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Effect of Blue-Green Algae in Soils with Different Texture: (b) on Microbial Communities of Soils

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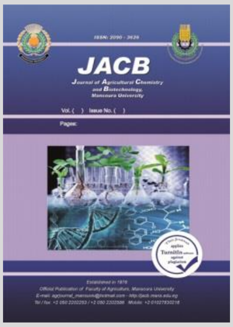

ABSTRACT

Applicability of cyanobacteria strains (*Nostoc lichenoides, Nostoc indistinguendun, Nostoc favosum*) and their mixture for effect on microbial communities of soil under four levels of inorganic nitrogen (0, 20, 40 and 60% N) was used with recommended doses of nitrogen (70 kg N fed^{-1}). This experiment was carried out in two types of soil texture (sandy and clay loam) to enumerate the number of viable bacteria, azotobacter, actinomycetes, and fungi. Results indicated that the cyanobacterial strains varied significantly and pronounced an increase in all microbes. So, the sandy soil count was lower than clay loam soil. The treatment with *Nostoc favosum* recorded the highest total counts of bacteria (270.9 $\times 10^6$ CFU/g dry soil) compared to those found by the other strains of tested cyanobacteria. The addition of cyanobacteria to the sandy soil increased the number of Azotobacter, and the best number of azotobacter in the mixture was (52.3$\times 10^3$ CFU/g dry soil) compared to uninoculated (20.5$\times 10^3$ CFU/g dry soil). However, inoculating two soil types with the mixture of cyanobacterial strains gave the highest Actinomycetes counts compared with individual strain. Also, the treatment of types soil with the mixture of cyanobacterial strains gave the highest counts of fungi compared with any other inoculated. The inoculation with other cyanobacteria strains and their mixture increased the soil microbial population including, total counts of bacteria, Azotobacter, Actinomycetes, and fungi.

Keywords: cyanobacterial strains, soil microbial communities.

INTRODUCTION

Cyanobacteria are the most critical microorganisms because they provide the soil with a fixed of nitrogen (Roger and Watanabe, 1986). Zulpa *et al.* (2008) found the effect of products by cyanobacterial strains (*Tolypothrix tenuis* and *Nostoc muscorum*) on the nutrients content and the microbial activity of the soil under the waste of maize and on the degradation of these waste of maize . Both cyanobacterial strains' were increased biomass and extracellular products of the soil's microbial activity. Anjali (2010) stated that cyanobacteria are essential to soil microflora. However, it forms a tiny part, yet they have extensive use as biofertilizers as they can fix atmospheric nitrogen. Ghazal *et al.* (2011) found that inoculation with several cyanobacteria strains were significant increased microbial activity , increases organic matter in soil and available nutrients content, including nitrogen. They added that treatment with several cyanobacteria strains also increased soil *Azospirilla* and other microorganisms populations, such as cyanobacteria, Azotobacter, Actinomycetes and fungi. Therefore, the present study summarizes the beneficial effects of cyanobacterial strains on wheat plants, highlighting the soil microbial community, including viable bacteria, azotobacter, actinomycetes, and fungi.

MATERIALS AND METHODS

Cyanobacterial strains

The three strains from cyanobacteria (*Nostoc lichenoides*, *Nostoc indistinguendun*, and *Nostoc favosum*) were isolated and identified using a modified Watanabe medium (Watanabe *et al.*, 1951). These strains were the most high for fixed nitrogen (El-Nawawy *et al.*, 1958) and mainted for use.

Soil samples

In these study two soil types were used (sandy and clay loam soils), and some physicochemical properties were determined (Afify *et al.*, 2023).

Experimental design and microbiological analysis

The current study was carried out at the greenhouse of the Faculty of Agriculture, Al-Azhar University, Cairo, Egypt, in 2021. The three of cyanobacteria strains and their mixture were inoculated, with different nitrogen levels (0, 20, 40 and 60 % N) used from recommended dose (70 kg N fed^{-1}), addition control as well as their interaction on yield, and its components of wheat. Pots were filled with 10 kg of sandy and clay loam soil samples from the Cairo-Alexandria Desert and El-Gharbia Governorate, respectively. The soil was thoroughly mixed uniformly with inorganic NPK, before baking the pots,. In addition, pour plate method was used for total counts of viable bacteria, azotobacter, actinomycetes, and fungi were determined and to enumerate all microbe's numbers in the two types of soil samples (Skerman and Hillard, 1967). The colonies of bacteria were counted after being incubated for three days at 30º C. Colony forming units (CFU/ gram dry soil) was used for recorded the total counts of microbial communties.

Statistical analysis

The collected data were subjected to the analysis of variance (ANOVA) and a completely randomized design was performed according to Steel and Torrie (1980). The least

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significant difference (LSD) at 5% were used for compared the differences among the means.

RESULTS AND DISCUSSION

Total counts of bacteria

The data presented in Figs. (1 and 2) shows the effect of cyanobacteria strains with nitrogen levels on the total counts of bacteria (×10^6 CFU/g dry soil) of wheat in different soil types (sandy and clay loam). Data recorded that inoculation with cyanobacteria resulted in an increase in the counts of bacteria present in the rhizosphere compared with the control, where the control recorded in the uninoculated sandy soil (8.9×10^6 CFU/g dry soil). The total count of bacteria in the soil was differed between the treatments of cyanobacterial strains and the mixture with the 60% N was recorded (97.8×10^6 CFU/g dry soil) in Fig. (1). The count of bacteria in the sandy soil was lower than in the clay loam soil. The treatment with *Nostoc favosum* recorded the the most high value for bacterial counts (270×10^6 CFU/g dry soil) compared to those founed by the other cyanobacterial strains.

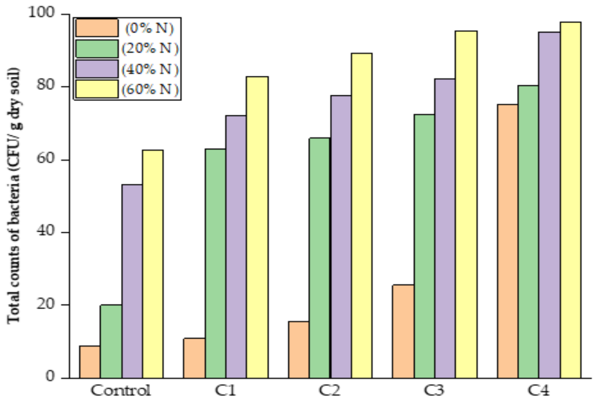

Fig. 1. Effect of cyanobacteria strains with nitrogen levels; Control, *Nostoc lichenoides* (C1), *Nostoc indistinguendun* (C2), *Nostoc favosum* (C3), and cyanobacteria mixture (C4) on total counts of bacteria (× 10^6 CFU/g dry soil) of wheat in sandy soil. The least significant difference (LSD) at 5% = 26.42

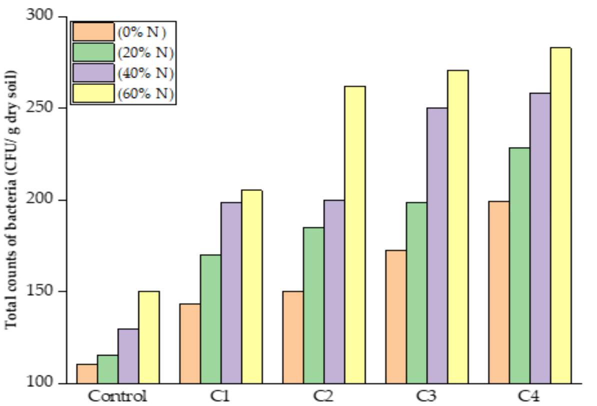

Fig. 2. Effect of cyanobacteria strains with nitrogen levels; Control, *Nostoc lichenoides* (C1), *Nostoc indistinguendun* (C2), *Nostoc favosum* (C3), and cyanobacteria mixture (C4) on total counts of bacteria (× 10^6 CFU/ g dry soil) of wheat in clay loam soil. The least significant difference (LSD) at 5% = 26.42

However, the inoculation of two soil types with the cyanobacterial strains mixture recorded the highest bacterial counts (283×10^6 CFU/g dry soil) compared to any inoculated alone. The data are in good harmony with Belnap *et al.* (2001b). Biological soil crusts usually consist of many microorganisms, the most famous of which are cyanobacteria, which work through their secretions to raise the number of microbes in the soil and improve its properties, unless the crust is in an early successive stage. Biological soil surface crusts are standard in dry lands, performing various parts, such as colonization of substrates (Chamizo *et al.*, 2012), carbon sequestration, and respiration (Kheirfam, 2020). Biological soil crusts comprise one or more cyanobacteria, fungi, algae, lichens, and mosses (Belnap, 2006). El-Zawawy (2019) recorded that the treatment with a mixture of cyanobacteria and inorganic nitrogen recorded the higher number of viable bacteria counts than the other tested cyanobacteria species.

Total counts of Azotobacter

Data presented in Figs. (3 and 4) show the effect of different nitrogen levels and cyanobacteria strains on total counts of Azotobacter (×10^3CFU/g dry soil) of wheat in different soils (sandy and clay loam). The addition of cyanobacteria to the sandy soil increased the number of azotobacter, and the best number of azotobacter with the mixture was (52.3×10^3CFU/g dry soil) compared to the control (17.2×10^3CFU/g dry soil). The counts of azotobacter in the clay loam soil was the highest compared with other type of soil. The treatment with *Nostoc favosum* recorded the higher counts of Azotobacter rather than recorded by the other cyanobacterial strains. However, the treatments of two soils types by the mixture of cyanobacterial strains recorded higher counts of azotobacter than any inoculated done alone. The mixture in clay loam soil scored (310.6×10^3 CFU/g dry soil), then *Nostoc favosum* (285.3×10^3CFU/g dry soil), followed by *Nostoc indistinguendun* (218.5×10^3CFU/g dry soil), and the highest was *Nostoc lichenoides*, which scored (182.1×10^3 CFU/g dry soil). These data are in good harmony with Belnap *et al.* (2001b), who found that biological soil crusts usually consist of different organisms, the most famous of which are cyanobacteria, which work through their secretions to raise the number of microbes present in the soil and improve their properties unless the crust is in an early successive stage.

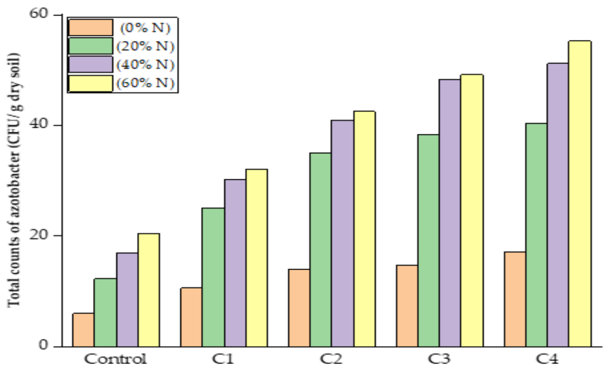

Fig. 3. Effect of cyanobacteria strains with nitrogen levels; Control, *Nostoc lichenoides* (C1), *Nostoc indistinguendun* (C2), *Nostoc favosum* (C3), and cyanobacteria mixture (C4) on total counts of Azotobacter (× 10^3CFU/g dry soil) of wheat in sandy soil. The least significant difference (LSD) at 5% = 16.33

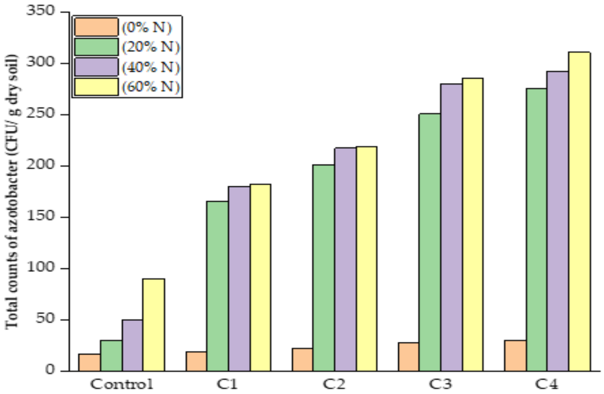

Fig. 4. Effect of cyanobacteria strains with nitrogen levels; Control, *Nostoc lichenoides* (C1), *Nostoc indistinguendun* (C2), *Nostoc favosum* (C3), and cyanobacteria mixture (C4) on total counts of Azotobacter (× 10^3CFU/g dry soil) of wheat in clay loam soil. The least significant difference (LSD) at 5% = 16.33

Total counts of Actinomycetes

Data in Figs. (5 and 6) showed that the counts of actinomycetes (× 10^5CFU/ g dry soil) in sandy soil were lower than in clay loam soil. The treatment with *Nostoc favosum* showed the higher counts compared to those founded by the other cyanobacterial strains. The treatment of two soil types with the mixture of cyanobacterial strains recorded the highest actinomycetes counts than any inoculated alone. The cyanobacterial mixture in sandy soil scored (20.4×10^5CFU/g dry soil), then *Nostoc favosum* (17.3×10^5CFU/g dry soil), followed by *Nostoc indistinguendun* (16.1×10^5CFU/g dry soil), and the lowest was *Nostoc lichenoides*, which scored (15.7×10^3CFU/g dry soil). While clay loam soil has a number ranging from (24.9 to 68.8×10^5CFU/g dry soil). The data are in good harmony with **Belnap *et al.* (2001b)** reported that biological soil crusts usually consist of different organisms, the most famous of which are cyanobacteria, which work through their secretions to raise the number of microbes present in the soil and improve their properties, unless the crust is in an early successive stage.

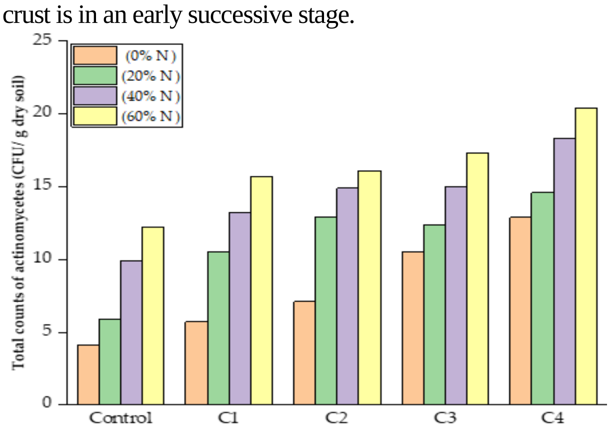

Fig. 5. Effect of cyanobacteria strains with nitrogen levels; Control, *Nostoc lichenoides* (C1), *Nostoc indistinguendun* (C2), *Nostoc favosum* (C3), and cyanobacteria mixture (C4) on total counts of Actinomycetes (× 10^5CFU/g dry soil) of wheat in sandy soil. The least significant difference (LSD) at 5% = 6.79

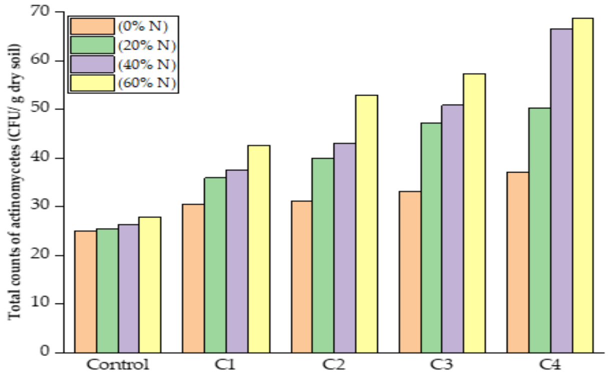

Fig. 6. Effect of cyanobacteria strains with nitrogen levels; Control, *Nostoc lichenoides* (C1), *Nostoc indistinguendun* (C2), *Nostoc favosum* (C3), and cyanobacteria mixture (C4) on total counts of Actinomycetes (× 10^5CFU/g dry soil) of wheat in clay loam soil. The least significant difference (LSD) at 5% = 6.79

Total counts of fungi

The data presented in Figs. (7 and 8) shows the effect of cyanobacteria strains with different nitrogen levels on the total counts of fungi (×10^3/g soil) in different types of soils (sandy and clay loam). The results of inoculation with cyanobacteria showed an increase in the counts of fungi present in the rhizosphere compared to the control, where the control was recorded in the uninoculated sandy soil (3.9×10^3/g soil). Counts of fungi in soil was differed according to the inoculated cyanobacterial strains recorded in the mixture (27.6×10^3/g soil). Fig. (8) shows that the count of fungi in sandy soil was lower than in clay loam soil. The treatment with *Nostoc favosum* founed the most high counts of fungi (60×10^3/g soil) compared with the other cyanobacterial strains. While, the treatments of two types soil by the cyanobacterial strain's mixture recorded the highest fungi counts (64.9×10^3/g soil) than any individual inoculated . The data are in good harmony with Belnap *et al*. (2001a). The essential role in the ecosystem function of arid environments, found as Cyanobacteria and biological soil crusts which form an important part of the soil surface. An assemblage of soil particles, microoganisms can develop in the first few millimeters of the soil.

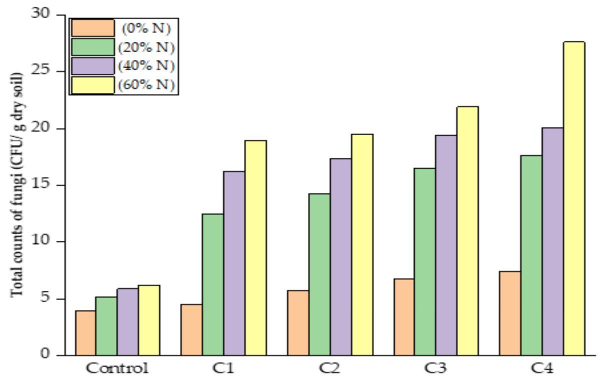

Fig. 7. Effect of cyanobacteria strains with nitrogen levels; Control, *Nostoc lichenoides* (C1), *Nostoc indistinguendun* (C2), *Nostoc favosum* (C3), and cyanobacteria mixture (C4) on total counts of fungi (× 10^3/g soil) of wheat in sandy soil. The least significant difference (LSD) at 5% = 6.86

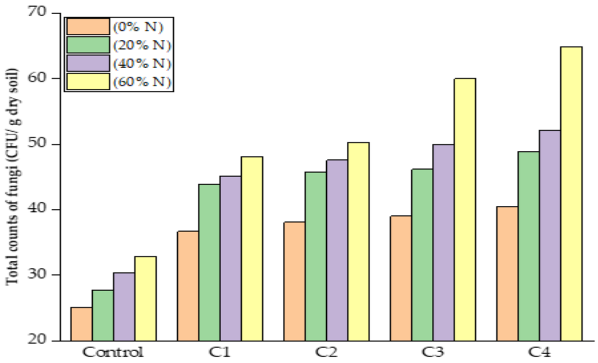

Fig. 8. Effect of cyanobacteria strains with nitrogen levels; Control, *Nostoc lichenoides* (C1), *Nostoc indistinguendun* (C2), *Nostoc favosum* (C3), and cyanobacteria mixture (C4) on total counts of fungi (× 10^3/g soil) of wheat in clay loam soil. The least significant difference (LSD) at 5% = 6.86

CONCLUSION

The inoculation with several cyanobacteria strains increased significant bacterial communities, soil organic matter and nutrients content such as nitrogen, which improve the plant. They also added that the treatment with mixture cyanobacteria strains increased soil bacterial populations (Ghazal *et al*., 2011).

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تأثير الطحالب الخضراء المزرقة في الأراضي ذات القوام المختلف: (ب) على المجتمعات الميكروبية في التربة

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الملخص

استخدمت سلالات من السيانوبكتيريا (*N. lichenoides, N. indistinguendun, N. favosum*) بصورة منفردة أو في مخلوط وذلك لدراسة تأثيرها على المجتمعات الميكروبية في التربة تحت أربعة مستويات من النتروجين (صفر ،20 ،40 و60 % من النيتروجين الموصي به (70كجم نيتروجين/ فدان). تم إجراء التجربة على نوعين من التربة وهما (الرملية والطميية الطينية) لتقدير العدد الكلي للبكتيريا، الأزوتوباكتر، الأكتينوميستات والفطريات. وقد أشارت النتائج أن سلالات السيانوبكتيريا أظهرت فروق معنوية واضحة في زيادة العدد الكلى لكل هذه الميكروبات تحت الدراسة، وكان التفوق واضح في التربة الطميية الطينية عن التربة الرملية. من ناحية أخرى، أظهر التلقيح بسلالة *N. favosum* زيادة في العدد الكلى للبكتريا (270.9×10^6 CFU/g dry soil) مقارنة بالسلالات الأخرى. بالإضافة إلى أن تلقيح التربة الرملية بالسيانوبكتيريا تزيد من العدد الكلى للأزوتوباكتر مقارنة بالكنترول، حيث وجد أن العدد الكلى للأزوتوباكتر مع مخلوط سلالات السيانوبكتيريا (52.3×10^3CFU/g dry soil) مقارنة بمعاملة الكنترول(20.5×10^3CFU/g dry soil). كما سجلت النتائج أن التلقيح بمخلوط سلالات السيانوبكتيريا أعطى أعلى عدد كلى من الأكتينوميستات عن التلقيح بصورة منفردة وذلك في كلا نوعي التربة تحت الدراسة. وجد أيضاً ان التلقيح بمخلوط سلالات السيانوبكتيريا في كلا نوعي التربة سجل أعلى الأعداد لفطريات التربة (64.9×10^3 CFU/g dry soil) بالمقارنة بالتلقيح بصورة مفردة. عموما يمكن القول إن تلقيح التربة بسلالات السيانوبكتيريا المختلفة ومخلوطها يزيد من المجتمعات الميكروبية في التربة حيث يزيد الأعداد الكلية للبكتيريا، الأزوتوباكتر، الأكتينوميستات والفطريات.