J. Agric. Sci. Mansoura Univ., 29(9): 5231 - 5244, 2004

YIELD AND ESSENTIAL OIL QUALITY OF CORIANDER AS INFLUENCED BY CHICKEN MANURE, ROCK PHOSPHATE, SULFUR AND A PHOSPHATE SOLUBILIZING BACILLUS TREATMENTS.

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ABSTRACT

A field trial was achieved during the two consecutive growing seasons of 2001/2002 and 2002/2003 at the Experimental Farm of Faculty of Agriculture, Cairo University to investigate the associative impact of phosphate solubilizing *Bacillus megatherium*, chicken manure, rock phosphate and/or sulfur and its influence on growth parameters, fruit yield and oil yield quality of coriander. The results show that full dose of chicken manure significantly overcame its half dose for all the measured growth and yield parameters. Application of *Bacillus megatherium*, as a phosphate solubilizer, induced matchable results to that obtained due to the use of full dose of chemical fertilizers, while inclusion of rock phosphate and/or sulfur resulted in further increases for all tested parameters. An associative effect was found between, chicken manure, biofertilizer, rock phosphate and/or sulfur. The combined effect of half dose of chicken manure, biofertilizer, rock phosphate and/or sulfur produced reasonable results while full dose of chicken manure in presence of the same previous fertilization sources revealed significant increases, in comparison with the positive control, for all tested parameters. Biofertilization of coriander combined with full dose of chicken manure and sulfur augmented limonene oil constituents with 30.69 % over the positive control. Linalool as the main oil compound of coriander, was increased due to the use of *Bacillus megatherium* combined with full dose of chicken manure that reached 2.5 % over the positive control.

Keywords: growth parameters, yield quality, bio-organic fertilizer Coriander, essential oil

INTRODUCTION

Coriander (*Coriandrum sativum* L.) "Family Apiaceae" is an annual medicinal herb widely cultivated in Egypt. Coriander fruit oil repeatedly used as a flavor for meats, canned foods, spicy, sauces, backed goods confectionery and perfumes (khattab and Helmy, 2002). From the pharmaceutical point of view, coriander also used as antirheumatic, antiseptic, astringent, carminative, diuretic, laxative, stimulant and hypotensive (Guenther, 1961 and Fenaroli, 1971). The intensive application of chemical fertilizers increased crops productivity but with low quality (Lain *et al.* 1996 and wang *et al.*, 1996). The use of low price fertilization sources such as organic manure, rock phosphate and biofertilizers is of great importance to minimize the agricultural costs in addition to the great quality of the resultant yield and reduction of environmental pollution problems. The coincident use of rock phosphate and phosphate solubilizing bacilli to release soluble phosphate was recorded by many investigators (Kucey, 1983). This work aims at looking for the best bio-, organic or bio-organic treatments that lead to produce a high coriander yield with good quality.

MATERIALS AND METHODS

A field trial was achieved at the Experimental Farm of Faculty of Agriculture, Cairo University during the two consecutive seasons of 2001/2002 and 2002/2003. The soil was silty loam of the following characteristics: Sand, 25 %; silt, 54 %; loam, 21 %, organic matter, 0.39 %; total N, 1.12 %; total P, 0.088 %; total K, 0.20 %; total C, 0.23 %; pH, 7.84; and EC (dS/m), 2.35; The soluble cations (meq/L) were Mg^{++}, 0.6; Ca^{++}, 0.3; K^{+}, 8.25 and Na^{+}, 14.56. The soluble anions (meq/L) were $SO_4^{=}$, 8.5 ; Cl^{-}, 12.5 and HCO_3^{-}, 2.5 . Chicken manure, sulfur and rock phosphate were applied during soil preparation for cultivation according to the respective treatments. The sulfur and rock phosphate were applied with one rate for each, 50 kg sulfur/fed. and 20 kg P/fed. respectively, whereas the two rates of chicken manure were applied i.e., half dose (40 kg N/fed.) and full dose (80 kg N/fed.). The applied chicken manure had the following characteristics: organic matter (%), 47.16; Ash (%), 52.84; pH, 8.86; EC (dS/m), 6.87; C/N ratio, 21:1; total N (%), 1.31; total P (%), 0.57; total K (%), 0.93; Fe (mg/100g), 7777.0; Mn (mg/100g), 28.4; Cu (mg/100g), 7.3; Zn (mg/100g), 253.0. As for rock phosphate had the following characteristics: total P (g/kg^{-1}), 110; K_2O (%), traces; SiO_2 (%), 9.0; Al_2O_3 (%), 0.9; Fe_2O_3 (%), 1.2; Total CU (mg kg^{-1}), 19.0; Total Zn (mg kg^{-1}), 127.0; Total Fe (g kg^{-1}), 10.0; Total Mn (mg kg^{-1}), 284.0 The recommended doses of NPK were 300 kg ammonium sulfate (20 %), 100 kg superphosphate (15.5 %) and 50 kg potassium (48 %). The experimental area was divided into plots of 6 M^2 for each, comprising of 3 rows, 3 m long and 60 cm width. Fruits of coriander (obtained from Cultivation and Production of Medicinal and Aromatic Plants, National Research Centre, Cairo, Egypt) were sown on 13th November 2001 and 28th October 2002 in hills of 30 cm apart at the rate of 4-5 fruits/hill. Biofertilization was done using a liquied culture of phosphate solubilizing bacilli (*Bacillus megatherium*) containing $5.2x10^7$ cell/ml immediately after fruit sowing according to the respective treatments at rate of 40 L/fed. (Khattab and Gomaa, 2003).

The following treatments were implemented:

- Positive control (100 % NPK)
- Half dose of chicken manure + Rock phosphate (R.p)
- Half dose of chicken manure + Sulfur (S)
- *Half dose of chicken manure + Bacillus megatherium (Bio)*
- Half dose of chicken manure + R.p + Bio
- Half dose of chicken manure + S. + Bio
- Half dose of chicken manure + R.p + S. + Bio
- Full dose of chicken manure + R.p
- Full dose of chicken manure + S

- Full dose of chicken manure + *Bio*
- Full dose of chicken manure + R.p + Bio
- Full dose of chicken manure + S. + Bio
- Full dose of chicken manure + R.p + S. + Bio

The various treated plots were irrigated separately to prevent the interference between the tested treatments . After one month later the developed plants were thinned to two plants per hill. The experiment was designed as split plots of three replicates, where chicken manure occupied the main plots and Rock phosphate, sulfur and biofertilizer were represented in the sub-plots. At the beginning of May 2002 and 2003 plants were harvested. The following growth and yield parameters were determined: plant height (cm), branches number/plant, plant dry weight (g), fruits dry weight (g/plant) and estimated fruit yield (Kg/fed.). The nitrogen percent was determined in dry fruits of the second season according to A.O.A.C. (1970) and consequently the protein content and nitrogen uptake were calculated.

The obtained fruits samples from each treatment were separately subjected to hydro-distillation to determine volatile oil content for three hours using Clevenger apparatus according to Egyptian pharmacopoeia (1984). Samples of 50 g dry fruits from each replicate in each treatment were placed separately in a round flask for essential oil extraction. The volume of the extracted essential oil was then determined and recorded on the basis of oil volume to fruits dry weight (ml/100g dry fruits) . Estimated volatile oil yield (L/fed.) was also calculated.

The essential oil constituents were analyzed and determined in the oil samples of the second season. Samples were then dehydrated over anhydrous sodium sulfate and stored in silica vials with Teflon-sealed caps at refrigerator (2 °C) in the absence of light for gas chromatographic analysis. The dehydrated oil of each treatment was separately subjected to GLC analysis with (HP) 6890 Series Hewlett Pakarad. The separation was carried out with column, HP (Carbowax 20 M), 25 m length X 0.32 mm I.D., film thickness 0.3 µm. The flow rates (ml/min) of the carrier nitrogen gas (N_2), hydrogen (H_2) and air were 30, 30 and 300 consecutively. The column temperature was programmed from 60 °C to 190 °C at the rate of 8 °C/min. The injection temperature was maintained at 240 °C and detector at 280 °C . The relative peak area for each individual constituent was then averaged in each accession and data were then recorded for each constituent as a relative percent of the essential oil . The identification of these compounds was achieved by matching their retention times with those of authentic samples injected with the same conditions.

Statistical analysis :

With the exception of the identification of essential oil constituents which was conducted only in the second season. Statistical analysis was made according to Snedecor and Cochran (1990) using M stat program version 4. Combined analysis was performed for the two growing seasons as the obtained results followed the same pattern. Means of various treatments were compared by Duncan's Multiple Range test (Waller and Duncan, 1969) at 5 % probability level.

RESULTS

A comparison between various fertilization sources in addition to the chicken manure doses and their effects on plant height, branches number and plant dry weight was shown in Table (1). As to the applied rates of chicken manure, it was found that full dose significantly overcame the half dose for all tested parameters in both growing seasons. Further, the diverse sources tested treatments produced results significantly overcame the positive control except, branches number in the second season and rock phosphate treatment in the first season for plant dry weight. Application of the biofertilizer as such surpassed the positive control regarding plant height and plant dry weight in both growing seasons. Inoculation of rock phosphate and/or sulfur with the phosphate solubilizing bacilli (*Bacillus megatherium*) induced the highest significant values for all tested parameters in both seasons.

Table (1): Effect of chicken manure doses and various treatments on plant height, branches number and plant dry weight of coriander.

Parameters› / Effective factor*		Plant height (cm)		Branches number/plant		Plant dry weight (g)	
		1 st season	2 nd season	1 st season	2 nd season	1 st season	2 nd season
Ch. M.	Ch.M1	99.5 b	98.9 b	10.4 b	10.8 b	41.9 b	42.7 b
	Ch.M2	103.7 a	104.8 a	11.7 a	12.6 a	54.5 a	55.9 a
Fertilizer Sources	Control	94.7 c	99.2 e	10.0 c	11.3 bc	41.0 d	45.2 c
	R.P.	101.5 b	101.2 cd	10.5 b	11.0 c	42.3 d	43.3 d
	Sulfur	101.5 b	101.8 bc	10.7 a	11.3 bc	47.2 c	47.3 b
	Bio	101.5 b	100.7 d	11.5 a	11.8 abc	50.5 b	51.7 a
	R.P.+Bio	101.8 b	102.7 b	11.7 a	12.2 ab	51.2 b	52.3 a
	S.+Bio	104.2 a	105.2 a	11.5 a	12.5 a	51.2 b	52.5 a
	RP.+S.+Bio	106.0 a	102.2 bc	11.7 a	11.8 abc	54.0 a	52.7 a

Values within each column followed by the same letter are not statistically significant at 5 % level.
Ch. M. = chicken manure Ch. M1 = chicken manure half dose S = Sulfur
R. P. = Rock phosphate Ch. M2 = chicken manure full dose Bio = biofertilizer
Control = Recommended dose of mineral fertilizer (NPK)

Table (2) shows the effect of chicken manure doses as well as the different fertilization sources on fruit yield, oil content and estimated dry fruits yield of coriander. Full dose of chicken manure significantly overcame the half dose for all tested parameters in both seasons. Except oil content application of phosphate solubilizing *Bacillus megatherium* induced results comparable to the positive control, while inclusion of rock phosphate and/or sulfur produced the highest increases over the positive control for all tested parameters in both seasons.

Table (2): Fruit yield, oil content and estimated dry fruits yield of coriander due to the application of chicken manure doses and the different fertilization sources

Parameters›		Fruit yield (g/plant		Oil content (ml/100g fruits)		*EY of dry fruits (Kg/fed.)	
Effective factor*		1 st season	2 nd season	1 st season	2 nd season	1 st season	2 nd season
Ch. M.	Ch.M1	27.2 b	29.9 b	0.471 b	0.471 b	601.4 b	660.0b
	Ch.M2	33.4 a	35.8 a	0.514 a	0.518 a	742.3 a	794.4 a
Fertilizer Sources	Control	25.0 e	33.0 b	0.527 a	0.508 b	555.0 e	732.7 b
	R.P.	26.3 de	28.7 c	0.463 c	0.455 d	577.8 de	624.8 c
	Sulfur	27.5 d	29.6 c	0.458 c	0.462 d	610.7 d	656.2 c
	Bio	31.7 c	33.2 b	0.478 bc	0.485 c	698.0 c	736.3 b
	R.P.+Bio	33.0 bc	34.5 b	0.498 abc	0.507 b	732.8 b	766.2 b
	S.+Bio	34.0 ab	36.3 a	0.507 ab	0.517 ab	755.0 ab	806.8 a
	RP+S.+Bio	34.8 a	34.6 b	0.518 ab	0.528 a	773.5 a	767.5 b

Values within each column followed by the same letter are not statistically significant at 5 % level .
Ch. M. = chicken manure Ch. M1 = chicken manure half dose S = Sulfur
R. P. = Rock phosphate Ch. M2 = chicken manure full dose Bio = biofertilizer
Control = Recommended dose of mineral fertilizer (NPK) * EY = estimated yield

The impact of chicken manure doses and the other fertilization sources on the estimated volatile oil yield, nitrogen content, protein content and nitrogen uptake was presented in Table(3). Concerning the estimated oil yield, the biofertilizer as such or when combined with rock phosphate and/or sulfur resulted in significant differences in comparison with the positive control *in the first season, while these differences were not significant in the second* season It is worthy to mention that full dose of chicken manure treatment produced estimated yield of volatile oil significantly surpassed the half dose treatment in both seasons. For nitrogen and protein contents, Table (3) indicates that the various treatments induced results comparable to the positive control where the differences were not significant. Table (3) also indicates that biofertilization of coriander either used alone or combined with either rock phosphate and/or sulfur overcame the other treatments for nitrogen uptake, but the highest significant differences were recorded due to the combined treatments when compared to the positive control. Once again, the full dose of chicken manure surpassed the half dose treatment for all nitrogen and protein measurements.

Table (4) reveals the interaction between chicken manure doses and the other fertilization sources and its effect on plant height, branches number/plant and plant dry weight. Biofertilization of coriander in the presence of half dose of chicken manure resulted in significant plant height when compared to the positive control, while the results of branches number/plant and plant dry weight were similar to those of the positive control without significant differences. Further increases were recorded when either rock phosphate or sulfur were included with half dose of chicken manure and biofertilizer. Application of full dose of chicken manure induced further increases for the majority of tested growth parameters either when compared with the positive control or half dose of chicken manure. The maximum augmentations for all tested parameters were obtained owing to the combined application of full dose of chicken manure, biofertilizer, rock phosphate and sulfur.

Table (3): The impact of chicken manure doses and diverse fertilization sources on estimated volatile oil yield, nitrogen and protein measurements of coriander fruits.

Parameters› / Effective factor*		*EY of volatile oil (L/fed.)		Nitrogen content (%)	Protein content (%)	Nitrogen uptake (g/plant)
		1 st season	2 nd season	2 nd season	2 nd season	2 nd season
Ch. M.	Ch.M1	2.831 b	3.094 b	3.51 b	21.92 b	1.05 b
	Ch.M2	3.816 a	4.110 a	4.62 a	28.87 a	1.31 a
Fertilizer Sources	Control	2.923 d	3.677 ab	3.40 a	21.27 a	1.12 bc
	R.P.	2.575 e	2.843 c	3.62 a	22.62 a	1.04 c
	Sulfur	2.835 d	3.057 bc	3.52 a	21.98 a	1.04 c
	Bio	3.387 c	3.585 ab	3.60 a	22.50 a	1.20 a
	R.P.+Bio	3.677 b	3.888 a	3.72 a	23.27 a	1.29 a
	S.+Bio	3.848 ab	4.180 a	3.59 a	22.42 a	1.30 a
	Rp+S.+Bio	4.018 a	3.978 a	3.64 a	22.72 a	1.28 a

Values within each column followed by the same letter are not statistically significant at 5 % level.
Ch. M. = chicken manure Ch. M1 = chicken manure half dose S = Sulfur
R. P. = Rock phosphate Ch. M2 = chicken manure full dose Bio = biofertilizer
Control = Recommended dose of mineral fertilizer (NPK) * EY = estimated yield

Table (4): The combined influence of various fertilization sources on tested Growth parameters of coriander

Parameters› / Treatments*		Plant height (cm)		Branches number/plant		Plant dry weight (g)	
		1 st season	2 nd season	1 st season	2 nd season	1 st season	2 nd season
Ch. M.1	Control	94.7 f	95.7 g	10.0 bc	10.3 ef	41.0 ef	43.0 f
	R.P.	95.3 f	96.0 g	9.0 c	9.3 f	36.0 g	37.0 g
	Sulfur	97.3 f	97.7 f	10.0 bc	10.7 def	38.0 fg	39.3 g
	Bio	101.3 e	100.3 e	11.0 ab	11.3 cde	43.7 de	45.3 ef
	R.P.+Bio	102.7cde	103.0 c	11.0 ab	11.7 bcde	44.3 de	46.0 e
	S.+Bio	103.0 cde	103.7 c	10.7 abc	12.0 abcd	44.0 de	45.3 ef
	RP.+S.+Bio	102.0 de	102.7 c	11.3 ab	12.3 abc	46.3 cd	47.3 de
Ch. M.2	Control	94.7 f	95.7 g	10.0 bc	10.3 ef	41.0 ef	43.0 f
	R.P.	107.7 ab	106.3 b	12.0 a	12.7 abc	48.7 c	49.7 d
	Sulfur	105.7 bc	106.0 b	11.3 ab	12.0 abcd	56.3 b	55.3 c
	Bio	101.7 e	101.0 de	12.0 a	12.3 abc	57.3 b	58.0 b
	R.P.+Bio	101.0 e	102.3 cd	12.3 a	12.7 abc	58.0 b	58.7 b
	S.+Bio	105.3 bcd	106.7 b	12.3 a	13.0 ab	58.3 b	59.7 b
	RP.+S.+Bio	110.0 a	108.7 a	12.0 a	13.3 a	61.7 a	62.3 a

Values within each column followed by the same letter are not statistically significant at 5 % level.
Ch. M1 = chicken manure half dose Ch. M2 = chicken manure full dose Bio = biofertilizer
R. P. = Rock phosphate S = Sulfur Control = Recommended dose of mineral fertilizer (NPK)

Table (5) indicates the associative effect of different bio- and organic treatments in the presence of rock phosphate and/or sulfur on fruit yield (g/plant), oil content and the estimated yield of dry fruits of coriander. Regarding fruit yield per plant, inoculation with the phosphate solubilizer *Bacillus megatherium* combined with half dose of chicken manure produced increases in comparison with the positive control that were significant in the first season. Further significant increases were recorded, in comparison with the positive control, when rock phosphate and/or sulfur were applied. Moreover, full dose of chicken manure induced more increases in fruit yield, the highest values were obtained when biofertilizer, rock phosphate and/or sulfur were included. As to coriander oil content, insignificant differences were found, when compared to the positive control, due to the application of half dose or full of chicken manure, biofertilizer, rock phosphate and/or sulfur. Concerning of the estimated yield of dry fruits inoculation with *Bacillus megatherium* in the presence of half dose of chicken manure as such or when combined with rock phosphate and/or sulfur resulted in significant increases in comparison with the positive control in both seasons. The highest values were obtained with application of full dose of chicken manure and inoculation biofertilizer alone or combined with rock phosphate and/or sulfur compared to the positive control in both seasons.

Table (5): The associative effect of chicken manure, rock phosphate, sulfur and biofertilizer on fruit, oil content and estimated fruit yield of coriander.

Parameters› / Treatments*		Fruit yield (g/plant		Oil content (ml/100g fruits)		*EY of dry fruits (Kg/fed.)	
		1 st season	2 nd season	1 st season	2 nd season	1 st season	2 nd season
Ch. M.1	Control	25.0 e	29.7 h	0.527 ab	0.513 bc	555.0 e	658.7 f
	R.P.	22.0 f	25.7 i	0.440 de	0.410 f	475.0 f	546.7 g
	Sulfur	24.0 ef	26.4 i	0.430 e	0.420 f	533.0 e	587.0 g
	Bio	28.3 d	31.3 gh	0.450 cde	0.457 e	619.0 d	695.7 ef
	R.P.+Bio	29.7 cd	32.3 fg	0.477 bcde	0.487 d	658.7 cd	718.3 de
	S.+Bio	30.3 cd	34.0 def	0.480 bcde	0.497 cd	673.3 c	755.0 cde
	RP+S.+Bio	31.3 c	36.3 bcd	0.497 abcd	0.503 cd	695.7 c	806.7 bc
Ch. M.2	Control	25.0 e	29.7 h	0.527 ab	0.513 bc	555.0 e	658.7 f
	Rp.	30.7 cd	31.7 fgh	0.487 abcd	0.500 cd	680.7 c	703..0 ef
	Sulfur	31.0 c	32.7 efg	0.487 abcd	0.503 cd	688.0 c	725.3 de
	Bio	35.0 b	35.0 cde	0.507 ab	0.513 bc	777.0 b	777.0 cd
	Rp+Bio	36.3 ab	36.7 bc	0.520 ab	0.527 ab	807.0 ab	814.0 bc
	S.+Bio	37.7 a	38.7 ab	0.533 a	0.537 a	836.7 a	858.7 ab
	Rp+S.+Bio	38.3 a	39.5 a	0.540 a	0.543 a	851.3 a	876.3 a

Values within each column followed by the same letter are not statistically significant at 5 % level .

Ch. M1 = chicken manure half dose Ch. M2 = chicken manure full dose
R. P. = Rock phosphate S=sulfur Bio=biofertilzer
* EY = estimated yield Control = Recommended dose of mineral fertilizer (NPK)

The interaction among various sources of fertilization and its impact on estimated volatile oil yield, nitrogen and protein contents and nitrogen uptake was presented in Table (6). Of estimated volatile oil yield, the various bio-treatments in the presence of half dose of chicken manure induced results comparable to the positive control. Moreover, including the full dose of chicken manure to the same biofertilization treatments revealed the significant augments in comparison with the positive control in the first season. Nevertheless, the significancy disappeared in the second season. As to the nitrogen and protein parameters, it was found that the phosphate solubilizing bacterium when combined with rock phosphate and/or sulfur produced matchable results in comparison with the positive control either in the presence of full or half dose of chicken manure. Furthermore, the highest values were recorded due to the application of full dose of chicken manure.

Table (6): The interaction among chicken manure, biofertilizer, rock phosphate and sulfur on estimated oil yield, nitrogen content, protein content and nitrogen uptake of coriander.

Parameters→ Treatments↓		*EY of volatile oil (L/fed.) 1 st season	*EY of volatile oil (L/fed.) 2 nd season	Nitrogen content (%) 2 nd season	Protein content (%) 2 nd season	Nitrogen uptake (g/plant) 2 nd season
Ch. M.1	Control	2.923 ef	3.293 de	3.30 c	20.63 c	0.98 de
	Rp.	1.937 h	2.183 f	3.60 abc	22.53 abc	0.93 e
	Sulfur	2.293 g	2.463 ef	3.50 bc	21.87 bc	0.92 e
	Bio	2.833 f	3.177 de	3.60 abc	22.50 abc	1.13 cd
	Rp+Bio	3.157 de	3.497 cd	3.60 abc	22.53 abc	1.16 cd
	S.+Bio	3.233 d	3.750 abcd	3.63 abc	22.69 abc	1.24 bc
	Rp+S.+Bio	3.440 d	3.293 de	3.50 bc	21.88 bc	1.27 bc
Ch. M.2	Control	2.923 ef	4.060 abcd	3.30 c	20.63 c	0.98 de
	Rp.	3.213 de	3.513 cd	3.63 abc	22.69 abc	1.15 cd
	Sulfur	3.377 d	3.650 bcd	3.53 bc	22.06 bc	1.15 cd
	Bio	3.940 c	3.993 abcd	3.60 abc	22.50 abc	1.26 bc
	Rp+Bio	4.197 bc	4.280 abc	3.83 ab	23.94 ab	1.41 ab
	S.+Bio	4.463 ab	4.610 ab	3.53 bc	22.10 bc	1.37 b
	Rp+S.+Bio	4.597 a	4.663 a	3.97 a	24.80 a	1.57 a

Values within each column followed by the same letter are not statistically significant at 5 % level.
Ch. M1 = chicken manure half dose Ch. M2 = chicken manure full dose
R. P. = Rock phosphate S=sulfur Bio=biofertilzer
* EY = estimated yield Control = Recommended dose of mineral fertilizer (NPK)

The interaction among the different studied organic, biofertilizer and inorganic treatments and its influence on coriander oil constituents were presented in Tables (7a and 7b). Regardless of the treatments, Linalool, camphor, α-terpinene, α-pinene, limonene, geraniol, geranyl acetate and γ-terpinene represented the major oil constituents in an descending order. They are formed 95.72 % of the oil constituents. The total identified compounds were 98.51 %. In comparison with positive control, biofertilization with phosphate solubilizing bacterium in the presence of half dose chicken manure induced little increases for linalool, camphor and α-terpinene. Additional increase was recorded for camphor constituent due to inclusion of sulfur to the same previous treatment. Tables (7a and b) also shows that the combined treatments of rock phosphate + sulfur + biofertilizer in the presence of half dose of chicken manure and rock phosphate + biofertilizer + full dose of chicken manure increased limonene component when compared to the positive control. Each of Geraniol and Geranyl acetate constituents was increased over the positive control owing to the application of full dose of chicken manure + biofertilizer and rock phosphate treatment. Geranyl acetate also was increased due to the treatment of full dose of chicken manure + sulfur + biofertilizer, while biofertilizer in the presence of full dose of chicken manure increased linalool component in comparison with the positive control.

Table (7a):The interaction between the different treatments and its impact on the relative percentage of coriander oil constituents.

No	Treatments› / Compounds˘	Control.	Chicken manure (half dose)						Mean
			R.P.	Sufur	Bio	R.P.+ Bio	S + Bio	R.P.+ S + Bio	
1	α-Pinene	3.73	3.30	3.56	3.58	2.97	3.68	3.56	3.48
2	Camphene	0.40	0.41	0.51	0.44	0.36	0.44	0.39	0.42
3	β-Pinene	0.52	0.51	0.94	0.50	0.46	0.54	0.52	0.57
4	Myrcene	0.85	0.83	0.76	0.77	0.74	0.80	0.74	0.78
5	P.Cymene	traces	0.11	0.07	0.07	0.10	0.10	0.08	0.09
6	Limonene	1.89	2.13	1.71	2.00	2.35	1.72	2.56	2.05
7	γ-terpinene	1.63	1.89	1.79	1.72	1.67	1.75	1.60	1.72
8	Camphor	5.72	6.16	5.99	5.77	4.95	7.23	5.59	5.92
9	Linalool	75.10	73.68	73.2	75.11	75.68	73.29	75.07	74.5
10	α-terpinene	4.37	4.23	4.73	4.47	4.47	3.93	3.90	4.30
11	Linalyl acetate	0.37	0.23	0.32	0.27	0.26	0.30	0.29	0.29
12	Carvone	0.39	0.31	0.33	0.31	0.32	0.29	0.29	0.32
13	Borneol	0.22	0.35	0.14	0.09	0.08	0.08	0.08	0.15
14	Nerol	0.19	0.25	0.26	0.13	0.14	0.13	0.10	0.17
15	Geraniol	1.89	2.06	2.11	1.73	2.03	1.91	1.72	1.92
16	Geranyl acetate	1.78	2.09	2.05	1.83	1.83	1.81	1.81	1.89
Total identified		99.1	98.50	98.5	98.80	98.4	98.0	98.30	98.5
Un-identified comp.		0.9	1.50	1.50	1.20	1.60	2.0	1.70	1.49

Cont.=control R.P. = Rock phosphate S = Sulfur Bio = biofertilizer

DISCUSSION AND CONCLUSION

Application of low price and safe fertilizers is of great importance in agriculture to economize the cost and get products of good quality for human consumption. As it was expected, the full dose of chicken manure overcame the half dose and resulted in significant increases for each of plant height, branches number, plant dry weight, fruit yield (g/plant), oil content, estimated fruit yield (kg/fed.), estimated volatile oil yield (L/fed.) in both growing seasons, and also contents of nitrogen and protein and nitrogen uptake in the second season (Tables 1, 2 and 3). This could be attributed to that full dose of chicken manure meets the nutritional requirements of coriander more than the half dose. These results are in agreement with those obtained by Eghaball and Power (1994). They found that organic fertilizers were excellent

Table (7b): The interaction between the different treatments and its impact on the relative percentage of coriander oil constituents.

No	Treatments› / Compounds˅	Cont.	Chicken manure (full dose) R.P.	Sulfur	Bio	R.P.+ Bio	S + Bio	R.P.+ S + Bio	Mean
1	α-Pinene	3.73	2.43	3.63	2.59	2.90	3.95	2.92	3.15
2	Camphene	0.40	2.32	0.41	0.29	0.36	0.41	0.36	0.36
3	β-Pinene	0.52	0.42	0.57	0.43	0.51	0.57	0.49	0.50
4	Myrcene	0.85	0.73	0.86	0.68	0.79	0.86	0.72	0.78
5	P.Cymene	traces	0.09	0.12	0.08	0.08	0.12	0.10	0.09
6	Limonene	1.89	1.74	2.43	1.61	2.47	1.91	1.87	2.00
7	γ-terpinene	1.63	1.71	1.90	1.44	1.66	1.82	1.61	1.68
8	Camphor	5.72	4.85	6.53	5.56	5.75	6.45	5.39	5.75
9	Linalool	75.10	76.10	73.40	76.98	75.36	74.2	76.56	75.39
10	α-terpinene	4.37	4.66	3.70	3.20	4.11	3.96	4.07	4.01
11	Linalyl acetate	0.37	0.44	0.35	0.60	0.26	0.22	0.13	0.39
12	Carvone	0.39	0.30	0.29	0.26	0.31	0.32	0.30	0.31
13	Borneol	0.22	0.36	0.30	0.27	0.31	0.35	0.30	0.30
14	Nerol	0.19	0.23	0.21	0.13	0.13	0.24	0.20	0.19
15	Geraniol	1.89	2.12	1.64	1.73	1.94	1.82	1.73	1.84
16	Geranyl acetate	1.78	1.94	1.99	1.76	1.86	2.02	1.54	1.84
Total identified comp.		99.1	98.40	98.30	97.60	98.80	99.2	98.3	98.52
Un-identified compo.		0.9	1.60	1.70	2.40	1.20	0.80	1.70	1.48

Cont.=control   R.P. = Rock phosphate   S = Sulfur   Bio = biofertilizer

sources of nutrients for crop and improving physical and chemical properties of the soil. And also, Alghadban (1998) reported that organic fertilization significantly increased the herb and essential oil yields of spearmint and marjoram compared with the recommended N. P and K fertilization for those plants. On the other hand, chicken manure may be increase soil organic matter, exchangeable Mg^{+2}, K^{+} and available P (Bahango *et. al.* 1988). Bahango *et. al.* (1988) and Ohallorans *et al.* (1993) they found that fertlization with chicken they manure increased not only available nitrogen but also exchangeable potassium in the soil.

In most cases, biofertilization as such induced matchable results to the positive control (Tables 1, 2 and 3), while further augmentation were observed when rock phosphate and/or sulfur were included into the biofertilizer's treatments. These increases could be ascribed to the solubilization of phosphate solubilizinng *Bacillus* on rock phosphate that lead to releasing more available phosphorus for plant nutrition due to secretion of different types of organic acids (Kucey, 1983), as well as the acidic action of sulfur in the soil. It is worthy to mention that the treatment of phosphate solubilizing bacteria + rock phosphate + sulfur induced the most significant increases over the positive control (Tables 1, 2 and 3). The superiority of rock phosphate + sulfur with rock phosphate alone in increasing macro- and micronutrients in the soil may be due to the oxidation of sulfur to sulfuric acid by *Thiobacillus spp.* bacteria, the decreasing soil pH and the increased availability of nutrients (Rajan, 1987 and Kumar et. al., 1992).

Regarding the interaction among the various tested treatments, it was found that application of phosphate solubilizing *Bacillus megatherium* in the presence of rock phosphate induced matchable results for plant height, the number of branches per plant, and fruit contents of nitrogen and protein (%) either when half or full dose of chicken manure were applied (Tables 4 and 6). On the other hand, the use of full dose of chicken manure combined with the biofertilizer, rock phosphate, and/or sulfur significantly overcame other treatments for all tested parameters in both seasons (Tables 4, 5 and 6). In the presence of full dose of chicken manure + rock phosphate + sulfur + biofertilizer the increasing percentages were 47.62, 42.23, 42.34 and 48.97 for plant dry weight, fruit yield (g/plant), estimated fruit yield (kg/fed.) and estimated oil yield in comparison with control in both seasons, consecutively. But also with applied half dose of chicken manure combined with aforementioned treatments the increases over the recommended dose of mineral fertilization were 11.43, 23.58, 23..79 and 8.33 % for the same previous parameters in both seasons respectively. These findings were found in agreement with Khattab and Gomaa (2003) since they found that the combination of full dose of organic manure (Chicken manure or compost) and *Azotobacter vinelandii* resulted in highly increase followed by the half recommended dose of these organic manure together with *Azotobacter vinelandii* for growth parameters and yield of genovese basil. Kandeel and Sharaf (2003), they showed that mixed inoculation with three biofrtilizers supplemented with half dose of NPK gave the highest and significant increase of growth parameters, oil content (%) and oil yield of marjoram, as well as, the N, P and K % in the plant herb. Kandeel et. al. (2002) reported that inoculation of sweet basil with *Azotobacter* + *Azosopirillum* supplemented with half dose of the recommended dose of mineral N-fertilizer, significantly increased plant growth, oil % and oil yield plot^{-1} compared with uninoculated plants and given full dose of nitrogen. El-Sawy et. al. (1998) reported that inoculation with a mixture of *Azotobacter*, *Azosopirillum* and VAM amended with full dose of P as rock phosphate and inorganic N-fertilization, in combination with VAM inoculation, increased plant growth and khellin production of *Ammi visnaga* L. plant.

Concerning the impact of interaction of various treatments on coriander oil components , Table (7a and 7b) show that the composite treatment of half dose of chicken manure + rock phosphate + sulfur + biofertilizer induced the highest increase percent over the positive control for limonene constituent that reached 35 followed by rock phosphate + biofertilizer + full dose of chicken manure treatment that produced 30.69 % over the positive control. As for linalool constituent, the main component of coriander oil, the biofertilizer combined with full dose of chicken manure had the highest increase over the positive control that reached 2.5 %. Also, α-terpinene, the third main component of the oil, increased over control with full dose of chicken manure + rock phosphate by about 6.64 %. For camphor constituent, the associative effect of half dose of chicken manure, sulfur and biofertilizer recorded the highest increase over the positive control reaching 26.4 %. The previous results proved that, linalool, camphor, α-terpinene, α-pinene, limonene, geraniol, geranyl acetate and γ-terpinene represented the major oil constituents of coriander, they formed about 95.72 % of the oil constituents. These results were in agreement with those obtained by Hirvi *et. al.* (1986), Hussien (1995) and Khattab and Helmy (2002) they found that the main constituents of coriander oil were linalool, camphor, α-terpinene, limonene, geraniol, geranyl acetate, γ-terpinene, β-pinene, and α-pinene.

In conclusion, the application of phosphate solubilizing *Bacillus megatherium* combined with full dose of chicken manure, rock phosphate and/or sulfur induced the highest records for the majority of measured parameters. Furthermore and in combination with the positive control, the bio-organic treatments in presence of rock phosphate and/or sulfur, as cheap row materials for fertilization improved coriander oil yield quality where the main oil constituents of linalool, camphor α-terpinene, α-pinene and limonene. The half dose of chicken manure induced reasonable results when combined with the biofertilizer and the other fertilization sources but the dominancy was for full dose of chicken manure in combination with the same fertilization treatments.

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تأثير زرق الدواجن وصخر الفوسفات والكبريت والباسيللس المذيبـــة للفوسـفاتذ على محصول وجودة الزيت الطيارللكسبرة

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تم إجراء تجربة حقلية خلال موسمين متتاليين (٢٠٠١/٢٠٠٢ و ٢٠٠٢/٢٠٠٣) فى المزرعة التجريبية لكلية الزراعة جامعة القاهرة لدراسة التأثير المصاحب لتفاعل بكتيريا الباسيللس المذيبة للفوسفور مع زرق الدواجن و صخر الفوسفات والكبريت الزراعى وتأثيره على قياسات النمو ومحصول الثمار والزيت ، وجودة الزيت الطيار فى الكسبرة. ولقد أظهرت النتائج تفوق إضافة الجرعة الكاملة من زرق الدواجن معنوياً عن نصف الجرعة فى جميع قياسات النمو والمحصول. وبحقن البكتيريا المذيبة للفوسفور كان التأثير متشابه مع إضافة الجرعة الموصى بها من التسميد الكيماوى . وعند إضافة صخر الفوسفات أو الكبريت كل منهم على حدة أومجتمعين معاً فى وجود البكتيريا المذيبة للفوسفور كان هناك زيادة معنوية فى جميع القياسات المدروسة مقارنة بالجرعة الموصى بها من التسميد الكيماوى . وكان هناك تأثير للتفاعل بين زرق الدواجن والسماد الحيوى وصخر الفوسفات والكبريت ، حيث أدى إضافة نصف الجرعة من زرق الدواجن مع السماد الحيوى وصخر الفوسفات والكبريت الى حدوث زيادة فى قياسات النمو والمحصول ولكن كان التأثير أفضل عند إضافة الجرعة الكاملة من زرق الدواجن الى نفس المصادر السمادية السابقة مقارنة بالجرعة الموصى بها من التسميد الكيماوى لجميع القياسات المدروسة. وبالنسبة لمكونات الزيت فقد وجد عند الحقن بالسماد الحيوى واضافة الجرعة الكاملة من زرق الدواجن والكبريت زيادة مركب الليمونين بنسبة ٣٠,٦٩ % عن الكنترول. ولكن المركب الرئيسى الليناول زاد بنسبة ٢,٥ % بحقن البكتيريا المذيبة للفوسفور مع الجرعة الكاملة من زرق الدواجن مقارنة بالكنترول.