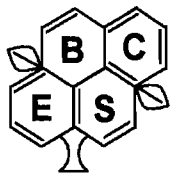

Journal

THE CHEMICAL CONSTITUENT AND VEGETATIVE AND YIELDING CHARACTERISTICS OF FENNEL PLANTS TREATED WITH ORGANIC AND BIO-FERTILIZER AS A SUBSTITUTE OF MINERAL FERTILIZER

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ABSTRACT

This experiment was conducted on the farm of Faculty of Agriculture, Al-Azhar University, Assiut branch to investigate the possibility of using of organic and bio-fertilizers instead of mineral fertilizers and the subsequent effects on vegetative growth, yielding, volatile and crude oils and the secondary metabolites on fennel plants. The obtained results due to different mineral and organic, as well as, bio-fertilizer indicated the augmentation on vegetative growth, yield, essential oil and crude oil. The interaction between recommended NPK x bio-fertilizer mixture treatment and the interaction of 40 m3 of organic manure and bio-fertilizer mixture treatment were the most effective on the above parameters.

Keyword: - fennel, organic, bio-fertilizer, yield, flavonoid and saponin.

INTRODUCTION

Fennel (Foeniculum vulgare) belongs to the family of the Apiaceae, which is an annual, biennial or perennial aromatic herb, depending on the variety (Farrell 1988, Wichtl and Bisset, 1994). It is a source of phytochemical hormones (saponins), flavonoids, lipids, proteins and essential oils. 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 (Watt and Breyer, 1962). The

Egyptian government in collaboration with the WHO seeks to protect fennel plants that serve as sources for pharmaceutical compounds and who might increase the export of these plants from Egypt to all over the world (Egypt Magazine, 2000). Botanically the seeds are defined as fruits (Bhati et al. 1988 and Buntain and Chung, 1994). Fennel is used in folk medicine as a stimulant, diuretic, carminative and sedative (Charles et al. 1993) and galactagogic, emmenagogic, expectorant and antispasmodic (Chiej, 1984). Fennel is also considered as a spice due to terpenoid compounds isolated from its fruits volatile oil (Masada, 1976). Also fennel fruits are widely used in the preparation of various dishes like soups, sauces, pastries, confectioneries, pickles and meat dishes etc. (Bhati et al. 1988). The leaf stalks and the tender shoots are also used in salads. Fennel is used in cooking for liqueurs (Bhati et al. 1988). The essential oil of fennel is used to flavor different food preparations and in perfumery industries. The essential oil of fennel is used to flavor different food preparations and in perfumery industries. The oil, which contains fenchone is of paramount importance in pharmaceutical and other industries as well as in confectionery (Abdallah et al. 1978). To increase the crops quality especially medicinal and aromatic plants, organic fertilization is more acceptable than chemical fertilizers and organic farming is a quality standard to be matched well by small farmers in Egypt (Abou El-Fadl et al. 1990).

It is recommend that completely or partial substitution of mineral fertilization (NPK) by using of organic and bio-fertilizers which are safe and economic to farmer. Many researchers have pointed out efficacy of organic manures of increasing growth, yield and essential oil production of celery (Mahajan et al 1977), Achilla (Sayed,1993) groundnut (Mehta et al 1995), roselle (Ezz-Eldin and Abd-Elmoaz,1998) anise (Safwat et al, 2001), cumin (Safwat and Badran 2002), and fennel (Badran and Safwat 2004). Meanwhile, bio-fertilizers (N fixing and P dissolving bacteria) had an effective role in partial replacement of N and P mineral fertilization. This role was revealed by Mehta et al.(1995) on groundnut, Ibrahim (2002) on fennel, Safwat et al (2001) on anise and Soliman (2002) on anise, (Badran et al 2002) on black cumin, Safwat and Badran (2002) on Cumin and (Badran and Safwat 2004) on fennel.

Bio-fertilizer mixture consisted of N fixing and P + K dissolving bacteria.

This experiment was conducted to study the effect of NPK and organic (3 levels) with or without bio-fertilizers on vegetative characters and seed yields of fennel plant. Also, NPK, crude oil, essential oil, saponins and flavonoids were determined. The chemical characteristics such as: volatile oil percentage, volatile oil quantity per plant and per fed., and crude oil were recorded as well as flavonoids and saponins.

MATERIALS AND METHODS

The present study was carried out at the Experimental form, Faculty of Agriculture, AL-Azhar University, (Assiut Branch) during two successive seasons, (2005/2006 and 2006/2007) to study the influence of organic manure with or without bio-fertilizers mixture on fennel (Foeniculum vulgare) growth, yield, crude oil, and volatile oil. Organic manure (cattle) was provided from the animal production form Faculty Agriculture, AL-Azhar University, (Assiut Branch) while the bio-fertilizers were brought from Faculty Agriculture, Ain-Shams University, to be used as seed inoculants in this study before sowing. Seeds were sown on Nov. 15th of the both seasons. The experimental plot 3 × 3 m in hills 50 cm apart, each plot contained 6 rows (60 cm apart) and each row contained 5 hills. Four weeks from planting, plants were thinned to two plants/ hill. The experimental treatments were layed out in a randomized complete block design with 3 replicates. All agricultural practices were performed as usual.

The physical characteristics of the soil used are presented in Table (1) and chemical analysis of the organic manure is shown in Table (2). The ten treatments were as follows:-

1) Control (no additions)
2) Bio-fertilizer mixtures (Azotobacter sp., Bacillus megatherium var Phosphaticum, and Bacillus circulans).
3) N P K recommended fertilizers.
4) N P K (recommended) + bio-fertilizer mixtures.
5) 20 m3/fed cattle manure.
6) 20 m3/fed cattle manure + bio-fertilizer mixtures.
7) 30 m3/fed cattle manure.
8) 30 m3/fed cattle manure + bio-fertilizer mixtures.
9) 40 m3/fed cattle manure.

10) 40 m3/fed cattle manure + bio-fertilizer mixtures. The organic manure was added before sowing while soil preparing process, meanwhile, seeds was inoculated by the bio-fertilizer mixture.

The following data were recorded: plant height, number of branches / plant, herb dry weight g / plant, number of umbels / plant, fruit yield g /plant and the fruit yield kg /fed. was calculated. Statistical analysis was carried out according to the method of Snedecor and Cochram (1982).

Table (1): Physico-chemical characteristics of the used soil.

Mechanical analysis				pH	EC ds/m	CaCO3 %	Cation					Anion			
Sand %	Silt	Clay	Texture				N(ppm)	P (ppm)	K meq/L	Ca (meq/L)	Mg (meq/L)	CO3	HCO3	CL	SO4
25	40	35	clay loam	7.9	2.15	1.65	123	9.4	0.31	10.38	5.12	Zero	2.34	8.13	10.23

Farm yard manure was used as an organic matter. The analysis of the used manure is given in Table (2).

Table 2: Analysis of organic manure used in Al-Azhar Farm.

Organic fertilizer	C%	OM %	C/N ratio	Macro elements (%)					Micro elements	
				N %	P %	K %	Ca %	Mg %	Fe %	Mn ppm
Cattle manure	18.71	37.41	11.62	1.61	0.7325	1.2706	0.1667	0.6965	0.6499	190.217

Chemical analysis:

Volatile oil percentage in fennel fruits was extracted by steam distillation, while, crude fat extracted by diethyl ether using Soxhlet apparatus according to A.O.A.C. (1990). GC was carried out on the sampled that represent the highest percentage of crude and essential oil of the second season.

Fatty acid methyl esters derived from crude oil were analyzed with HEWLETT PACKARD (HP) 6890 series GC system with capillary column (BP-70), length =60 m, diameter = 320 µm and film thickness = 0.25 µm equipped with (FID) detector and the detector temperature was 300oC. Temperature program was 70oC with initial

time 2 min. Separation rate was (40 and 4 min.) with final temperature at (120 and 220oC) and final time at (2 and 10 min.), respectively. The inlet temperature was 250oC (splitless), with flow rate 2 ml/ min. Carrier gases were N2 with 30 ml/min., H2 at 30 ml/min. and air at 300 ml/min. Fatty acids percentage were expressed as percentage of total fatty acid methyl esters. The authentic samples of fatty acids methyl esters were also injected under the same condition for the identification of fatty acids.

Essential oil constituents were analyzed with Agilent Technologies 6890 N Network GC System (HP) with capillary column (HP-5) phenyl methyl siloxane, length =30 m, diameter = 320 μm and film thickness = 0.25 μm equipped with (FID) detector and the detector temperature was 280oC. Temperature program was 70oC with initial time 2 min. Separation rate was 4 min. with final temperature at 190oC and final time at 25 min. The inlet temperature was 250oC (split = 15 sec.), with flow rate 3 ml/ min. carrier gases were N2 with 30 ml/min., H2 at 30 ml/min. and air at 300 ml/min. The authentic samples of fenchone, cis-anethol, trans-anethol, limonene, cineol, α– pinene, β-pinene, and farnsone were also injected under the same conditions for identification of constituents of anise essential oil.

Chemical properties of fixed oil:

The chemical properties of fennel fixed oil were determined according to A.O.A.C. (1990).

Analysis of Flavonoids and Saponins

The analysis of flavonoid and saponins from seeds of fennel were carried out by using silica gel column chromatography. The columns were washed with various solvents (Diethyl ether, n-propanol, ethanol and methanol) on the basis of their polarity order (Aritomi and Kawaski, 1984: Gulfraz et al. 2004).

RESULTS AND DISCUSSION

The main objective of this study was to find out whether sufficient and high quality yields of the fennel crop can be produced without chemical fertilizers but only with the sources allowed by organic farming.

The four studied vegetative growth characters, plant height, number of branches/plant, number of umbels/plant, and herb dry

weight were greatly increased, in both seasons, due to the use of mineral and organic fertilizer with/without bio-fertilizers as shown in tables (3) and (4). Also, overall vision to table 3 and 4, all treatments gave higher results than that obtained from control ones. Bio-fertilizer mixture treatment alone had earned a significant increasing on the vegetative growth parameters on both seasons. The recommended mineral fertilization NPK has more significant increasing results. Interaction between recommended NPK x bio-fertilizer mixture was the most effective treatment in increasing the fennel vegetative parameters on both seasons. All of the other treatments, organic manure (20 m3, 30m3 and 40 m3/ fed.) with or without bio-fertilizer mixture were significantly increased more than control once on both seasons. Seed yield (g)/ plant and herb dry weight were the most significantly increased by treating fennel plants and soil by recommended NPK x bio-fertilizer mixture on both seasons. All of the other treatments were also higher than of control as shown in table 3 and 4. Generally, there was a positive co-relation response relationship between the rate of cattle manure with or without addition of bio-fertilizer mixture and the recommended dose of NPK on the above mentioned parameters.

Table (3) Effect of mineral and organic with or without bio-fertilizer mixture on vegetative growth characters of fennel plants during 2005/2006 and 2006/2007 seasons.

Treatment	Plant heigh		Branch number/plant		2006/2007	
	2005/2006 season	2006/2007 season	2005/2006 season	2006/2007 season	2005/2006 season	2006/2007 season
Control	156.70 f	161.0 E	8.67 F	9.67 F	64.67 E	69.67 F
Bio	170.0 E	174 D	11.00 E	12.00 E	72.00 D	76.00 E
N P K	193.0 AB	200.0 A	14.00 BC	15.33 ABC	91.67 A	96.67 AB
N P K + Bio	195.7 A	201.7 A	15.33 A	16.00 A	93.33 A	98.67 A
Organic (1)	169.0 E	177.0 D	11.33 E	12.67 DE	80.00 C	83.00 D
Organic + Bio	181.0 D	180.0 CD	12.33 DE	13.67 CDE	83.33 B	86.33 CD
Organic (2)	181.0 CD	186.3 BC	13.33 BCD	14.00 BCD	84.00 B	89.00 C
Organic(2)+Bio	188.70 BC	190.0 B	13.00 CD	15.00 ABC	90.67 A	94.00 B
Organic(3)	190.3 ABC	196.7 A	13.67 CD	15.00 ABC	90.67 A	95.00
Organic(3)+Bio	193.0 AB	198.7 A	14.67 AB	15.67 AB	92.33 A	97.67 AB

Table (4) Effect of mineral and organic manure with or without Bio-fertilizer mixture on yield characters of fennel plants during 2005 / 2006 and 2006 / 2007 season.

Treatment	Dry weight of plant(g)		Dry weight of plant(g)		Seed yield (g) / plant	
	2005/2006 season	2006/2007 season	2005/2006 Season	2006/2007 season	2005/2006 Season	2006/2007 season
Control	84.93 I	87.53 H	50.37 E	53.17 E	994.9 E	105.2 E
Bio.	86.50 H	89.92 G	55.27 D	57.60 D	1091.7 D	1137.8 D
N P K	103.67 C	107.43 C	64.99 AB	70.17 A	1283.8AB	1386.0 A
N P K + Bio	106.20 A	112.07 A	68.00 A	70.95 A	1339.3 A	1401.5 A
Organic (1)	92.00 G	94.67 F	67.80 A	61.60 CD	1171.4CD	1216.8 CD
Organic + Bio	94.00 F	94.17 E	59.30 CD	64.65 BC	128.5 BC	1277.0 BC
Organic (2)	93.67 F	96.73 E	62.70 BC	64.13 BC	1210.4BC	1266.8 BC
Organic(2)+Bio	96.33 E	100.20 D	61.28 BC	65.67 BC	1256.6ABC	1297.0 BC
Organic(3)	101.83 D	106.27 C	63.60ABC	67.37 AB	1260.2ABC	1330.7 AB
Organic(3)+Bio	106.77 B	109.83 B	68.20 A	71.07 A	1374.2 A	1403.8 A

Table 5 shows the nitrogen, phosphorus and potassium content in the treated fennel plants of this experiment. The best results obtained by treating plants with recommended NPK x Bio-fertilizers for two seasons. All treatments caused increasing in the NPK content in the both seasons than the control treatment. Here, we can see the recommended inorganic NPK only gave the second ones in significantly increment on NPK content of fennel plants on both seasons. It is obvious that bio-fertilizer mixture only have no effect on NPK level in fennel plants. But, the interaction between organic manure (40 m3/ fed) and the bio-fertilizer mixture bacteria was most effective than that of the individuality of ones alone specially, at high levels of organic manure. Indeed, P became known as the master key to agriculture because lack of available P in soils limited the growth of both cultivated and uncultivated plants (Foth and Ellis, 1997). Potassium is a macronutrient which's essentiality for plant growth is known since the work of von Liebig, published in 1840 (Foth and Ellias, 1997). Potassium is associated with many enzymes involved in photosynthesis, organic compound synthesis and translocation of organic compounds.

Table (5) NPK contained of fennel plant treated with mineral, organic and bio-fertilizers.

Treatment	%N		%P		%K	
	2005/2006 season	2006/2007 season	2005/2006 Season	2006/2007 season	2005/2006 season	2006/2007 season
Control	2.063 H	1.937 j	0.250 I	0.300 H	2.200 G	2.263 F
Bio.	2.137 G	2.037 I	0.273 H	0.337 G	2.217 G	2.347 F
N P K	2.680 B	2.593 B	0.433 BC	0.553 B	3.320 AB	3.413 A
N P K + Bio	2.760 A	2.653 A	0.463 A	0.577 A	3.390 A	3.463 A
Organic (1)	2.150 G	2.093 H	0.300 G	0.380 F	2.620 F	2.670 E
Organic + Bio	2.200 F	2.180 G	0.300 F	0.410 E	2.653 F	2.717 E
Organic (2)	2.397 E	2.293 F	0.363 E	0.423 D	2.803 F	2.893 D
Organic(2)+Bio	2.457 D	2.357 E	0.400 D	0.460 D	3.013 D	3.047 C
Organic(3)	2.573 C	2.460 D	0.417 CD	0.500 C	3.170 C	3.260 B
Organic(3)+Bio	2.680 B	2.567 C	0.450 AB	0.553 B	3.307 B	3.413 A

Data in Table 6 show the crude and essential oils percentage and yield of treated fennel plants and control. The highest levels were recorded from the 40 m3 of organic manure x bio-fertilizer mixture of the chemical characteristics (crude, essential oils %, essential oil {ml} / plant and essential oil {L}/ fed.). The other treatments were around the average of control treatment.

Table (6) Effect of mineral and organic with/without bio-fertilizers on crude oil and essential oil yield of fennel seeds.

Treatment	Crude oil %		Essential oil % in the fruits		Essential oil yield (ml) /plant		Essential oil yield (L) /fed	
	2005/2006 season	2006/2007 Season	2005/2006 season	2006/2007 season	2005/2006 season	2006/2007 season	2005/2006 season	2006/2007 season
Control	8.20 FG	8.293 G	3.330 E	3.387 D	1.677 G	1.803 G	33.12 G	35.62 G
Bio.	8.187 G	8.280 G	3.513 C	3.537 BC	1.947 F	2.037 F	38.45 F	40.23 F
N P K	8.217 F	8.317 F	3.697 B	3.693 A	3.693 A	2.583 AB	47.08ABC	51.03 AB
N P K + Bio	8.120 H	8.230 H	3.697 AB	3.713 A	3.713 A	2.637 AB	49.58 AB	52.08 AB
Organic (1)	8.300 E	8.403 E	3.343 DE	3.443 D	3.443 D	2.123 EF	39.31 EF	41.94 EF
Organic + Bio	8.350 D	8.447 D	3.393 D	3.467 CD	3.467 CD	2.243 DE	41.94 DE	44.31 DE
Organic (2)	8.400 C	8.493 C	3.547 C	3.590 B	3.590 B	2.300 D	42.86 D	45.43 D
Organic(2)+Bio	8.410 BC	8.517 B	3.570 C	3.590 B	3.590 B	2.373 CD	44.71 CD	45.88 CD
Organic(3)	8.420 B	8.530 B	3.673 AB	3.730 A	3.730 A	2.510 BC	46.28 BC	49.58 BC
Organic(3)+Bio	9.200 A	9.317 A	3.730 A	3.773 A	3.773 A	2.680 A	50.24 A	52.94 A

Table (7) indicated the fractionated fatty methyl esters of the four treatments. Lauric acid and Stearic acid contents were high in control and NPK treatments, but reduced in the others. Oleic acid content represents the major percentage of fatty acid methyl esters, but the plants received 40 m3 of organic manure x bacterial bio-fertilizer mixture, 40 m3 of organic manure and recommended NPK x bacterial bio-fertilizer mixture have the highest ratio of oleic acid (57.98, 57.23 and 57.02 respectively) and the all treatments gave high records than the control treatments. Linoleic acid was the second highest ratio of FAME of all treatments, but fennel plants received recommended NPK x bacterial bio-fertilizer mixture, 40 m3 of organic manure and 40 m3 of organic manure x bacterial bio-fertilizer mixture have the highest ratios (34.48, 32.12 and 31.76%).

Table (7) relative amount of fennel fixed oil constituents from GC of control and treated plants with mineral, organic manure and with / without Bio-fertilizers mixture of second season (2006 / 2007).

Components	Control	NPK	NPK+Bio	Organic(3)	Organic(3)+Bio
Lauric acid	5.82 %	5..94	2.12	2.13	2.16
Stearic acid	11.98 %	10.99	3.38	3.25	3.06
Oleic acid	30.28 %	48.52	57.02	57.23	57.98
Linoleic acid	19.65 %	25.68	34.48	32.12	31.76
linolenic acid	1.41 %	1.84	1.51	1.50	1.50
Unknown (b)	18.43 %		1.45		

The data in Table 8 represent the fractionated volatile oil constituents as a result of treating fennel plants with different kinds and levels of fertilizations. The major constituent is fenchone that the characterized smell odor of fennel. Plants received 40 m3 of organic manure x bacterial bio-fertilizer mixture represent the highest content of fenchone more than all treatments (88.80%) and recommended NPK x bacterial bio-fertilizer mixture (88.37%). On the other hand, the recommended mineral NPK treatment had significantly reduced the fenchone content (73.47%) than control treatment (84.51%).

Table (8) relative amount of fennel volatile oil constituents from GC of control and treated plants with mineral, organic manure and with / without Bio-fertilizers mixture of second season (2006 / 2007).

Component	Control	NPK	NPK + Bio	Organic(3)	Organic(3)+Bio
α- pinine	4.02	5.11	4.01	3.84	3.94
β- pinene	0.37	0.58	0.43	0.22	0.12
d-Limonine	2.63	2.11	1.85	2.10	0.43
Cineol	0.36	1.96	1.40	0.91	1.91
Fenchone	84.51	73.47	88.37	86.30	88.80
Cis-anethol	1.21	0.67	0.90	0.81	0.22
Trans-anethol	0.36	1.25	1.30	1.42	1.79
Farnsone	0.43	2.11	0.38	0.98	0.10
Unknown	0.42	3.77	0.56	0.58	0.32
Unknown	1.13	3.28	0.76	1.53	0.31
Unknown	0.71	1.19	0.41	0.92	0.71
Unknown	3.29	4.43	1.30	1.39	0.35

The chemical properties of fennel fixed oil revealed that no significant differences between all tested of treated seeds oil. All of acid, ester, saponification, iodine and peroxide values were approximately around the trusted factors (Table 9).

Table (9) Chemical properties of fennel fixed oil

Treatment	Acid Value	Ester Value	Sap. value	Iodine value	Peroxide value
Control	1.1	175.8	174.0	89	8.2
Bio.	1.1	176.6	174.2	90	8.0
N P K	1.1	176.3	174.1	89	7.9
N P K + Bio	1.2	176.3	174.1	88	8.1
Organic (1)	1.2	176.4	173.9	89	8.2
Organic + Bio	1.1	176.4	174.0	88	8.1
Organic (2)	1.1	175.9	174.1	87	7.9
Organic(2)+Bio	1.2	176.4	174.0	89	8.2
Organic(3)	1.1	176.4	174.1	88	8.0
Organic(3)+Bio	1.1	176.4	174.2	87	7.9

Table (10) illustrates the saponins percentages of the treated fennel plants in the experiment. The plants received 40 m3 of organic manure x bacterial bio-fertilizer mixture and 20 m3 of organic manure x bacterial bio-fertilizer mixture showed the highest content (38.23 and 38.16%) of saponins overall. The lowest content was obtained from the plants treated 20 m3 of organic manure treatment. All of the other treatments gave the average percentage as well as control treatment.

Table (10) The Saponin percentage (%) of Foeniculum vulgare fruits

Sample	Control	Bio.	N P K	N P K + Bio	Organic (1)	Organic (1) + Bio	Organic (2)	Organic(2)+ Bio	Organic(3)	Organic(3)+ Bio
Sap.%	**31.10**	**33.12**	**30.10**	**29.50**	**19.20**	**38.16**	**30.50**	**36.12**	**27.58**	**38.23**

Table 11 demonstrates flavonoid content of treated fennel plants in the experiment. All of the treatments showed an average content of flavonoid. The lowest content was of the plants treated with recommended mineral NPK and 20 m3 of organic manure x bacterial bio-fertilizer mixture (24.16% of the two). The flavonoid highest content was found on the recommended mineral NPK x 20 m3 of organic manure x bacterial bio-fertilizer mixture treatment (26.20%) but not significantly high than control treatment.

Table (11) The Flovonoid percentage (%) of Foeniculum vulgare fruits.

Sample	Control	Blo.	N P K	N P K + Bio	Organic (1)	Organic (1) + Bio	Organic (2)	Organic(2)+ Bio	Organic(3)	Organic(3)+ Bio
fla.%	26.17	25.10	24.16	26.20	25..25	24.16	24.90	25.09	26.00	25.50

The extensive use of manufactured chemical fertilizers on the Egyptian soils has increased crops productivity but compromised quality especially for medicinal and aromatic plants which therefore are not acceptable for export. Organic fertilizers are excellent sources of nutrients for crop production and improving physical and chemical properties of soil (Eghaball and Power, 1994).

Organic matter is essential for plant growth, because it has been suggested that humic substances can have a direct effect on plant growth, assuming a hormonal action of humic substances (Varanini and Pinton, 1995). Soil organic matter is the component of mineral soils that makes it possible for successful growth of most plants. Soil organic matter can increase water holding capacity and cation exchange capacity in sandy soil. Soil organic matter supplies nutrients, it is a buffer against pH change, it protects against plant diseases, protects against heavy metal and salt toxicity, detoxifies pesticides and prevents their leaching, promotes microbial breakdown of toxic substances and supports micro-organisms that recycle nutrients and soil formation (Varanini and Pinton, 1995).

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المحتوي الكيميائي والصفات الخضرية والمحصولية لنباتات الشمر المعاملة بالتسميد العضوي والحيوي كبديل للسماد الكيماوي

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أجريت هذه الدراسة بمزرعة كلية الزراعة بأسيوط – جامعة الأزهر لمعرفة مدى تأثير احلال الأسمدة العضوية مع/ بدون البكتريا المثبتة للنيتروجين والميسرة للفوسفور والبوتاسيوم بديلا عن الأسمدة الكيماوية. ودراسة اثر ذلك على كل من الصفات الخضرية والمحصولية والزيت الطيار والخام وبعض النتجات الثانوية.

اظهرت نتائج الدراسة ان هذه الصفات والمكونات قد زادت نتيجة لهذه المعاملات. فقد ادت المعاملة بخليط من الاسمدة الكيماوية مع خليط البكتريا & الاسمدة العضوية مع خليط البكتريا الى الحصول على اعلى الصفات الخضرية و المحصولية ومحتوى NPK على الاطلاق. في حين ادت المعاملة بمستوى 40 م3 من السماد العضوي مع خليط البكتريا الى الحصول على اعلى نسبة من الزيت الطيار والخام. واظهرت جميع المعاملات مستوى متقارب جدا في محتواها من المنتجات الثانوية.