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CYANOBACTERIA INOCULATION AS NITROGEN SOURCE MAY SUBSTITUTE PARTIALLY MINERAL NITROGEN IN MAIZE PRODUCTION

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ABSTRACT

Two field experiments were carried out at a private farm at Sakkara, EL-Badrasheen, Giza, Governorate, Egypt, during two successive Summer seasons of 2004-2005 to study the influence of cyanobacteria inoculation in different rates (0, 50 and 100% of the recommended dose, i.e., 3.5 kg dried cyanobacteria inoculum fed^{-1}) individually or in presence and/ or absence of different nitrogen levels (0, 25, 50 and 100% of the recommended dose, (i.e.),100 kg N fed^{-1}) on maize yield and yield components, some maize grain technology characters (protein, oil, carbohydrates and ash percentages) as well as the biological activity of the soil remained after maize harvesting as represented by total count bacteria, cyanobacteria count, CO_2 evolution, dehydrogenase (DHA) and nitrogenase (N_2-ase) activities Results revealed that all tested treatments increased significantly both maize yield and its components over the control treatment. The highest yield components values were due to 100% N + 100% cyanobacteria and they were comparable to those recorded in presence of 50% N + 100% cyanobacteria treatment. Also the values of maize yield components obtained due to 100% N treatment were not significantly different from those attained due to 100% N + 100% cyanobacteria and 50% N + 100% cyanobacteria treatments. Cyanobacteria inoculation at the rate of 50% combined with 100% N recorded the highest maize protein and carbohydrate percentages. Indefinite trend was noticed of maize oil % in response to cyanobacteria inoculation despite the highest insignifecant oil % increments were noticed due to 50% N + 100% cyanobacteria treatment Also, Indefinite response was observed for ash % due to cyanobacteria inoculation. For soil biological activity, cyanobacteria inoculation enhanced significantly any of total count bacteria, cyanobacteria count, CO_2 evolution, dehydrogenase and nitrogenase activities compared to the control treatment received no inoculation. In conclusion, the use of cyanobacteria inoculation technology in cereal crop production such as maize may lead to reduce the amount of mineral nitrogen required for maize production by 50% as well as it ensures good yield quality and safe the environment contaminations resulted from the extensive use of the costly and hazard the so called mineral nitrogen fertilizer.

INTRODUCTION

The period since the 1950s has seen exciting advances in understanding biological nitrogen fixation (BNF). Progress in application of BNF technology to agriculture has been slower, but there have been important innovation. While much of the basic BNF research in the last 30 years has been focused on nodulated legumes and rhizobia, there have been relatively rapid advances in knowledge of other N_2- fixing systems. This includes the actinomycetes that form nodules on some non-leguminous shrubs and trees, free - living N_2- fixers associated with cereals and the cyanobacteria. The latter are widely distributed in nature and form prominent autotrophic microbial populations of wetland soils. Reducing the amount of the organic matter, in turn, affect soil aggregates stability. Considering the very low efficiency of applied nitrogenous fertilizer in crop cultivation, may lead to extensive and undue use of chemical fertilizers may lead to serious environmental problems, some of which are accumulation of NO_3 and NO_2 to hazardous levels in the underground water and plant tissues. So, for the production of healthy food, it may be necessary to find out and exploit potential alternative sources of plant nutrients to sustaining soil fertility such as biofertilizers with the minimum addition of chemical fertilizers. Biofertilizers are safe from the environmental point of view, cheaper and at the same time satisfy the nutrient demands of crop plants (Badawy *et al.*, 1996). One of the most promising biofertilizer is cyanobacteria, either as free-living microorganisms or as symbionts with the water *Azolla* fern. Cyanobacteria as biofertilizer utilization in rice fields is common and promising (Venkataraman and Tilak, 1990). Recent researchers have shown that cyanobacteria also help to reduce soil alkalinity and this opened up possibilities for bioreclamation of such inhospital environment. Very recent reports by Thajuddin and Subramanian (2005) showed that cyanobacteria have beneficial effects on a number of other crops rather than rice such as barely, oats, tomato, radish, cotton, sugar cane, maize, chilli and lettuce. They also added that cyanobacteria have received worldwide attention for their possible use in mariculture, food, feed, fuel, fertilizer, and colorant, production of various secondary metabolites including vitamins, toxins, enzymes and pollution abatement. Jagannath *et al.* (2002) found that cyanobacteria inoculation enhanced the overall growth parameters of chickpea. It enhanced all morphological and biochemical characters such as proteins, carbohydrates, total nitrogen uptake, net grain and biomass yield of chickpea. Salem (1999) found that cyanobacteria inoculated to soybean can be successfully overcoming the adverse effect resulted from the saline stress condition. Abd El- Rasoul *et al.* (2004) indicated that inoculation with cyanobacteria to wheat, exhibited an economical view that it can save about 50% of mineral nitrogen amounts required for wheat production. They also showed that this treatment has enhanced the NPK uptake by wheat plants and grains, soil microbial activity in terms of increasing the numbers of soil fungi, *Actinomycetes*, total bacteria, total cyanobacteria count, CO_2 evolution and dehydrogenase activity. El- Gaml (2006) reported that maize inoculation with a mixture of cyanobacteria strains significantly enhanced maize grain yield, NPK uptake by grains and stover, soil organic matter, reduced both soil reaction and soil electrical conductivity, and increased soil particle size aggregates. These benefits achieved due to cyanobacteria inoculation, are in turn increased the nutrients availability to the cultivated plants that ensure high yield and grain quality. Cyanobacteria bring out directly or indirectly a number of changes in the physical, chemical and biological properties of the soil and soil-water interface in inoculated soils. Mandal *et al.* (1999) and Mussa *et al.* (2002) for example revealed that cyanobacteria liberate extra cellular or organic compounds and photosynthetic O_2 during their growth and contribute biomass. In a cumulative review, Roger and Kulasooriya (1980) reported that besides increasing soil nitrogen fertility, cyanobacteria have been said to benefit rice plants by producing growth-promoting substances. More direct evidence for hormonal effects has come primarily from treatments of rice seedlings with cyanobacterial culture or their extracts. Presoaking of rice seeds in cyanobacteria cultures or extracts has decreased losses from sulphate – reducing processes and this has been attributed to the enhancement of germination and a faster seedlings growth due to cyanobacterial exudates.

This work is designed to study the effect of cyanobacteria inoculation individually to maize variety single hybrid 10 cultivated in clayey soil under different nitrogen levels on maize yield and yield components, grain technology characters and the biological activity in soil remained after maize harvesting in terms of total bacteria and total cyanobacteria counts, CO_2 evolution, dehydrogenase and nitrogenase activities.

MATERIALS AND METHODS

Two field experiments were carried out at a private farm in Sakkara. El Badrasheen, Giza, Governorate, Egypt, during two successive Summer seasons of 2004-2005 to study the influence of cyanobacteria inoculation in different rates (0, 50 and 100% of the recommended dose, i.e., 3.5 kg dried cyanobacteria inoculum fed^{-1}) individually or in combination in presence and/ or absence of different nitrogen levels (0, 25, 50 and 100% of the recommended dose i.e.,100 kg N fed^{-1}) on the maize growth, yield and yield components, some maize grain technology characters (protein, oil, carbohydrates an ash percentages) as well as the biological activity of the soil remained after maize harvesting as represented by total count bacteria, cyanobacteria count, CO_2 evolution, dehydrogenase (DHA) and nitrogenase (N_2-ase) activities. The soil used was clayey in texture, having pH 7.55, total N 0.20% (Jackson, 1973), total P 0.02% (Olsen *et al.*, 1954) and organic matter 2.19% (Walkley and Black, 1934).

Prior to maize grains cultivation the uniform recommended practices recommended by the Ministry of Agriculture and Land Reclamation were completed. Phosphate and potassium fertilizers were added at the rates of 30 kg P_2O_5 fed^{-1} (calcium superphosphate 15.5% P_2O_5) and 48 kg K_2O fed^{-1} (potassium sulphate 50% K_2O_5).

The experimental area was divided into plots of 3 x 3.5 m. Grains of *Zea maize* variety single hybrid 10 were inoculated with cyanobacteria inoculum, which is composed of a mixture of individual strains namely, *Nostoc muscorum, Nostoc calcicola, Anabaena oryzae and Clyndrospermum muscicola.* These strains were kindly supplied with Prof. Dr. F. M. Ghazal, Agric. Microbiol. Dept. Soils, Water & Environ. Inst., Agric. Res. Center, Giza, Egypt. Maize grains were then drilled in rows 30 cm apart. Nitrogen fertilizer was applied in 4 levels, (i.e.), zero, 25, 50 and 100% of the recommended dose (100 kg N fed^{-1}) in the form of urea (46% N). These nitrogen levels were added in two split equal doses, (i.e.), 20 days after sowing and 50 days later.

The experimental design was in a split plot design with 12 treatments in three replications. Nitrogen fertilization levels of 0, 25, 50, and 100 % N represent the main plot, while the rates of dried cyanobacteria inoculum (0, 50, and 100 %) represent the sub plots. The experiment comprises the following treatments:

1- Control without nitrogen and/or cyanobacteria inoculation.
2- Zero cyanobacteria + 25% N.
3- Zero cyanobacteria 50% N.
4- Zero cyanobacteria 100% N.
5- Zero N + 50% cyanobacteria.
6- Zero N + 100% cyanobacteria
7- 50% cyanobacteria + 25% N.
8- 50% cyanobacteria + 50% N.
9- 50% cyanobacteria + 100% N.
10- 100% cyanobacteria + 25%N.
11- 100% cyanobacteria + 50%N.
12- 100% cyanobacteria + 100%N.

Analytical procedures:

At harvest, maize yield and yield components were recorded. The remained soil was sampled and subjected to determine total count bacteria (Allen, 1959), cyanobacteria count (Allen and Stanier, 1968), CO_2 evolution (Pramer and Schmidt, 1964), dehydrogenase activity (DHA) (Casida *et al.*, 1964) and nitrogenase activity (Hardy *et al.*, 1968). Maize grains quality such as protein%, oil%, and ash % were determined according to the methods outlined in A. A. O. A. C. (1980). While, carbohydrates % in grains were determined as described by Dubios *et al.* (1965).

All obtained data for both tested seasons were tabulated and suLjected to the combined statistical analysis as described by Gomez and Gomez (1984).

RESULTS

The idea of cyanobacteria inoculation in different rates was monitored in two field experiments conducted at private farm in Sakkara, El Badrasheen, Giza, Governorate, Egypt, to investigate its effect of different cyanobacteria inoculation rates in the presence and/or absence of different mineral nitrogen levels on maize yield and yield components, some maize grains technology characters and soil biological activity in terms of total bacteria count, cyanobacteria count CO_2 evolution, dehydrogenase (DHA) and nitrogenase (N-ase) activities.

Maize yield and yield components:

Data in Table (1) indicate the effect of cyanobacteria inoculation in different rates (0, 50 and 100% of the recommended inoculum rate) in the presence and/or absence of different mineral nitrogen levels (0, 25, 50 and 100% of the recommended –N dose) and maize yield components.

Results revealed that all the tested treatments increased significantly both maize yield and yield components over the control treatment. However, the highest yield component values were 27.30 ardab fed^{-1} (grain yield), 2.85 ton fed^{-1} (Stover yield) 37.30g (1000-grain weight), 24.18cm (ear length) and 228.20 g (grain weight era^{-1}) due the treatment received 100% N + 100% cyanobacteria. These high values were not significantly different from those of 26.60 ardab fed^{-1} (grain yield), 2.76 ton fed^{-1} (strove yield), 36.82 g (1000 – grain weight), 24.06 cm (ear length) and 226.14 g (grain weight ear^{-1}) due the treatments received 50% N + 100 % cyanobacteria. Also, it was noticed that the recorded values of maize yield components due to 100% N application were not significantly different from those achieved by both 100% N + 100% cyanobacteria and 50% N + 100% cyanobacteria treatments (Table1).

Inoculation with cyanobacteria at the rate of 50% combined with any of the different nitrogen levels enhanced all tested maize yield components but without reaching the level of significance between each others. In contrast, inoculation with cyanobacteria at the rate of 100% combined with 50% N increased significantly the maize yield components compared to those recorded due to 25% N + 50% cyanobacteria. These results explain that it is more beneficial to inoculate cyanobacteria at the rate of 100% combined with 50% N in maize production.

Table (1): Effect of cyanobacteria inoculation and nitrogen fertilization on maize yield components (Data are a mean of two tested seasons)

Cyanobacteria inoculation rate	Nitrogen level	Grain yield Ardab^{-1}	Stover yield Ton fed^{-1}	100 grain weight (g)	Ear length (cm)	Grain weight g ear^{-1}
Control	Control	5.30	0.80	31.70	17.20	131.60
	25 %	12.82	1.30	33.80	19.15	180.66
	50 %	15.60	1.60	34.00	20.17	189.56
	100 %	26.80	2.90	34.95	22.20	210.95
50 %	Control	7.20	1.20	32.20	18.60	140.16
	25 %	16.10	1.85	35.00	23.16	196.13
	50 %	19.95	2.16	35.60	23.50	200.16
	100 %	21.20	2.80	36.00	23.85	215.85
100 %	Control	9.30	1.82	32.60	18.92	145.18
	25 %	18.16	2.04	36.35	24.00	209.15
	50 %	26.60	2.76	36.82	24.06	226.14
	100 %	27.30	2.85	37.30	24.18	228.20
L.S.D at 0.05	Nitrogen	2.11	0.52	3.12	2.05	30.60
	Treat	2.36	0.61	4.65	2.53	40.01
	Interaction	5.01	0.50	NS	NS	NS

Maize grains technology characters:

Data in Table (2) indicate the effect of cyanobacteria inculcation at different rates and the use of nitrogen fertilization at different levels both individually and/or in combination on some maize grain technology characters, (i.e.), protein %, oil %, carbohydrate % and ash %.

Table (2): Effect of cyanobacteria inoculation and nitrogen fertilization on maize grain technology characters (Data are a mean of two tested seasons)

Cyanobacteria inoculation rate	Nitrogen level	Protein %	Oil %	Carbohydrate %	Ash %
Control	Control	5.00	4.20	63.8	1.16
	25 %	5.69	4.66	66.73	1.22
	50 %	5.32	5.16	65.62	1.23
	100 %	5.51	5.12	65.59	1.40
50 %	Control	11.40	5.08	53.20	1.05
	25 %	13.56	5.37	56.70	1.11
	50 %	11.52	5.21	58.62	1.11
	100 %	11.52	5.34	55.81	1.32
100 %	Control	12.80	5.16	55.70	1.21
	25 %	13.70	5.23	56.44	1.23
	50 %	14.26	5.54	55.58	1.23
	100 %	12.26	5.36	56.41	1.23
L.S.D at 0.05	Nitrogen	0.58	NS	NS	NS
	Treatment	0.85	NS	4.85	NS
	Interaction	NS	NS	NS	NS

Due to protein %, all cyanobacteria inoculation rates increased significantly maize protein % in comparison with the control treatment and/or the treatment received only mineral nitrogen. The highest maize protein % of 14.26 was due to the treatments received 50% N + 100 % cyanobacteria followed by 13.70 % due to the 25 % N + 100 % cyanobacteria treatment and finally 13.56 % (25% N + 50 % cyanobacteria).

For oil %, indefinite trend was noticed due to cyanobacteria inoculation despite it achieved slight increases over both control and the treatment received mineral nitrogen only. However, the highest oil percentages of 5.54, 5.37 and 5.36 were due the treatments of 50% N + 100% cyanobacteria, 25% N + 50% cyanobacteria and 100% N + 100% cyanobacteria, respectively.

Carbohydrate % showed significant decreases due to cyanobacteria inoculation, since it has been dramatically lessened when compared to the control and/or the treatments received mineral nitrogen only. However, the highest carbohydrate % of 66.73 was resulted in response to 25% N treatment.

No significant trend was noticed due to ash % in response to any of cyanobacterial inoculation and/or mineral fertilization both individually and in combination at all rates and levels, respectively. However, the highest ash % of 1.40 was due to 100% N treatment.

Soil biological activity:

Data in Table (3) indicate the soil biological activity for soil remained after maize harvesting in terms of total bacterial count, cyanobacteria count, CO_2 evolution, dehydrogenase (DHA) and nitrogenase (N_2–ase) activities in response to both cyanobacteria inoculation and nitrogen fertilization, both individually or combined together each in different rates.

Due to cyanobacteria count, the highest values were recorded due the treatments received 25% N + 50% cyanobacteria and 25 % N + 100% cyanobacteria. The corresponding count values were 14.7 and 16.6 cfu g $soil^{-1}$ x 10^3. However, inoculation with cyanobacteria generally enhanced the cyanobacteria count over those recorded by the control treatment and/or those received different nitrogen levels only.

Same trend was noticed with the soil total bacterial count, since the highest count of 42.10 cfu g^{-1} soil x 10^6 was due 25% N + 100% cyanobacteria followed by 30.20 cfu g^{-1} soil x 10^6 for 25% N + 50% cyanobacteria. Increasing the nitrogen level up to 100% showed a drastic decrease in the counts of both cyanobacteria and total bacteria count. Also The treatments received nitrogen only were less in total bacteria count than those received nitrogen combined with cyanobacteria inoculation.

Owing to any of CO_2 evolution, DHA and N_2-ase, it was detected that inoculation with cyanobacteria led to increase their values over both control and the treatments received nitrogen only. However, their highest values were 205.00 mg CO_2 100g $soil^{-1}$ h^{-1} (CO_2 evolution), 14.30 mL H_2 g dwt. $soil^{-1}$ (DHA) and 26.15 μmole C_2H_4 g dry weight $soil^{-1}$ (N_2-ase). These values were recorded due to 25%N + 100 % cyanobacteria treatment. Generally, inoculation with cyanobacteria enhanced the biological activity of the soil, and this trend was more pronounced in the treatments received 25% N + 50 % cyanobacteria. Also, it is of worth to note that the use of 100% nitrogen led the soil biological activity to be dramatically decreased against the increase noticed with decreasing nitrogen level accompanied with cyanobacteria inoculation.

Table (3): Effect of cyanobacteria inoculation and nitrogen fertilization on soil biological activity and soil nitrogenase activity (Data are a mean of two tested seasons)

Cyanobacteria rate	N. level	Cyano count cfu g $soil^{-1}$ x10^3	Bact. count cfu g $soil^{-1}$ x10^6	CO_2 evolution mg 100 g $soil^{-1}$	Dehydrogenase activity mL H_2 g $soil^{-1}$ h^{-1}	Nitrogenase activity μmole C_2H_4 g dwt $soil^{-1}$
Control	Control	5.00	16.00	107	15.20	1.20
	25 %	8.60	27.00	145	20.3	1.60
	50 %	7.10	26.00	140	18.85	1.30
	100 %	8.10	24.00	131	16.75	0.92
50 %	Control	9.60	20.80	135	17.75	12.10
	25 %	14.70	30.20	151	22.65	16.20
	50 %	12.00	28.10	141	20.72	15.10
	100 %	6.20	20.10	138	18.10	14.00
100 %	Control	12.00	36.00	170	34.20	17.20
	25 %	16.60	42.10	205	41.30	26.15
	50 %	14.20	40.20	185	36.20	21.30
	100 %	4.30	38.60	180	32.50	17.00

DISCUSSION

Results of this study emphasized that the inoculation with cyanobacteria to maize at the rate of 100% along with 50 % N dose increased both grain and stover yields over the other tested treatments without significant differences from those obtained by the use of full N dose. This trend stands in well agreement with Abd EL- Rasoul *et al.* (2004) who indicated that all yield wheat parameters increased significantly due to cyanobacteria inoculation combined with 50 % N recommended dose. This may due to that the nitrogen released to soil through nitrogen fixed by cyanobacteria inoculated to soil becomes available to the cultivated plants. Moreover, cyanobacteria are known to excrete extra-cellularlly a number of compounds like polysaccharides, peptides, lipids...etc. during their growth in soil, these compounds hold or glue soil particles together in the form of micro-aggregates and hence improve nutrient availability and consequently enhanced the plant growth parameters (Mandal *et al.,* 1999). Dry cyanobacteria surrounded with sheath when inoculated to cereal crops and get moistened due to irrigation and swell up to ten times their dry size and their ability to intercept and store water benefits both the crustal organisms as well as vascular plants, add to soil organic matter content and increased the soil fertility (Mishra and Pabbi, 2004). Recently, there is a great deal of interest in creating novel association between agronimically important plants, particularly cereals such wheat, maize and rice and N_2-fixing microorganisms including cyanobacteria (Spiller *et al.*, 1993). The heterocystous cyanobacterium *Nostoc sp.* is usual among characterized cyanobacteria in its ability to form tight association with cereal crops such as wheat and maize roots and penetrate both roots epidermis and cortical intracellular space (Gantar *et al.*, 1991). The N_2- fixed by *Nostoc* sp. in association with wheat is taken up by the plant and supports its growth, improving grain yields and grain quality (Gantar *et al.,* 1995). Inoculation with the nitrogen fixing *Azospirillum* to wheat as biofertilizer combined with ½ recommended N dose increased significantly grain and straw yields and NPK- uptake by grains and straw, improved the grain quality (protein, dry gluten and flour extract percentages) compared to the control without inoculation (AL- Kassas, 2002). Inoculation with cyanobacteria combined with $^1/_4$ N dose increased significantly both wheat protein and carbohydrate contents over the control treatment without inoculation and the full nitrogen dose treatments (Gaffar and AL-Kassas, 2005).

Shrivastava and Sinha (1992) showed that the biofertilizers such as cyanobacteria inoculated to cereal crops are likely to assume greater significance as complement and /or supplement to chemical fertilizers in improving the nutrient supplies to cereal crops because of high nutrient turn-over in the cereal production system, decreasing cost of fertilizers and greater consciousness on environmental protection. Cyanobacteria have been reported to benefit plants by producing growth promotion substances (the nature of which is said to resemble gibbrillin and auxin), vitamins, amino acids, polypeptides, antibacterial and antifungal substances that exert phytopathogen biocontrol and polymers, especially exopolysaccharides, that improve plant growth and productivity (Zaccaro *et al.*, 2001). Abd El- Rasoul *et al.* (2004) in a field wheat cultivation trial revealed that increasing nitrogen levels from ¼ N to full – N dose increased significantly the carbohydrate wheat grain percentages. They added that cyanobacteria inoculation under different N levels improved wheat grain quality (flour extract percentage, Protein percentage, dry gluten and ash percentage and increased significantly wheat grain carbohydrate percentage over the control treatment without cyanobacteria inoculation. However the highest carbohydrate percentage was due to the treatment inoculated with cyanobacteria + ½ N dose.

Generally inoculation with cyanobacteria increased significantly the soil biological activity in presence or absence of nitrogen over the control treatment with priority of those resulted due to 100% cyanobacteria + 25% N dose treatment. This treatment gave higher values for total cyanobacteria count, total count bacteria, CO_2 evolution, dehydrogenase activity (DHA) and nitrogenase activity compared to the other tested treatments. However, Abd **El- Rasoul *et al.* (2004),** in wheat, **El-Zeky *et al.* (2005)** in rice and both Abo EL- Eyoun (2005) and EL-Gmal (2006) in maize found that inoculation with cyanobacteria combined with low level of nitrogen ($^1/_2$ N dose) increased significantly these biological parameters over the control treatment and their values were comparable to those recorded by the use of the full recommended nitrogen dose. They explained that biofertilization led to increase microorganisms' community in soil through increasing the organic matter, microbial activity and in turn increased dehydrogenase and nitrogenase activities and CO_2 evolution and subsequently improved soil fertility and the plant growth performance. AL- Kassas (2002) reported that Inoculation with the nitrogen fixing *Azospirillum* to wheat increased the soil *Azospirilla* and other microbial population including fungi, actinomycetes and *Azotobacter* , and consequently increased both the dehydrogenase activity and CO_2 evolution, which are considered as index for biological activity and soil fertility (Ghazal, 1980).

In conclusion, this work led to take in consideration much attention for establishing the technology of cyanobacteria inoculation to cereal crops with a view of saving partially some of the expensive and none eco-friendly mineral nitrogen fertilizers. Further studies on the other cereal crops rather than maize need to be carried out for more confirmation.

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التلقيح بالسيانوبكتريا كمصدر نيتروجينى بديل جزئيا للسماد النيتروجينى المعدنى فى انتاج الذرة

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اجريت تجربتين حقليتين بمزرعة خاصة بمنطقة سقارة – البدرشين- محافظة الجيزة وذلك لدراسة أثر التلقيح بالسيانوبكتريا بمعدلات مختلفة منفردة أوبمصاحبة مستويات مختلفة من النيتروجين على محصول الذرة ومكوناته وبعض صفاته التكنولوجية وكذا النشاط البيولوجى فى التربة بعد حصاد الذرة. وقد كانت أهم انتائج ما يلى:-

١- كل المعاملات تحت الدراسة أدت الى زيادة معنوية فى محصول الذرة ومكوناته.

٢- سجلت أعلى قيم لمكونات محصول الذرة استجابة للمعاملة ١٠٠% نيتروجين + ١٠٠% سيانوبكتريا وكانت هذه القيم غير مختلفة معنويا عن تلك المسجلة استجابة للمعاملة ٥٠% نيتروجين + ١٠٠% سيانوبكتريا أو المعاملة ١٠٠% نيتروجين فقط.

٣- سجلت المعاملة ٥٠% نيتروجين + ١٠٠% سيانوبكتريا أعلى نسب مئوية لكل من البروتين والكربوهيدرات فى الذرة.

٤- لم يلاحظ اتجاها معينا بالنسبة لمحتوى الذرة من الزيت استجابة للتلقيح بالسيانوبكتريا بالرغم من الزيادة التى سجلت استجابة للمعاملة ٥٠% نيتروجين + ١٠٠% سيانوبكتريا.

٥- أيضا لم يكن هناك اتجاها معينا لنسبة رماد الذرة المئوية استجابة للتلقيح بالسيانوبكتريا.

٦- بالنسبة للنشاط البيولوجى للتربة فقد لوحظ أن التلقيح بالسيانوبكتريا أدى الى زيادة أعداد كل من السيانوبكتريا والميكروبات الكلية بالتربة وكذا كمية ثانى أكسيد الكربون المتصاعدة ونشاط كل من انزيمى الديهيدروجينيز والنيتروجينيز.

٧- من هذه الدراسة يمكن استنتاج أن استخدام تكنولوجيا التلقيح بالسيانوبكتريا فى انتاج محاصيل الحبوب مثل الذرة يمكن أن يوفر حوالى ٥٠% من النيتروجين المعدنى اللازم لانتاج الذرة مع ضمان بيئة نظيفة. وعلى أى حال فإن استخدام تكنولوجيا التلقيح بالسيانوبكتريا يحتاج الى المزيد من التجارب مع محاصيل الحبوب الأخرى لزيادة التأكد من النتائج.