J. Agric. Sci. Mansoura Univ., 32 (12): 10403 - 10415, 2007

EFFECT OF VARIOUS TYPES OF BACTERIAL INOCULATION ALONG WITH A STARTER DOSE OF N ON GROWTH, YIELD AND YIELD COMPONETS OF CANOLA

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ABSTRACT

Canola is a newly introduced oil crop into the Egyptian agriculture, it is absolutely necessary to conduct research work in order to maximize its both productivity and reduce costs. During both seasons (2003/04 and 2004/05) a field experiment was carried out in the Experimental farm of the Agricultural Research Center (ARC) at Giza to evaluate the response of three canola varieties namely Sero4, Pactol and AD204 to inoculation with four types of bacteria (*Rhizobia, diazotrophs, Bacillus* and a mixture of them). Nitrogen was applied at 15 as starter dose and 50 kg N fed^{-1} without inocl. (recommended) in two equal spilt doses applied at 21 and 35 days after planting. Results of 140 day old plants indicate that inoculation in general, had a positive effect on seed quality (% germination, shoot and radical length, seedling weight and electrical conductivity). Yield and yield components of inoculated canola plants receiving 15 kg N fed^{-1} were higher as compared to uninoculated canola plants with full N-fertilizer dose (50 kg N fed^{-1}). Inoculated plants produced seeds with higher oil content.

INTRODUCTION

Several advantages are favoring canola (*Brassica nopusl.*) to be grown in Egypt such as less water requirements, high productivity (≥1000 kg fed^{-1}), oil content (≥ 40%) and protein content (≥20%), (Mahrous, 1991, Kandil and Mahrous, 1996 and Mona., 2000). Many investigators studied the effect of nitrogen fertilizer on canola seed yield, oil content, total crude protein, total carbohydrates and other traits (Lewis *et al.* 1987, Noureldin *et al.*, 1994 a & b; Hammad and El-Sherbiny, 1999 and Awadalla, 2003).

Chemical fertilizers are important sources for plant nutrition, however, they are expensive and cause environment pollution. Therefore, the attention is paid towards the use of biofertilizers. Microorganisms provide many benefits to the plant, especially bacteria, which have the ability to produce plant growth substance, by producing and secreting some phytohormones such auxins, gibberallins and cytokinines and | or by supplying biological fixed nitrogen (Antuon *et al.*, 1998 and Chiarini *et al.*, 1998). The relatively high contribution of biological nitrogen fixation to non-legume crops could be clear by the discovery of endophytic Bacterial colonization of roots, stems and leaves of plants. *Azotobacter, Asospirilla* and *Bacillus polymyxa* associated with different non-legumes grown in various soils were reported to have positive significant contributions to N-status of plant- soil system,

(Chanway *et al.*, 1988; Fayez, 1990 and Pacovesky, 1990 and Mona *et al.*, 2000).

On the other hand, indirect mechanism as suppression of bacterial, fungi and nematode pathogens by production of various metabolites, also, increased uptake of nutrients such as nitrogen, phosphorus and potassium.

In general, inoculation with respective bacteria strains (PGPR) increased plant growth, yield and yield components, (Hoflid *et al.*,1997, Galal and Thabet., 2002 and Ragab and Rashad, 2003).

Therefore, the present study aims to investigate the interactive effects of some N_2-fixing bacteria belong to *Rhizobia, Azotobacter, Azospiriilia* and *Bucillus polymax* using PGRR inocula and NPK fertilizers doses on metabolic activity and nutrients uptake efficiency of three canola cultivars grown on clay loam soil under field conditions.

MATERIALS AND METHODS

A field experiment was carried out at the experimental farm of the Agricultural Research Center (ARC) at Giza during to success winter seasons 2003/2004 -2004/2005 to evaluate growth, yield and yield components of canola plants as affected by bacteria inoculation. Before planting soil samples were collected from different parts of the experimental sites as a composite sample for chemical and mechanical analyses according to Black *et al.* (1965) (Table 1). During seed bed preparation, P_2O_5 and K_2O were added as single superphosphate (15.5% P_2O_5) and potassium sulphate (48% K_2O) at rates of 100 kg and 50 kg fed^{-1}, respectively.

Sero 4, Pactol and AD 204 seed canola varieties were planted at a rate of 4 kg seed fed^{-1} in rows 50 cm apart. Six treatments for each canola varieties were included as follows:
1) Unioculated + 15 kg N fed^{-1} 2) unioculated + 50 kg N fed^{-1} 3) *Rhizobia* inocula + 15 kg N fed^{-1} 4) Diazotrophs inocula + 15 kg N fed^{-1} 5) *Bacillus polymyxa* inocula + 15 kg N fed^{-1} and 6) Mixed inocula + 15 kg N fed^{-1}. The treatment were in three replicates each and arranged in split plot design with plot area of 3 × 3.5 m (10.5 m^2).

Bacterial strains: *Azotobacter chroococcum, Azospirillum brasilense* (Diazotrophsbacteria), *Bacillus polymyxa* (indophytic bacteria) and *Rhizobium legeminsarum* biovar *phaseolii* (symbiotic bacteria), were kindly obtained from Agriculture Microbiology Department, Soils, Water and Environment Res. Inst., ARC, and they used as inocula for each treatment for coating canola seeds at a rate of 4 g/100 g $seed^{-1}$ with seed load $\geq 10^4$ cell per $seed^{-1}$.

Nitrogen fertilizer as ammonium sulphate (20.5 %N) was applied at rates of 15 and 50 kg N fed^{-1} in two equal split doses at 21 and 35 days after planting.

At harvest (140 day old plants),the following characters were measured:

Table 1: Analysis of soil samples obtained from experimental sites in Giza

Analysis		Giza fields	
		Season 1	Season 2
Mechanical analysis			
Coarse sand		6.41	7.71
Fine sand		23.71	24.74
Silt		30.89	27.21
Clay		38.99	40.34
Texture		Clay loam	Clay loam
Chemical analysis			
Organic carbon		0.71	0.73
Organic matter		1.24	1.27
Total nitrogen		0.17	0.19
Water holding capacity		54.32	56.37
pH		7.62	7.43
EC dSm^2		2.9	2.8
Anions and cations (meq l^{-1})			
Bicarbonate	$CO_3^{=}$	08.40	8.11
Chloride	Cl^{-1}	11.71	10.57
Sulphate	$SO_4^{=}$	14.92	26.24
Calcium	Ca^{++}	9.53	8.61
Magnesium	Mg^{++}	2.57	2.60
Sodium	Na^{+}	22.93	25.71

A) Laboratory tests:

A-1 Standard germination: seeds were incubated in filter paper at 20 °C for 7 days. Normal seedlings were counted according to international values I.S.T.A. (1993) and expressed as germination percentage (%).

Seedling characteristics were assessed by measuring radical length (cm), shoot length (cm), fresh and dry weight of seedling (g $plant^{-1}$).

A-2-Electrical conductivity: the electrical conductivity of seed leachate was determined according to procedure described by A.O.S.A., 1983. The conductivity per gram of seed weight for each sample is calculated by the following formula:

$$Ms.cm^{-1}g^{-1} = \frac{\text{Conductivity (Ms) for each sample}}{\text{Weight of seed(g) of the same sample}}$$

B- Chemical determinations: B1- Nitrogen: total nitrogen in seed was determined using Kjeldahl apparatus (A.O.A.C., 1990). Crude protein was calculated by multiplying the total nitrogen by 6.25.

B-2- Total carbohydrates percentage was evaluated according to A.O.A.C. (1990)

B-3- Crude Oil (%) was determined using sexhlet apparatus and hexane as a solvent according to A.O.A.C. (1990).

B-4- Potassium content was estimated in the digest reffered previously by flame photometer (Corning 410) according to the method described by Chapman and Partt (1961).

B-5- Total phosphorus content was determined in the digested solution as described by Jackson, 1973.

C- Agronomic determinations: plant height (cm), number of branches $plant^{-1}$, weight of 1000 seed (g $seed^{-1}$) and seed yield kg fed^{-1} were determined.

Data were subjected to analysis of variance according to Steel and Torrie (1980).

RESULTS AND DISCUSSION

Data in Tables 2 & 3 show the characters which were significantly affected by the interaction between various bacteria inocula and N-fertilizer. Results indicate that application of 15 kg N fed^{-1} gave the lowest percentage of 84.8 for standard germination and consequently, it recorded the lowest values of 5.55 and 2.54 cm irrespective to shoot and radical length and 0.0153 and 0.0017 mg $plant^{-1}$ for seedling fresh and dry weight, respectively.

Table (2): Standard germination, shoot and radical length of the harvested canola seeds as affected by various bacterial inocula under clay loam soil condition

Treatment	Variety	% standard germination			Shoot length (cm)			Radical length (cm)		
		1st	2nd	Comb.	1st	2nd	Comb.	1st	2nd	Comb.
T1 *		83.3	86.2	84.8	5.82	5.28	5.55	2.53	2.55	2.54
T2		87.0	88.2	87.6	6.49	7.32	6.91	2.95	3.01	2.98
T3		94.0	94.0	94.0	6.85	7.34	7.10	3.22	2.98	3.10
T4		93.3	93.0	93.2	6.66	6.33	6.50	3.03	2.95	2.99
T5		88.7	88.7	88.7	7.81	7.86	7.84	2.95	3.14	3.05
T6		92.3	91.2	91.8	7.34	7.58	7.46	2.85	2.90	2.88
LSD 0.05		**3.2**	**3.0**	**1.91**	**0.89**	**0.81**	**0.53**	**0.33**	**0.27**	**0.18**
	V1 **	90.7	88.9	89.8	6.57	6.82	6.70	2.83	2.97	2.90
	V2	91.0	92.0	91.5	6.71	6.70	6.71	2.89	2.83	2.86
	V3	87.7	89.7	88.7	7.20	7.33	7.27	3.05	2.97	3.01
LSD 0.05		**2.7**	**1.6**	**1.48**	**NS**	**0.47**	**0.39**	**0.18**	**NS**	**0.11**
T1	V1	85.0	85.5	85.3	5.28	4.95	5.12	2.40	2.53	2.47
T1	V2	84.0	88.0	86.0	5.63	4.85	5.23	2.53	2.63	2.58
T1	V3	81.0	85.0	83.0	6.57	6.05	6.31	2.67	2.50	2.59
T2	V1	86.0	86.5	86.3	6.32	7.47	6.90	2.78	3.13	2.96
T2	V2	89.0	91.0	90.0	6.20	6.85	6.53	2.80	2.67	2.74
T2	V3	86.0	87.0	86.5	6.95	7.65	7.30	3.28	3.22	3.25
T3	V1	92.0	93.0	92.5	6.07	7.05	6.56	3.13	2.95	3.04
T3	V2	93.0	91.0	92.0	7.95	7.00	7.48	3.20	2.80	3.00
T3	V3	97.0	98.0	97.5	6.53	7.97	7.25	3.33	3.20	3.27
T4	V1	96.0	92.0	94.5	6.68	5.98	6.33	2.80	2.85	2.83
T4	V2	94.0	95.0	94.5	6.50	6.60	6.55	3.25	2.95	3.10
T4	V3	90.0	92.0	91.0	6.80	6.40	6.60	3.03	3.05	3.04
T5	V1	86.0	85.0	85.5	7.85	8.15	8.00	3.13	3.58	3.36
T5	V2	95.0	94.0	94.5	6.85	7.35	7.10	2.63	2.78	2.71
T5	V3	85.0	87.0	86.0	8.72	8.09	8.41	3.10	3.08	3.09
T6	V1	99.0	91.5	95.3	7.22	7.32	7.27	2.75	2.78	2.77
T6	V2	91.0	93.0	92.0	7.15	7.60	7.38	2.93	3.13	3.03
T6	V3	87.0	89.0	88.0	7.65	7.80	7.73	2.88	2.80	2.84
LSD 0.05		**6.5**	**4.0**	**3.61**	**NS**	**NS**	**NS**	**NS**	**0.35**	**0.27**

*** T1 uninoculated + 15kg N fed^{-1}**
T2 uninoculated + 50kg N fed^{-1}
T3 Rhizobia inoculated + 15kg N fed^{-1}
T4 Diazotrophs inculted + 15kg N fed^{-1}
T5 Bacillus inculated + 15kg N fed^{-1}
T6 Mixture + 15kg N fed^{-1}

**** V1: Sero 4**
V2: Pactol
V3: AD204

Table (3): Seedling fresh and dry weight of harvested canola plants as affected by various bacterial inocula under clay loam soil conditions

Treatment	Variety	Seedling fresh weight (mg/plant)			Seedling dry weight (mg/plant)		
		1st	2nd	Comb.	1st	2nd	Comb.
T1 *		0.0138	0.0167	0.0153	0.0017	0.0017	0.0017
T2		0.0200	0.0199	0.0200	0.0019	0.0019	0.0019
T3		0.0211	0.0225	0.0218	0.0022	0.0021	0.0021
T4		0.0223	0.0222	0.0223	0.0021	0.0019	0.0020
T5		0.0213	0.0220	0.0216	0.0019	0.0020	0.0019
T6		0.0213	0.0244	0.0229	0.0018	0.0018	0.0018
LSD 0.05		**0.0030**	**0.0025**	**0.0014**	**0.009**	**0.0002**	**0.0016**
	V1 **	0.0230	0.0251	0.0241	0.0021	0.0021	0.0021
	V2	0.0191	0.0190	0.0190	0.0019	0.0018	0.0018
	V3	0.0178	0.0198	0.0188	0.0019	0.0018	0.0018
LSD 0.05		**0.0060**	**0.0049**	**0.0015**	**NS**	**0.0001**	**0.0012**
T1	V1	0.0163	0.0200	0.0182	0.0017	0.0018	0.0017
T1	V2	0.0123	0.0137	0.0130	0.0018	0.0016	0.0017
T1	V3	0.0129	0.0164	0.0146	0.0017	0.0016	0.0017
T2	V1	0.0204	0.0205	0.0204	0.0021	0.0022	0.0021
T2	V2	0.0213	0.0189	0.0201	0.0017	0.0019	0.0018
T2	V3	0.0184	0.0205	0.0194	0.0018	0.0018	0.0018
T3	V1	0.0260	0.0279	0.0269	0.0025	0.0022	0.0023
T3	V2	0.0208	0.0211	0.0210	0.0023	0.0020	0.0021
T3	V3	0.0164	0.0186	0.0175	0.0020	0.0021	0.0024
T4	V1	0.0248	0.0268	0.0258	0.0024	0.0024	0.0018
T4	V2	0.0213	0.0196	0.0204	0.0020	0.0017	0.0018
T4	V3	0.0210	0.0201	0.0205	0.0019	0.0018	0.0018
T5	V1	0.0281	0.0277	0.0279	0.0021	0.0022	0.0021
T5	V2	0.0142	0.0171	0.0157	0.0015	0.0017	0.0016
T5	V3	0.0215	0.0213	0.0214	0.0022	0.0021	0.0021
T6	V1	0.0226	0.0279	0.0252	0.0017	0.0019	0.0018
T6	V2	0.0246	0.0237	0.0241	0.0021	0.0020	0.0020
T6	V3	0.0167	0.0218	0.0192	0.0016	0.0017	0.0016
LSD 0.05		**NS**	**0.0012**	**0.0036**	**NS**	**0.0004**	**0.0029**

* T1 uninoculated + 15kg N fed^{-1}
T2 uninoculated + 50kg N fed^{-1}
T3 Rhizobia inoculated + 15kg N fed^{-1}
T4 Diazotrophs inculted + 15kg N fed^{-1}
T5 Bacillus inculated + 15kg N fed^{-1}
T6 Mixture + 15kg N fed^{-1}

** V1: Sero 4
V2: Pactol
V3: AD204

The application of 50 kg N fed^{-1} led to significant increases in all abovemotioned tested seed parameters as compared to 15 kg N fed^{-1} treatment. All inoculation treatments had a positive significant effect as compared to 50 g N fed^{-1} treatment and recorded percentage increases up to 6, 13, 22, 15 and 11 for standard germination, shoot length, radical length, seedling fresh weight and seedling dry weight respectively.

Data in Tables (2&3) reveal that AD 204 variety had positive significant effect as compared to other two varieties siro 4 and pactol at shoot and radical length. Poctal variety gave the highest percentages at standard germination as compared to other tested varieties. Sero 4 variety had the greatest values at seedling fresh and dry weights.

Interaction effect between varieties and various treatments was shown in Tables (2&3) and results indicate that the application of various bacterial inocula gave a significant difference as compared to treatments received 15 or 50 kg N fed^{-1}. In general the best inoculant used was rhizobial inoculation followed by Diazotrophic bacteria, *Bacillus bolymyxa* and finely the mixture inoculant. However, benefical rhizobacteria are often referred to as plant growth promoting rhizobacteria (PGPR). These encompass all bacteria that inhabit plant roots and exert a positive effect by various mechanisms, ranging from a direct influence (e.g., increased solubilization and uptake of nutrients or production of plant growth regulators), to an indirect effect (e.g., suppression of pathogens by producing either siderophores or antibiotics (Kloepper *et al.*, 1989, Glick *et al.*, 1997).

These beneficial bacteria are also referred to as yield-increasing bacteria (YIB) (Chen *et al.*,1994).

Results of electrical conductivity (EC) of leachate of harvested canola seeds are shown in Table (4). Data reveal that irrespective time of determination, the mixture inoculation had the lowest value of EC followed by *Bacillus polymyxa*, Diazotrophic bacteria, rhizobobial inoculation, 15 kg N fed^{-1} and 50 kg N fed^{-1}, also variety Poctal possess the highest EC value (21.15 Ms $cm^{-1}g^{-1}$), while, the varieties AD 204 and Sero 4 had recorded less value being (12.95 and 11.82 Ms $cm^{-1}g^{-1}$) respectively. In general all treatments decreased the values of the electrical conductivity among both seasons and this means that the application of various inocula types led to a high seed availability to germinate, in this respect, Krystyna and Stefenia (2000) reported that there is a positive relationship between seed quality test and field emergence of some legume plants.

Data in Table (5) reveal that in combined analysis of both seasons, all treatments had a significant effect among the tested parameters as compared to 15 kg N fed^{-1} applied to plants. The treatment received 15 kg N fed^{-1} recorded the lowest values of (122.2 cm $plant^{-1}$, 8.9 No.$plant^{-1}$, 1.40 g 1000 $seed^{-1}$ and 21.64 g $plant^{-1}$) for plant height, number of branches, 1000-seed weight and yield of plant, respectively. Variety Pactol scored significant deference in plant height and number of branches as compared to other two tested varieties but variety AD204 recorded the highest yield of plant (27.78 g $plant^{-1}$) and variety Siro4 scored highest 1000 seed g^{-1} (2.46 g 1000 $seed^{-1}$).

The application of various bacterial inoculation had a positive effect on all the tested parameters test and no significant deference found between them and /or application of recommended N treatment.

Table (4): Electrical conductivity of harvest canola seeds as affected by various bacterial inocula under clay loam soil conditions

Treatment	Variety	EC (24 hrs) Mscm^{-1}g^{-1}			EC (48 hrs) Mscm^{-1}g^{-1}			EC (72 hrs) Mscm^{-1}g^{-1}		
		1st	2nd	Comb.	1st	2nd	Comb.	1st	2nd	Comb.
T1*		13.97	14.15	14.06	15.05	15.52	15.29	15.68	15.66	15.67
T2		16.17	16.98	16.58	18.04	18.31	18.18	20.32	20.27	20.30
T3		12.79	13.14	12.97	14.57	14.64	14.61	16.47	16.67	16.57
T4		11.02	11.67	11.35	12.79	12.91	12.85	13.82	14.59	14.21
T5		9.86	10.64	10.25	11.57	11.72	11.65	12.75	12.16	12.46
T6		9.35	9.68	9.52	11.18	11.01	11.10	12.60	12.67	12.64
LSD 0.05		0.64	0.72	0.42	0.33	0.19	0.16	0.38	0.43	0.25
	V1**	9.08	9.57	9.33	10.92	10.84	10.88	11.77	11.86	11.82
	V2	17.96	18.61	18.29	19.57	19.88	19.73	20.98	21.32	21.15
	V3	9.53	9.94	9.74	11.11	11.33	11.22	13.06	12.83	12.95
LSD 0.05		0.44	0.32	0.26	0.18	0.16	0.12	0.33	0.25	0.20
T1	V1	11.43	12.40	11.92	12.90	13.05	12.98	13.82	13.11	13.47
T1	V2	23.15	23.56	23.36	23.91	24.90	24.41	23.40	23.97	23.69
T1	V3	7.33	6.49	6.91	8.33	8.60	8.47	9.82	9.90	9.86
T2	V1	16.69	16.94	16.82	17.35	17.91	17.63	17.56	17.81	17.69
T2	V2	21.53	22.81	22.17	23.33	23.90	23.62	26.61	26.78	26.70
T2	V3	10.29	11.18	10.74	13.44	13.11	13.28	16.79	16.22	16.51
T3	V1	12.51	13.44	12.98	14.59	14.39	14.49	16.01	16.01	16.01
T3	V2	18.42	18.15	18.29	19.03	19.58	19.31	19.26	19.86	19.56
T3	V3	7.44	7.81	7.63	10.10	9.94	10.02	14.15	14.15	14.15
T4	V1	2.60	2.59	2.60	4.88	4.82	4.85	5.57	6.64	6.11
T4	V2	20.39	21.67	21.03	21.65	22.12	21.89	22.49	23.11	22.80
T4	V3	10.07	10.76	10.42	11.85	11.79	11.82	13.40	14.02	13.71
T5	V1	4.52	5.63	5.08	7.36	6.93	7.15	8.40	8.03	8.22
T5	V2	13.36	13.84	13.60	15.45	15.32	15.39	17.40	16.97	17.19
T5	V3	11.68	12.45	12.07	11.90	12.90	12.40	12.43	11.47	11.95
T6	V1	6.76	6.45	6.61	8.45	7.93	8.19	9.27	9.56	9.42
T6	V2	10.90	11.62	11.26	14.06	13.44	13.75	16.74	17.20	16.97
T6	V3	10.39	10.97	10.68	11.02	11.65	11.34	11.79	11.26	11.53
LSD 0.05		1.07	0.77	0.63	0.45	0.38	0.28	0.82	0.62	0.49

* T1 uninoculated + 15kg N fed^{-1}
T2 uninoculated + 50kg N fed^{-1}
T3 Rhizobia inoculated + 15kg N fed^{-1}
T4 Diazotrophs inculted + 15kg N fed^{-1}
T5 Bacillus inculated + 15kg N fed^{-1}
T6 Mixture + 15kg N fed^{-1}

** V1: Sero 4
V2: Pactol
V3: AD204

Data in Table (6) indicate that irrespective of varieties, the application of 15 kg N fed^{-1} with or without bacterial inocula recorded the lowest percentages of 11.97 and 42.84 for carbohydrate and oil and 526.7 kg fed^{-1} for seed yield fed $^{-1}$. Data presented in Table (6) show the effect of various bacterial inocula on the carbohydrate percentage, the analysis of variance indicate that the four trails were significantly affected in the most varieties and gave high seed quality tolerance under stress conditions. These results are in harmony with those obtained by Khan *et al.*, (1989) and Afiah et al., (1999), who reported that reducing and non reducing sugars were accumulated in sorghum due to water stress. It may be concluded that accumulation of solutes could be considered as screening parameter for salinity tolerance.

Table (5): Yield parameters of canola plants as affected by different type of bacterial inoculation and two levels of N-fertilizer under clay loam soil conditions

Treatment	Variety	Plant height cm/plant			Number of branches (no/plant)			1000-seed weigh (g/1000seed)			Yield g/plant		
		1st	2nd	Comb	1st	2nd	Comb	1st	2nd	Comb.	1st	2nd	Comb
T1 *		121.4	131.1	126.3	10.5	10.5	10.5	1.78	1.75	1.77	22.75	22.66	22.71
T2		135.3	132.2	133.8	12.3	13.1	12.7	2.26	2.32	2.29	25.81	26.36	26.10
T3		130.8	130.6	130.7	14.3	13.6	14.0	2.39	2.42	2.41	30.32	28.91	29.62
T4		133.9	136.3	135.1	14.0	15.7	14.9	2.35	2.40	2.38	31.15	26.50	28.83
T5		139.9	135.7	137.8	15.2	14.0	14.6	2.26	2.34	2.30	30.62	25.44	28.03
T6		134.4	137.8	136.1	15.4	14.1	14.8	2.33	2.38	2.36	27.65	30.36	29.01
LSD 0.05		8.1	NS	5.96	1.5	1.8	1.1	0.12	0.26	0.13	1.98	3.11	1.72
	V1 **	131.7	134.4	133.1	12.8	13.2	13.0	2.37	2.55	2.46	28.46	28.41	28.44
	V2	135.1	136.2	135.7	14.3	13.4	13.9	2.28	2.23	2.26	26.34	25.50	25.92
	V3	131.1	131.3	131.2	13.7	13.9	13.8	2.04	2.03	2.04	29.35	26.21	27.78
LSD 0.05		NS	3.1	2.41	1.0	NS	0.7	0.12	0.16	0.09	1.89	1.42	1.15
T1	V1	117.0	127.7	122.4	8.1	9.7	8.9	1.87	2.09	1.98	22.14	23.52	22.83
T1	V2	131.0	137.7	134.4	11.6	11.1	11.4	2.02	1.85	1.94	21.18	22.09	21.64
T1	V3	116.3	128.0	122.2	11.7	10.6	11.2	1.46	1.33	1.40	24.94	22.38	23.66
T2	V1	135.3	137.3	136.3	11.8	12.6	12.2	2.43	2.71	2.57	27.04	27.41	27.23
T2	V2	136.3	135.3	135.8	12.3	13.1	12.7	2.28	2.10	2.19	24.65	26.32	25.49
T2	V3	134.3	124.0	129.2	12.9	13.6	13.3	2.08	2.16	2.12	25.74	25.40	25.57
T3	V1	133.3	132.0	132.7	14.3	13.4	13.9	2.23	2.50	2.37	28.40	32.26	30.33
T3	V2	136.0	131.3	133.7	13.7	13.5	13.6	2.76	2.70	2.73	30.82	25.65	28.24
T3	V3	123.0	128.3	125.7	14.9	13.9	14.4	2.19	2.07	2.13	31.74	28.83	30.29
T4	V1	132.3	133.3	132.8	13.7	16.1	14.9	2.72	2.75	2.74	32.98	27.90	30.44
T4	V2	135.7	137.7	136.7	14.4	14.3	14.4	2.26	2.28	2.27	28.23	24.84	26.54
T4	V3	133.7	138.0	135.9	13.9	16.8	15.4	2.07	2.16	2.12	32.23	26.75	29.49
T5	V1	137.3	138.0	137.7	15.1	13.9	14.5	2.48	2.68	2.58	30.18	26.09	28.14
T5	V2	137.3	137.3	137.3	16.1	14.2	15.2	1.90	2.11	2.01	27.00	23.83	25.42
T5	V3	145.0	131.7	138.4	14.5	13.8	14.2	2.40	2.24	2.32	34.67	26.39	30.53
T6	V1	135.0	138.0	136.5	13.8	13.3	13.6	2.47	2.59	2.53	30.01	33.27	31.64
T6	V2	134.0	137.7	135.9	17.9	14.5	16.2	2.48	2.35	2.42	26.17	30.28	28.23
T6	V3	134.3	137.7	136.0	14.4	14.5	14.5	2.05	2.19	2.12	26.77	27.53	27.15
LSD 0.05		NS	NS	5.90	NS	NS	NS	0.30	NS	0.23	NS	NS	NS

* T1 uninoculated + 15kg N fed^{-1}
T2 uninoculated + 50kg N fed^{-1}
T3 Rhizobia inoculated + 15kg N fed^{-1}
T4 Diazotrophs inculted + 15kg N fed^{-1}
T5 Bacillus inculated + 15kg N fed^{-1}
T6 Mixture + 15kg N fed^{-1}

** V1: Sero 4
V2: Pactol
V3: AD204

Data of oil content (%), variety AD204 recorded the highest oil content (50.97%) and scrod significant deference as compared to Pactol (44.33%) and Siro (47.92%) varieties. In general, and irrespective of inoculation with various bacterial inocula to various varieties led to increase significantly the percentage of oil content, as compared to treatments received 15 and 50 kg N fed^{-1}. Also, *Rhizobium* inoculation had a superiority (49.68) against other inocula used and followed by Diazotrophic (49.08), mix. (48.24) and *Bacillus polymyxa*.

Seed yield (Kg fed^{-1}) is presented in Table (6). Data indicate that the treatment received 15 kg N fed^{-1} gave the lowest seed yield (526.7 kg fed^{-1}) and the application of 50 kg N fed^{-1} (855.5 kg fed^{-1}) gave a significant increase as compared to the application of 15 kg N fed^{-1}. Inoculation with various bacterial inocula recorded higher increases as compared to 50 kg N fed^{-1} treatments and scored 11%, 8%, 5% and 9% for rhizobia, diazotrophs, Bacillus and mixed inocula in the same order. There is no significant deference between the three tested varieties in the yield fed^{-1}; which gave 910.0, 889.0 and 850.8 kg fed^{-1} for sero 4, AD204 and Pactol variety, respectively. The highest seed yield obtained (1109.4 kg fed) and oil content (52.81%) were for AD204 variety inoculated with *Bacillus polymyxa* in presences of 15 kg N fed^{-1}.

Table (6): Yield kg fed^{-1}, carbohydrate % and oil% of 3 different varieties of canola plants as affected by various bacterial inocula under clay loam soil condition

Treatment	Variety	Carbohydrate %			Oil %			Yield kg /feddan		
		1st	2nd	Comb.	1st	2nd	Comb.	1st	2nd	Comb.
T1 *		11.85	12.09	11.97	45.18	45.29	45.24	525.1	525.2	526.7
T2		18.75	18.65	18.70	46.51	46.51	46.51	826.3	884.6	855.5
T3		15.29	15.25	15.27	49.38	49.98	49.68	970.2	925.1	847.7
T4		14.68	15.33	15.01	49.15	49.01	49.08	997.4	848.7	923.1
T5		22.73	23.27	23.00	47.59	47.76	47.68	980.1	814.1	897.1
T6		19.29	19.08	19.19	48.36	48.11	48.24	885.1	971.5	928.3
LSD 0.05		0.30	0.57	0.28	1.67	0.85	0.81	160.5	99.5	123.1
	V1**	17.01	17.08	17.05	47.85	47.98	47.92	910.7	909.2	910.0
	V2	17.95	18.27	18.11	44.41	44.25	44.33	884.9	816.6	850.8
	V3	16.34	16.49	16.42	50.83	51.11	50.97	939.2	838.7	889.0
LSD 0.05		0.11	0.21	0.11	0.53	0.64	0.39	140.3	138.4	NS
T1	V1	11.93	11.60	11.77	45.20	44.79	45.00	708.5	752.4	730.6
T1	V2	11.02	11.68	11.35	43.08	42.60	42.84	677.8	706.9	692.4
T1	V3	12.60	13.00	12.80	47.27	48.49	47.88	798.1	716.2	757.1
T2	V1	15.42	15.92	15.67	46.40	46.14	46.27	865.3	877.2	871.3
T2	V2	24.90	24.46	24.68	44.38	43.79	44.09	784.1	842.3	813.2
T2	V3	15.94	15.56	15.75	48.77	49.60	49.19	823.7	812.8	818.3
T3	V1	16.67	15.85	16.26	48.17	49.60	48.89	908.8	1032.3	970.6
T3	V2	17.63	17.95	17.79	47.87	47.82	47.85	986.3	808.3	897.3
T3	V3	11.57	11.94	11.76	52.11	52.53	47.85	1015.7	922.0	968.9
T4	V1	14.46	15.23	14.85	50.36	50.65	52.32	1055.4	892.8	974.1
T4	V2	16.74	17.26	17.00	44.09	44.28	50.51	902.4	794.9	848.7
T4	V3	12.84	13.51	13.18	52.99	52.10	44.19	1031.4	854.4	942.9
T5	V1	20.89	22.10	21.50	47.42	47.61	52.55	965.8	834.9	900.4
T5	V2	23.65	25.08	24.37	42.68	42.74	47.52	864.1	762.6	913.4
T5	V3	23.66	22.63	23.15	52.67	52.94	42.71	1109.4	844.5	976.5
T6	V1	22.67	21.76	22.22	49.55	49.07	52.81	960.3	1064.6	1012.5
T6	V2	13.77	13.22	13.50	44.37	44.31	44.34	837.4	969.0	903.3
T6	V3	21.42	22.27	21.85	51.15	50.97	51.06	856.6	881.0	868.9
LSD 0.05		0.27	0.52	0.28	1.30	1.57	0.97	138.3	143.2	120.8

* T1 uninoculated + 15kg N fed^{-1}
T2 uninoculated + 50kg N fed^{-1}
T3 Rhizobia inoculated + 15kg N fed^{-1}
T4 Diazotrophs inculted + 15kg N fed^{-1}
T5 Bacillus inculated + 15kg N fed^{-1}
T6 Mixture + 15kg N fed^{-1}

** V1: Sero 4
V2: Pactol
V3: AD204

Yield components of the three canola varieties (Protein%, (P) phosphorus (ppm) and (K) potassium%) are shown in Table (7). Significant increases were found among all the tested parameters with different treatments and various varieties. AD204 variety recorded 28.07 and 1.04 % for protein and phosphorus contents. The application of various bacterial inocula gave the highest yield component values as compared to the treatment received 50 kg N fed^{-1}. These data are in agreement with Mona *et al.*, 2000 and Asghar *et al.*, 2002 who reported that application of bacterial inoculation had a positive effect on growth, yield and yield components of canola plants and added that the percentage increases attributed to inoculation were 126, 131 and 100 for seed yield, protein and oil yield as compared to untreated treatment.

Table (7): Yield components of canola plants as affected by various bacterial inocula under clay loam soil condition

Treatment	Variety	Protein %			P %			K %		
		1st	2nd	Comb.	1st	2nd	Comb.	1st	2nd	Comb.
T1 *		24.86	25.29	25.08	0.70	0.71	0.71	0.30	0.32	0.31
T2		27.84	28.23	28.04	0.95	0.97	0.96	0.43	0.44	0.44
T3		28.53	28.29	28.41	0.83	0.83	0.83	0.42	0.42	0.42
T4		25.84	25.87	25.86	0.94	0.93	0.94	0.45	0.47	0.46
T5		27.15	27.06	27.11	0.83	0.87	0.85	0.38	0.39	0.39
T6		27.73	27.67	27.70	0.98	1.02	1.00	0.39	0.40	0.40
LSD 0.05		0.78	1.09	0.58	0.01	0.01	0.02	0.01	0.01	0.02
	V1 **	25.18	24.93	25.06	0.77	0.78	0.78	0.36	0.37	0.37
	V2	27.76	28.18	27.97	0.82	0.83	0.83	0.43	0.45	0.44
	V3	28.04	28.09	28.07	1.03	1.05	1.04	0.39	0.40	0.40
LSD 0.05		0.35	0.36	0.24	0.03	0.03	0.02	0.03	0.01	0.01
T1	V1	23.60	23.97	23.79	0.72	0.74	0.73	0.31	0.32	0.32
T1	V2	25.22	25.08	25.15	0.61	0.60	0.61	0.24	0.26	0.25
T1	V3	25.78	26.81	26.30	0.79	0.80	0.80	0.35	0.37	0.36
T2	V1	26.22	26.76	26.49	0.77	0.78	0.78	0.38	0.40	0.39
T2	V2	28.96	29.85	29.41	0.95	0.95	0.95	0.51	0.51	0.51
T2	V3	28.35	28.08	28.22	1.13	1.17	1.15	0.40	0.39	0.40
T3	V1	26.84	26.16	26.50	0.80	0.78	0.79	0.45	0.43	0.44
T3	V2	30.86	31.70	31.28	0.29	0.25	0.27	0.53	0.52	0.53
T3	V3	27.89	27.01	27.45	1.41	1.45	1.43	0.28	0.30	0.29
T4	V1	21.60	21.49	21.55	0.75	0.77	0.76	0.28	0.31	0.30
T4	V2	28.72	29.17	28.95	1.12	1.06	1.09	0.52	0.58	0.55
T4	V3	27.21	26.95	27.08	0.94	0.97	0.96	0.54	0.53	0.54
T5	V1	24.59	23.80	24.20	0.77	0.78	0.78	0.43	0.44	0.44
T5	V2	28.85	28.65	28.75	0.86	0.94	0.90	0.33	0.34	0.34
T5	V3	27.99	28.74	28.37	0.86	0.88	0.87	0.37	0.40	0.39
T6	V1	28.22	27.42	27.82	0.79	0.81	0.80	0.33	0.34	0.34
T6	V2	23.93	24.64	24.29	1.13	1.20	1.17	0.44	0.48	0.46
T6	V3	31.04	30.95	31.00	1.02	1.05	1.04	0.39	0.39	0.39
LSD 0.05		0.84	0.87	0.58	0.07	0.07	0.05	0.07	0.01	0.03

* T1 uninoculated + 15kg N fed^{-1}
T2 uninoculated + 50kg N fed^{-1}
T3 Rhizobia inoculated + 15kg N fed^{-1}
T4 Diazotrophs inculted + 15kg N fed^{-1}
T5 Bacillus inculated + 15kg N fed^{-1}
T6 Mixture + 15kg N fed^{-1}

** V1: Sero 4
V2: Pactol
V3: AD204

In general, inoculation of canola plants with different bacterial inocula are of rather economic value as compared to other treatments. The values of yield parameters of inoculated plants received 15 kg N fed^{-1} were higher against uninoculated plants treated with full N-fertilizer dose (50 kg N fed^{-1}).

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تأثير لقاحات بكتيرية مختلفة مع جرعة تنشيطية من الازوت على النمو والمحصول ومكوناته للكانولا

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لما كان محصول الكانولا من المحاصيل الزيتية حديثة الاستزراع فى مصر فقد اجرى هذا البحث فى محطة بحوث الجيزة- مركز البحوث الزراعية- الجيزة فى موسمين شتويين متعاقبين (٢٠٠٣ – ٢٠٠٤ / ٢٠٠٤ – ٢٠٠٥) وذلك لتقييم استجابة ثلاثة أصناف من محصول الكانولا هم (سرو٤- باكتول- AD204) للتلقيح باربعة انواع من اللقاحات البكتيرية (الريزوبيا – مثبتات الازوت الحرة- الباسيلس بلوميكسا- خليط منهم). كان معدل التسميد الازوتى المستخدم ١٥و ٥٠ كجم نيتروجين/فدان) تم وضعه على دفعتين متساويتين فى عمر ٢١ و٣٥ يوم من الزراعة.

وكانت اهم النتائج المتحصل عليها مايلى:

- كان التلقيح بصفة عامة له تأثيرا ايجابيا على كل قياسات كفاءة البذور المختبرة مثل نسبة الانبات – سمك البادرات – سمك الجذورالاولية- معامل التوصيل الكهربى وذلك مقارنة بمعاملة التسميد الازوتى الكامل (٥٠ كجم نتروجين/فدان).
- ايضا زاد المحصول نتيجة لمعاملة التلقيح والتسميد بمعدل ١٥كجم نتروجين/فدان مقارنة بالمعاملة عدم التلقيح والتسميد لـ ٥٠كجم نتروجين للفدان.
- بصفة عامة يمكن القول بان التلقيح كان ذو قيمة اقتصاديا أكبر من المعاملات الأخرى حيث تفوق فى محصول البذور ومحصول الزيت .