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USING OF CYANOBACTERIA OR *AZOLLA* AS ALTERNATIVE SOURCES OF NITROGEN FOR RICE PRODUCTION

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ABSTRACT

Two field experiments were carried out at EL- Serw Agricultural Research Station (ARC) Damietta Governorate, in two successive summer Seasons of 2002 and 2003. These experiments were done to evaluate the efficiency of both cyanobacteria and *Azolla* as nitrogen source sharing mineral nitrogen fertilizer in rice production, in comparison with the use of the full recommended nitrogen dose (60 kg N fed^{-1}). Results reveal that *Azolla* inoculated to rice was superior than cyanobacteria. Increasing nitrogen level up to 60 kg N fed^{-1} increased significantly rice grain and straw yields. The combination of either cyanobacteria or *Azolla* with mineral nitrogen was more beneficial than the use of mineral nitrogen alone. Forty kg N fed^{-1} gained rice yield not significantly different from that attained due to 60 kg N fed^{-1}. Same treatment lead to increases in N-uptake for grain and straw, Soil biological activity which is represented by soil total bacterial count, total fungi, total actinomycetes, dehydrogenase activity and carbon dioxide evolution. Generally, both cyanobacteria and *Azolla* can Partially substitute nitrogen in rice cultivation with priority to *Azolla*, saving the high cost of mineral nitrogen fertilizer by about 60 % and reduced the hazards resulted from the extensive use of mineral nitrogen fertilizers.

INTRODUCTION

Application of high input technologies has resulted in significant increase in agricultural productivity. There is, however, a growing concern about the adverse effects of indiscriminate use of chemical fertilizers on soil fertility. Cyanobacteria either in free living or in symbiotic form (*Azolla*) offer an economically and ecologically sound alternative to chemical fertilizers for realizing the ultimate goal of increased productivity, especially in rice cultivation. In a wetland rice ecosystem, nitrogen fixation by the free living and/or symbiotic cyanobacteria also significantly supplements soil nitrogen. Mishra and Pabbi, (2004) noted that cyanobacteria also called blue green algae evolved very early in the history of life and share some of the characteristics of the gliding bacteria on hand and those of higher plants on the other. Cyanobacteria can both, photosynthesize and fix atmospheric nitrogen, and these abilities, together with great adaptability to various soil types, make them ubiquitous. Cyanobacteria also have a unique potential to contribute a variety of agricultural and ecological situations especially in rice paddy fields. However, the continuous use of chemical fertilizers inflicted deleterious effects on soil organic matter reserves, thereby creating further deficiency in soil nitrogen. That is why global attention has been drawn to find out the alternatives and supplements to chemical nitrogenous fertilizers. In rice fields the addition of cyanobacteria and/or *Azolla* could be priority to address this problem.

Azolla is a small aquatic fern harbors the nitrogen fixing cyanobacterium *Anabaena azollae*, as a symbiont in a cavity located on its upper green leaf. The *Anabaena* in the plant apex is undifferentiated and activity divides among the leaf primordial, but lacks a nitrogen fixing ability (Hill, 1977). At the leaf matures, *Anabaena* increases its number and heterocyst frequency and becomes able to fix the atmospheric nitrogen and supplies the fixed nitrogen to the fern (Maejima *et al.*, 2002).

The role of cyanobacteria and *Azolla* in supplying N to rice fields is well documented. Some workers found that inoculating rice fields with cyanobacteria and/or *Azolla* combined with $^2/_3$ full nitrogen dose, increased significantly rice yield compared to the use of full nitrogen dose (Mandal *et al.*, 1999 and Herzalla *et al.*, 2002). Hammad *et al.*, (1997) concluded that introducing cyanobacteria combined with N and P chemical fertilizers to rice crop gave the chance for saving (about 50% of required N and P) helping to face their expensive prices nowadays, raising the harvest index under low level of N, increasing N and P use efficiency, saving biofertilizers for irrigated rice cultivation., saving the environment from the pollution by high concentration of chemical nitrogen fertilizers and subsequently producing a satisfactory and good rice yield. Hossain *et al.*, (2001) reported that the use of *Azolla* grown as dual with rice could fulfill the entire requirements of nitrogen for rice. *Azolla* incorporated into rice fields increased significantly rice uptake of N, P and S.

Furthermore, in addition to the role of cyanobacteria and *Azolla* in supplying N to rice fields, they also bring about, directly or indirectly, a number of changes in the physical, chemical and biological properties of the soil and soil water interface in rice fields. For example, cyanobacteria liberate extracellular polysaccharides and /or organic compounds and photosynthetic O_2 during their growth, while *Azolla* prevent a rise in the pH, reduce water temperature, curb NH_3 volatilization and suppress weeds; and both of them contribute biomass. On decomposing, they influence the redox activity and result in the formation of different organic acids in soil. All such changes brought about by cyanobacteria and *Azolla* in soil may ultimately influence positively the plant-available nutrients and also soil characteristics (Mandal *et al.*, 1999). They also noted that in addition to liberation of O_2 by cyanobacteria and *Azolla* in rice fields, they release carbonaceous metabolites, soil enzyme activities, CO_2 and in turn increasing the soil fertility leading to good yield and better nutrients plant uptake.

This work is an attempt to evaluate the effect of cyanobacteria and/or *Azolla* each individually or in combination with different N-levels on rice yield components, N- uptake and soil biological activity after rice harvesting (Dehydrogenase activity, CO_2 evolution and microbial count).

MATERIALS AND METHODS

Two field trails were carried out during the two successive seasons of (2002 – 2003) at El Serw Agricultural Research Station (Damietta Governorate) to study the effect of inoculation with both cyanobacteria and/or *Azolla* in presence of different levels of N fertilizer, on rice yield and its components in addition to nitrogen uptake of grain and straw yields.

The soil of experimental plots was clayey with pH 8.2, organic matter 0.84%, total nitrogen 0.042%, available N 39 ppm, available P 9.1ppm and available K 542 ppm. The soil analyses were done according to (Black, 1965).

A split- plot design with four replicates was used. The main plots were arranged to study the nitrogen fertilization levels (20, 40, and 60 kg N fed^{-1}), while the sub-plots were assigned to the biofertilizer inoculation treatments namely control without inoculation, inoculation with cyanobacteria and inoculation with *Azolla*.

Nurseries were established using Giza 178 rice variety in both tested seasons of experimentation. The establishment of nurseries were on May, 6^{th} 2002 and May, 13^{th} 2003), while transplanting was done on June, 11^{th} 2002 and June 17^{th} 2003). All plots received the same uniform amount of P_2O_5 as super-phosphate (15% P_2O_5) at the rate of 100 kg N fed^{-1} before transplanting.

Azolla was used as fresh *Azolla* incorporated into the soil by labors feet in parallel with rice seedlings transplanting, while cyanobacteria were inoculated 7 days after transplanting using dry soil based inoculum of mixed cyanobacteria strains viz. *Anabaena oryzae, Nostoc muscorum, Tolypothrix tenuis* and *clyndrospermum muscicola*. Nitrogen fertilizer in the form of ammonium sulphate (20% N) at the tested rates was added in two equal split doses, the first addition was at transplanting to activate biofertilizer, while the second addition was added one month later.

At harvest, rice yield and its components (Plant height, number of productive tillers, panicle length, panicle weight, 1000 grain weight, grain and straw yield) were recorded.

Nitrogen content of grain and straw were determined using Micro Kjeldahl technique.

Nitrogen uptake of both grain and straw were calculated as (kg N fed^{-1}) by multiplying nitrogen percentage by the dry weight of both grain and straw yields per fed.

The remained soil after rice harvesting was exposed for total bacteria count (Allen, 1959), total fungi count (Martin, 1950), Actinomycetes count (Williams and Davis, 1965), CO_2 evolution (Pramer and Chmidt, 1964) and dehydrogenase activity (Casida *et al.*, 1964).

All data were tabulated and subjected to statistical analysis according to (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Effect of cyanobacteria, *Azolla* inoculation and nitrogen fertilization on rice yield components and N-uptake by grain and straw:

Data in Table (1) indicate the effect of nitrogen fertilizer levels, Cyanobacteria and *Azolla* inoculation on rice yield components.

Due to nitrogen levels, obviously both 40 kg N and 60 kg N fed^{-1} increased significantly all tested rice yield components compared to 20 kg N fed^{-1} level. However, the highest recorded values of rice yield components were 99.40 cm (plant highest), 20.27 (number of productive tillers), 21.10 cm (panicle length), 3.10 g (panicle weight), 22.91 (1000 grain weight), 3.88 tones fed^{-1} (grain yield) and 4.43 tones fed^{-1} for straw yield. These recorded values were achieved by applying 60 kg N fed^{-1} and were significantly higher than those recorded by applying any of 20 or 40 kg N fed^{-1}.

Table (1): **Rice yield and its components as affected by nitrogen fertilization and cyanobacteria or *Azolla* inoculation (Data are a mean of two seasons)**

Treatments	Plant height (cm)	NO. of productive tillers	Panicle Length (cm)	Panicle weight (g)	1000 Grain weight (g)	Grain Yield ton fed^{1}	Straw yield ton fed^{1}
N-rates (A)							
20 kg N fed^{-1}	95.20	17.58	19.01	2.13	21.56	3.18	4.10
40 kg N ed^{-1}	96.90	18.89	19.48	2.57	22.59	3.52	4.32
60 kg N fed^{-1}	99.40	20.27	21.10	3.10	22.91	3.88	4.43
F Test	**	**	**	**	**	**	**
L.S.D. 0.05	1.68	0.79	0.47	0.11	0.45	0.06	0.07
Inoculation type (B)							
Cont.	93.59	18.02	19.10	2.34	21.51	3.19	4.16
Cyano.	97.88	19.17	20.17	2.66	22.61	3.57	4.27
Azolla	100.10	19.43	20.73	2.79	22.93	3.61	4.41
F Test	*	*	*	*	*	**	*
L.S.D 0.05	2.20	0.11	0.53	0.13	0.63	0.05	0.09
AXB							
F Test	N.S	N.S	N.S	*	*	*	N.S
L.S.D. 0.05	-	-	-	-	-	-	-

Both cyanobacteria and *Azolla* inoculation increased significantly all tested rice yield components. The highest values of rice yield components were recorded by the treatment inoculated with *Azolla* rather than those obtained by Cyanobacteria inoculation. The corresponding higher significant values were 100.10 cm (plant height), 19.43 (number of productive tillers) , 20.73. cm (panicle length) 2.79 g (panicle weight) , 22.93 g (1000 grain weight) , 3.61 tones fed-1 (grain yield) and 4.41 tones fed-1 for straw yield . In this respect, Singh *et al.,* (1988) explained that this behavior may due to that the unavailability of nitrogen from cyanobacteria blooms developed at later growth stage of rice crop, indicating lower nitrogen uptake by rice as a result of poor N- use efficiency. While , in case of *Azolla* inoculation , fresh *Azolla* is characterized by its early high mineralization rate when incorporated into soil at rice seedling transplanting , which , in turn exhibited higher N-availability to rice crop and rice N- use efficiency , which in turn produced higher yield than cyanobacteria inoculation (Mussa and Ghazal, 2002). However, it is of worth mention that the level of significance achieved by biofertilizer inoculation was less than those recorded due to nitrogen fertilization. Nevertheless, both treatments that received cyanobacteria and/or *Azolla* inoculation, relatively gave significantly higher rice yield components than those recorded by the control treatment without inoculation.

Data in Table (2) revealed a positive significant interaction effect due to nitrogen levels and cyanobacteria or *Azolla* on panicle weight, 1000 grain weight and grain yield. Data exhibit a significant positive interaction effect on panicle weight, 1000 grain weight and grain yield parameters. All combination between the tested nitrogen levels and cyanobacteria or *Azolla* inoculation gave significantly higher values for these parameters compared to the control treatments. The highest significant interaction values are due to *Azolla* inoculation rather than cyanobacteria inoculation. The combination of 40 kg N fed^{-1} with *Azolla* inoculation gave significantly the highest values of 3.81 g (panicle weight) , 23.95 g (1000 grain weight) and 3.95 tones fed^{-1} for grain yield compared to other values obtained by the combination of the other tested nitrogen levels combined with either cyanobacteria or *Azolla* inoculation. However, cyanobacteria inoculation combined with 40 kg N fed^{-1} recorded higher values of these parameters than those observed in case of the combination of 20 or 60 kg Nfed^{-1} with cyanobacteria inoculation (Table 2). Similar results were obtained by Mandal *et al.,* (1999) and Herzalla *at al.,* (2002). They found that inoculation of rice fields with cyanobacteria and/or *Azolla* combined with 2/3 full nitrogen dose increased significantly rice yield compared to the use of full nitrogen dose.

Nevertheless, it is of importance to note that *Azolla* inoculation combined with 40 kg N fed^{-1} was significantly superior to cyanobacteria accompanied with 40 kg N fed in affecting these parameters. On the other hand , it is worth mention that inoculation with *Azolla* combined with 40 kg N fed^{-1} rather than cyanobacteria can be recommended as nitrogen saver and environmental safer from the extensive mineral nitrogen application.

Table (2): The interaction effect between inoculation with *Azolla* or Cyanobacteria and Nitrogen fertilization on rice yield and its components (Data are a mean of two seasons)

N. level / Inoculation	Panicle weight (g)			1000 grain weight (g)			Grain yield ton fed^{-1}		
	20 kg N fed^{-1}	40 kg N fed^{-1}	60 kg N fed^{-1}	20 kg N fed^{-1}	40 kg N fed^{-1}	60 kg N fed^{-1}	20 kg N fed^{-1}	40 kg N fed^{-1}	60 kg N fed^{-1}
Control	2.02	2.30	2.71	20.19	21.99	22.36	2.59	3.25	3.36
Cyanobacteria	2.17	3.58	3.17	22.08	22.82	22.98	3.22	3.75	3.69
Azolla	2.21	3.81	3.38	22.48	23.95	23.36	3.35	3.95	3.88
F. Test		*			*			*	
L.S.D. 0.05		0.12			0.52			0.05	

N-uptake by grain and straw:

Data in Table (3) indicate the effect of nitrogen fertilization and cyanobacteria and *Azolla* inoculation on both nitrogen percent and nitrogen uptake for rice grain and straw. Increasing nitrogen level from 20 to 60 kg N fed^{-1} increased significantly both N % and N-uptake for rice grain and straw. The highest N % and N-uptake values were 1.33, 0.61 and 48.53 and 27.48 kg N fed^{-1} in respective to rice grain and straw. However, the highest N-percentage and N-uptake values were achieved due to 60 kg N fed^{-1}

treatment which gave significantly higher percentage values compared to other N treatments.

Table (3): Nitrogen content and uptake of rice grain and straw yield as affected by nitrogen fertilization and cyanobacteria or *Azolla* inoculation (Data are a mean of two seasons)

Treatments	Nitrogen % of grain	Nitrogen Uptake of grain (kg N fed^{-1})	Nitrogen % of Straw	Nitrogen uptake of Straw (kg N fed^{-1})
N-rates (A)				
20 kg N fed^{-1}	1.12	36.71	0.52	20.30
40 kg N fed^{-1}	1.29	45.37	0.57	24.63
60 kg N fed^{-1}	1.33	48.53	0.61	27.48
F Test	**	*	*	*
L S.D at 0.05	0.03	2.41	0.03	1.85
Inoculation (B)				
Cont.	1.24	38.28	0.53	22.04
Cyano.	1.28	46.01	0.57	24.48
Azolla	1.30	48.97	0.59	26.89
F Test	**	*	*	*
L.S.D at 0.05	0.01	2.97	0.02	1.74
AXB				
F Test	N.S	N.S	N.S	N.S
L.S.D at 0.05	-	-	-	-

Owing cyanobacteria and *Azolla* inoculation, data in Table (3) revealed that they cause positive significant increases in both N % and N-uptake for both rice grain and straw compared to the control treatment. The highest nitrogen percentages and nitrogen uptake values for both rice grain and straw were achieved in response to *Azolla* inoculation treatments. Hossain *et al.*, (2002) reported that *Azolla* incorporated into rice fields increased significantly rice uptake of nitrogen. The corresponding nitrogen percentages were 1.30 (straw) and 0.59 (grain), while nitrogen uptake values were 48.97 kg N fed^{-1} (straw) and 26.89 kg N fed^{-1} (grain). These obtained results due *Azolla* inoculation were significantly than those recorded by cyanobacteria inoculation except for nitrogen percent in straw. The results are in accordance with those obtained by (Ghazal *et al.*, 1997 and Abd El-Rasoul *et al.*, 2004) who stated that *Azolla* inoculation was more beneficial than cyanobacteria inoculation especially in rice cultivation. *Azolla* incorporated at rice transplanting mineralized fastly and 75% of its nitrogen becomes available to rice plants within one week, while cyanobacteria tended to for blooms initially and after their death long time later release their fixed nitrogen at probably late stage of rice growth. Moreover, the incorporation of *Azolla* into to soil suddenly increased the C: N ratio of the soil favoring microbial proliferation and the subsequent immobilization of available nitrogen. The mineralization released significant amount of nitrogen within 6-8 weeks because of decay of added *Azolla*. Consequently, *Azolla* gave its nitrogen by gradual mineralization which decreases the loss of nitrogen by leaching volatilization or denitrification (Mussa *et al.*, 2003). In Burma, On the contrary, Mya and Tun, (1981) postulated that cyanobacteria biofertilizer is more suitable than *Azolla* in rice cultivation, since it is needed in small quantity and it could be multiplied in simple open air culture at very low cost. While, *Azolla* which is needed in large quantity does not grow abundantly in the dry zone of Burma and no time could be spared for the cultivation in the field prior to transplantation of rice seedlings.

Nevertheless, no significant effects were detected due to the interaction resulted from the combination between both nitrogen levels fertilization and *Azolla* or cyanobacteria inoculation (Table 3). The current data revealed that 40 kg N fed^{-1} combined with either cyanobacteria or *Azolla* inoculation gave significantly higher plant height and grain yield than those obtained by the use of 60 kg N fed^{-1}. Herzalla *et al*, (2002), revealed that *Azolla* inoculation combined with 40 kg N fed^{-1} was superior than the use of 60 kg N fed^{-1} indicating that 40 kg N fed^{-1} plus *Azolla* was more beneficial for rice grain and straw. However, they added that at higher levels of nitrogen, most of the nitrogen probably is subjected to leaching, volatilization and denitrification. With increasing nitrogen, the available form of nitrogen will increase and becomes highly susceptible to leaching, volatilization and losses. Furthermore, plants at higher levels of nitrogen may not take more than their requirements, because they were satisfied with optimum level of nitrogen (Ghazal *et al.*, 1997).

Soil microorganisms:

Data in Tables (4 & 5) indicate the effect of cyanobacteria or *Azolla* inoculation to rice under different nitrogen levels on total microorganisms count, dehydrogenase activity and CO_2 evolution in soil after rice harvesting.

The number of total bacteria, total fungi and total actinomycetes show a positive significant response to both cyanobacteria and *Azolla* inoculation. On the other hand, increasing nitrogen levels from 20 kg N fed^{-1} up to 60 kg N fed^{-1} slightly increased the total bacterial count and total fungal count compared with those recorded by 40 kg $Nfed^{-1}$ treatment (Table 4). While increasing nitrogen level increased significantly the total actinomycetes count only.

The highest bacterial, fungal and actinomycetes counts were recorded in response to *Azolla* inoculation combined with 40 kg N fed^{-1} .The corresponding count numbers were 54.62 x 10^4 (bacteria), 83.34 x 10^2 (fungi) and 155.33 x 10^3 (actinomycetes). Inoculation with $^1/_4$ recommended N dose beside cyanobacteria inoculation in wheat cultivation significantly increased the total count of bacteria ,fungi, *Azotobacter*, nitrogen fixing bacteria and actinomycetes (Abd El-Rasoul *et al.*, 2004). Furthermore, Rao and Burns, (1990) previously stated that beside fixing atmospheric N_2, cyanobacteria produce vitamins and plant growth stimulation hormones, excrete polysaccharides thereby improving soil aggregation, stimulate some beneficial soil microorganism which improve soil organic matter and consequently increased the soil microorganisms number. (Mandal *et al.*, 1999) reported a significant increase in the organic carbon content in soil due to successive *Azolla* cropping with rice plants which in turn increased soil fertility through enhancing the growth and biomass of soil microorganisms.

Table (4): Effect of cyanobacteria, *Azolla* inoculation and N-fertilization on soil microorganisms count (Data are a mean of two seasons)

N-fertilization (Kg N fed^{-1})	Treatments			Means
	Control	cyanobacteria	Azolla	
	Total bacteria cfu g^{-1} soil x10^{4}			
20	7.57	36.33	51.51	31.80
40	60.60	38.55	54.62	36.59
6C	12.52	35.33	50.00	32.62
Means	12.23	36.74	52.04	
L.S.D at 5%				
N	1.87			
Inoculation	2.10			
Interaction	3.60			
	Total Actinomycetes cfu g^{-1} soil x 10^{3}			
20	86.33	106.67	109.67	99.56
40	109.67	132.67	155.33	129.57
60	86.67	109.67	130.00	108.78
Means	92.89	113.37	131.67	
L.S.D at 5%				
N	24.90			
Inoculation	20.01			
Interaction	16.10			

Table (5): Effect of cyanobacteria, *Azolla* inoculation and N-fertilization on soil dehydrogenase activity and CO_2 evolution (Data are a mean of two seasons)

N-fertilization (Kg N fed^{-1})	Treatments			Means
	Control	cyanobacteria	Azolla	
	Dehydrogenase activity (mg TPF 100 g^{-1} soil)			
20	95.25	122.67	145.75	121.22
40	102.95	183.25	200.21	162.14
60	112.65	151.10	168.21	154.70
Means	103.62	163.06	171.39	
L.S.D. at 5%				
N	5.30			
Inoculation	4.85			
Interaction	9.29			
	CO_2 evolution (mg CO_2 100 g^{-1} soil)			
20	210.75	325.00	457.50	331.08
40	321.75	479.50	510.75	437.17
60	288.13	466.75	462.00	405.63
Means				
L.S.D. at 5%				
N	7.35			
Inoculation	11.78			
Interaction	19.72			

Soil Dehydogenase activity and CO_2 evolution

In concern with dehydrogenase activity (DHA) and CO_2 evolution of soil remained after rice harvesting data in Table (5) indicated that inoculation with either cyanobacteria or *Azolla* increased significantly both DHA and CO_2 evolution.

However, the values recorded in response to *Azolla* inoculation were significantly higher than those due to cyanobacteria inoculation. The highest DHA value of 200 mg TPF 100 g^{-1} soil was attained by 40kg N fed^{-1} plus *Azolla* inoculation followed by 183.25 mg TPF 100g^{-1}soil for 40kg N fed^{-1} combined with cyanobacteria inoculation. Same trend was achieved due to CO_2 evolution, since the highest value of 510.25 mg CO_2 100 g^{-1} soil followed by 479.50 mg CO_2 100 g^{-1} soil were gained by 40kg N fed^{-1} plus *Azolla* inoculation and 40kg N fed^{-1} combined with cyanobacteria inoculation, respectively.

Abd El-Rasoul *et al.*, (2004) reported that wheat inoculation with cyanobacteria combined with $^1/_4$ recommended N dose led to increased both soil DHA activity and CO_2 evolution after wheat harvesting. They explained that inoculation with cyanobacteria increased the soil microbial biomass which in turn increased both DHA activity and CO_2 evolution due to the massive respiration process due these increased microorganisms.

Generally, it could be concluded that application of *Azolla* and cyanobacteria technology in rice production gave the chance for saving the costly chemical N fertilizer (about 30%) with priority to *Azolla* inoculation which lead to decrease nitrogen losses more than cyanobacteria, increased n-use efficiency, saving the form pollution with the high concentration of chemical nitrogen with fertilizers and consequently producing a satisfactory and good rice yield.

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السيانوبكتريا أو الأزولا كمصدر بديل للنيتروجين في إنتاج الأرز

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معهد بحوث الأراضي والمياه والبيئة – مركز البحوث الزراعية – الجيزة – مصر

أجريت تجربتان حقليتان بمحطة بحوث السرو بمحافظة دمياط – مركز البحوث الزراعية على محصول الأرز في صيف موسمي ٢٠٠٢ -٢٠٠٣ وذلك لدراسة أثر التسميد الحيوى بالسيانوبكتريا والأزولا في ووجود مستويات مختلفة من النيتروجين (٢٠ و ٤٠و٦٠ كجم نيترجين / فدان) وذلك بالمقارنة مع التسميد بالمعدل الموصى به من النيتروجين لمحصول الأرز (٦٠كجم ن للفدان) على المحصول ومكوناته ومحتواه من النيتروجين وكذلك النشاط البيولوجى في التربة بعد حصاد الأرز متمثلا في أعداد الميكروبات بالتربة ونشاط انزيم الديهيدروجينيز وكمية ثاني أكسيد الكربون المتصاعد. هذا وقد أوضحت النتائج ما يلي:-

١- أدى التسميد النيتروجيني بالمعدل الموصى به (٦٠كجم ن للفدان) الى زيادة كل من محصولي الحبوب والقش وكذلك المحتوى النيتروجيني لهما وذلك بالنسبة لمعاملة المقارنة.
٢- كان التلقيح بالسيانوبكتريا والأزولا في وجود جزء من النيتروجين الموصى به أفضل من التسميد النيتروجيني الكامل. وقد تفوق التلقيح بالأزولا على التلقيح بالسيانوبكتريا.
٣- أعطى التسميد بـ ٤٠كجم ن للفدان مع التلقيح بكل من بالسيانوبكتريا والأزولا محصولا غير مختلف معنويا عن ذلك المتحصل عليه عند التسميد بـ ٦٠كجم ن للفدان.
٤- أدى التسميد بـ ٤٠كجم ن للفدان مع التلقيح بكل من بالسيانوبكتريا والأزولا الى زيادة المحتوى النيتروجيني لكل من الحبوب والقش وكذا النشاط البيولوجي بالتربة بعد حصاد الأرز متمثلا في زيادة كل من أعداد الميكروبات بالتربة ونشاط انزيم الديهيدروجينيز وكمية ثاني أكسيد الكربون المتصاعد وذلك بالمقارنة مع المعاملات الأخرى تحت الدراسة.
٥- أوضحت الدراسة بصفة عامة بأن التلقيح بأى من السيانوبكتريا أوالأزولا فى زراعة الأرز يمكن أن يوفر ولو جزء من السماد النيترجيني الذي يحتاجه الأرز والذي يمثل حوالي ٣٠% من الكمية وبالتالي ٣٠% من الثمن وكما أنه يقلل أيضا من التلوث البيئى الناتج عن الاستخدام المكثف للأسمدة النيتروجينية الكيميائية.