Journal of Agricultural Chemistry and Biotechnology

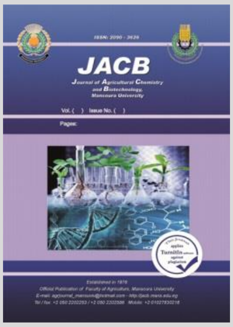
Journal homepage & Available online at: www.jacb.journals.ekb.eg

Effect of Blue-Green Algae in Soils with Different Texture: (a) on Enhancement Growth and Yield of Wheat Plant

Aida H. Afify[1*]; Mohamed H. Sheta[2] and Aml S. Elzallal[1]

[1] Microbiol. Dept., Fac. Agric., Mansoura Univ., Mansoura, Egypt
[2] Soils and Water Department, Faculty of Agriculture, Al-Azhar University, Cairo, Egypt

Cross Mark



ABSTRACT

Blue-green algae (cyanobacteria) can play an important role in fixing atmospheric nitrogen and it supplies plants with nitrogen they need in the soil. The blue-green algae were selected as a biofertilizer for the wheat plant. A pot experiment was carried out at the Agriculture Faculty, Al-Azhar University, Cairo, Egypt, in 2021 to investigate the growth and yield of wheat by using cyanobacteria strains with two types of soil. These cyanobacteria strains were isolated and identified as *Nostoc lichenoides*, *Nostoc indistinguendun* and *Nostoc favosum* and their inoculants were added individually and in a mixture. Sandy and clay loam soil textures were used, using four inorganic nitrogen levels (0, 20, 40 and 60 % N) was used from recommended dose (70 kg N fed^{-1}). Generally, data introduced that the highest significant increase in plant height, spikes number, spikes dry weight, grains weight and 1000-grain weight with 40 to 60% levels inorganic nitrogen when used in clay loam soil and mixture from cyanobacterial inoculants treatment. From these results, the blue-green algae have reduced the use of chemical fertilizers for nitrogen application from 40 to 60% compared with recommended doses of nitrogen.

***Keywords*:** Cyanobacterial strains, growth, yield, wheat.

INTRODUCTION

Wheat is one of the most important cereal crops in Egypt and the world. Also, it is the most important source of stable food in urban and rural societies for human nutrition (Gerba *et al.*, 2013). In the soil, cyanobacteria have several functions including fixing nitrogen, carbon and generating exopolysaccharides when used as inoculants, which improve soil fertility and structure (Shatta *et al.*, 2014). Gantar *et al.* (1991) studied the colonization by N_2-fixing cyanobacteria of a wheat. It is suggested that *Nostoc* 259B releases nitrogenous compounds into growth medium, which crops can take. Consequently, less N-fertilizer might be required. The increase in growth parameters was attributed to substantial increase of N_2-fixation in soil due to the nitrogenase activity of inoculated cyanobacteria Abd-Alla *et al.* (1994). Mahmoud (1999) reported the promotive effect of the cyanobacteria *Nostoc muscorum* on the growth of the plant. He studied the effect of cyanobacteria as biofertilizer on seed germination and related processes of wheat, sorghum, maize, and lentil. Germination of the seed of the tested crop plant either in the live inoculum, algal filter at, or boiled algal extract of the nitrogen-fixing cyanobacterium *Nostoc muscorum* was significantly increased, as well as growth parameters and content of nitrogenous compounds, compared with controls. These increases could be attributed to enhancing growth of plants. Afify *et al.* (2022a) studied the inoculation with *Anabaena cylindrica*, with doses of inorganic nitrogen on the growth and yield of wheat and reported the highest significant increase of vegetative and yield parameters of the wheat plant. Also, the cyanobacteria have been saved the inorganic nitrogen application by 25% compared with recommended doses. Similarly, Afify *et al.* (2022b) recommended that using cyanobacterial inoculum in the presence of a 75% dose of inorganic nitrogen enhance the wheat plant's growth and yield and reduce chemical fertilizer usage. Therefore, this study aimed to determine the effect of inoculation with three cyanobacterial strains and their mixture and different doses of inorganic nitrogen in two types of soil texture on the growth and yield of wheat.

MATERIALS AND METHODS

Wheat grains used

The grains were kindly obtained from the Wheat Research Institute, Agricultural Research Center (ARC), Giza. Egypt as wheat grains (*Triticum aestivum* L.) cultivar Giza 171.

Cyanobacterial strains

The cyanobacterial strains were isolated and identified according to Watanabe *et al.*, (1951) by using modified Watanabe medium. The cyanobacterial strains belong to *Nostoc lichenoides*, *Nostoc indistinguendun* and *Nostoc favosum*. These strains were determined for their ability to fix nitrogen (El-Nawawy *et al*., 1958).

Soil samples

Two soils *viz* sandy and clay loam soils were used in the current experiment, some physicochemical properties were determined (Afify *et al.*, 2023).

Inorganic fertilizers used

Phosphate as calcium superphosphate (15% P_2O_5) and potassium as potassium sulfate (48% K_2O) fertilizers at rates of 150 and 50 kg fed^{-1}, respectively, while nitrogen fertilizer was added as ammonium nitrate (33.5% N) in two

[*] Corresponding author.
E-mail address: aidaafify@yahoo.com
DOI: 10.21608/jacb.2023.193477.1044

split doses, at the first prior to wheat sowing and the second after 30 days from sowing.

Experimental design and cultivation

This study was carried out at the greenhouse Faculty of Agriculture, Al-Azhar University, Cairo, Egypt, cyanobacteria strains were inoculation as *Nostoc lichenoides, Nostoc indistinguendun, Nostoc favosum* and their mixture with different nitrogen levels (0, 20, 40 and 60% N) addition was used from recommended dose (70 kg N fed^{-1}), control (untreated) as well as two types of soils with different texture, yield and grain of wheat were determined. Pots with a diameter of 30 cm were filled with 10 kg of sandy and clay loam soil from the surface layer (0-30 cm) from the Cairo-Alexandria Desert Road near Sadat City and El-Gharbia Governorate, respectively**.** Five wheat grains mixed with 1ml of cyanobacteria strain (1.5 x 10^7cfu) were then sowed. Plant height (cm), spikes number, spikes dry weight (g pot^{-1}), grains weight (g pot^{-1}) and 1000-grain weight (g) were determined.

Statistical analysis

A completely randomized design was performed. The data were obtained to the analysis of variance (ANOVA) according to Steel and Torrie (1980). The least significant difference (LSD) at 5% was used to compare the differences among the means.

RESULTS AND DISCUSSION

The previous study (Afify *et al.,* 2023) showed that the most efficient cyanobacterial strains in their capacity of produced fixed nitrogen. Then, it could be reported that the cyanobacterial strains are *Nostoc lichenoides*, *Nostoc indistinguendun* and *Nostoc favosum*. Therefore, these strains were chosen, and their mixtures were to mixtures were to be used as a biofertilizer for this experiment.

Growth and yield traits

For evaluation of the effectiveness of the suggested cyanobacterial strains and their mixtures on the growth and yield of wheat, certain parameters such as plant height, spikes number, spikes dry weight, the weight of 1000-grain, and grains weight were monitored in the designed pots experiment under various nitrogen fertilizers levels (0, 20, 40 and 60 %) with the two types of soils texture.

Plant height (cm)

Data collected on plant height as affected by cyanobacteria strains and their mixture with nitrogen levels are presented in Table (1). Regarding nitrogen levels effect on data presented in Table (1) indicates that levels of nitrogen had a significant increase in plant height. Increasing nitrogen levels resulted in being more effective in enhancing plant height. High values of plant height were produced with increasing nitrogen level to 60% pointing out that the application of nitrogen significantly affected plant height. Considering the cyanobacteria effect, it was recognized that various strains significantly increased plant height (Table 1). The highest values of plant height were obtained when a mixture of cyanobacteria was used. On the other hand, the lowest values of plant height were given when *Nostoc favosum* was used. The highest values of plant height were recorded with clay loam soil under different nitrogen levels and different strains of cyanobacteria. While the lowest values were observed with sandy soil under different nitrogen levels and the strains of cyanobacteria. These data are in harmony with those reported by El-Zawawy (2019) and Abou Tahoun *et al*. (2020).

Table 1. The cyanobacteria strains with nitrogen levels on plant height (cm) of wheat in different soil

Soil type	Cyanobacteria	Nitrogen levels			
		0%	20 %	40%	60%
Sandy	Control	50.89	60.42	66.18	75.14
	Nostoc lichenoides	64.13	67.22	76.15	79.00
	Nostoc indistinguendun	60.90	67.00	75.18	78.14
	Nostoc favosum	60.00	66.15	75.12	77.00
	Mixture of cyanobacteria	65.13	68.13	77.18	80.12
Clay loam	Control	65.22	76.56	78.65	80.17
	Nostoc lichenoides	74.00	79.12	81.15	93.12
	Nostoc indistinguendun	73.12	79.09	80.99	92.21
	Nostoc favosum	72.22	78.58	79.86	90.00
	Mixture of cyanobacteria	77.25	82.76	91.61	94.58
LSD 0.05		5.0			

Spikes number

Data recorded of spikes number as affected by four nitrogen levels, two types of soil and different strains of cyanobacteria are presented in Table (2). Regarding the effect of nitrogen fertilizer levels on spike number, the results in Table (2) clarified that increasing nitrogen fertilizer level significantly affects spikes number. In connection to the cyanobacteria effect, data in Table (2) showed that significant effects were exerted by using *Nostoc lichenoides* performed better than the others in sandy soil. On the other hand, using a mixture of cyanobacteria performed better than the other in clay loam soil. As for types of soil effect, spikes number were detected between the tested soils. From the data in Table (2), it became a fact that the highest values of spikes number were recorded with clay loam soil under different nitrogen levels and different strains of cyanobacteria. At the same time, the lowest values were observed with sandy soil under different nitrogen levels and various strains of cyanobacteria, the authors of Ghazal *et al.* (2018), Abou Tahoun *et al.* (2020), and Sadvakasova *et al.* (2022) also found the same results.

Table 2. The cyanobacteria strains with nitrogen levels on spikes number of wheat in different soil

Soil type	Cyanobacteria	Nitrogen levels			
		0%	20 %	40%	60%
Sandy	Control	2.00	5.00	6.67	7.00
	Nostoc lichenoides	4.67	5.33	7.67	8.66
	Nostoc indistinguendun	5.33	5.67	7.33	8.33
	Nostoc favosum	5.00	5.33	7.00	8.00
	Mixture of cyanobacteria	5.00	7.00	8.00	8.33
Clay loam	Control	3.00	6.00	7.00	8.00
	Nostoc lichenoides	5.67	6.33	7.33	8.00
	Nostoc indistinguendun	5.15	6.66	7.66	7.66
	Nostoc favosum	5.55	6.00	7.00	7.00
	Mixture of cyanobacteria	6.33	7.33	8.0	8.66
LSD 0.05		1.99			

Spikes dry weight (g pot^{-1})

Data collected on spikes dry weight as affected by cyanobacteria strains with nitrogen levels are presented in Table (3). Considering the nitrogen level effect it was recognized that various nitrogen levels had a great effect on spikes dry weight. The higher values of spikes dry weight were obtained when 60% N was added. In comparison, the lower values of spikes dry weight were given when 0% N was added. This could be attributed mainly to the low nitrogen in the soil, so the application of nitrogen encourages and increase the efficiency of the formation of tillers, consequently increasing the spikes dry weight, which indicates that the higher response to nitrogen by the plant is due to its capacity to increase photosynthetic activity. Regarding the cyanobacteria effect, data arranged in Table (3) indicates that strains of cyanobacteria had a significant effect on spikes dry weight. Using *Nostoc lichenoides* and a mixture of cyanobacteria was more effective in enhancing spikes dry weight. While low values of spikes dry weight were produced when no cyanobacteria were added. No significant differences were observed regarding the spikes dry weight using different soil Table (3). Authors Ghazal *et al.* (2018), Abou Tahoun *et al.* (2020), and Sadvakasova *et al.* (2022) also published a similar result.

Table 3. The cyanobacteria strains with nitrogen levels on spikes dry weight (g pot^{-1}) of wheat in different soil

Soil type	Cyanobacteria	Nitrogen levels			
		0%	20 %	40%	60%
Sandy	Control	10.37	15.55	18.85	20.13
	Nostoc lichenoides	13.83	16.55	21.00	24.11
	Nostoc indistinguendun	13.94	17.85	22.50	24.67
	Nostoc favosum	14.59	18.00	23.15	24.90
	Mixture of cyanobacteria	15.85	19.22	24.90	25.12
Clay loam	Control	11.25	17.54	19.72	21.85
	Nostoc lichenoides	14.22	17.12	22.55	25.73
	Nostoc indistinguendun	14.54	18.43	23.85	26.51
	Nostoc favosum	14.87	19.00	24.34	26.92
	Mixture of cyanobacteria	16.98	21.90	25.12	27.75
LSD 0.05		3.63			

Weight of 1000-grain (g)

Data collected on 1000-grain weight as affected by cyanobacteria strains with nitrogen levels are presented in Table (4). Regarding the effect of nitrogen fertilizer levels on 1000-grain weight the data in Table (4) clarified that increasing nitrogen fertilizer levels up to 40% significantly affects 1000-grain weight. While the lower values were given with 0% N added. That could be attributed mainly to the low nitrogen in the soil, so the application of nitrogen encourages and increase the efficiency of the formation of grains consequently, increasing the 1000-grain weight. From data listed in Table (4), it became the fact that using a mixture of cyanobacteria increased 1000-grain weight. However, the lowest 1000-grain weight was produced when no cyanobacteria were added. Table (4) shows that the clay loam soil significantly increased the 1000-grain weight more than the sandy soil. The results were similar to those of Ghazal *et al.* (2018), Abou Tahoun *et al.* (2020), and Sadvakasova *et al.* (2022).

Table 4. The cyanobacteria strains with nitrogen levels on 1000-grain weight (g) of wheat in different soil

Soil type	Cyanobacteria	Nitrogen levels			
		0%	20 %	40%	60%
Sandy	Control	39.33	42.10	43.12	42.18
	Nostoc lichenoides	41.60	43.15	44.23	44.10
	Nostoc indistinguendun	41.53	43.12	44.15	43.91
	Nostoc favosum	41.55	43.00	44.12	43.79
	Mixture of cyanobacteria	42.15	43.17	45.15	44.00
Clay loam	Control	40.77	39.11	43.85	43.03
	Nostoc lichenoides	41.77	42.30	44.77	44.27
	Nostoc indistinguendun	41.70	42.00	44.70	44.17
	Nostoc favosum	41.19	41.92	44.65	44.00
	Mixture of cyanobacteria	42.17	43.15	45.19	44.95
LSD 0.05		1.993			

Grains weight (g pot^{-1})

Data related to grains weight as affected by various nitrogen fertilizer levels, cyanobacteria strains and different soil types are presented in Table (5). Data in Table (5) showed that nitrogen fertilization significantly affected the grains weight in different soils. Therefore, increasing nitrogen fertilizer levels gradually increased grains weight in wheat plants by up to 60%. On the contrary, the lowest grains weight values were obtained when no nitrogen fertilizer was used. Moreover, the results showed that the cyanobacterial mixture gave the highest value of grains weight. Regarding different soil effects, data arranged claimed that different soil significantly affected grains weight without using nitrogen fertilization. Using clay loam soil was reported to be more effective in developing grains weight at 60% of nitrogen fertilization. Data are in good harmony with those found by Abou Tahoun *et al.* (2020).

Table 5. The cyanobacteria strains with nitrogen levels on grains weight (g pot^{-1}) of wheat in different soil

Soil type	Cyanobacteria	Nitrogen levels			
		0%	20 %	40%	60%
Sandy	Control	8.10	13.90	15.77	17.30
	Nostoc lichenoides	10.33	14.35	16.33	18.45
	Nostoc indistinguendun	11.12	15.15	17.17	19.33
	Nostoc favosum	12.25	15.49	18.71	20.28
	Mixture of cyanobacteria	13.89	16.15	19.20	21.45
Clay loam	Control	9.50	14.05	16.20	18.35
	Nostoc lichenoides	12.90	15.51	17.52	20.35
	Nostoc indistinguendun	11.59	15.71	18.44	21.22
	Nostoc favosum	12.99	15.82	19.35	22.15
	Mixture of cyanobacteria	14.58	16.25	20.37	23.65
LSD 0.05		2.5			

The role of nitrogen for efficiency in the photosynthesis of plants which, due to increased leaf area might be increasing dry matter production and yield. In this study, development in wheat growth and yield under the increasing nitrogen rates were reported by Stirk *et al.* (2002). The same effect of cyanobacteria this result is like those reported by Karthikeyan *et al.* (2007) and El-Zemrany (2017), who reported the effects of inoculant with cyanobacterial strains on wheat showed differences in terms of the appearance of plants. This was in plant height, dry weight, and grain yield of wheat crop. Therefore, it would be recommended to apply these cyanobacterial strains as bio-fertilizers (Zaki *et al.* 2021).

CONCLUSION

Based on our findings, co-applying the cyanobacterial strains, their mixture has considerably increased wheat growth and yield by improving plant height, spikes number, spikes dry weight, the weight of 1000-grain, and grains weight. Furthermore, this application decreases the requirement for chemical fertilizers. As a result, this application might be a simple, cost-effective, and efficient method of increasing wheat output while using minimal chemical fertilizers.

REFERENCES

Abd-Alla, M.H.; Mahmoud, A.L.A. and Issa, A.A. (1994). Cyanobacterial biofertilizer improved growth of wheat. Phyton., 34(1): 11–18.

Abou Tahoun, A.M.; El-Zaway, H.A.H. and Abd El-hakim, A.F. (2020). Effect of irrigation treatments and cyanobacteria with different nitrogen fertilization levels on wheat yield and quality grown on sandy soils. Arch. Agric. Sci. J. (3)3: 358–373.

Afify, Aida H.; Ashour, Eman H.; Mehesen, Ahlam A. and Zaki, Randa. M. (2022a). Efficiency evaluation of cyanobacterial strain, its extract and compost tea as biofertilizers on yield of wheat plant. J. Agric. Chem. Biotechnol., 13 (8): 65–73.

Afify, Aida H.; Mehesen, Ahlam A.; Ashour, Eman H. and Zaki, Randa M. (2022b). Effect of compost tea, cyanobacterial strains and their extracts on growth and productivity of wheat plant. J. Agric. Chem. Biotechnol., 13 (11):101–109.

Afify, Aida H.; Sheta, M. H. and Elzallal, Amal S. (2023). Impact of cyanobacteria inoculation on some physical and chemical properties with different texture. J. Agric. Chem. Biotechnol., 14(1): 1–6.

El-Nawawy, A. S.; Lotei, M. and Fahmy, M. (1958). Studies on the ability of some blue-green algae to fix atmospheric nitrogen and their effect on growth and yield of paddy soils. Agric. Res. Rev., 36:308-320.

El-Zawawy, H. A. (2019). Effect of nitrogen-fixing cyanobacteria on the growth of wheat crop. J. Agric. Chem. Biotechnol., 10 (11): 221–225.

El-Zemrany, H. M. (2017). Association of N2- fixing cyanobacteria with wheat (*Triticum vulgare* L.) roots. African J. Microbiol. Res., 11(15):626–630.

Gantar, M.; Kerby, N.W. and Rowell, P. (1991). Colonization of wheat (*Triticum vulgare* L.) by N_2-fixing cyanobacteria: II. An ultrastructural study. New-Phytol., 118: 485–492.

Gerba, L.; Getachew, B. and Walelign, W. (2013). Nitrogen fertilization effects on grain quality of durum wheat (*Triticum aestivum* L. var. *durum*) varieties in central Ethiopia. Agric. Sci., 4(3): 123–130.

Ghazal, F.M.; Mahdy, S.M.; Abdelfattah, M.S.; Elsadany,A.Y. and Doha, N. (2018). The use of cyanobacteria as biofertilizer in wheat cultivation under different nitrogen rates. Nat. Sci. 16(4):30–35.

Karthikeyan, N.; Prasanna, R.; Nain, L. and Kaushik, B.D. (2007). Evaluating the potenial of plant growth promoting cyanobacteria as inoculants for wheat. Eur. J. Soil Biol., 43(1), 23–30.

Mahmoud, S. A. (1999). Promotive effect of the cyanobacterium *Nostoc muscorum* on the growth of some crop plants. Acta Microbiol. polonica (Poland), 48(2): 163–171.

Sadvakasova, A.K.; Kossalbayev, B.D.; Token, A.I.; Bauenova, M.O.; Wang, J.; Zayadan, B.K.; Balouch, H.; Alwase, S.; Leong, Y. K.; Chang, J. and Allakhverdiev, S. (2022). Influence of Mo and Fe on photosynthetic and nitrogenase activities of nitrogen-fixing cyanobacteria under nitrogen starvation. Cells, 11(5): 904.

Shatta, A. M.; Mahmoud, A. H. H.; El-Kotkat, M. B. O. and El-Zawawy, H. A. H. (2014). Potential of inoculation with some types of cyanobacteria on improving soil characteristics. J. Agric. Chem. Biotechnol., 5(12): 319–330.

Steel, R. G and Torrie, J. H. (1980). Principles and procedures of statistics. A biometrical approach, 2nd Edition, McGraw-Hill Book Company, New York.

Stirk, W.A.; Ördög, V.; Van Staden, J. and Jăger, K. (2002). Cytokinin and auxin like activity in cyanophyta and microalgae. J. Appl. Phycol., 14: 215–221.

Watanabe, A.; Nishigaki, S. and Konishi, C. (1951). Effect of nitrogen-fixing blue-green algae on the growth of rice plants. Nature, 168(4278): 748–749.

Zaki, Randa M.; Mehesen, Ahlam A.; Ashour, Eman H. and Afify, Aida H. (2021). Characterization of soil-indigenous cyanobacterial strains and bioactivity assessment. J. Agric. Chem. Biotechnol., 12(11): 195–199.

تأثير الطحالب الخضراء المزرقة في الأراضي ذات القوام المختلف: (أ) تحسين النمو والمحصول لنبات القمح

عايدة حافظ عفيفي[1]، محمد حامد شتا[2] وأمل شريف الزلال[1]

[1] قسم الميكروبيولوجي - كلية الزراعة - جامعة المنصورة - المنصورة – مصر.
[2] قسم الأراضي والمياه - كلية الزراعة - جامعة الأزهر - القاهرة – مصر.

الملخص

تعتبر الطحالب الخضراء المزرقة من مثبتات النيتروجين الجوي حيث تمد النباتات باحتياجاتها من النيتروجين في التربة. لذلك، في هذه الدراسة أقيمت تجربة أصص بكلية الزراعة جامعة الأزهر بالقاهرة، مصر، خلال عام 2021م وذلك لدراسة تأثير استخدام لقاحات مختلفة من الطحالب الخضراء المزرقة كسماد حيوي على نمو ومحصول القمح المنزرع في التربة الرملية والتربة الطمية الطينية. وكان لقاح السيانوبكتيريا يشمل ثلاث سلالات من طحلب النوستوك في صورة منفردة وكذلك في صورة مخلوط من هذه السلالات الثلاثة مع إضافة السماد النيتروجيني المعدني بنسب مئوية متدرجة (صفر ،20 ،40 و60 % من النيتروجين الموصي به (70كجم نيتروجين/ فدان). وكانت النتائج المتحصل عليها وجود فرق معنوي في طول النبات، عدد السنابل، الوزن الجاف للسنابل، وزن الحبوب ووزن الألف حبة لنبات القمح وذلك عند إضافة النيتروجين المعدني من 40 إلى60% في كلاً من التربة الرملية والطميية الطينية المعاملة بمخلوط لقاح السيانوبكتيريا. من هذه النتائج نجد أن التلقيح بالطحالب الخضراء المزرقة (السيانوبكتيريا) أدى إلى توفير من40 إلى60% من النيتروجين الموصي به.