EFFECT OF IRRIGATION INTERVALS AND BIOFERTILIZATION ON GROWTH AND OIL YIELD OF *NIGELLA SATIVA* L. UNDER El-ARISH CONDITIONS

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ABSTRACT

A field experiment was established to evaluate the effect of three irrigation intervals of 2 , 4 and 7 days and inoculation with a mixture of *Azotobacter* and *Asospirillum* alone and/or in the presence of 0, 50 and 100 kg N/fed and the non-inoculated control (given 100 kg N/fed) on the growth, volatile oil and fixed oil of black cumin (*Nigella sativa* L.) plants. The obtained results showed that the short irrigation interval every 2-days was the best for producing taller plants, with more branches, heavier fresh and dry weight/plant, higher number of fruits, seed yield/plant, more total carbohydrates content, higher percentage and yield of volatile and fixed oil in dry seeds than the long intervals every 4 and 7-days in the two seasons. Also the growth and yield parameters of the plants significantly increased as a result of inoculation of symbiotic N_2-fixers (*Azotobacter* and *Asospirillum*) with inorganic fertilizer followed by the same mixture given 50 kg N/fedd and then control (100 kg N/fed) treatment, as the best results in this respect were obtained from the inoculation with the mixture of *Azotobacter* and *Asospirillum* given full dose (100 kg N/fed), comparing to the lowest values which resulted from biofertilizer mixture only. Dealing with the effect of the interaction between the used different watering intervals and fertilization, it could be noticed that the studied growth and yield parameters considerably improved as a result of watering interval at 2-days and inoculation with symbiotic N_2-fixers (*Azotobacter* and *Asospirillum*) supplemented with half or full dose of inorganic N-fertilizer in the two seasons, against the lowest values resulted from the irrigated plants every 7-days and inoculated with biofertilizer only. So, it could be recommended to use irrigation every 2-days combined inoculation with the mixture of *Azotobacter and Asospirillum* in the presence of full dose of

inorganic N-fertilizer to obtain the best growth parameter and oil yield of *Nigella sativa* L. plant
Key words: Irrigation intervals - biofertilization - oil yield -*Nigella sativa* L

INTRODUCTION

Nowadays, there is the National Project for Sinai Development to increase the National income of Egypt. For this purpose, the answer could be partly found in medicinal plants cultivation, which occupies a prominent economic position. Black cumin (*Nigella sativa* L.) is among the medicinal plants that can be cultivated in the new land. Most of promising lands in El-Arish are situated near the Mediterranean Sea, as insufficient available water irrigation with high concentration of salinity from wells water is generally used for irrigation. Also, the world began to recently come back to nature, in particular for utilizing medical herbs and use microorganisms in biofertilization to reduce or replace the chemical fertilizers. Otherwise, more investigations about black cumin watering and biofertilization requirements are still needed for improving its growth and yield parameters. The effective role of water supply on the growth and production of several medicinal plants was observed by many investigators. **El-Gamassy *et al.*, (1977)** on mint; **El-Khateeb and Boselah (1991)** on periwinkle; **Afify *et al.*, (1993)** on *Salvia officinalis* L.; **El-Shafie *et al.*, (1994)** on roselle and ***Eid et al.*, (1996)** on anise found that providing the plants with suitable water amounts resulted in better growth and yield than those grown under drier conditions.

Concerning, the effect of biofertilization on the growth and productivity of medicinal plants **El-Sawy *et al.*, (1998)** on *Ammi visnaga*; **Saleh *et al.*, (1998)** on datura; **Harridy** and **Amara (1998)** on roselle and **Kandeel *et al.*, (2002)** on sweet basil found that inoculation with a mixture of *Azotobacter* and *Asospirillum* amendment with full dose of inorganic N-fertilizer remarkably increased plant growth and yield.

From the previously mentioned review of literature, it could be observed that both water and biofertilizers had an effective role on the growth and yield of the studied plants. This investigation

aimed to determine of the suitable water interval and biofertilizer on the growth and yield parameters of (*Nigella sativa L.*) plants under El-Arish environmental conditions.

MATERIALS AND METHODS

This investigation was conducted at the Experimental Farm of the Faculty of Environmental Agriculture Science at El-Arish, Suez Canal University during two successive seasons of 2001/2002 and 2002/2003 to study the effect of irrigation intervals and biofertilizer on growth and oil yield of black cumin plants. Active strains of *Azotobacter chroococcum* and *Asospirillum lipoferum* were provided from the unit of Biofertilizers, Soil Research Institute. The physical and chemical properties of the used soil were determined before cultivation and are shown in Table (a). The well water was used to obtain water irrigation treatments every 2, 4 and 7-days in the two seasons by using drip irrigation system, as the plants were irrigated by sufficient water to maintain soil moisture at 65 - 70% of the field capacity and the chemical analysis of this water is shown in Table (b). In mid October during the two seasons seeds of black cumin were sown on pipe lines from plastic material of 16 mm diameter. The spaces between them were 75 cm and the distance between hills was 45 cm. Thinning to one plant/hill was made 30-days after sowing; the area of each plot was 30 m^2 (15 x 2 m) with 3 rows. Organic manure was added to the soil before cultivation at a rate of 20 m^3 /fed.

The inoculation was carried out for seeds before cultivation with the mixture of *Azotobacter* and *Asospirillum*. Ammonium nitrate (33.5% N) at two rates; i.e. recommended field rate of inorganic N-fertilization (300 kg/fed equal 100 kg N) and half of this dose (50 kg N), added to the soil in 3 equal parts, the first addition was 30-days after planting, and other parts were added interval every 4 weeks. A split plot design with three replications were used. The main plots were irrigated intervals every 2, 4 and 7-days . The sub-plots were control N_0 (without microbial inoculation + 100 kg/fed of N-fertilizer); N_1 (*Azotobacter* and *Asospirillum* with 0 kg/fed of N-fertilizer); N_2 (*Azotobacter* and *Asospirillum* with 50 kg/fed of N-fertilizer) and N_3 (*Azotobacter* and *Asospirillum* with 100 kg/fed of N-fertilizer).

All treatments including control received equal dose of both P and K. Phosphorus and potassium were added at 200 and 150 kg/fed of calcium super phosphate (15.5% P_2O_5); and potassium sulphate (48% K_2O)respectively. Phosphorus was added during soil preparation; while potassium was added as 2 equal side dressings during the growing seasons. At harvest (5th of May); plant height (cm), branches number per plant, fresh and dry weight (g) and seed yield/plant (g) were recorded; also, essential oil percentage was determined in the seeds according to **British Pharmacopoeia (1963).** The oil yield per plant was then calculated, while the fixed oil content of the seeds was estimated **(A. O. A. C. 1990).** Moreover, total carbohydrates content was determined in the dried banes according to **Herbert *et al.*, (1971).**

Table (a): Mechanical and chemical analysis of the soil before conducting the experiment in both seasons.

Mechanical analysis	Seasons 2001	2002
Soil properties		
Coarse sand%	27.95	27.90
Fine sand%	62.05	61.60
Silt%	7.00	7.05
Clay%	3.00	3.10
Soil texture	Sandy	Sandy
Chemical analysis		
Ca^{++} (meq/L)	1.20	1.60
Mg^{++} "	0.90	1.00
Na^{+} "	22.00	21.10
K^{+} "	0.60	0.68
Cl^{-} "	23.10	22.90
$CO_3^{=}$ "	-	-
HCO_3^{-} "	0.87	0.85
$SO_4^{=}$ "	0.73	0.63
ECe (dSm^{-1})	2.50	2.45
pH	8.27	8.63
Organic matter (%)	0.16	0.20
$CaCO_3$ (%)	3.06	3.06

Table (b): Chemical analysis of the used irrigation water.

Ca^{++} (meq/L)	10.60
Mg^{++} "	5.80
Na^{+} "	32.70
K^{+} "	0.98
Cl^{-} "	40.50
$CO_3^{=}$ "	-
HCO_3^{-} "	5.50
$SO_4^{=}$ "	3.90
ECe dSm^{-1}	5.00(3200) ppm

Data of both seasons were tabulated and statistically analyzed according to the procedure described by **Snedecor and Cochran (1981)** using L.S.D. method for comparing between means of treatments.

RESULTS AND DISCUSSION

1-Plant height and main number of branches/plant:

1.1: Effect of irrigation intervals:

It is evident from data in Table (1) that the plant height and main number of branches/plant increased gradually with reducing watering intervals in the two experimental seasons. The treatment of irrigation every 2-days resulted in significantly taller plants with more number of branches/plant than the treatments of irrigation every 4 and 7-days in the two seasons, respectively. On the other hand, the treatment of watering every 7-days gave the lowest values in this respect. These results may be due to the effect of used watering every 2-days on increasing the growth of root system, consequently, increasing the nutrients uptake needed for plant growth. Besides, enhancing the rates of physiological processes and increasing the hydrostatic pressure on the cell wall, which is necessary for the enlargement of cell. Hence, enhancement of the assimilated food and increase the cell elongation and division, consequently, the whole growth of plant could be increased **(Wasfy, 1998)**. These results are similar to those obtained by **Eid et al., (1996)** on *Pimpinilla ainisum* and **Khattab *et al.*, (2002)** on *Salvia splendens*.

1.2: Effect of biofertilizers and N-fertilization:

Data in Table (1) clearly show that during the two seasons plant growth significantly affected by dual inoculation with *Azotobacter* and *Asospirillum*. The maximum values were recorded with the treatment of inoculation with the mixture of *Azotobacter* and *Asospirillum* given 100 kg/fed of N-fertilizer followed by 50 kg/fed of N-fertilizer, respectively. The obtained results indicated also that the alone inoculation with the mixture of *Azotobacter* and *Asospirillum* without inorganic N-fertilizer remarkably decreased the plant height and number of branches/plant compared with the

Table (1): Effect of irrigation intervals and biofertilization on the plant height, number of branches/plant, fresh and dry weight/ plant of *Nigella sativa L.* in two seasons (2002 and 2003)

Treatments		Plant height (cm)		Branches No./plant		Plant fresh weight (g)		Plant dry weight (g)	
Watering intervals	Fertilization	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
Watering intervals									
2-days		78.500	79.500	14.500	15.250	79.250	81.750	33.000	35.500
4-days		61.250	60.250	11.250	11.500	72.250	74.000	30.750	33.000
7-days		41.500	39.250	8.500	8.750	47.910	47.330	18.250	19.830
L.S.D	0.05	1.525	2.930	0.672	1.073	3.272	6.215	0.763	2.419
	0.01	2.072	3.983	0.913	1.458	4.448	8.447	1.036	3.288
Fertilization treatment									
	N_0	62.660	62.330	11.660	12.000	70.440	72.660	29.660	32.000
	N_1	52.000	52.330	8.330	8.000	50.660	54.440	20.000	22.330
	N_2	60.330	59.660	11.000	10.000	67.770	68.000	28.000	30.000
	N_3	66.660	64.330	14.660	14.660	80.000	80.660	34.660	35.440
L.S.D	0.05	1.760	3.384	0.775	1.239	3.779	7.176	0.880	2.794
	0.01	2.393	4.599	1.054	1.684	5.136	9.754	1.197	3.797
Interaction between watering x fertilization									
2-days	N_0	80.000	82.000	15.000	17.000	83.000	85.000	34.000	37.000
	N_1	69.000	71.000	9.000	11.000	62.000	67.000	27.000	29.000
	N_2	78.000	79.000	14.000	14.000	77.000	78.000	32.000	34.000
	N_3	87.000	86.000	20.000	19.000	95.000	97.000	39.000	42.000
4-days	N_0	65.000	64.000	12.000	12.000	74.000	80.000	31.000	35.000
	N_1	51.000	52.000	9.000	9.000	57.000	58.000	23.000	27.000
	N_2	63.000	61.000	11.000	10.000	71.000	69.000	29.000	31.000
	N_3	68.000	64.000	13.000	15.000	87.000	89.000	40.000	39.000
7-days	N_0	43.000	41.000	8.000	7.000	54.000	53.000	24.000	24.000
	N_1	36.000	34.000	7.000	4.000	33.000	38.000	10.000	11.000
	N_2	40.000	38.000	8.000	6.000	46.000	42.000	14.000	19.000
	N_3	47.000	43.000	11.000	10.000	58.000	56.000	25.000	25.330
L.S.D	0.05	3.049	5.861	1.343	2.146	6.576	12.429	1.525	4.839
	0.01	4.144	7.966	1.825	2.917	8.896	16.896	2.073	6.577

N_0 100 kg/fed of N-fertilizer.

N_1 Azotobacter + Azospirillum

N_2 50 kg/fed of N-fertilizer and Azotobacter + Azospirillum

N_3 100 kg/fed of N-fertilizer and Azotobacter + Azospirillum

control. On the other hand, it was noticed that adding 50 kg/fed of N-fertilizer to *Azotobacter* + *Asospirillum* inoculation gave low values compared with control but, without significant differences between themselves.These results may be due to the influence of the biofertilizer on enhancing soil acidity (pH values) and water retention in the rooting medium hence the availability and absorption of nutrients could be enhanced, leading to more initiation and elongation of stem cells **Mostafa (2002)**. Similar trend of results were cleared by **Kandeel *et al.*, (2002)** on *Ocimum bassilicum* plants and **Khattab *et al.*, (2000)** on *Gladiolus hybrida*.

1.3: Effect of interaction:

The recorded data in Table (1) clearly indicated that plant height and number of branches/plant increased with reducing watering intervals and increasing N-fertilization with *Azotobacter* + *Asospirillum* in the two seasons. The best results in this respect were obtained from the treatment of irrigation every 2-days with the highest N-dose (100 kg/fed N-fertilizer) and inoculation with mixture of *Azotobacter* + *Asospirillum*. Meanwhile, the treatment of watering every 7-days with bacterial inoculation alone gave the shortest plants in the two seasons. These results reflect the important role of the adequate water and N supply for stimulating the growth of *Nigella sativa* L. plants. Similar results were obtained by **Maheshwari *et al.*, (1998)** on palmarosa who recorded that by applying *Azotobacter* together with 20 Kg N + 20 kg P /ha under rainfed condition resulted in significantly higher herb yield.

2-Fresh and dry weights of herb:

2.1: Effect of watering intervals:

The reported data in Table (1) clearly show that the fresh and dry weight per plant significantly increased as a result of decreasing irrigation intervals and reached maximum values in the case of irrigation every 2-days in the two seasons. Otherwise, the lowest values in this respect were obtained by the longest watering interval of 7-days in the two experimental seasons. These results may be due to the role of water availability on increasing the biosynthates accumulated, consequently increased the dry matter of herb. Similar trends of results were obtained by **El-Khateeb and**

Boselah (1991) on periwinkle and **Khattab (2002)** on *Salvia splendens* plants.

2.2: Effect of biofertilizers and N-fertilization:

It was clear from data in Table (1) that the maximum values were recorded with the treatment of inoculation with the mixture of *Azotobacter* + *Asospirillum* given full of N/fertilizer (100 kg/fed of N-fertilizer). Also the alone inoculation with the mixture of *Azotobacter* + *Asospirillum* gave remarkably the lowest values of fresh and dry weight/plant compared with the other treatment. On the other hand, it was noticed that adding 50 kg/fed of N-fertilizer with *Azotobacter* + *Asospirillum* inoculation decreased the values compared with control but, without significance between themselves. The beneficial effect of symbiotic nitrogen fixers on plant development could be attributed to N2-fixation **(Abd El-Azeem,1998)**, production of growth promoting substances (**El-Haddad *et al*, 1986)** and to successful competition of these organisms with antagonists of plant growth **(Abo El-Ela, 1997).** Also, **Fayez *et al.*, (1985)** reported that for living nitrogen fixing bacteria e.g. *Azotobacter* and *Asospirillum* were found to have not only the ability to fix nitrogen but also to release certain phytohormones of gibberellic and indolic nurture, which could stimulate plant growth, absorption of nutrients and phytohormones process. These results are confirmed by those of **El-Sawy *et al.*, (1986)** on *Hyoscyamus muticus* and **Saleh *et al.*, (1998)** on *Datura stramonium* plants.

2.3: Effect of interaction:

The recorded data in Table (1) clearly indicated that both fresh and dry weights of black cumin considerably increased with decreasing irrigation intervals and raising the nitrogen level in the two seasons. The highest values in this respect were obtained from the treatment of watering every 2-days and inoculation *with Azotobacter* + *Asospirillum* supplemented with 100 kg/fed N-fertilizer in the two seasons. Otherwise, the least records were obtained for plants irrigated every 7-days and inoculated with N_2-fixers bacteria without fertilizer. Using inoculation with *Azotobacter* + *Asospirillum* given high dose of N-fertilizer

treatment under each watering intervals increased the fresh and dry weight/plant, but increasing irrigation intervals under each level of fertilizer decreased it. Similar results were obtained by **Maheshwari *et al.*, (1991)** who recorded high biomass and oil yields of palmarosa by using *Azotobacter* alone and *Azotobacter* with 40-80 Kg N/ha under rainfed and irrigated condition, respectively.

3-Number of fruits and weight of seeds per plant:

3.1: Effect of watering intervals:

Data in Table (2) clearly show that both number of fruits and weight of seeds/plant increased gradually with decreasing watering intervals and reached the maximum values by watering the plants every 2-days in the two seasons. Simultaneously, the treatment of watering every 2-days gave significantly higher number of fruits and heavier weight of seeds/plant than the treatment of irrigation every 7-days in both seasons. On the other hand, irrigation every 7-days gave the lowest values in this respect. These results may be due to that the short watering intervals was more suitable for forming more number of fruits/plant through enhancing the vegetative biomass which gave large number of flowers, consequently the fruits could be increased. These results may find support in the obtained results by **El-Shafie *et al.*, (1994)** on roselle.

3.2: Effect of biofertilizers and N-fertilization:

It is clear from data in Table (2) that number of fruits and weight of seeds/plant in black cumin plants considerably influenced by inoculation with N_2-fixers bacteria and inorganic N-fertilizer. The highest number of fruits and weight of seeds/plant were recorded with the treatment of dual inoculation of *Azotobacter* + *Asospirillum* supplemented with high dose of inorganic N-fertilizer followed by the treatment of control and half dose of inorganic N-fertilizer, but with insignificant differences between the later treatments. It is evident that treating plants with bacterial inoculation alone gave the lowest values in this respect. Similar findings were noticed by **El-Sawy *et al.*, (1998)** *on Ammi visnaga*, **Wang *et al.*, (1995)** on tuberose and **Chauhan *et al.*, (1996)** on

Table (2): Effect of irrigation intervals and biofertilization on number of fruits/ plant, seeds dry weight and total carbohydrats on the leaves of Nigella sativa L. in two seasons (2002 and 2003)

Treatments		Number of fruits/plant		Seeds dry weight (g)		Total carbohydrate(%)	
Watering intervals	Fertilization	1st season	2nd season	1st season	2nd season	1st season	2nd season
Watering intervals							
2-days		21.830	22.167	10.342	10.583	16.979	17.341
4-days		16.250	16.500	7.025	7.300	16.573	17.903
7-days		11.000	9.667	4.258	4.325	16.941	16.452
L.S.D	0.05	0.641	1.158	0.532	0.599	0.895	0.689
	0.01	0.871	1.573	0.860	0.815	1.217	0.936
Fertilization							
	N_0	17.333	17.667	7.467	8.067	17.736	18.200
	N_1	11.111	11.222	4.767	5.311	13.973	14.207
	N_2	16.000	15.667	7.578	7.100	15.292	15.936
	N_3	21.000	19.889	9.022	9.133	18.969	19.384
L.S.D	0.05	0.749	1.337	0.730	0.692	1.034	0.795
	0.01	1.006	1.817	0.993	0.941	1.405	1.081
Interaction between watering x fertilization							
2-days	N_0	24.000	25.000	10.900	11.800	17.917	18.287
	N_1	16.333	16.000	6.500	7.633	14.320	14.433
	N_2	21.000	22.000	11.600	10.600	15.970	16.747
	N_3	27.000	26.667	12.367	12.300	19.710	19.897
4-days	N_0	18.000	18.000	7.300	7.900	18.133	18.410
	N_1	10.000	11.000	4.900	5.200	13.920	14.407
	N_2	16.000	16.000	7.100	6.800	15.130	15.837
	N_3	22.000	21.000	8.800	9.300	19.107	19.557
7-days	N_0	10.000	10.000	4.200	4.500	17.167	17.903
	N_1	6.000	7.667	2.900	3.100	13.680	13.780
	N_2	12.000	9.000	4.033	3.800	14.777	15.423
	N_3	14.000	12.000	5.900	5.800	18.150	18.700
L.S.D	0.05	1.282	2.316	1.265	1.199	1.791	1.378
	0.01	1.742	3.147	1.719	1.629	2.434	1.873

Indian mustard *(Brassica juncea)* who stated that with inoculation of seeds with *Azotobacter* or *Asospirillum* and given 0 – 60 Kg N / ha, seed yield and seed oil content were increased.

3.3: Effect of interaction:

Data in Table (2) indicated that the interaction between fertilization and short irrigation intervals (2-days) caused an increase in the number of fruits and weight of seeds/plant compared to without inorganic N-fertilizer treatment or those of other irrigation intervals. Using inoculation with the mixture of *Azotobacter* + *Asospirillum* and in the presence of full dose of inorganic N-fertilizer treatment under each irrigation interval increased the number of fruits and weight of seeds/plant; but, increasing watering interval under each level of fertilizer decreased it. Generally, the differences were significant in both seasons. Similar results were obtained by **Maheshwari *et al.*, (1991)** on palmarosa

4-Total carbohydrate (%)

4.1: Effect of watering intervals:

The total carbohydrate (%) in the dry leaves of black cumin plants was found to be slightly increased with decreasing irrigation intervals in the two seasons, (Table,2). These results are in agreement with those obtained **Khattab (2002)** on *Salvia splendens* plants.

4.2: Effect of biofertilizers and N-fertilization:

Results in Table (2) show that total carbohydrate (%) in the dry leaves of *Nigella sativa* L. plants affected by N-fertilization especially at its high level either alone or in combination with biofertilizer during the first and second seasons. It was significantly increased with increasing nitrogen levels. The mixture of N-fixing bacteria alone had a little affect on total carbohydrate (%), while the combination between full dose of N-fertilizer and the mixture of N-fixing bacteria had a greater effect then the control.

4.3: Effect of interaction:

Data in Table (2) show that the interaction between fertilization and irrigation intervals was significant and the best result was obtained by using irrigation every two days under the level of full dose of inorganic N-fertilizer with inoculation by the mixture of *Azotobacter* + *Asospirillum* in both seasons. These results are in line with those of **Maheshwari *et al.*, (1998)** on palmarosa.

5: Percentage and yield of volatile and fixed oil in dry seeds of *Nigella sativa* L. plants:

5.1: Effect of watering intervals:

The recorded data in Table (3) clearly indicated that the percentage and yield of volatile and fixed oil in dry seeds of *Nigella sativa L.* plants increased with reducing watering intervals and reached their maximum values by watering every 2-days in the two seasons. Meanwhile, the treatment of irrigation every 4-days gave intermediate values during two seasons. Otherwise, the lowest values in this respect were produced by the treatment of irrigation every 7-days. These results are in line with reported by **Maheshwari *et al.*, (1992)** on *Cymbopogon martini* plants.

5.2: Effect of biofertilizers and N-fertilization:

It was clear from data in Table (3) for both seasons that volatile and fixed oil percentage and yield of black cumin plants were considerably influenced by inoculation with N_2-fixers bacteria and inorganic N-fertilization. Generally, the highest records were produced with plants inoculated with *Azotobacter* + *Asospirillum* together in the presence of full dose of inorganic N-fertilizer. In the second, rank were the value observed with plants inoculated with the same bacterial mixture and given half dose of inorganic N-fertilizer. The increases in oil percentage obtained with the two treatments were significant when compared with the same bacterial mixture but without adding inorganic N-fertilizer. Similar findings were reported by **Kandeel *et al.*, (2002)** on sweet basil.

Table (3): Effect of irrigation intervals and biofertilization on volatil and fixed oils of *Nigella sativa* L. seed in two seasons (2002 and 2003)

Treatments		Volatile oil percentage		Volatile oil yield (ml/plant)		Fixed oil percentage		Fixed oil yield (ml/plant)	
Watering intervals	Fertilization	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
Watering intervals									
2-days		0.157	0.154	0.017	0.016	30.887	31.280	3.366	3.340
4-days		0.160	0.160	0.012	0.012	29.836	30.836	2.120	2.216
7-days		0.145	0.143	0.063	0.007	29.843	29.763	1.277	1.297
L.S.D	0.05	0.054	0.075	0.016	0.008	0.533	1.696	0.232	0.341
	0.01	0.073	0.102	0.020	0.012	0.724	2.046	0.316	0.463
Fertilization									
	N_0	0.167	0.167	0.012	0.011	32.078	31.926	2.403	2.567
	N_1	0.127	0.119	0.006	0.006	26.760	26.760	1.280	1.417
	N_2	0.140	0.143	0.011	0.010	29.647	30.288	2.236	2.157
	N_3	0.183	0.180	0.018	0.018	32.270	32.423	3.097	2.977
L.S.D	0.05	0.062	0.087	0.017	0.010	0.615	1.738	0.268	0.394
	0.01	0.084	0.118	0.023	0.013	0.836	2.362	0.364	0.535
Interaction between watering x fertilization									
2-days	N_0	0.160	0.170	0.017	0.012	32.340	32.620	3.530	3.840
	N_1	0.130	0.117	0.008	0.009	27.020	27.463	1.780	2.080
	N_2	0.150	0.140	0.017	0.015	29.980	30.847	3.480	3.270
	N_3	0.190	0.190	0.028	0.023	34.210	34.170	4.690	4.170
4-days	N_0	0.180	0.180	0.013	0.001	32.070	31.843	2.340	2.510
	N_1	0.130	0.130	0.008	0.007	26.510	26.530	1.300	1.360
	N_2	0.140	0.150	0.010	0.010	29.360	30.247	2.080	2.040
	N_3	0.190	0.180	0.017	0.017	31.410	31.887	2.760	2.960
7-days	N_0	0.160	0.150	0.007	0.007	31.823	31.613	1.340	1.410
	N_1	0.120	0.110	0.003	0.003	26.750	26.283	0.780	0.810
	N_2	0.130	0.140	0.006	0.006	29.610	29.770	1.147	1.160
	N_3	0.170	0.170	0.010	0.013	31.190	31.403	1.840	1.810
L.S.D	0.05	0.107	0.151	0.029	0.017	1.066	3.010	0.464	0.682
	0.01	0.146	0.205	0.040	0.023	1.448	4.092	0.630	0.926

5.3: Effect of interaction:

Data in Table (3) show that the interaction between using fertilization and irrigation intervals were significant for percentage and yield of volatile and fixed oil in the two seasons. Generally, the inoculation with *Azotobacter +Asospirillum* in the presence of inorganic N-fertilizer caused an increase in percentage and yield of volatile and fixed oils compared to either uninoculation or treatments without N-fertilization. Also, with increasing irrigation intervals under each level of fertilizer treatment values were decreased. However, increasing the inorganic N-fertilizer or using the mixture bacterial with high dose of inorganic N-fertilizer under each level of irrigation intervals increased the values in this respect. The maximum values were resulted from inoculation with bacteria in the presence of full dose of inorganic N-fertilizer at short irrigation interval (2-days), while without inorganic N-fertilizer treatment at long irrigation interval (7-days) gave the minimum values in this respect. These results are in line with those stated concerning the effect of interaction between fertilization and irrigation by **Maheshwari *et al.*, (1998)** on palmarosa

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الملخص العربي

تأثير فترات الري و التسميد الحيوي علي النمو و محصول الزيت لنباتات حبة البركة تحت ظروف العريش

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أجريت تجربة حقلية لموسمين ٢٠٠١-٢٠٠٢ / ٢٠٠٢-٢٠٠٣ بمزرعة كلية العلوم الزراعية البيئية بالعريش لدراسة تأثير فترات الري كل (٢ ، ٤ ، ٧ أيام) و التسميد الحيوي علي النمو و محصول الزيت لنبات حبة البركة تحت ظروف العريش ، وشملت كل فترة ري التلقيح بخليط من اللقاح البكتيري مضافا إليها التسميد النيتروجيني المعدني باستخدام ثلاث معاملات هي ٠ ، ١٥٠ ، ٣٠٠كجم/ للفدان من نترات امونيوم والتي تعادل (٠- ٥٠- ١٠٠ كجم نيتروجين / للفدان) علي الترتيب – بالإضافة إلي معاملة الكنترول لكل فترة ري بدون لقاح بكتيري ولكن مضاف إليها ٣٠٠كجم نترات امونيوم (١٠٠كجم نيتروجين/ للفدان) و هي الكمية الموصي بها .

وقد أوضحت النتائج المتحصل عليها أن ري النباتات كل يومين قد أعطت زيادة في طول النبات و عدد الأفرع والوزن الطازج والجاف و عدد الثمار و وزن البذور/ نبات و النسبة المئوية ومحصول الزيت الطيار و الثابت في البذور وذلك بالمقارنة بفترات الري الاخري (٤، ٧ أيام) و التي أعطت قيم اقل في الموسمين.

وبالنسبة للتسميد أوضحت النتائج زيادة في صفات النمو والمحصول للنباتات الملقحة بخليط من اللقاح البكتيري المكون من الازوتوباكتر و الازوسبيريلليم مع السماد النيتروجيني المعدني ، و تم الحصول علي اعلي القيم من المعاملة بمخلوط من اللقاح البكتيري (الازوتوباكتر و الازوسبيريلليم) مع إضافة الكمية الكاملة من السماد النيتروجيني المعدني و يليها المعاملة المضاف إليها نصف الكمية الكاملة من السماد و الكنترول دون اختلافات معنوية في معظم الحالات ، ونتجت اقل القيم المتحصل عليها من المعاملة بخليط من اللقاح البكتيري فقط بدون إضافة سماد معدني.

وقد أوضحت النتائج أن أفضل القيم لصفات النمو و محصول الزيت لحبة البركة نتجت من المعاملة بالري كل يومين باستخدام مخلوط اللقاح البكتيري المكون من الازوتوباكتر مع الازوسبيريلليم مع إضافة كل الكمية الموصي بها من السماد ، بينما اقل القيم نتجت من الري كل (٧) أيام مع المعاملة بالملقحات البكتيرية فقط دون إضافة السماد النتروجيني المعدني .

ومن تلك النتائج يمكن التوصية عموما بالري للنباتات حبة البركة كل يومين و التسميد بأسمدة حيوية من الازوتوباكتر مع الازوسبيريلليم مع إضافة نصف الكمية من السماد النيتروجيني المعدني (٥٠ كجم نيتروجين للفدان) لتقليل استخدام السماد النيتروجيني المعدني او الكمية الموصي بها (١٠٠ كجم نيتروجين للفدان) لحصول علي أحسن صفات للنمو و اعلي محصول من البذور و الزيت الطيار و الثابت .