J. Agric. Sci. Mansoura Univ., 32 (2): 1367 - 1377, 2007

CYANOBACTERIA CAN COMPENSATE A PART OF MIERAL NITROGEN REQUIRED FOR WHEAT PRODUCTION

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ABSTRACT

At present, a great interest in establishing novel associations between higher plants and a variety of N_2-fixing microorganisms has entered the scientific scene arising from the prospects and the possibilities of their potentially application. . In this paper, data presented is obtained during the co-cultivation of local cyanobacteria strains prepared as a biofertilizer (cyanobacterial soil based inoculum, CSBI) for wheat cultivated in sandy soil. Results revealed that cyanobacteria inoculation (CSBI) exhibited an economical view that it can save about 25 % of the mineral nitrogen amounts required for wheat crop production. The trend was noticed when CSBI inoculation was applied at the rate of 3 kg fed^{-1} along with 90 kg N fed^{-1}, which recorded a grain yield not significantly different from that obtained by 120 kg N fed^{-1} the full recommended nitrogen dose. Cyanobacteria inoculated to wheat crop have also improved the fertilizer nitrogen use efficiency and the fertilizer nitrogen utilization percentage. As well as CSBI, generally enhanced the sandy soil biological activity in terms of increasing its total cyanobacteria count, total fungi count, *Actinomycetes* count total bacterial count, CO_2 evolution, dehydrogenase activity as index for the soil fertility and nitrogenase activity. These increases were in comparison with uninoculated plants (control treatment).

INTRODUCTION

The use of the conventional chemical farming methods, which substantially increased crop production, was once regarded as a kind of agriculture revolutions, which would solve all problems relating to producing sufficient food for the ever growing world population. However, this belief was later over-shadowed by the emergence of numerous environmental and social problems associated with the heavy use of agrochemicals in intensive farming systems. The conventional farming methods are generally associated with degradation of the environment. Among other things, soil degradation is one of the most serious problems, which affect crop production. Increasing prices of agrochemicals especially nitrogen often leaves farmers with low profit. Uncertain availability of those agrochemicals, especially in the developing countries such Egypt, is often a serious constraint for the farmers in their attempt to increase crop production. Such problems have directed the attention of the agriculturists world-wide to seek alternative methods of farming.

In attempting to develop productive, profitable and sustainable agriculture systems, several agriculturists turn to modern farming methods, which are based on biotechnologies. One of the several approaches to achieve this goal is using the nitrogen fixing cyanobacteria in order to improve soil fertility and productivity. The use of nitrogen fixing cyanobacteria ensures entirely or partially the mineral nitrogen required for some cereal crops production such as wheat and maize (Tantawy, 2006).

Many microorganisms bear extracellular sheath of considerable thickness external to their outer membrane, providing a protective and favorable microenvironment. These sheaths are usually composed mainly of polysaccharides. In plant-microbe associations, polysaccharide, regardless of whether it is of plant or microbial origin, may enable close contact to take place between both partners that is required for either symbiotic or parasitic relationships. N_2 fixing bacteria are capable of forming symbiotic association with various plants and fungi (Stewart et al., 1982). In infected roots of cycads, the filaments of symbiotic cyanobacteria are confined to intercellular spaces, which contain mucilage (Linbald et al., 1985). The mucilage produced in the glands of *Gunnera* also plays an important role in the infection process by providing a matrix through which hormogonia of *Nostoc* symiont move (Bergman et al., 1992). The cyanobacterial symiont in cavities of *Azolla* appears to be confined within a mucilaginous matrix of plant origin (Braun-Howland and Nierzwicki-Bauer, 1990). All these observations are consistent with the postulation of Rees (1989) that "the symbiotic associations with cyanobacteria may be regarded as natural immobilized cell system". In all other plant-cyanobacteria a symbiosis except *Azolla*, each new plant has to be infected (Vagnoli et al., 1992).This implies the involvement of signal transduction, recognition sites and mechanisms of attachment. However, the extent of the specificity of interactions between cyanobacteria and the partner is uncertain since some cyanobacteria capable of forming functional association are constituent of free living soil microflora (Peters, 1990).

Recently, there is a great deal of interest in creating novel association between agronimically important plants, particularly cereals such wheat 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 wheat 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). 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, wheat, 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, colorant, production of various secondary metabolites including vitamins, toxins, enzymes and pollution abatment. 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.

Abd El- Rasoul *et al.* (2004) indicated that inoculation with cyanobacteria combined with EM (a bacterial mixture) 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, 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, and available NPK in soil.

El-Zeky et al. (2005) in rice and Abo El- Eyoun (2005) in maize found that inoculation with cyanobacteria combined with low level of nitrogen ($^1/_2$ full N dose) increased significantly these 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 cyanobacteria biofertilization led to increase microorganisms' community in soil through increasing the organic matter, microbial activity and in turn increasing dehydrogenase and nitrogenase activities and CO_2 evolution and subsequently improved soil fertility and the plant growth performance.

This work aims to study the effect of cyanobacteria inoculation on wheat productivity, wheat nitrogen uptake, wheat nitrogen attributes as well as on soil biological activity.

MATERIALS AND METHODS

A field experiment was carried out at the Experimental Farm of Agricultural Research Center, Ismailia, Governorate, Egypt, during the winter season of 2005/2006 to study the influence of cyanobacteria inoculation in presence and/ or absence of different nitrogen levels on wheat productivity, wheat nitrogen uptake, wheat nitrogen attributes as well as soil biological activity.

The soil used was sandy in texture, having available N (12.5 mg kg^{-1}), available P (6.1 mg kg^{-1}) and available K (43 mg kg^{-1}) with PH 8.14 and EC 1.2 dSm^{-1}. These characters were determined according to the methods described by Black (1965).

The field was prepared by ploughing and puddling. It was then divided into 21 plots (3 m × 4 m each) representing 7 treatments with three replicates in randomized block design. The treatments consisted of control (no nitrogen), full recommended dose (RD) of the dried cyanobacterial soil based inoculum CSBI (10kg fed^{-1}), nitrogen at the rate 120 kg $Nfed^{-1}$(full N dose), 3kg CSBI fed^{-1} + 90 kg $Nfed^{-1}$, 5kg CSBI fed^{-1}+ 60 kg $Nfed^{-1}$, 6 kg CSBI fed^{-1}+ 60 kg $Nfed^{-1}$and 10kg CSBI fed^{-1}+ 50 kg $Nfed^{-1}$.

The soil based cyanobacteria inoculum is composed of a mixture of nitrogen fixing cyanobacteria strains namely *Anabaena variabilis, Nostoc muscorum, Aulosira fertilissima, Tolypothrix tenuis and Nostoc* sp., which were kindly supplied by the Dept. of Microbiol., Soils, Water & Environ. Res. Inst., Agric. Res. Center, Giza, Egypt.

Wheat seeds variety Giza 168 were sowed on December 15, 2005and were harvested on May 20, 2006. Uniform application of phosphate @ 30 P_2O_5 kg as super- phosphate (15 % P_2O_5) and potassium @ 48 kg as K_2O

were done as basal to each plot. Cyanobacteria inoculation was executed after 40 days from wheat seed sowing. Ammonium sulphate (20.5 % N) nitrogen treatments were applied in two equal doses 10 days after sowing and 35 days later. Irrigation was done using the sprinkler system.

Wheat rhizosphere plants were sampled after 75 days from sowing to determine total cyanobacteria count (Allen and Stanier, 1968), total fungi (Martin, 1950), *Actinomycetes* (Williams and Davis, 1965), total bacterial count (Allen, 1959), CO_2 evolution (Pramer and Schmidt, 1964), dehydrogenase (Casida *et al.*, 1964) activity (DHA) as index for the soil fertility and nitrogenase activity (N_2-ase) (Hardy et al., 1973).

At harvest wheat yield components such as straw yield (kg fed^{-1}) and grain yield (ardab fed^{-1}), 1000-grain weight (g), plant height (cm), number of grains $spike^{-1}$, harvest index in percent $\frac{kg\ grain}{kg\ grain + strawyeild} \times 100$ and biological yield (Straw yield + Grain yield) (Yanni, 1991) as well as nitrogen attributes in terms of total nitrogen uptake (kgN fed^{-1}), fertilizer nitrogen use efficiency, fertilizer nitrogen utilization efficiency were determined by the following equations suggested by Moll et al. (1982):-

N-use efficiency $= \frac{kg\ grain}{kg\ N\ added}$

Fertilizer-N utilization efficiency =kg grain fed^{-1}/total kg N uptake fed^{-1}x 100

The obtained results were subjected t statistical analysis as described by Gomez and Gomez (1982).

RESULTS

Wheat yield components:

Data in Table (1) indicates the effect of cyanobacteria inoculation and / or ammonium-N fertilization each either applied alone at the recommended dose or combined together with different levels on the yield components of wheat crop variety Giza 168.

Results revealed that all the tested treatment increased significantly straw and grain yield over the control treatment except for the grain yield due to the 10 kg CSBI fed^{-1} treatment. The highest grain and straw yields were attained by the use of 120 kg Nfed-1 treatment. The highest straw and grain yields were attained by the use of 120 Kg N fed^{-1} treatments. The corresponding yield amounts were 4340 kg fed^{-1} and 18.41 ardab fed^{-1}, respectively. However, the highest straw and grain yields were not significantly different from those of 4216 kg fed^{-1} and 17.70 ardab fed^{-1} respectively due to 3 kg CSBI + 90 kg N fed^{-1}. Both of 120 kg N fed^{-1} and 3 kg CSBI + 90 kg N fed^{-1} treatments were also significantly higher than the other treatments received different levels of both CSBI inoculum and nitrogen. The inoculation with 10 kg CSBI fed^{-1} (cyanobacteria inoculum) alone slightly raised the straw and grain yields insignificantly over the control treatment (Table 1). These insignificant increases in the wheat straw and grain yields represent 8 and 12% over the control treatment, respectively.

Table (1) Effect of cyanobacteria (CSBI) inoculation and nitrogen fertilization on wheat yields components

Treatments	Straw yield (kg.fed^{-1})	grain yield (ard*.fed^{-1})	Biol. Yield ** (kg.fed^{-1})	1000-grain weight (g)	Plant height (cm)	No. of grains spikes $^{-1}$	Harvest index %
Control	1940	5.90	2825	39.41	80.80	40	31.33
10 kg SBI fed^{-1}	2100	6.70	3105	40.17	81.50	42	33.38
120 kg-N fed^{-1}	4340	18.41	7100	46.58	95.50	58	38.89
3kg SBI fed^{-1} + 90 kg-N fed^{-1}	4216	17.70	6781	45.28	94.20	55	39.15
5kg SBI fed^{-1} + 60 kg-N fed^{-1}	3355	15.22	5638	43.02	93.20	52	40.49
6 kg SBI fed^{-1} + 75 kg-N fed^{-1}	3720	16.23	6155	45.41	94.15	55	39.55
10 kg SBI fed^{-1} + 50kg-N fed^{-1}	2655	12.80	4575	42.12	93.50	53	41.96
L. S. D. < 0.05	349	0.82	433	2.24	5.14	10.00	2.40

*** ard. = Ardab = 150 kg.**
**** Biol. Yield = Biological yield.**

For biological yield, the highest two values of 7100 and 6791 kg fed^{-1} recorded by 120 kg N fed^{-1} and 3 kg CSBI + 90 kg N fed^{-1} treatments were insignificantly different and significantly higher than the other tested treatments.

Due to 1000-grain weight, same as noticed in straw and grain yields was observed, since all applied treatments attained significantly higher 1000-grain weight over both the control and 10 kg CSBI treatments. However, the highest 1000-grain weight of 46.58 g was due to 120 kg fed^{-1} followed by 45.26 g for 3 kg CSBI + 90 kg N fed^{-1} treatment. These two high values were not significantly different from each others.

The plant height of wheat plants exhibited significant increases over the control treatment (80.80 cm) except for 10 kg CSBI fed^{-1} treatment (81.50 cm). The highest plant height measurement (95.50 cm) was due to 120 kg N fed^{-1} treatment. This high plant height value was not significantly different from the other tested treatments.

The number of grains spike^{-1} recorded the highest value of 58 grains spike^{-1} by the use of 120 kg N fed^{-1} treatment. This high number of grain spike^{-1} was not significantly different from those of 55, 52, 55 and 53 grains spike^{-1} due to 3 kg CSBI + 90 kg N fed^{-1} and 5 kg CSBI + 60 kg N fed^{-1}and 10 kg CSBI + 30 kg N fed^{-1}, respectively.

Harvest index percentage fluctuated within a relatively narrow range indicating that its per cent was significantly higher than those of control and 10 kg CSBI treatments. However, the highest harvest index percentage (41.96) was due to 10 kg CSBI fed^{-1}+ 30 kg N fed^{-1} treatment. This high per cent was significantly higher than the other treatments received mixed levels of both nitrogen and CSBI treatments.

Wheat nitrogen attributes:

Nitrogen attributes (Table 2) are explained as amount of nitrogen taken up by wheat crop (straw, grain and total N-uptake), fertilizer N-use efficiency and fertilizer-N utilization efficiency.

Nitrogen uptake amounts for both straw and grains had significantly increased over the control treatments when wheat received both nitrogen and CSBI inoculum either each applied alone or in combination at different levels. The highest N-uptake amount for straw (9.48 kg N fed^{-1}) was attained by 3 kg CSBI fed-1 + 90 kg N fed^{-1}. This high amount was relatively caught significantly level in comparison with all other treatments except for 120 kg N fed^{-1}treatments (8.95 kg N fed^{-1}).

Table (2): Effect of cyanobacteria (CSBI) inoculation and nitrogen fertilization on wheat plants-nitrogen attributes

Treatments	Nitrogen uptake (kg N $fed^{-1)}$)		Total nitrogen uptake (kg N fed^{-1})	N-use efficiency kg grain kg N^{-1} added	Fertilizer utilization efficiency %
	Straw	Grains			
Control	3.24	10.30	13.54	----------	----------
10 kg SBI fed^{-1}	3.90	12.20	16.10	----------	----------
120 kg-N fed^{-1}	8.95	43.20	52.15	23.00	52.92
3kg SBI fed^{-1} + 90 kg-N fed^{-1}	9.48	41.50	50.98	29.50	52.08
5kg SBI fed^{-1} + 60 kg-N fed^{-1}	7.38	35.40	42.78	38.05	53.37
6 kg SBI fed^{-1} + 75 kg-N fed^{-1}	8.14	36.30	44.44	32.47	54.79
10 kg SBI fed^{-1} + 50kg-N fed^{-1}	4.92	35.30	40.22	38.40	47.74
L . S . D . < 0.05	0.66	1.87	2.24	----------	----------

The same attitude showed in nitrogen uptake by straw, was also noticed for nitrogen uptake by wheat grains. Although the highest grain uptake amount of 43.20 kg $Nfed^{-1}$ was recorded due to120 kg N fed^{-1}it did not touch the level of significance when compared with that of 41.5 recorded by 3kg CSBI fed^{-1}+ 90kg N fed^{-1}. Meanwhile, these two values were significantly higher than all other tested treatments including both of control and 10 kg CSBI fed^{-1} treatments.

Due to the total nitrogen up-take amounts by wheat crop, it was observed that all treatment exceeded significantly the N-uptake amount over the control treatment (13.54 kg $Nfed^{-1}$). Again, as noticed with N-uptake by wheat straw and grain, the highest total N-uptake by wheat crop of 52.15 kg N fed^{-1} (120 kg N fed^{-1}) was not significantly higher than that of 50.98 kg N fed^{-1} (3kg CSBI fed^{-1}+ 90kg N fed^{-1}). This attitude led to conclude that the use of 3 kg CSBI fed^{-1}+ 90 kg N fed^{-1} (52.15 kg N fed^{-1}) could economically satisfy the recommended level of nitrogen (120 kg N fed^{-1}).

It is also obvious that increasing nitrogen level added decreased the N-use efficiency as for instance wheat plants treated with 120 kg $Nfed^{-1}$ gave 23.00 kg grain / kg N added while plant received 3 kg CSBI fed^{-1}+ 90 kg N fed^{-1}, 5kg CSBI fed^{-1}1 + 60 kg N $fed^{-1}$and 6kg CSBI fed^{-1}+ 75 kg N fed^{-1} and 10kg CSBI fed^{-1}+ 50 kg N fed^{-1}gave 29.50, 38.05, 32.47 and 38.40 kg grain / kg N added, respectively.

The percentage of fertilizer N utilized by the plants decreased with the increase in the levels of nitrogen application (Table 2). Thus plants fertilized with 6 kg CSBI fed^{-1} + 75 kg $Nfed^{-1}$ recovered applied nitrogen most efficient (84.79%), while 120 kg $Nfed^{-1}$ and 3 kg CSBI fed^{-1}+ 90 kg N fed^{-1} resulted in less recovery of 52.92 and 52.08 %, respectively.

Soil biological activity:

Data in Table (3) indicate the soil biological activity after 75 days from seed wheat sowing in terms of cyanobacteria count, total fungi count, actinomycetes count, total bacteria count, CO_2 evolution, as well as dehydrogenase (DHA) and nitrogenase (N- ase) activities as affected with either individual nitrogen or cyanobacteria inoculation and /or both combined together at different levels.

Generally, all tested soil biological activity parameters under the effect of the tested treatments were higher than those of the control treatment. The treatment of 10 kg CSBI fed^{-1}+ 50 kg N fed^{-1} gave the highest total count numbers of 6.20 x10^3, 17.9 x10^2 12.16 x 10^3 and 17.90 x 10^6 cfu g^{-1}dwt.soil for total cyanobacteria, total fungi, total Actinomycetes and total bacteria, respectively. Also, same trend noticed in prevailing microorganisms was achieved for CO_2, DHA and N-ase activity. The corresponding highest values were 148.62 mg 100 g soil^{-1} (CO_2), 64.95 µg TPF mg 100 g^{-1}dwt.soil day^{-1} and 670.32 mmole C_2H_4 g^{-1}dwt.soil h^{-1}, respectively. However, it was noticed that increasing nitrogen level led to decrease the soil biological activity in terms of the results for the abovementioned tested parameters. Generally, inoculation with cyanobacteria enhanced extremely the biological activity in the poor sandy soil.

Table (3): Effect of cyanobacteria (CSBI) inoculation and nitrogen fertilization on some soil biological characters after 75 days from sowing

Treatments	Cyanobacteria count Cfu g dwt. soil^{-1} x 10^3	Total fungi Cfu g dwt. soil^{-1} x 10^2	Actinomycetes Cfu g dwt. soil^{-1} x 10^3	Total bacteria Cfu g dwt. soil^{-1} x 10^6	CO_2 evolution mg CO_2 100 g soil^{-1}	Dehydrogenase activity (µg TPF 100 g soil^{-1} day^{-1}	Nitrogenase activity mmole C_2H_4 g dwt^{-1} h^{-1}
Control	0.85	9.00	3.20	9.00	77.00	19.20	315.00
10 kg SBI fed^{-1}	1.66	13.20	7.15	13.20	112.00	35.21	430.20
120 kg-N fed^{-1}	0.53	15.31	8.92	15.31	121.20	46.31	500.36
3kg SBI fed^{-1} + 90 kg-N fed^{-1}	3.60	16.80	10.36	16.80	136.11	53.20	570.41
5kg SBI fed^{-1} + 60 kg-N fed^{-1}	4.70	15.46	9.03	15.46	125.20	47.13	516.32
6 kg SBI fed^{-1} + 75 kg-N fed^{-1}	4.30	16.20	9.95	16.23	135.10	51.15	558.11
10 kg SBI fed^{-1} + 50kg-N fed^{-1}	6.20	17.90	12.16	17.90	148.62	64.95	670.32

DISCUSSION

The modern day intensive crop cultivation requires the use of nitrogen fertilizers. However, fertilizers are short supply, expensive and are not eco-friendly. Therefore, it is important to explore the possibility of supplementing nitrogen fertilizer with biofertilizers of microbial origin. Microbial processes are fast and consume relatively less energy than industrial processes. In this study, cyanobacteria as a biofertilizer is used beside nitrogen either each alone or both combined together in different levels in wheat production.

These obtained results are in agreement with those described by Abd-Alla *et al.* (1994) who attributed the increase in wheat growth parameters to the substantial increases of N_2 fixation in soil due to nitrogenase activity released by cyanobacteria inoculation. Consequently, this could explain that when we reduce the recommended nitrogen dose required for wheat cultivation, cyanobacteria could compensate this reduction either it was 25 % reduction (90 kg $Nfed^{-1}$) or 60% reduction (75kg $Nfed^{-1}$) of the nitrogen recommended dose.

They also added that inoculation of wheat with cyanobacteria either alive or killed led to a significant increase in dry- matter accumulation over control treatments.

El-Mancy *et al.* (1997) revealed that cyanobacteria inoculation to rice (CSBI) increased significantly both rice grain and straw yields to the extent of 2.07 and 17.06 % over the control, respectively. Combination treatment of CSBI inoculation along with N and P chemical fertilizers can lead to saving chemical N fertilizer (about 50 %) improving NPK uptake and N and P recovery, reducing the bad effects of the high doses from chemical fertilizers and consequently increasing the possibility for producing high and good rice yield.

Mandal *et al.* (1999) stated that inoculation of rice fields with cyanobacteria (CSBI) might help to regenerate quickly and improve the soil structure. CSBI are known to excrete extracellularly a number of compounds like polysaccharides, peptides, lipids etc. during their growth in soil particles and hold /glue them together in the form of micro-aggregates.

This soil improvement resulted from cyanobacteria inoculation has reflected on soil fertility and consequently on improving the cultivated crop.

Gantar (2000) emphasized the cyanobacteria-wheat association and stated that when wheat seedlings are co-cultivated with *Nostoc sp*. in hydroponics, the cyanobacteria colonizes the endo-rhizosphere at low frequency. He suggested that mild sonication of the roots dramatically increased the number of cyanobacteria within the root tissues. The cyanobacteria penetrated the roots in the form of motile filaments (hormogonia), at once inside, they divided and transformed into aseriate packages, which showed nitrogenase activity. Thus, co-cultivation of wheat with cyanobacteria could partially meet the wheat nitrogen needs.

Due to soil biological activity, many authors emphasized the present obtained results. A build of the soil organic matter due to cyanobacteria inoculation in soil was early claimed by De and Sulaiman (1950). The addition of organic matter to soil resulted from cyanobacteria inoculation explained the increase of soil biological activity due to the increase caused in the soil microbial community (Mandal et al., 1999). They also added that cyanobacteria, like P-solubilizing bacteria, are known to have the ability to mobilize bound phosphate. They have been shown to solubilise insoluble $(Ca)_3 (PO_4)_2$, which let the soluble phosphorus (the energy source of the soil microorganisms) to be available in soil. As well as, cyanobacteria are photosynthetic organisms, in the medium of their growth; they release a lot of

O_2 during photosynthesis. This oxygen encourages the aerobic to increase their proliferation, which in turn increase the biological activity for the soil. These processes led to raise the enzyme activities and CO_2 evolution amount in soil especially in the rhizosphere area. EL-Zeky et al. (2005) in wheat and Tantawy (2006) in maize supported the obtained results in the present work with their findings, which revealed that *Azotobacter* and cyanobacteria inoculation both individually or in combination in presence and absence of different levels of nitrogen increased both *Azotobacter* and cyanobacteria counts and CO_2 evolution amount, dehydrogenase and nitrogenase activities in rhizosphere area. They explained that both *Azotobacter* and cyanobacteria not only fix atmospheric nitrogen but also the released secondary metabolites into soil, such as polysaccharides, peptides, lipids, amino acids , vitamins and growth promoting like substances, which in turn enhance the soil microbial community, soil enzymatic activities and CO_2 evolution.

Generally, cyanobacterial fertilizers are a promising alternative to avoid soil pollution caused by agrochemicals and recover the nutrient content and soil structure lost after as they bring to soil combined nitrogen (some of them are N- fixers and secrete exoploysaccharide that improve soil structure and bio-active substances that enhance the plant growth.

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السيانوبكتريا يمكنها تعويض جزء من النيتروجين المعدنى المطلوب لانتاج القمح

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لقد أعطى فى الوقت الحاضر الكثير من الاهتمام لمصاحبة الكائنات الدقيقة المثبتة لنيتروجين الهواء الجوى للنباتات الراقية حيث احتل هذا الاهتمام مسرح الاحداث العلمية انطلاقا من نجاح هذة العلاقة وكذلك امكانية استخدامها بكفاءة. ولذلك قد أجريت تجربة حقلية لتقييم امكانية استخدام لقاح السيانوبكتريا كسماد حيوى نيتروجينى ليسد جزء من احتياجات القمح النيتروجينية والمنزرع فى اللأراضى الرملية. فى هذة الدراسة كانت النتائج المتحصل عليها من مصاحبة سلالات من السيانوبكتريا المعدة كسماد حيوى فى صورة لقاح محمل على التربة لنبات القمح والتى أوضحت أن التلقيح بالسيانو بكتريا أظهر ناحية اقتصادية حيث أمكن توفير حوالى 25 % من السماد النيتروجينى الذى يحتاجة انتاج محصول القمح . وهذا التوفير كان أكثر وضوحا عند استخدام لقاح السيانوبكتريا بمعدل 3 كجم/ هكتار بالاضافة الى 90 كجم نيتروجين / فدان حيث أعطى محصولا لايختلف معنويا عن ذلك المتحصل عليه باستخدام كمية النيتروجين الموصى بها (120 كجم نيتروجين / فدان) لنبات القمح. كما أدى التلقيح بالسيانوبكتريا الى تحسين كل من كفاءة استخدام السماد النيتروجينى والنسبة المئوية للنيتروجين المستعمل. وكذلك أدى التلقيح بالسيانوبكتريا الى تحسن النشاط البيولوجى للتربة الرملية , وقد اتضح ذلك فى صورة زيادة كل من اعداد خلايا السينوبكتريا- الفطريات- الأكتينوميسيتس-البكتريا –كمية ثانى أكسيد الكربون المتصاعدة- نشاط كل من انزيمى الديهيدروجينيز والنيتروجينيز وذلك بالمقارنة مع المعاملة الغير ملقحة بالسيانوبكتريا(معاملة المفارنة).

J. Agric. Sci. Mansoura Univ., 32 (2): 1367 - 1377, 2007

1368 1369 1370 1371 1372 1373 1374 1375 1376 1377

1368 1369 1370 1371 1372 1373 1374 1375 1376 1377