fennel, namely Mohamed and Abdou (2004), El-Kouny and Salem (2006), Tanious (2008), Azzaz *et al*. (2009), Abdou *et al*. (2012), Jamshidi *et al*. (2012), Valiki *et al*. (2015), Ali *et al*. (2016), Abo-kutta (2016), Abd El-Aleem *et al*. (2017), Singh *et al*. (2018) and Lal *et al*. (2019).

Table 3. Effect of compost and bio-fertilization. as well as. their combination treatments on plant height (cm) and stem diameter of *Foeniculum vulgare,* Mill. plants during the first and second seasons.

Bio-fertilization treatments (B)	Compost levels, ton/fed. (A)									
	0	10	15	20	Mean (B)	0	10	15	20	Mean (B)
	The 1st season (2018/2019)					The 2nd season (2019/2020)				
Plant height (cm)										
Control	51.77	72.89	77.22	84.11	71.50	53.32	75.08	79.54	86.63	73.64
PHOS	53.88	75.44	86.11	89.77	76.30	55.50	77.70	88.69	92.46	78.59
EM	66.33	81.44	95.55	97.77	85.27	68.32	83.88	98.42	100.70	87.83
MA	63.33	76.77	90.77	91.00	80.47	65.23	79.07	93.49	93.73	82.88
PHOS + EM	69.66	102.11	113.77	**115.66**	100.30	71.75	105.17	117.18	**119.13**	103.31
PHOS + MA	69.22	82.33	100.22	107.11	89.72	71.30	84.80	103.23	110.32	92.41
PHOS+EM +MA	71.77	113.00	**116.77**	**119.22**	**105.19**	73.92	116.39	**120.27**	**122.80**	**108.35**
Mean (A)	63.71	86.28	97.20	**100.66**		65.62	88.87	100.12	**103.68**	
L.S.D. at 5 %	**A: 3.34**	**B: 2.65**		**AB: 5.30**		**A: 3.55**	**B: 2.79**		**AB: 5.58**	
Stem diameter (cm)										
Control	0.45	0.69	0.80	0.96	0.73	0.47	0.72	0.84	1.01	0.76
PHOS	0.57	0.76	0.97	0.98	0.82	0.60	0.80	1.02	1.03	0.86
EM	0.63	0.93	1.17	1.22	0.99	0.66	0.98	1.23	1.28	1.04
MA	0.60	0.78	1.06	1.10	0.89	0.63	0.82	1.11	1.16	0.93
PHOS + EM	0.66	1.25	1.29	1.37	1.14	0.69	1.31	1.35	1.44	1.20
PHOS + MA	0.65	0.95	1.23	1.26	1.02	0.68	1.00	1.29	1.32	1.07
PHOS+EM+MA	0.67	1.27	1.43	**1.63**	**1.25**	0.70	1.33	1.50	**1.71**	**1.31**
Mean (A)	0.60	0.95	1.14	**1.22**		0.63	0.99	1.19	**1.28**	
L.S.D. at 5 %	**A: 0.05**	**B: 0.07**		**AB: 0.14**		**A: 0.08**	**B: 0.09**		**AB: 0.18**	

PHOS: Phosphorein
EM: Effective microorganisms
MA: Minia azotein

Table 4. Effect of compost and bio-fertilization, as well as, their combination treatments on main branches/plant and secondary branches/plant of *Foeniculum vulgare*, Mill. plants during the first and second seasons.

Bio-fertilization treatments (B)	Compost levels, ton/fed.									
	0	10	15	20	Mean (B)	0	10	15	20	Mean (B)
	The 1st season (2018-2019)					The 2nd season (2019-2020)				
	Number of main branches/plant									
Control	1.61	2.83	3.05	3.27	2.69	1.64	2.89	3.11	3.33	2.74
PHOS	1.94	2.90	3.31	3.35	2.88	1.98	2.96	3.37	3.42	2.93
EM	2.25	3.16	3.54	3.59	3.14	2.30	3.22	3.61	3.66	3.20
MA	1.97	2.97	3.37	3.38	2.92	2.01	3.03	3.44	3.45	2.98
PHOS + EM	2.52	3.67	4.90	5.42	4.13	2.57	3.74	5.00	5.53	4.21
PHOS + MA	2.36	3.26	3.64	3.73	3.25	2.40	3.33	3.71	3.81	3.31
PHOS + EM + MA	2.81	4.16	5.65	**6.79**	**4.85**	2.87	4.24	5.76	**6.93**	**4.95**
Mean (A)	2.21	3.28	3.92	**4.22**		2.25	3.34	4.00	**4.30**	
L.S.D. at 5 %	A: 0.28	B: 0.15		AB: 0.30		A: 0.30	B: 0.18		AB: 0.36	
	Number of secondary branches/plant									
Control	4.02	5.80	7.22	8.55	6.40	4.06	5.86	7.29	8.64	6.46
PHOS	4.60	6.66	9.33	9.89	7.62	4.64	6.73	9.42	9.99	7.70
EM	4.89	8.22	10.93	11.33	8.84	4.94	8.30	11.04	11.44	8.93
MA	4.89	7.11	9.95	10.77	8.18	4.94	7.18	10.05	10.88	8.26
PHOS + EM	5.46	12.36	13.55	14.76	11.53	5.52	12.48	13.69	14.91	11.65
PHOS + MA	5.18	8.33	11.88	12.44	9.46	5.23	8.41	12.00	12.56	9.55
PHOS + EM + MA	5.57	12.66	15.63	**16.86**	**12.68**	5.62	12.79	15.79	**17.03**	**12.81**
Mean (A)	4.94	8.74	11.21	**12.09**		4.99	8.82	11.32	**12.21**	
L.S.D. at 5 %	A: 0.79	B: 0.58		AB: 1.16		A: 0.84	B: 0.61		AB: 1.22	

PHOS: Phosphorein
EM: Effective microorganisms
MA: Minia azotein

Table 5. Effect of compost and bio-fertilization, as well as, their combination treatments on herb dry weight/plant (g) of *Foeniculum vulgare*, Mill. plants during the first and second seasons.

Bio-fertilization treatments (B)	Compost levels (ton/fed) (A)									
	0	10	15	20	Mean (B)	0	10	15	20	Mean (B)
	The 1st season (2018/2019)					The 2nd season (2019/2020)				
	Herb dry weight/plant (g)									
Control	26.77	29.57	30.31	32.57	**29.81**	27.58	30.46	31.22	33.55	**30.70**
PHOS	27.11	30.23	32.78	33.10	**30.81**	27.92	31.14	33.76	34.09	**31.73**
EM	27.94	31.37	34.93	35.36	**32.40**	28.78	32.31	35.98	36.42	**33.37**
MA	27.34	30.24	33.31	34.26	**31.29**	28.16	31.15	34.30	35.29	**32.23**
PHOS + EM	28.45	36.80	38.24	39.32	**35.70**	29.30	37.90	39.38	**40.50**	**36.77**
PHOS + MA	28.28	31.63	36.01	36.96	**33.22**	29.13	32.58	37.09	38.07	**34.22**
PHOS + EM + MA	29.26	37.80	40.07	**41.17**	**37.08**	30.14	38.94	41.27	42.41	**38.19**
Mean (A)	**27.88**	**32.52**	**35.09**	**36.11**		**28.71**	**33.50**	**36.14**	**37.19**	
L.S.D. at 5 %	A: 1.00	B: 0.96		AB: 1.92		A: 1.04	B: 1.00		AB: 2.00	

PHOS: Phosphorein
EM: Effective microorganisms
MA: Minia azotein

Data present in Tables (3, 4 and 5) showed that all used six bio-fertilization treatments, significantly increased the fennel plant characters in comparison with control treatment, Phosphorein + Effective microorganisms + Minia zotein treatment was more effective than other treatments.

The role of bio-fertilization treatments in promoting fennel growth was reported by Tanious (2008), and Abdou *et al*. (2012) on fennel plants,

Kenawy (2010) and Ibrahim (2014) on *Ammi visnaga*, Al-Shareif (2006), Abd El-Naeem (2008) and Acimovic (2013) on caraway plants, Hemdan (2008), Nabizadeh *et al*. (2012) and Zand *et al*. (2013) on anise plants and Ahmed (2017) on black cumin.

The interaction between compost and bio-fertilization treatments was significant for all plant growth studied in both seasons Tables (3, 4 and 5). The combined treatment (20 ton/fed. compost with PHOS + EM + MA of bio-fertilizers) with interaction treatments was the best treatment.

3.2. Yield/plant and yield components

Data presented in Table (6) reported that supplying fennel plants with compost at 10, 15 and 20 ton/fed. led to significant increase in fruit yield/plant and per fed. as comparison with control plants. Such three treatments recorded 32.44, 40.41 and 43.05 in the first season and 34.06, 42.43 and 45.21 g/plant in the second season, respectively. So, the heaviest weights of fruits per fed. (1377.6 and 1446.72 kg) was obtained at 20 ton/fed. compost in both seasons, respectively.

In accordance with above mentioned results were those reported by El-Kouny and Salem (2006), Tanious (2008), Khalil *et al*. (2008), Azzaz *et al*. (2009), Abdou *et al*. (2012), Jamshidi *et al*. (2012), Mahmoudi and Asgharipour (2014), Abarghouei (2014), Ali *et al*. (2016), Eisa (2016), Abd El-Aleem *et al*. (2017) and Lal *et al*. (2019) on fennel plants. Safwat and Badran (2002), Badran *et al*. (2007), Asl and Moosavi (2012), Siamak and Sayed (2012), Forouzandeh *et al*. (2014), Helmy (2015), Roussis *et al*. (2017) and Abdou *et al*. (2019) on cumin plants, Acimovic (2013), Abd El-Salam (2015) and Pon Malar *et al*. (2015) on coriander plants.

Also, Data presented in Table (6) showed that all used six treatments of bio-fertilization significantly increased fruit yield/plant and fruit yield/fed. in both seasons compared to the control treatment. The highest values were obtained due to fertilizing fennel plants with PHOS + EM + MA as gave 44.88 g/plant facing control 26.57 in the first season and 47.13 g/plant facing control 27.89 g/plant during the second season. So, the heaviest yield/fed. (1436.16 and 1508.16 kg) in the two seasons, respectively.

These treatments are in agreement with those obtained by Kandeel *et al*. (2001) and Gamar *et al*. (2018) on fennel plants, Safwat and Badran (2002) and Sedigh *et al*. (2014) on cumin plants, Abd El-Latif (2002) and Abdou *et al*. (2009) on caraway plants, Hemdan (2008) and Zand *et al*. (2013) on anise plants, Hellal *et al*. (2011) on Dill plants and Ibrahim (2014) on khilla plants.

Table 6. Effect of compost and bio-fertilization, as well as, their combination treatments on fruit yield/plant and fruit yield/fed. of *Foeniculum vulgare*, Mill. plants during the first and second seasons.

Bio-fertilization treatments (B)	Compost levels, ton/fed. (A)									
	control	10	15	20	Mean (B)	control	10	15	20	Mean (B)
	The 1st season (2018)					The 2nd season (2019)				
	Fruit yield/plant (g)									
Control	21.95	24.31	26.66	33.34	26.57	23.05	25.53	27.99	35.01	27.89
PHOS	22.09	25.66	33.94	36.44	29.53	23.19	26.94	35.64	38.26	31.01
EM	23.27	29.22	39.77	40.66	33.23	24.43	30.68	41.76	42.69	34.89
MA	22.27	26.43	36.66	38.73	31.02	23.38	27.76	38.49	40.67	32.57
PHOS+EM	23.55	43.10	50.44	**51.21**	42.08	24.73	45.26	52.96	**53.77**	44.18
PHOS+MA	23.33	29.36	42.42	47.43	35.64	24.49	30.83	44.54	49.81	37.42
PHOS+EM+MA	23.99	49.00	**52.98**	**53.55**	**44.88**	25.19	51.45	**55.63**	**56.23**	**47.13**
Mean (A)	22.92	32.44	40.41	**43.05**		24.07	34.06	42.43	**45.21**	
L.S.D. at 5 %	A: 2.55	B: 1.45		AB: 2.90		A: 2.67	B: 1.56		AB: 3.12	
	Fruit yield/fed. (kg)									
Control	702.40	777.92	853.12	1066.88	850.24	737.60	816.96	895.68	1120.32	892.48
PHOS	706.88	821.12	1086.08	1166.08	944.96	742.08	862.08	1140.48	1224.32	992.32
EM	744.64	935.04	1272.64	1301.12	1063.36	781.76	981.76	1336.32	1366.08	1116.48
MA	712.64	845.76	1173.12	1239.36	992.64	748.16	888.32	1231.68	1301.44	1042.24
PHOS+EM	753.60	1379.20	1614.08	1638.72	1346.56	791.36	1448.32	1694.72	1720.64	1413.76
PHOS+MA	746.56	939.52	1357.44	1517.76	1140.48	783.68	986.56	1425.28	1593.92	1197.44
PHOS+EM+MA	767.68	1568.00	1695.36	1713.60	1436.16	806.08	1646.40	1780.16	1799.36	1508.16
Mean (A)	733.44	1038.08	1293.12	1377.60		770.24	1089.92	1357.76	1446.72	
L.S.D. at 5 %	A: 63.11	B: 73.11		AB: 46.22		A: 56.81	B: 70.55		AB: 41.10	

PHOS: Phosphorein
EM: Effective microorganisms
MA: Minia azotein

The interaction between compost and bio-fertilization treatments was significant for fruit yield/plant and fruit yield/fed. in both seasons. The best interaction treatments were obtained by adding compost at 20 ton/fed. plus either (PHOS + E.M. + M.A) or (PHOS + E.M) followed by adding 15 ton/fed. compost in combination with (PHOS + E.M + M.A).

The increase in growth parameters and fruit yield may be due to adding compost which improving soil structure (Suresh *et al.*, 2004). Moreover, bio fertilizers increase nitrogen fixation, phosphate dissolving bacteria growth promoting which increasing availability of soil nutrients (Hedge *et al.*,1999).

4. CONCLUSION

It can be concluded that to obtain the best growth and yield of fennel, must be supplying plants with compost at 20 ton/fed. with Phosphoren + Effective microorganisms + Minia Azotein.

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الملخص العربي

تأثير التسميد العضوى والحيوى على نبات الشمر البلدى تحت نظام الرى بالتنقيط فى الواحات البحرية

I- صفات النمو الخضرية وأنتاجية المحصول

[*]محمود عبدالهادي حسن عبده، [*]طارق عبدالناصر حلمى، [*]محمود صبحى سلام ، [*]أحمد على حسن.

[*]قسم البساتين – كلية الزراعة – جامعة المنيا– مصر

أُجرِيَ هذا البحث في مزرعة شركة رويال للأعشاب بالواحات البحرية موسمي (٢٠١٨/٢٠١٩) و (٢٠١٩/٢٠٢٠) لدراسة كيفية تحسين النمو والإنتاجية لنباتات الشمر البلدى فى الأراضى الرملية تحت نظام الرى بالتنقيط فى الواحات البحرية وذلك بدراسة تأثير التسميد العضوى (الكمبوست) بمعدلات (١٠ و ١٥ و ٢٠ طن/فدان وكذلك الكنترول) كعامل رئيسي، والتسميد الحيوي باستخدام البكتريا، كعامل ثانوي، وتشمل: (الفسفورين – الميكروبات الدقيقة النشطة – المنيا أزوتين) والتداخل بين العاملين.

وبعد التجربة لموسمين زراعيين متتاليين، تم الحصول على تأثيرات إيجابية فى جميع معاملات الكمبوست والتسميد الحيوي علي صفات النمو (طول النبات – قُطر الساق – عدد الافرع الرئيسية –عدد الافرع الثانوية – وزن العشب الجاف/النبات) وصفات المحصول (محصول الثمار/نبات – محصول الثمار/فدان) وذلك خلال موسمي النمو.

أفضل النتائج كانت عند إستخدام معدل ٢٠ طن/فدان من الكمبوست بالإضافة إلى التسميد الحيوى باستخدام بكتريا (منيا أزوتين + الميكروبات الدقيقة النشطة + الفوسفورين).