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INFLUENCE OF PLANT GROWTH PROMOTING BACTERIA (PGPB) ON CORIANDER (*Coriandrum sativum* L.) AND DILL (*Anethum graveolens* L.) PLANTS

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ABSTRACT

Field experiments were conducted at the experimental Farm of the Faculty of Agriculture, Kafrelsheikh University during 2013/2014 and 2014/2015 seasons to study the effect of *Azotobacter chrocooccum* and *Pseudomonas* sp. on coriander (*Coriandrum sativum*, L.) and dill (*Anethum graveolens*, L.) plants. Indole-3-acetic acid in the supernatant of a culture *A. chrocooccum* and *Pseudomonas* sp. was detected. It was shown that Indole-3-acetic acid was induced by the presence of tryptophan. The highest concentration of Indole-3-acetic acid was produced by both strains at the end of the logarithmic phase.

The bacterial strains were applied at the time of sowing as seed treatment. Data showed that *A. chrocooccum* surpassed *Pseudomonas* sp. in most vegetative growth and flowering characters (plant height, number of leaves/ plant, herb fresh and dry weights/ plant and umbels and umbellts number/plant), while *Pseudomonas* sp. gave the highest weight of 100 fruits, fruit yield per plant and per Feddan for both plants, respectively. The highest total chlorophyll contents were obtained when coriander and dill were treated with *Pseudomonas* sp. and *A. chrocooccum*, respectively. *Pseudomonas* sp. gave the best results for total carbohydrates, vitamin C, fresh herb and dry fruit oil % and fruits oil yield/ plant compared to *A. chrocooccum* or control treatments.

Coriander fruit treatments with *A. chrocooccum* and *Pseudomonas* sp. increased anatomical parameters such as xylem vessel diameter, thickness of phloem tissue and vascular bundle as well as vascular bundle width comparing with the control treatment. The obtained results exhibited that, these bacterial strains could be used to increase coriander and dill productivity under field conditions.

Keywords: Coriander and dill plants, Plant growth promoting bacteria, Indole-3-acetic acid, vegetative growth, anatomical parameters.

INTRODUCTION

Plant growth-promoting bacteria (PGPB) include both free living and symbiotic bacteria, typically found in the soil, that facilitate the growth and development of plants (Glick *et al.*, 1999). This can directly promote plant growth by facilitating the uptake of nutrients from the soil. Thus, (PGPB) can directly facilitate the proliferation of plants by fixing atmospheric nitrogen, producing siderophores which can mineral solubilize and provide it to plants, synthesizing phytohormones which can enhance various stages of plant growth, solubilizing minerals such as phosphorus and synthesizing enzymes that can modulate plant growth and development (Glick, 2007).

Nitrogen fixation and plant growth promotion by plant growth promoting bacteria are important criteria for an effective bio-fertilizer. Inoculation of associative and free living N_2-fixing bacteria has been shown to produce beneficial effects on plant growth, (Bashan and Holguin, 1998). *Azotobacter sp* besides fixing nitrogen it is also secreting certain growth hormones such as IAA, GA and Cytokinin (Coppola, *et al.*, 1971) which promote vegetative growth and root development.

The ability to produce the plant hormone indole-3-acetic acid (IAA) is widespread among soil, epiphytic, and tissue-colonizing bacteria (Costacurta and Vanderleyden 1995; Patten and Glick 1996; Barazani and Friedman. 1999). These genera from bacteria comprise *Azospirillum, Azotobacter, Rhizobium, Bradyrhizobium, Enterobacter, Xanthomonas, Klebsiella, Serratia, Pseudomonas*, cyanobacteria and sulfur oxidizing bacteria. These bacteria have shown to encourage plant growth, by promoting the out-break of secondary roots, acting as protectors against phytopathogenic microorganisms via plant hormones release and siderophores (Tien *et al.*, 1979; Fett *et al.*, 1987; Zimmer and Bothe 1988; Sekine *et al.*, 1989, Minamisawa and Fukai, 1991; Gamliel and Katan 1992; Amstroen, *et al.*, 1993; Bar and Okon, 1993; Glick, 1995; Patten and Glick, 1996). Auxins are known to affect much process in plant including cell elongation and adve ntitious root formation (Trigiano and Gray, 1996).

Coriander (*Coriandrum sativum*, L.) and dill (*Anethum graveolens*, L.) belong to family Apiaceae (Umbelliferae) and believed to have their beginnings in the Mediterranean region. The plants have a long and ancient history in many countries as culinary and medicinal herbs. The earliest known record of dill as a medicinal herb was found in Egypt 5,000 years ago when the plant was referred to as a "soothing medicine." Gladiators were fed meals covered with dill because it was hoped that the herb would grant them valor and courage (The Herb Society of America 2009).

Green coriander and dill are two of the most important aromatic crops in the entire world. There are two products of both plants that are used for human nutrition: fresh green herb and seeds (fruits). The two herbs are consumed fresh in soups and salads, food dressing and as flavoring ingredient. The green herbs are also employed for stem-distilled essential oil, which can be used in flavoring and aroma industries like perfumes, sops and creams. Herbs leaves are good source of vitamin "A" and "C" as well as minerals i.e Ca, K, P, Fe and Mn. As medical plants, herbs have been used to treat stomach disorders, intestinal complaints, colic, fatigue and indigestion (Guenther, 1961 and Fenaroli, 1971).

The present study was designed to produce bio-auxin (IAA) from *Azotobacter chrocooccum* and *Pseudomonas* sp. as well as asses their influence on growth, chemical constituents, essential oil yield and anatomical characteristics of coriander (*Coriandrum sativum*, L.) and dill (*Anethum graveolens*, L.).

MATERIALS AND METHODS

Source of microorganisms:

Two bacterial strains (*Azotobacter chrocooccum* and *Pseudomonas* sp. were isolated and identified in previous study (unpublished data) and were used in improvement of wheat plants under drought-stressed conditions (El-Afry *et al.*, 2012 a and b)

Indole-3-acetic acid production:

One hundred ml of Jensen's or king's B liquid medium supplemented with tryptophan (0.1g/l) with 1ml of a cell suspension of *Azotobacter chrocooccum* and *Pseudomonas* sp. (Jensen's broth medium, 10^7cfu/ml, incubated at 30°C and 150 rpm for 3days for *Azotobacter chrocooccum* or king's B liquid medium10^7cfu/ml, incubated at 30°C and 150 rpm for 3days for *Ps eudomonas* sp. respectively. The culture was incubated at 30°C and 150 rpm for 5days. The production of indole-3-acetic acid was determined daily by colorimetric analysis method as described below. The growth representing in cell number of the bacterial strain was determined by plating appropriate dilutions of liquid medium onto YMA medium.

Colorimetric analysis:

After centrifugation (6000 rpm.30 min), the liquid portion of an aliquot of liquid medium was used to determine of Indole-3-acetic acid (IAA) by the method described by Glickman and Dessaux (1995); Ahmad, *et al.*, (2005); El-Mahrouk and Belal, (2007) and the developed (30min) color was measured by spectrophotometer at 530nm. Concentrations were calculated from an adjusted calibration curve.

Effect of seed treatment with both bacterial strains on growth, chemical constituents, essential oil yield and histological parameters of coriander and dill plants under field conditions. Concentration of total chlorophyll pigment µg/g fresh weight was determined according to (Moran, 1982).

Cultivation of microorganisms:

Azotobacter chrocooccum and *Pseudomonas* sp. were cultivated in nutrient liquid medium. 200 ml nutrient liquid medium and inoculated with 2 ml of a cell suspension of (*Azotobacter chrocooccum* or *Pseudomonas* sp. (nutrient broth medium, 10^8 cfu / ml) was incubated at 30°C and 150 rpm for 3 days. The cultures were incubated at 30°C and 150 rpm for 5 days. Thereafter, two bacterial strains were applied on wheat as follows:

Field experiments were conducted at the experimental farm of the Faculty of Agriculture, Kafrelsheikh University during 2012 -13 and 2013-14 seasons to study the effect of two bacterial strains (*Azotobacter chrocooccum* and *Pseudomonas* sp.) on growth of coriander (*Coriandrum sativum*, L.) and dill (*Anethum graveolens*, L.) plants.

Seeds treatments:

Two bacterial strains were applied at the time of sowing as seeds treatment. Seeds were witted with 10 % sugar syrup, and thoroughly mixed with an amount of bacterial suspension (10^8 cfu / ml) for 30 min. enough to obtain 10^8 cfu / per gram of seeds and then dried.

Coriander and dill fruits were sown on 25th October in plots (5 * 3 meters). Each treatment represented by three plots and each plot consisting of three rows. Twenty five plants in each row (20 cm apart) were planted. All the plants received natural agricultural practices whenever needed. Two months after sowing, plants were harvested by cutting 4-5 mm above soil surface, and then plants reharvested 2 additional harvests at monthly intervals. At each harvesting time, fresh and dry weights of herb were recorded according to Gabal *et al.*, (1984).

Essential oil percentage in both fresh herb and dry seeds were determined by hydro-distillation in Clevenger's apparatus for 3 and 5h, respectively according to the Egyptian Pharmacopoeia (1984) then, the essential oil yield was calculated. Both total chlorophyll and Carbohydrates and vitamin "C" were determined. The obtained data were statistically analyzed according to Snedecor and Conchran, (1982).

Histological parameters:

The stems specimens were taken from the middle of the third internode of the plant stem base. Specimens were taken on day 30th after sowing. Specimens were fixed in formalin, alcohol and acetic acid mixture (FAA, 1: 18: 1; v/v), washed and dehydrated in alcohol series. The dehydrated specimens were infiltrated and embedded in paraffin wax (52-54 °C in. p.). The embedded specimens were sectioned using a rotary microtome (Leica RM 2125) at a thickness of 8 – 10 µm. Sections were mounted on slides and deparaffinized. Staining was accomplished with safranin and light green combination, cleared in xylene and mounted in Canada balsam (Ruzin, 1999). Ten readings from 3 slides were examined with electric microscope (Lieca DM LS) with digital camera (Lieca DC 300), and then photographed. The investigated histological features of the stem were thickness of either vascular bundle or phloem tissue as well as diameter of xylem vessels.

RESULTS AND DISCUSSION

By using specific medium supplemented with tryptophan (0.1 g/l) for *Azotobacter chrocooccum* and *Pseudomonas* sp. in a culture medium containing tryptophan as inducer for IAA, produced IAA, as detected by Glickmann and Dessaux, (1995) and El-Mahrouk and Belal, (2007), while the same strains did not produce IAA in the same medium without tryptophan. Most species use tryptophan to produce indole-3-acetic acid (IAA), mainly through indole-3-pyruvic acid and tryptamine pathways (Bar and Okon, 1993). The highest accumulation of IAA exhibited in the 48th hours of cultivation in the supernatant of *A. chrocooccum* and *Pseudomonas* sp. (Fig 1 and Fig. 2). The maximum accumulation of IAA occurred at the end of logarithmic phase, and after that the accumulation of IAA decreased at the beginning of the stationary growth phase. IAA accumulation coincided with increase in the specific growth rates of the cultures.

Figs. 1 and 2. Illustrate that IAA formation started when *A. chrocooccum* and *Pseudomonas* sp. grew on the medium supplemented with tryptophan. The highest accumulation of IAA exhibited in the 48th hours of

cultivation. The maximum accumulation of IAA occurred at the end of logarithmic phase, and after that the accumulation of IAA decreased at the beginning of the stationary growth phase. IAA accumulation coincided with increase in the specific growth rates of the cultures. Most species use tryptophan to produce indole-3-acetic acid (IAA), mainly through the indole-3-pyruvic acid and tryptamine pathways (Bar and Okon, 1993). The results obtained in this work provide useful information about the production behavior of IAA which is of importance for instance for the application in production of coriander and dill plants.

Our results are in agreement with previous findings reported by (Ernsten *et al.*, 1987, Fukuhara, *et al.*, 1994. Glickmann and Dessaux, 1995; Torres-rubio *et al.*, 2000), who found that addition of tryptophan in the growth medium led to production of IAA by many bacterial strains. Several different IAA biosynthetic pathways are used by prokaryotes, and a single bacterial strain can contain more than one pathway. Manulis *et al.*, (1998) reported that indole –3-acetic acid (IAA) biosynthetic pathways detected in *Erwinia herbicola pv. gypsophilae*. iaaM, iaaH, and ipdC are genes encoding tryptophan-2-monoxygenase, indole-3-acetamide hydrolase, and indole-3-pyruvate decarboxylase, respectively.

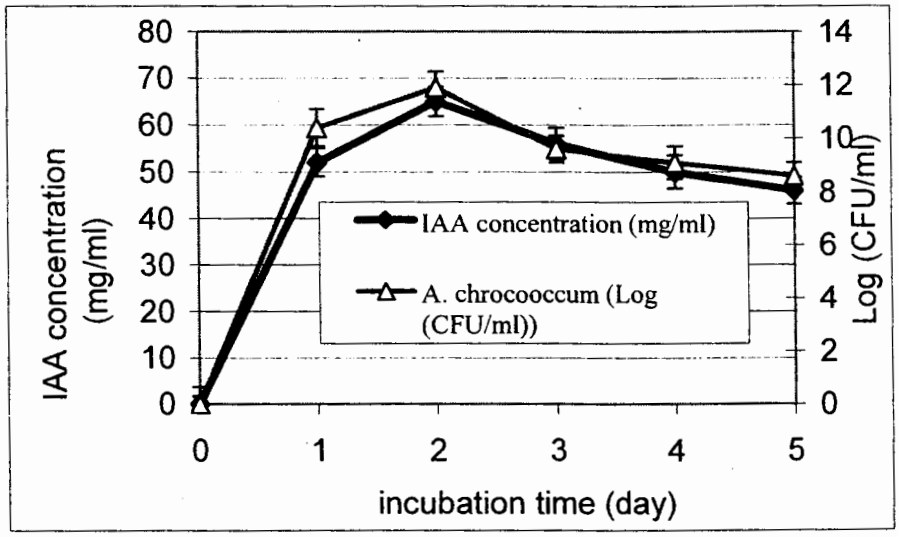

Fig. (1). IAA production by *Azotobacter chrocooccum* in submerged culture with tryptophan.

Effect of seed treatment with the both bacterial strains on growth, chemical constituents, essential oil yield and histological parameters of coriander (*Coriandrum sativum*, L.) and dill (*Anethum graveolens*, L.) plants under field conditions.

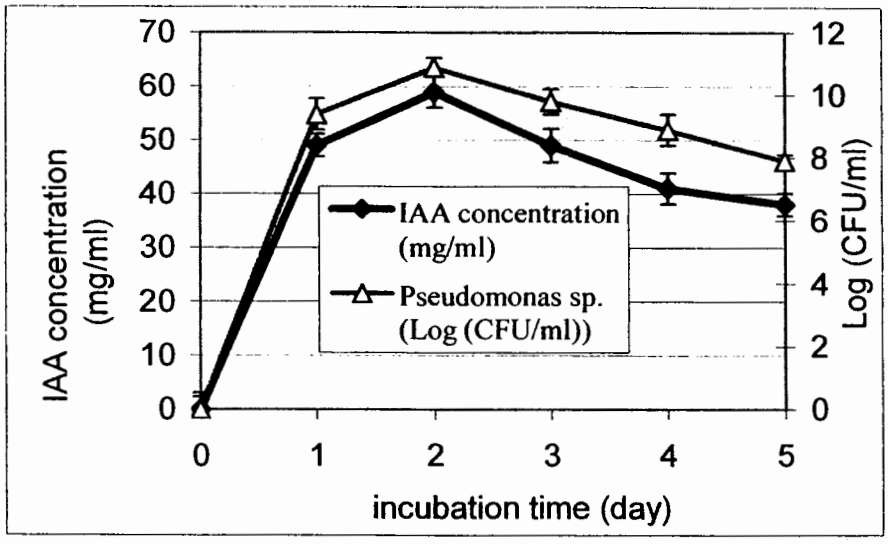

Fig. (2). IAA production by *Pseudomonas* sp. in submerged culture with tryptophan.

Vegetative growth and herb yield:

Data presented in Tables (1 and 2) show that growth parameters (plant height, number of leaves per plant) of coriander and dill plants increased gradually from the first to third cut, both treatments *Azotobacter chrocooccum* and *Pseudomonas* sp surpassed control whereas, *Azotobacter chrocooccum* surpassed *Pseudomonas* sp in the three cuts for the two plants. As for herb fresh and dry weights, data show that both treatments *Azotobacter chrocooccum* and *Pseudomonas* sp surpassed control for the two plants. *Azotobacter chrocooccum* treatment surpassed *Pseudomonas* sp treatment and second cut surpassed both first and second one.

Table (1): Effect of plant growth promoting bacteria on plant height and leaves number of coriander (*Coriandrum sativum*, L.) and dill (*Anethum graveolens*, L.) (Combined analysis of two seasons).

Treatments		Plant height (cm)			Mean	Leaves No. / plant			Mean
		1st cut	2cut	3nd cut		1st cut	2cut	3nd cut	
Coriander (*Coriandrum sativum* L.)	Control	9.45i	10.33h	11.50g	10.43c	6.31i	6.86h	7.10g	6.75c
	A. chrocooccum	15.82e	18.11c	20.64a	18.19a	8.38c	8.75b	8.80a	8.64a
	Pseudomonas sp.	14.50f	16.77d	19.43b	16.90b	7.52f	7.79e	8.23d	7.85b
	Mean	13.26c	15.07b	17.19a		7.40c	7.80b	8.04a	
Dill (*Anethum graveolens* L.)	Control	26.88i	31.76h	47.53e	35.39c	3.22i	4.06h	4.53g	3.94c
	A. chrocooccum	35,11f	60.29c	63.23b	52.88a	5.60e	6.03d	6.85b	6.16b
	Pseudomonas sp.	33.25g	57.84d	66.14a	52.41b	5.32f	6.75c	7.40a	6.49a
	Mean	31.75c	49.97b	58.96a		4.71c	5.61b	6.26a	

Means within each column followed by the same letter are not statistically different at 0.05 level (Duncan's range test)

Table (2): Effect of plant growth promoting bacteria on Herb fresh and dry weights of coriander (*Coriandrum sativum*, L.) and dill (*Anethum graveolens*, L.) (Combined analysis of two seasons).

Treatments		Herb fresh weight (g)/plant			Mean	Herb dry weight (g)/plant			Mean
		1st cut	2cut	3nd cut		1st cut	2cut	3nd cut	
Coriander (*C. sativum* L.)	Control	4.05i	5.21g	4.36h	4.54c	1.09h	1.25g	1.03i	1.12c
	A. chrocooccum	8.11e	9.52a	9.23b	8.95a	1.65d	1.96a	1.89b	1.83a
	Pseudomonas sp.	7.52f	8.42c	8.22d	8.06b	1.51f	1.77c	1.64e	1.64b
	Mean	6.56b	7.72a	7.27c		1.42c	1.66a	1.52b	
Dill (*A. graveolens* L.)	Control	3.86h	5.22g	3.85i	4.31c	0.68i	0.77g	0.73h	0.73c
	A. chrocooccum	10.43 c	13.49a	8.69d	10.87a	2.16c	2.57a	2.00d	2.24a
	Pseudomonas sp.	8.38e	10.55b	6.33f	8.42b	1.88e	2.42b	1.71f	2.01b
	Mean	7.55b	9.75a	6.29c		1.57b	1.92a	1.48c	

Means within each column followed by the same letter are not statistically different at 0.05 level (Duncan's range test)

Flowering and fruit characters and yield:

Data in Table (3) revealed that, flowering characters (umbels and umbellts numbers) were the highest when *Azotobacter chrocooccum* used compared to *Pseudomonas* sp and control for both coriander and dill as recorded 33.20 and 6.41, respectively for coriander and 33.26 and 23.40, respectively for dill. The heaviest weight of 100 fruit (1.43g for coriander and 2.62g for dill) were recorded with *Pseudomonas* sp. As for plant fruit yield, the obtained data varied in the case of dill from that obtained from coriander plant. *Pseudomonas* sp gave the highest coriander fruit yield (6.25g/ plant) whereas *Azotobacter chrocooccum* gave the highest dill fruit yield/ plant (5.60 g/ plant). The highest fruit yield /feddan for both coriander (237.52kg/fed) and dill (490.07kg/fed) resulted from *Pseudomonas* sp. treatment.

Table (3): Effect of plant growth promoting bacteria on umbels number, umbllets number/umbel, weight of 100 fruit and fruit yield per plant and per fadden of coriander (*Coriandrum sativum*, L.) and dill (*Anethum graveolens*, L.) (Combined analysis of two seasons).

Treatments		Umbels No. /plant	Umbellts No. / umbel	Weight of 100 fruit (g)	Fruit yield /plant (g)	Fruit yield (kg/fed.)
Coriander (*C. sativum* L.)	Control	22.88c	5.44c	0.86c	1.26c	137.61c
	A. chrocooccum	34.63a	7.29a	1.36b	5.78b	235.10b
	Pseudomonas sp.	33.20b	6.41b	1.43a	6.25a	237.52a
Dill (*A. graveolens* L.)	Control	21.00c	13.55c	1.25c	1.55c	283.65c
	A. chrocooccum	33.26a	23.40a	2.58b	5.60a	487.53b
	Pseudomonas sp.	30.05b	20.81b	2.62a	4.89b	490.07a

Means within each column followed by the same letter are not statistically different at 0.05 level (Duncan's range test)

Chemical constituents:

The results in the Table (4) revealed that, chemical components of both plants greatly influenced with both *Azotobacter chrocooccum* and *Pseudomonas* sp.compared to control. Second cut of *Pseudomonas* sp treatment of coriander plant exceeded all in total chlorophyll contents as gave 1.33 µg/g fresh weight whereas, in the case of dill plants the third cut of *Azotobacter chrocooccum* treatment was the best as recorded 1.51 µg/g fresh weight.

Table (4): Effect of plant growth promoting bacteria on total chlorophyll µg/g of coriander (*Coriandrum sativum*, L.) and dill (*Anethum graveolens*, L.) (Combined analysis of two seasons).

Treatments		Total chlorophyll (µg/g fresh weight)			Mean
		1st cut	2cut	3nd cut	
Coriander (*coriandrum sativum* L.)	Control	1.22i	1.25h	1.29f	1.25c
	A. chrocooccum	1.26g	1.34c	1.33d	1.31b
	Pseudomonas sp.	1.32e	1.40a	1.37b	1.36a
	Mean	1.27b	1.33a	1.33a	
Dill (*Anethum graveolens* L.)	Control	1.25i	1.29h	1.33g	1.29b
	A. chrocooccum	1.42e	1.55c	1.62a	1.20c
	Pseudomonas sp.	1.38f	1.43d	1.58b	1.46a
	Mean	1.35c	1.42b	1.51a	

Means within each column followed by the same letter are not statistically different at 0.05 level (Duncan's range test)

Table (5): Effect of plant growth promoting bacteria on total carbohydrates and vitamin "C" percentages of coriander (*Coriandrum sativum*, L.) and dill (*Anethum graveolens*, L.) (Combined analysis of two seasons).

Treatments		Total carbohydrates %			Mean	Vitamin "C" %			Mean
		1st cut	2cut	3nd cut		1st cut	2cut	3nd cut	
Coriander (*C. sativum* L.)	Control	13.88i	14.56h	15.11f	14.52c	33.29i	34.77h	36.21g	34.76c
	A. chrocooccum	14.79g	15.22d	16.03b	15.36b	38.55e	43.38d	44.60b	42.18a
	Pseudomonas sp.	15.13e	15.66c	16.14a	15.64a	36.81f	44.59c	44.82a	42.07b
	Mean	14.60c	15.15b	15.76a		36.22c	40.91b	41.88a	
Dill (*A. graveolens* L.)	Control	12.75d	13.73b	13.35c	13.28b	32.70i	35.30g	35.70f	34.57c
	A. chrocooccum	13.64bc	13.81ab	13.99ab	13.81a	35.24h	39.18d	40.03b	38.15b
	Pseudomonas sp.	13.80ab	13.92ab	14.12a	13.95a	36.33e	39.78c	41.16a	39.09a
	Mean	13.40b	13.82a	13.82a		34.76c	38.09b	38.96a	

Means within each column followed by the same letter are not statistically different at 0.05 level (Duncan's range test)

As for total carbohydrates, data in Table (5) show that third cut of coriander plant treated with *Pseudomonas* sp gave the highest percentage (16.14%), whereas, there was no significant difference among *Azotobacter chrocooccum* and *Pseudomonas* sp. through out the three cuts. The lowest percentage was in recorded control treatment. The third cut of *Pseudomonas*

sp. treatment gave the highest vitamin C percentage for both studied plants as recorded 44.82 % for coriander and 41.16% for dill plant compared to *Azotobacter chrocooccum* or control.

Essential oil contents:

Data in Table (6) revealed that, fresh herb oil percentage of both coriander and dill was the highest during the second cut of *Pseudomonas* sp treatment as gave 0.247 and 0.278%, respectively compared to *Azotobacter chrocooccum* or control. The highest dry fruits oil and fruits oil yield per plant resulted from *Pseudomonas* sp treatment for both studied plants as gave 0.371% and 0.232ml for coriander and 0.542% and 0.248ml for dill plant.

Table (6): Effect of plant growth promoting bacteria on fresh herb and dry fruits oil percentage and fruits oil yield of coriander (*Coriandrum sativum*, L.) and dill (*Anethum graveolens*, L.) (Combined analysis of two seasons).

Treatments		Fresh herb oil %			Mean	Dry fruits oil %	Fruits oil Yield/plant (ml)
		1st cut	2cut	3nd cut			
Coriander (*C. sativum* L.)	Control	0.095i	0.110g	0.107h	0.104c	0.236c	0.102c
	A. chrocooccum	0.175f	0.236b	0.215d	0.209b	0.364b	0.225b
	Pseudomonas sp.	0.189e	0.247a	0.223c	0.219a	0.371a	0.232a
	Mean	0.153c	0.197a	0.182b			
Dill (*A. graveolens* L.)	Control	0.129i	0.143g	0.132h	0.135c	0.388c	0.185c
	A. chrocooccum	0.188f	0.245c	0.229d	0.221b	0.526b	0.221b
	Pseudomonas sp.	0.212e	0.278a	0.256b	0.249a	0.542a	0.248a
	Mean	0.176c	0.222	0.206b			

Means within each column followed by the same letter are not statistically different at 0.05 level (Duncan's range test)

Anatomical study:

Data presented in Table (7) and Fig. (3) illustrated that, coriander seed treatments with *A. chrocooccum* and *Pseudomonas* sp. individually have a positive impact on coriander plant stem anatomical features in the present investigation. Where, led to an increase in xylem vessel diameter and thickness of phloem tissue, vascular bundle and vascular bundle width, as compared with control treatment. These results are in agreement with Metwaly, (2012) and El-Afry *et al.*, (2012 a and b) on wheat plants.

Table (7): Effect of plant growth promoting bacteria on anatomical features of coriander (*Coriandrum sativum*, L.) plant stem.

Treatments		Xylem vessel diameter µm	Phloem tissue thickness µm	Vascular bundle width µm	Vascular bundle thickness µm
Coriander (*C. sativum* L.)	Control	35.00^{B}	31.67^{B}	93.33^{C}	183.30^{C}
	A. chrocooccum	56.67^{A}	46.67^{A}	133.33^{A}	245.00^{B}
	Pseudomonas sp.	48.33^{A}	45.00^{A}	$115.OO^{B}$	231.67^{B}

Means within each column followed by the same letter are not statistically different at 0.05 level (Duncan's range test)

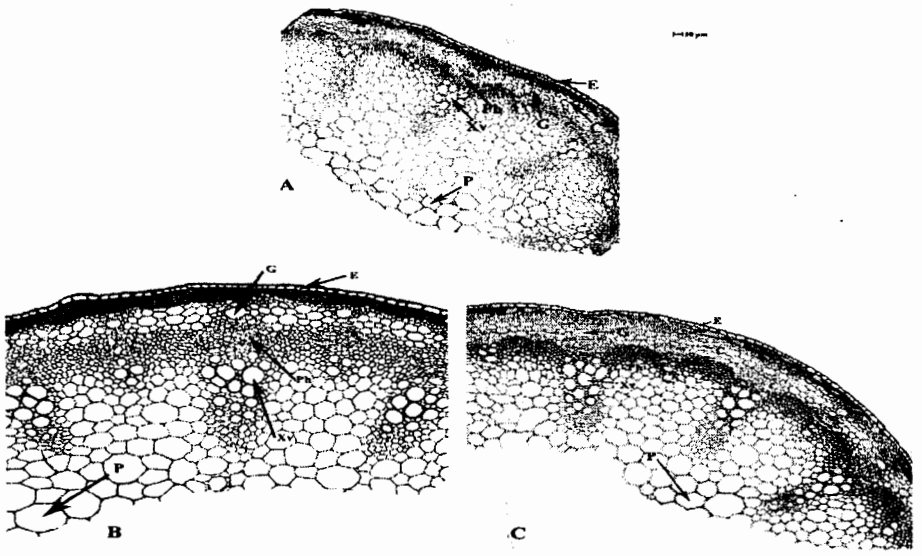

Fig. (3) Transverse sections through the coriander plant stem as affected by fruits soaking application with plant growth promoting bacteria.

Where:-

A: Control (untreated plant). B: *Azotobacter chrocooccum*.
C: *Pseudomonas* sp. E: Epidermis
G: Gland Xv: Xylem vessels
Ph: Phloem tissue P: Pith C: Cortex

Microbial inoculants that can promote plant growth and productivity is internationally accepted as an alternative source of N-fertilizer. It is environmental friendly and can be used to ensure a sustainable coriander and dill production. In this bio-fertilizer technology new systems are being developed to increase the biological N_2 fixation (BNF) with cereals and other non-legumes by establishing N_2-fixing bacteria within the roots (Cocking, 2000). Nitrogen fixation and plant growth promotion by plant growth promoting bacteria are important criteria for an effective bio-fertilizer.

Inoculation of associative and free living N_2-fixing bacteria have been shown to produce beneficial effects on plant growth, thus they are termed plant growth promoting rhizobacteria (PGPR) (Kloepper *et al.*, 1980; Bashan and Holguin, 1998). Significant increases in crop yields following application of PGPR have been documented under diverse field conditions (Bashan, 1998). They have been widely reported to fix atmospheric nitrogen with grasses and cereals (Dobereiner, 1997) and enhance nutrient uptake (Lin *et al.*, 1983; Murty and Ladha, 1988; Bashan and Holguin, 1998).

Azotobacter sp besides fixing nitrogen also secrete certain growth hormones such as IAA, GA and Cytokinins (Coppola *et al.*, 1971) which promote vegetative growth and root development.

CONCLUSION

From the foregoing results, it may be concluded that inoculation coriander (*Coriandrum sativum*, L.) and dill (*Anethum graveolens*, L.) plants with *A. chrocooccum* and *Pseudomonas* sp. under field conditions improved the growth parameters vegetative growth and flowering characters (plant height, number of leaves/ plant, herb fresh and dry weights/ plant and umbels and umbellts number/plant), while *Pseudomonas* sp. gave the heaviest weight of 100 fruits, fruit yield per plant and per Feddan for both plants, respectively. The highest total chlorophyll contents were obtained when coriander and dill were treated with *Pseudomonas* sp. and *A. chrocooccum*, respectively. *Pseudomonas* sp. gave the best results for total carbohydrates, vitamin C, fresh herb and dry fruit oil % and fruit oil yield/ plant as compared to *A. chrocooccum* or control treatments. Coriander seed treatments with *A. chrocooccum* and *Pseudomonas* sp. improved anatomical parameters such as xylem vessel diameter, thickness of phloem tissue, vascular bundle and vascular bundle width comparing with the control treatment. The obtained results exhibited that these bacterial strains could be used to increase coriander and dill productivity under field conditions.

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تـأثير البكتيريـا المـشجعة لنمـو النبـات (PGPB) علـى نباتـات الكزبـرة (*Coriandrum sativum* L.)والشبت (*Anethum graveolens* L.)

محمـــود عبـــد النبـــي حجـــازي* ، متـــولي محفـــوظ ســـالم متـــولي ** و السيد بلال عبد المنطلب بلال***

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أجريت تجارب حقلية في المزرعة التجريبية بكلية الزراعة - جامعة كفر الشيخ خلال موسمي نمو ٢٠١٣/٢٠١٤ و٢٠١٤/٢٠١٥ لدراسة تأثير كل من بكتيريا الأزتوباكتر كروكووكم *Azotobacter chrocooccum* وبكتيريا بسيدوموناس *Pseudomonas* sp. على كل من نبات الكزبرة والشبت. وقد أظهرت النتائج أنه قد تم تحديد الأندول أسيتيك أسيد في معلق لمزرعة لكل من بكتيريا الأزتوباكتر كروكووكم *Azotobacter chrocooccum* وبكتيريا بسيدوموناس *Pseudomonas* sp.. وقد أوضحت النتائج أنه يتم تحفيز إنتاج الأندول أسيتيك أسيد في وجود التربتوفان. وقد وجد أيضا أن أعلى تركيز من الأندول أسيتيك أسيد للسلالتين كان عند نهاية الطور اللوغاريتمي.

وقد تم معاملة البذور بكل من السلالات البكتيرية أثناء وقت الزراعة، وأظهرت النتائج أن بكتيريا الأزتوباكتر كروكووكم *A. chrocooccum* تفوقت على بكتيريا بسيدوموناس *Pseudomonas* sp. في معظم الصفات الخضرية والزهرية (طول النبات، عدد الأوراق / نبات، الأوزان الطازجة والجافة للعشب / نبات، عدد النورات والنويرات / نبات) ، في حين أن بكتيريا بسيدوموناس *Pseudomonas* sp. أعطت أثقل وزنا لمحصول مائة ثمرة والثمار لكل نبات ولكل فدان لكلا النباتين ، على التوالي.

قد تم الحصول على أعلى محتوى للكلوروفيل الكلي كل من الكزبرة والشبت عند معاملتها ببكتيريا بسيدوموناس *Pseudomonas* sp. وبكتيريا الأزتوباكتر كروكووكم *A. chrocooccum* على التوالي. وقد أعطت بكتيريا بسيدوموناس *Pseudomonas* sp. أفضل النتائج للكربوهيدرات الكلية، فيتامين س، النسبة المئوية لزيت الثمار الجافة والعشب الأخضر ومحصول زيت الثمار لكل نبات مقارنة بمعاملات بكتيريا الأزتوباكتر كروكووكم *A. chrocooccum* أو الكونترول.

وقد وجد أن معاملة بذور الكزبرة بكل من بكتيريا الأزتوباكتر كروكووكم *A. chrocooccum* وبكتيريا بسيدوموناس *Pseudomonas* sp. أدت إلى زيادة القياسات التشريحية مثل قطر أوعية الخشب، سمك نسيج اللحاء، سمك الحزمة الوعائية بالاضافة الي عرض الحزمة الوعائية مقارنة بمعاملة الكونترول. كما أظهرت النتائج التي تم الحصول عليها أنه يمكن إستخدام هذه السلالات البكتيرية لزيادة إنتاجية كل من الكزبرة والشبت تحت ظروف الحقل.