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INFLUENCE OF SOME PLANT GROWTH PROMOTING RHIZOBACTERIA ON *CORIANDRUM SATIVUM L.*

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ABSTRACT

Plant growth-promoting rhizobacteria (PGPR) are described to stimulate plant growth in especially the root system of plants. Domestic *Bacillus megaterium* LM1 and *Bacillus megaterium* LM2 strains were isolated from the soil of Medicinal and Aromatic Plants Research Farm, in El Qanater El Khairia, Horticulture Research Institute (HRI), Agricultural Research Centre (ARC).The isolated rhizobacteria were tested for phytohormones production and identified by PCR technique using 16SrRNA gene sequence analysis. In the field experiment *Coriandrum sativum* L plants were inoculated with the two strains either single or mixed together during 2016/2017 and 2017/2018. A Complete Randomized Block Design with three replicates was used.

The results revealed that both *Bacillus megaterium* LM1 and *Bacillus megaterium* LM2 strains increased the microbial enzyme activities in rhizosphere during life span. Growth parameters as plant height (cm), number of branches/plant, herb weight and fruit yield (g/plant and kg/ fed.) were determined. Application of *B. megaterium* LM1 and *B. megaterium* LM2 either individually or mixed increased coriander fruits yield by 15.09, 27.62 and 43.11% respectively in the first season and 21.52, 51.39 and 67.00 % respectively in the second one.

All treatments increased coriander Chlorophyll a, b and carotenoids content in comparison to the control. Moreover, the tested treatments increased coriander essential oil percentage and yield

(ml/plant) in both seasons, and the main component Linalool reached 72.55 % with the *B. megaterium* LM2 application .

Key words: *Coriandrum sativum* L, coriander, Plant growth-promoting rhizobacteria, *Bacillus megaterium*, essential oil, essential oil composition, linalool.

INTRODUCTION

Medicinal plants are known to be rich in secondary metabolites and are potentially useful to produce natural medicine. Coriander (*Coriandrum sativum* L.) which belongs to the family Apiaceae (Umbelliferae) is mainly cultivated from its seeds throughout the year **(Mhemdi *et al*., 2011)**. Coriander leaves and seeds, contain essential oil in varying quantity, impart flavour and aroma in foods and possess medicinal properties **(Mandal and Mandal, 2015)**.

Coriander has been reported to posses many pharmaceutical uses as antioxidant **(Darughe *et al*., 2012)**, antihyperglycemic **(Eidi *et al*., 2009)**, antiproliferative **(Nakano *et al*., 1998)**, anti-mutagenic **(Cortes *et al*., 2004)**, anti-lipidemic **(Sunil *et al*., 2012)**, anti-spasmodic **(Alison *et al*., 1999)**, hypotensive **(Burdock & Carabin, 2008)** and digestive stimulant **(Platel & Srinivasan, 2000)**. Coriander contains (0.03 to 2.6%) essential oil **(Nadeem *et al*., 2013)**, that is being used as an antimicrobial agent as it possesses broad spectrum activity **(Silva *et al*., 2011)**. Coriander extracts have phenolic compounds and flavonoides, suggesting their antioxidative activity **(Helle Wangensteen *et al*., 2004)**.

Microorganisms have been intentionally introduced into soil and rhizosphere environments in attempts to enhance certain beneficial activities such as improvement of aggregate stability **(Lynch,1981)**, suppression of plant pathogen **(Maplestone and Campbell,1989)** and promotion of plant growth .

Plant growth promoting rhizobacteria (PGPR) are a heterogeneous group of bacteria that can be found in the rhizosphere, at root surfaces and in association with roots, which can improve the extent or quality of plant growth directly and/ or indirectly. In last few decades a large array of bacteria including species of *Pseudomonas, Azospirillum, Azotobacter, Klebsiella, Enterobacter, Alcalisens, Arthobacter, Burkholderia, Bacillus* and *Serratia* have been reported to enhance plant growth **(Kloepper *et al* . 1989; Glick, 2012)**. The

direct promotion by PGPR either providing the plant with a plant growth promoting substances that are synthesized by the bacterium or facilitating the uptake of certain plant nutrients from the environment. Moreover, the main mechanisms by which PGPR directly contribute to the plant growth are phytohormone production such as auxins, cytokinins and gibberellins, lowering of ethylene levels, enhancing plant nutrition by solubilization of minerals such as phosphorus and iron, production of siderophores and enzymes, and induction of systemic resistance **(Bhattacharyya and Jha, 2012)**. PGPR stimulated nitrogen fixation **(Goswami *et al.*, 2016)** and indirectly benefit the plant growth by the biocontrol of deleterious microorganisms or root pathogens that inhibit plant growth, including antibiotic and hydrogen cyanide production, parasitism, competition for nutrients and niches within the rhizosphere, synthesis of extracellular enzymes to hydrolyze the fungal cell wall and decreasing pollutant hazards **(Bhattacharyya and Jha, 2012)**.

This experiment was conducted to study the influence of some plant growth promoting rhizobacteria obtained and identified from the rizosphere of coriander soil grown in El Qanater El Khairia Experimental Farm on the growth, fruits yield and essential oil production of *Coriandrum sativum L.*

MATERIALS AND METHODS

1-Source and identification of Plant growth promoting rhizobacteria (PGPR):

A clay soil sample was collected from the Experimental Farm of Medicinal and Aromatic Plants Research Department at El Qanater El Khairia, Horticulture Research Institute, (ARC), Egypt for the isolation of Plant Growth Promoting Rhizobacteria (PGPR) using the nutrient agar medium described by **(Difico, 1984)**. Developed colonies were selected and successive streaking on nutrient agar slant was made. Rhizobacterial isolates were tested for their quantitative production of plant growth promoting substances such as indol 3-acetic acid and gibberellic acid. Bacterial culture supernatant of isolates grown on King's broth medium **(King *et al.*, 1954)** supplemented with 0.1g/L tryptophan was used. IAA was determined according to **(Glickmann and Dessoux, 1995)** and total gibberellins according to **(Udagwa and Kinoshita, 1961).**

2- Bacteria identification:

The 16S rRNA sequence analysis has been used to clarify the taxonomic affinities of a wide range of taxa and as a powerful tool for assessing the genetic diversity of environmental samples **(Baker *et al*., 2003)**.

3- DNA Isolation:

Pure isolates were inoculated onto agar and incubated overnight at 37°C. Single colony was taken for isolation of DNA according to **(Sauer *et al*., 2005).**

DNA was recovered from the resulting sample using the Lego DNA Isolation kit (Top-Bio, Czech Republic) according to the manufacturer's instruction. Briefly, a pellet of the bacterial colony was re-suspended in binding buffer; silica was added and mixed 10 min by vortexing. Then the sample was centrifuged (14 000 rpm, 2 min), washed twice with washing buffer, acetone and then dried. DNA was purchased by elution with buffer (10 mM Tris-HCl, 1mM EDTA**).**

4- PCR and sequence analysis:

Primers and PCR conditions were used as described in the Fast MicroSeq 500 16S rDNA Bacterial Identification PCR Kit manufactory manual.

Sequencing of the PCR products using the chain termination method, was performed with the ABI PRISM Big Dye terminator kit (PE Applied Biosystems, USA) in conjunction with ABI PRISM (310 Genetic Analyzer). The nucleotide sequences were compared with sequence database using the BLASTN algorithms **(Altschul *et al.*, 1997).**

5- The field experiment:

This study was conducted in the Experimental Farm of Medicinal and Aromatic Plants Research Department in El Qanater El Khairia Horticulture Research Institute, A R C, Egypt in two successive seasons 2016/2017 and 2017/2018 to study the influence of selected PGPR on coriander . Plant growth, fruit yield and essential oil production were considered. Fruits (seeds) were sown on October 15th in both seasons in plots of 10.8 square meters (3.6 *3.0 M) with 5 rows for each one and were spaced at 25 cm in the rows. Fertilizers (NPK) were added at the recommended quantities in three additions,

the first was for all phosphorous amount which was added during soil preparation, the rest (NK) was applied in two equal doses, the 1st one was added 30 days after sowing and the 2nd was one month later. All plants received the recommended agricultural practices of irrigation and weeding.

The experiment consisted of 4 treatments, where the plant received one of the following treatments.

1-Control (without rhizobacteria inoculation)

2-Isolate No 9 which produces GA more than IAA (*Bacillus megaterium* LM1)

3-Isolate No 10 which produces IAA more than GA (*Bacillus megaterium* LM2)

4-Combination of the two isolates (*Bacillus megaterium* LM1 plus *Bacillus megaterium* LM2)

The treatments of Rhizobacterial strains namely (*Bacillus megaterium* LM1 - *Bacillus megaterium* LM2 and their combination) were applied to soil in liquid form at rates equivalent to 5 L/fed. at three successive soil application, one day after irrigation. The first application was made after sowing, the second after one month from the first addition and the third was added one month later. Each treatment was replicated three times. After 70 days from planting, soil samples were tested to determine microbial activity using the fluorescein di-acetate hydrolysis (FDA) according to the method described by **Schnurer and Rosswall, (1982).**

Growth parameters at harvest time as plant height, number of branches/plant, plant herb weight (g/plant), fruit yield (g/plant) and fruit yield (kg/fed.) were recorded. Plant chlorophyll a, b and caroteniods were determined in the fresh leaves samples according to **Saric *et al.*, (1976)**. Essential oil content (%) and essential oil yield (ml/plant) were determined according to Guenther (1961). The essential oil samples from the second season were analyzed for its components by gas liquid chromatography (GLC) analysis, as recommended by **Hoftman, (1967)** and **Bunzen *et al*., (1969).**

The experiment was designed in complete randomized blocks and the recorded data were statistically analyzed according to **Snedecor and Cochran (1968)**, using L.S.D. at 5%.

RESULTS AND DISCUSSION

Bacterial identification:

The most efficient isolates in producing plant growth promoting substances under investigation were selected and identified by The Fast MicroSeq 500 16S rDNA Bacterial Identification PCR Kit as *B. megaterium* LM1 and *B. megaterium* LM2 (sample No 9 and 10), respectively in **Figure (1 a , b).**

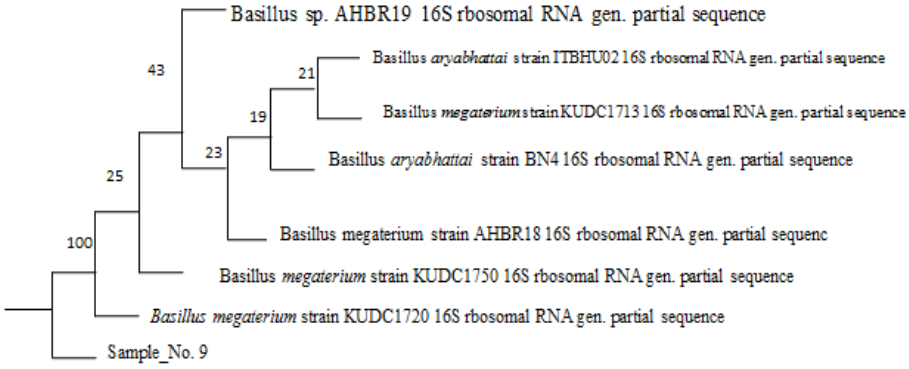

Figure (1 a): Phylogenetic dendrogram based up on 16S rDNA sequence (500bp) of *B.megaterium* LM1 strain compared with the sequence of standard strains obtained from the GenBank database

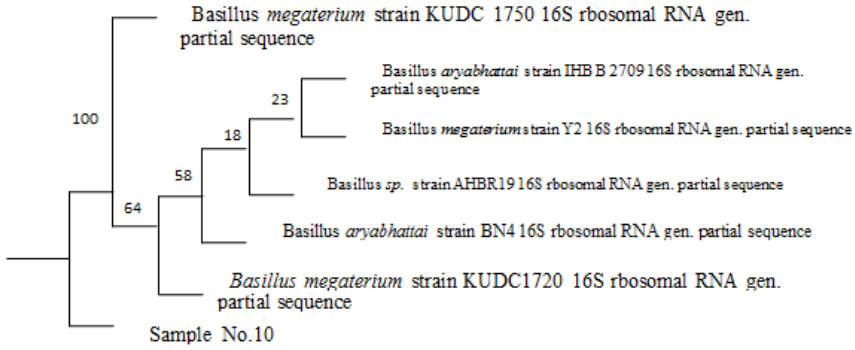

Figure (1 b): Phylogenetic dendrogram based up on 16S rDNA sequence (500bp) of *B.megaterium* LM2 strain compared with the sequence of standard strains obtained from the GenBank database.

Some biochemical characteristics of the isolated bacterial strains:

Some biochemical characteristics of both *B. megaterium* LM1 and *B. megaterium* LM2 were determined. These bacterial strains secreted both indole acetic acid (IAA) and gibberellins (GA) in their liquid culture. *B. megaterium* LM1gave larger amounts of GA (about 34.4µg/ ml) and produced about 5.95 µg/ ml from IAA. While *B. megaterium* LM2 gave larger amounts of IAA (about 9.18 µg/ ml) and 3.6 µg/ ml GA. According to **Tahir and Sarwar, (2013),** Phytohormones are indicator molecules that act as chemical messengers and show a vital role as growth and development managers in the plants. The capability of producing phytohormones widely disseminated among bacteria related with soil and plants. Studies have verified that the PGPR can stimulate plant growth through the production of auxins as IAA (**Tisha and Meenu, 2017**) and gibberellins (**Vejan *et al*., 2016).**

Microbial enzyme activities in rhizosphere of coriander during life span:

The total microbial activity was assessed by measuring fluorescein diacetate (FDA) hydrolysis releasing fluorescein under the action of microbial enzymes such as proteases, lipases and esterases **(Green *et al.*, 2006)**.

Data in **Table (1)** indicates that the content of fluorescein is correlated with the treatment type. The mixture of the strains showed the best activity measured after 70 days. The recorded figures were as the result 48.7 and 49.3 µg fluorescein / g soil in the first and second season respectively. All rhizosphere treated with PGPR gave more activity than those untreated soil (control).The obtained results were found to be in harmony with those obtained by **Ng, *et al*., (2012)** who mentioned that high microbial activity indicates effective root colonization combined with the ability of the isolates to survive and proliferate in the rhizosphere.

Table: (1) Effect of *B. megaterium* LM1, *B. megaterium* LM2 and their mixture on Microbial activity in soil.

treatments	*FDA (µg fluorescein / g soil)	
	First season 2016/2017	Second season 2017/2018
Control (without rhizobacteria inoculation)	38.7	40.0
B. megaterium LM1	46.0	47.0
B. megaterium LM2	43 .7	44.6
B. megaterium LM1 + LM2	48.7	49.3
LSD 0.05	4.18	1.38

* **FAD** = fluorescein diacetate

Effect of *B. megaterium* LM1, *B. megaterium* LM2 and their mixture them on vegetative growth of coriander:

I. plant height (cm):

The results recorded in both seasons **(Table 2)** showed that, coriander plant height (cm) significantly increased with addition of *B. megaterium* LM1, *B. megaterium* LM2 and the mixture of them compared to the control in the two seasons. Differences in height between plants receiving *B. megaterium* LM1 (93.33cm) and *B. megaterium* LM2 (98.33cm) individually were significant in the first season. However, insignificant differences in plant height between the two treatments were recorded in the second season (102.7 and 105.0 cm respectively). Data in (Table 2) also clearly emphasized that, mixed treatments showed the tallest plants compared with the rest treatments as well as control, it was also noticed that, the mixing the two rhizobacterial strains was found most effective in this regard in both seasons .The recorded values were 108.3 and 110.0 cm in the first and second season respectively. Such data were in harmony with the findings of **Brijesh *et al.*, (2017)**. According to **Rocheli *et al.*, (2015)** bacterial inoculants can enhance plant growth . The present results could be explained upon the findings of **Tsavkelova *et al.*, (2006)** who maintained that the IAA synthesizing capacity has been detected in many symbiotic and free living bacterial species present in rhizosphere. The auxin (IAA) play a role in division, expansion and differentiation of plant cells and tissues and inspires root elongation **William *et al.*, (2005)**. Also Gibberellines are a class of phytohormones being usually associated with amending plant

morphology by the extension of plant tissue, principally stem tissue. Production of IAA and solubilization of phosphate are the most common mechanisms implicated in a signal PGPR to promote plant growth and productivity **(Rufus *et al*., 2018).**

2. Number of branches/plant:

The number of branches/plant enlisted in **Table (2)** clearly show that, treated plants with rhizobacteria strains significantly increased the branch numbers/plant the largest number of branches were found with the plants treated by the mixture of both strains (13.33 in both seasons). These results were in agreement with the findings of **Chakraborty *et al*., (2013)**

3-Herb weight (g/plant):

There was a noticeable and gradual significant increase in herb weight (g/plant) with soil application of *B. megaterium* LM1, *B. megaterium* LM2 and the mix of them (110.0, 116.7 and 120.0 g/plant respectively) in the first season (Table 2) and The highest herb weight value (120.0 g/plant) was observed with the plants treated with the mixture of *B. megaterium* LM1 and *B. megaterium* LM2. While, in the second season this value was (125.0 g/plant), but the lowest values (91.67 and 95.00g/plant) were obtained from control plants in the first and second season respectively. This increase in herb weight is due to the application of PGPRs, similar results were observed by **Chakraborty *et al*., (2013)**

4-Fruit yield (g/plant) and (kg/fed.):

Data in **Table (2)** show that, plants treated with *B. megaterium* LM1, *B. megaterium* LM2 and their mixture significantly increased fruit yield (g/plant) in the first and second season. The highest fruit yield 32.33 and 38.41 (g/plant) were recorded with the plants received the mixture of both strains in the first and second season respectively followed by the application of *B. megaterium* LM2 (28.83 and 34.82 g/plant). *B. megaterium* LM1 treatments gave (26.00 and 27.95 g/plant) in the first and second season respectively was well.

The same trend was observed in fruit yield (kg/fed.). It is quite clear that the field experiment results indicated that, under application of rhizobacteria strains, fruits yield (kg/fed.) recorded significant increases. These data were in agreement with those reported by **Brijesh *et al*., (2016).** Application of *B. megaterium* LM1 and *B.*

megaterium LM2 individually increased the fruits yield (kg/fed.) by 15.09 and 27.62% respectively in the first season compared to 21.52 and 51.39% in the second one. In the mixed treatment was the most effective one; that gave the highest values (808.25 and 960.25 kg/fed.) with increment rates by (43.11 and 67.00%) in the first and second season respectively.

Table (2); Effect of *B. megaterium* LM1, *B. megaterium* LM2 and their mixture on vegetative growth of coriander:

Treatments	First season 2016/2017					
	Plant height (cm)	Number of branches/plant	Herb weight (g/plant)	Fruits yield (g/plant)	Fruits yield (kg/fed.)	Increments of fruit yield (%)
control(without rhizobacteria inoculation)	85.00	9.667	91.67	22.59	564.75	
B. megaterium LM1	93.33	12.33	110.0	26.00	650.00	15.09
B. megaterium LM2	98.33	13.33	116.7	28.83	720.75	27.62
B.megaterium (LM1 + LM2)	108.3	13.33	120.0	32.33	808.25	43.11
LSD 0.05	4.995	1.290	3.33	0.8286	7.365	
Second season 2017/2018						
control(without rhizobacteria inoculation)	95.00	11.00	95.00	23.00	575.00	
B. megaterium LM1	102.7	12.67	118.3	27.95	698.75	21.52
B. megaterium LM2	105.0	12.67	123.3	34.82	870.50	51.39
B. megaterium (LM1 + LM2)	110.0	13.33	125.0	38.41	960.25	67.00
LSD 0.05	2.514	0.9413	4.405	0.7395	2.06	

Effect of *B. megaterium* LM1 , *B. megaterium* LM2 and their mixture on coriander chemical composition:

1-Chlorophyll a, b and carotenoids content:

Table (3) show ranges of chlorophyll content found in different treatments under study. The chlorophyll content (Chl a and Chl b) was found to be maximum with mixing of the two rhizobacteria strains; *B. megaterium* LM1 and *B. megaterium* LM2 to show 0.391 and 0.479 mg/g fresh weight for Chl a and 0.558 and 0.723 mg/g fresh weight for Chl b in the first and second season, respectively. The minimum values were observed in the control treatment being 0.270 and 0.342

mg/g fresh weight for Chl a and 0.350 and 0.443 mg/g fresh weight for Chl b.

The carotenoids content was found to be maximum with those received the mixed treatment of the two rhizobacterial strains; being 0.145 and 0.220 mg/g fresh weight, while the minimum values were detected in control treatment which recorded 0.067 and 0.037 mg/g fresh weight in both seasons respectively. It has been recorded that chlorophyll contents were enhanced by the application of *B. megaterium* **(Chakraborty *et al*., 2012).** This increase in chlorophyll a, b and carotenoids is due to the application of PGPRs which in turn increased growth of coriander plant. Similar results were observed by **Khandaker *et al*., (2012)** and **Naeem *et al*., (2018)** who justified that the application of two growth regulators (GA3 and 2,4D) had a marked increase in both chlorophyll and carotenoids content in *Coriandrum sativum*.

Table: (3) Effect of *B. megaterium* LM1 , *B. megaterium* LM2 and their mixture on Chlorophyll a, b and carotenoids content of coriander:

treatments	First season 2016/2017			Second season 2017/2018		
	Chl.a	Chl.b	carotenoid	Chl.a	Chl.b	carotenoid
Control (without rhizobacteria inoculation)	0.270	0.350	0.067	0.342	0.443	0.037
B. megaterium LM1	0.334	0.447	0.093	0.406	0.567	0.130
B. megaterium LM2	0.370	0.498	0.104	0.427	0.631	0.176
B. megaterium (LM1 + LM2)	0.391	0.558	0.145	0.479	0.723	0.220
LSD 0.05	0.063	0.063	0.019	0.0894	0.0632	0.028

2-Essential oil percent and essential oil yield (ml/plant):

Generally there was a significant increase in essential oil percent under the influence of the tested rhizobacterial strains in the two seasons **(Table 4).** A noticeable and gradual increase in essential oil percent was detected between used treatments. Where, treatment with B. *megaterium* LM1 gave (0.36 and 0.40%) in the first and second season, respectively. The addition of *B. megaterium* LM2 gave 0.43% in the first season and 0.46% in the second season. The highest

essential oil content (0.46% and 0.48%) was obtained with the combination treatment in the first and second season, respectively.

The essential oil yield (ml/plant), revealed (Table 3) that, all tested treatments were effective in increasing the essential oil yield (ml/plant) in coriander fruits during the tested seasons.

Regarding, all tested applications there were significant differences between essential oil yields (ml/plant) under the influence of rhizobacterial strains compared to the control. The highest essential oil yields (0.151 and 0.180 ml/plant) were recorded with the plants received the mixture of the two strains in the first and second season respectively. These results were similar to that obtained by **Brijesh *et al*., (2017).**

Table: (4) Effect of *B. megaterium* LM1 , *B. megaterium* LM2 and their mixture on coriander essential oil and essential oil yield:

treatments	First season 2016/2017		Second season 2017/2018	
	Essential oil (%)	Essential oil yield (ml/plant)	Essential oil (%)	Essential oil yield(ml/plant)
Control (without rhizobacteria inoculation)	0.24	0.054	0.27	0.071
B. megaterium LM1	0.36	0.093	0.40	0.130
B. megaterium LM2	0.43	0.125	0.46	0.152
B. megaterium (LM1 + LM2)	0.46	0.151	0.48	0.180
LSD 0.05	0.14	0.020	0.14	0.045

3-Essential oil components:

The GLC analysis was carried out for the essential oil of coriander fruits treated with *B. megaterium* LM1 , *B. megaterium* LM2 and their mixture as well as control treatment in the second season . Data were recorded in **Table (5)** and illustrated in **Fig (2-5).**

Table (5) GLC analysis of coriander fruits essential oil under the influence of the application of *B. megaterium* LM1, *B. megaterium* LM2 and their mixture:

Treatments / components	Control (without rhizobacteria)	*B. megaterium* LM1	*B. megaterium* LM2	*B. megaterium* LM1 +*B.megaterium* LM2
α pinene	5.39	5.56	5.54	7.72
Myrcene	1.77	1.66	1.64	0.32
β- pinene	3.01	2.63	2.73	1.31
P- cymene	7.11	7.23	6.73	6.87
Linalool	69.78	71.01	72.55	70.67
Geraniol	3.78	3.66	4.22	4.05
Terpinene-4-ol	0.38	0.39	0.82	0.30
Borneol	0.82	0.78	-	0.28
Lenalyl acetate	0.38	0.20	-	-
Gyranyl acetate`	3.75	3.79	4.30	2.9

Data revealed the existence of 10 compounds which were identified as α-pinene , β-pinene , Myrcene, P- cymene, Linalool (as the major constituent), Geraniol, Terpinene-4-ol, Borneol, Lenalyl acetate and Gyranyl acetate. The major constituent of the essential oil (Linalool) was increased with the rhizobacteria strains treatments individually or mixed in comparison with the control and the highest value was (72.55%) with the *B. megaterium* LM2 treatment.

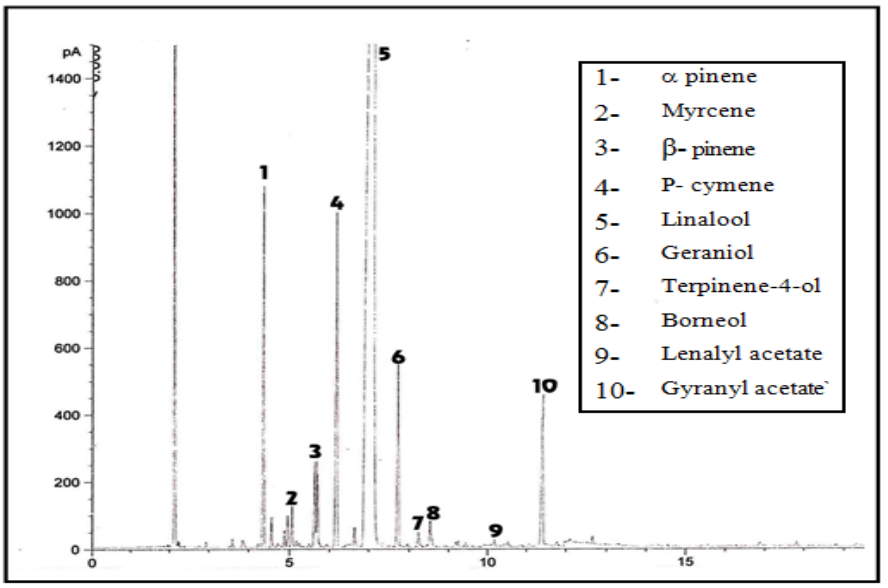

Fig. (2): Essential oil components of coriander fruits (without rhizobacteria inoculation)

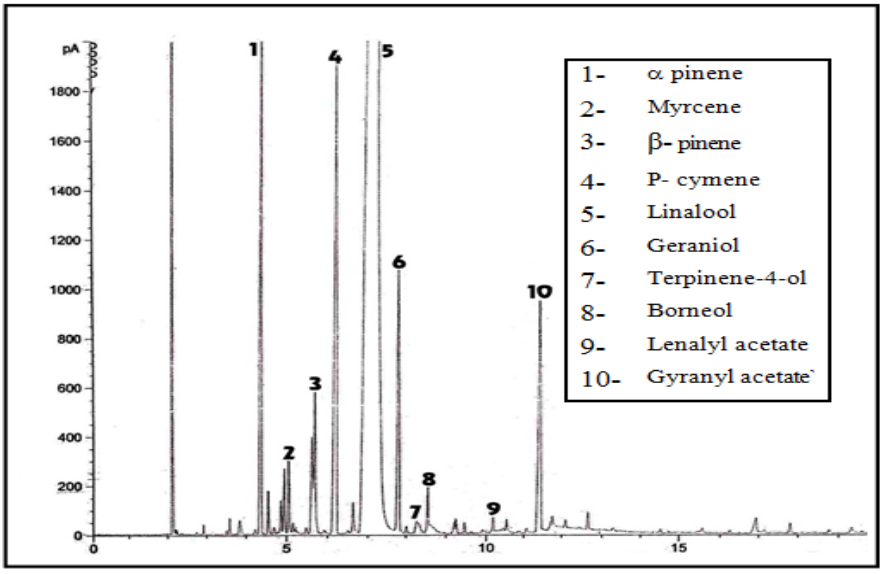

Fig. (3): Effect of *B. megaterium* LM1 application on coriander fruits essential oil components .

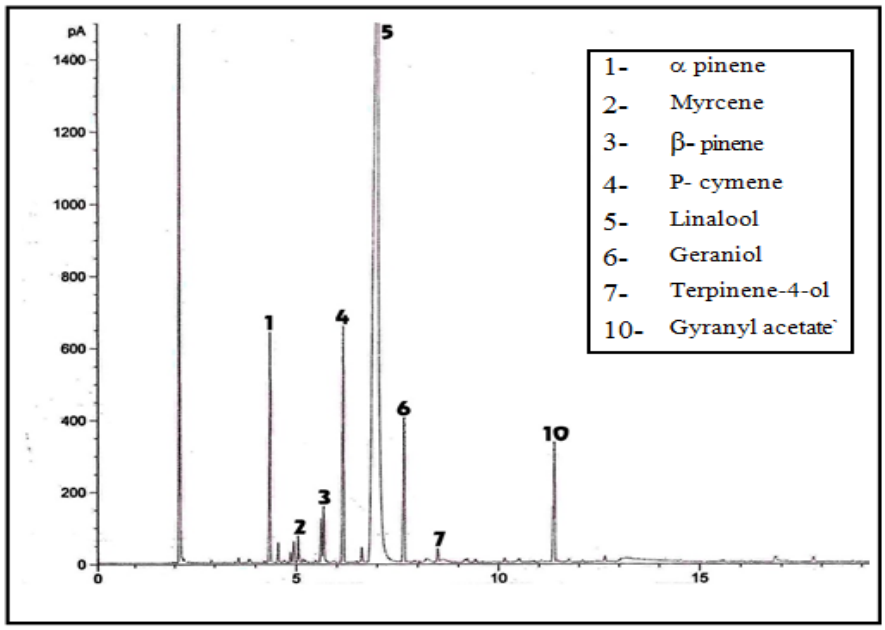

Fig. (4): Effect of *B. megaterium* LM2 application on coriander fruits essential oil components .

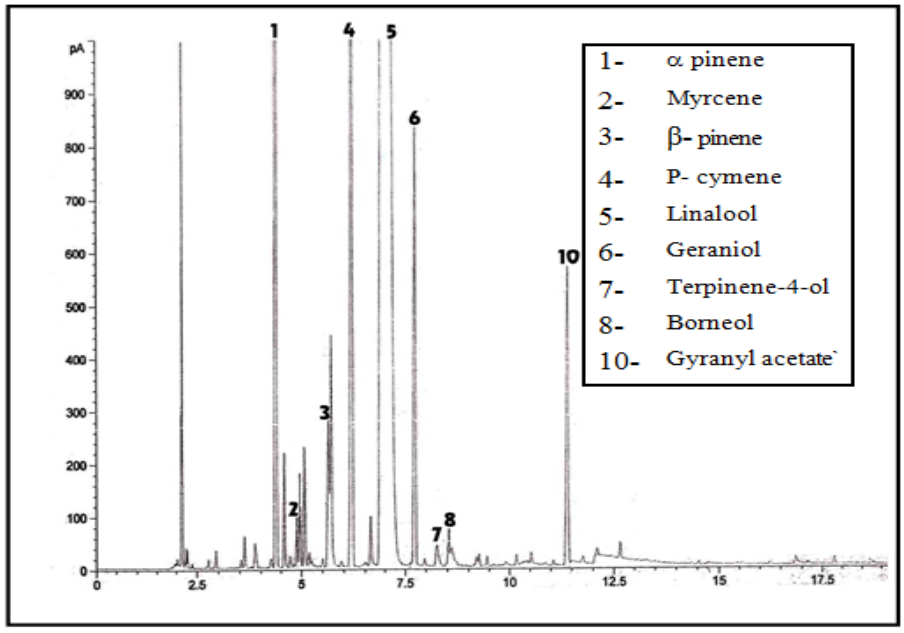

Fig. (5): Effect of *B. megaterium* (LM1+ LM2) application on coriander fruits essential oil components .

Conclusion

From the present study, it could be concluded that many rhizosphere microorganisms *as Bacillus megaterium* (LM1 and LM2) able to stimulate coriander plant growth, fruit yield and essential oil production.

Bacillus. megaterium LM1 secretes amount of GA higher than IAA. While *Bacillus. megaterium* LM2 secretes amount of IAA higher than GA. The highest plant height, number of branches, herb weight, fruits yield, chlorophyll (Chl a and Chl b) and carotenoids content, essential oil percentage and yield were recorded with the plants received the mixture of both strains in the first and second season.

Recommendation

It could be recommended to use mixture of *Bacillus megaterium* (LM1 and LM2) as Plant Growth-Promoting Rhizobacteria (PGPR) to increase coriander plant growth, fruit yield and essential oil production.

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تأثير بعض البكتريا المفرزة لمنظمات النمو على الكسبرة

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البكتريا المحفزة للنمو (PGPR) يمكنها تحفيز نمو النبات بالتزامن مع تحفيز عمل النظام الجذري و فى هذه الدراسة تم عزل السلالتين *Bacillus megaterium* LM1 و *Bacillus megaterium* LM2 من تربة مزرعة قسم بحوث النباتات الطبية والعطرية بالقناطر الخيرية - معهد بحوث البساتين - مركز البحوث الزراعية و تم اختبار البكتريا المعزولة لإنتاج الهرمونات النباتية ثم تعريفها من خلال تقنية PCR وتحليل التسلسل الجينى SrRNA16 . في التجربة الحقلية تم معاملة نباتات *Coriandrum sativum* L بالسلالتين

كل منهما منفردا و مخلوط السلالتين معا خلال موسمى 2017/2016 و 2017/ 2018 باستخدام تصميم قطاعات كامله العشوائيه فى ثلاثة مكررات.

أوضحت النتائج أن اضافة بكتريا *Bacillus megaterium* LM1 و *Bacillus megaterium* LM2 ادت الى زيادة النشاط الإنزيم الميكروبي في منطقة الجذور خلال فترة الزراعة و كذلك زيادة قياسات النمو مثل ارتفاع النبات (سم) وعدد الفروع /نبات و وزن العشب ومحصول الثمار (جم /نبات و كجم/ فدان) كذلك ادت اضافة *B. megaterium* LM2 , *B. megaterium* LM1 بشكل فردي أو فى مخلوط الى زيادة محصول الثمار للكسبرة بنسبة 15.09 و 27.62 و 43.11٪ على التوالي في الموسم الأول و 21.52 و 51.39 و 67.00٪ على التوالي في الموسم الثانى مقارنة بالكنترول. علاوة على ذلك ادت كل المعاملات الى زيادة محتوى الكلوروفيل (a و b) و الكاروتينات بالمقارنة بالكنترول.

بالإضافة إلى ذلك فان معاملات الدراسة ادت الى زيادة النسبة المئوية (٪) للزيت العطرى للكسبرة وكذلك محصول الزيت العطري (مل/ نبات) بينما وصل المكون الرئيسي Linalool إلى 72.55٪ مع المعاملة بالسلالة *B. megaterium* LM2.