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Effect of Compost Tea, Cyanobacterial Strains and their Extracts on Growth and Productivity of Wheat Plant

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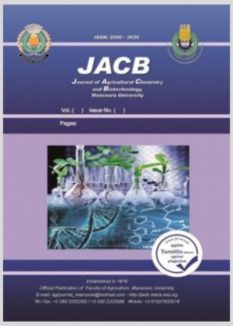

ABSTRACT

Applicability of compost tea, cyanobacterial strains of *Anabaena cylindrica*, *Nostoc calcicola* and their extracts for enhancing growth and productivity of wheat plant were tested under glass house conditions. Individual and mixture with doses of inorganic nitrogen were the main treatments of the presented work. Results indicated that all the tested treatments were varied significantly in their effects during the tested three growth phases of 60, 90 and 120 days from planting. Due to use of C_{75}TNANEAE (N 75 % + compost tea + *Nostoc calicola* , *Anabaena cylindrica* and their extracts), highly significant increase in vegetative and yield growth parameters, chemical content and NPK content (in shoot, root, straw and grains) were obtained. Biofertilizers treatments were found to have pronounced increase in the number of viable bacterial count and the N_2-fixing cyanobacteria in soil. So, utilization of the cyanobacterial inoculum which containing *Anabaena cylindrica* and *Nostoc calcicola,* their extracts and compost tea in the presence of 75% dose of N for enhancing growth and yield of wheat plant and reduce chemical fertilizers usage were recommended.

Keywords: Wheat (*Triticum aestivum* L.), Cyanobacterial strarins, Cyanobacterial extracts, Compost tea.

INTRODUCTION

Wheat plant has a vital part of the traditional diet and one of the highest per capita consumption rates in the world (McGill *et al.*, 2015). Nowadays, many efforts for wheat production with low cost and high efficiency and with increasing of awareness of environment by applying of bio-organic fertilizers such compost tea and cyanobacteria that may contribute to sustainable agro-ecosystems and decrease the pollution of the agricultural environment through reduce dependent on inorganic fertilizers (El-Bably *et al.*, 2018).

Cyanobacteria are the most important microorganisms in terms of soil fertility and bioactivity. These species are important in this system because they provide a constant supply of fixed nitrogen (Roger and watanabe, 1986). Compost tea is used as a viable alternative to traditional fertilizer systems in several applications (Scheuerell and Mahaffee, 2002). Cyanobacterial extracts are fertilisers can be prepared a by different materials such as water (Shariatmadari *et al.*, 2013) and chemicals such as methanol (Chookalaii, 2020) used to have final cyanobacterial extract.

Hauka *et al.* (2012) reported that the plant growth promotion provided by inoculation with mixed better than alone or when the strains were mixed in a consortia inoculum. Also, Rana *et al.* (2012) found that *Anabaena* sp. CW1, *Calothrix* sp. and *Anabaena* sp. CW2 improving the nutritional quality of wheat grains, in terms of protein content and important micronutrients (Fe, Cu, Zn, and Mn). El-Zemrany (2017) found that dry weight of the inoculated plant seedlings root with *Nostoc muscorum* and *Anabaena variabilis* augmented by more than 3-fold of the control, wherever the shoots were promoted by more than 36% as compared to the control.

Burjus *et al.* (2020) studied that mixed of cyanobacteria with less mineral fertilizers was provided wheat growth and yield similar to that achieved by the rate of urea (46% nitrogen) and diammonium phosphate. Application of *Anabaena circinalis* and *Nostoc commune* improve yield, yield components, number of spikes /pot, number of grains / spike, chlorophyll, flag leaf area (cm^2), and protein % of wheat compared with control under salinity effects.

Afify *et al.* (2019) and Abou Elatta *et al.* (2019) showed the effect of (*Anabaena oryzae* D and *Nostoc muscorum* K) on rice. The result indicated that highly significant increase in plant height, panicle length, number of tillers/plant, number of panicles/plant, biomass and grain yield t/ha. On the other hand, there were no significant for 1000 grain weight and harvest index. The cyanobacteria have been saved the inorganic nitrogen application by 20-25% compare with recommended nitrogen application. Cyanobacteria can be considered a promising source for the development of new biostimulants as they are known to produce a variety of biologically active molecules that can positively affect plant growth, nutrient use efficiency, qualitative traits of the final product, and increase plant tolerance to abiotic stresses (Santini *et al.*, 2021). El-Bably *et al.* (2018) showed substantial improvements in the vegetative growth parameters tested, i.e., plant height, number of branches, stem diameter, aerial fresh and dry weights due to all treatments, with relative superiority of the foliar spraying with cyanobacterial extract and compost tea procedue.

Therefore, aim of the present study was to determine the effect of inoculation with two cyanobacterial strains, their extract and compost tea as individual or mixture with doses of inorganic nitrogen on the growth and yield of wheat plant.

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MATERIALS AND METHODS

Cyanobacterial strains

Anabaena cylindrica and *Nostoc calcicole* as fixed nitrogen Zaki *et al.* (2021) were isolated and identified by Zaki (2022) in Microbiol. Dept., Fac. of Agric. Mansoura Univ., Mansoura, Egypt.

Soil samples collection

Soil samples were collected from different sites in El – Dakahlia and Kafr El-Sheikh governorates. Some physio-chemical properties of soil samples collected for cyanobacteria isolation were analysed according to Piper (1950) and Jackson (1958) and soil textural were clay loam (Afify *et al.*, 2022).

Wheat grain

Wheat grains (*Triticum aestivum* L.) cv. Gemmiza 12 were kindly obtained from Wheat Research Institute, Agricultural Research Center (ARC), Saka, Kafr El sheikh, Egypt.

Mineral fertilization

The pots soil was plowed three times in perpendicular directions. Phosphate fertilizer at 15 kg phosphorus pentoxide (P_2O_5)/fed was broadcasted as calcium super-phosphate (15% P_2O_5) on the dry soil surface (El-Saadny, 2013). Nitrogen fertilizer in the form of urea (46.5%N) at the rate of 37.5, 56.25 and 75 kg N/fed which represent 50% ,75% and 100 % from the final recommended doses was applied in to equal doses, before the first and second irrigation. Potassium fertilizer in the from potassium sulphate (48% K_2O) at the rate of 24 kg K/fed was applied with the first dose of nitrogen fertilizer.

Compost tea

Compost water extract (Compost Tea) was added three times with foliar spray at a rate of (1:5 v/v) till the end of the experiments and was brought kindly from Agric. Microbiol. Dept., Agric. Res. Center (ARC), Sakha, Kafr El sheikh, Egypt.

Preparation of cyanobacterial extracts

The two selected cyanobacterial strains (*Anabaena cylindrica* and *Nostoc calcicole*) were cultured in 500 ml flasks containing BG-11_0 medium for 14 days under continuous illumination (5000 lux) and at 28-30°C, with constant agitation. Cultures were harvested and cells were washed with distilled water. Cell extracts were prepared by grinding the cyanobacterial growth in distilled water with a mortar and blender. Cyanobacterial extract containing 5.0 g of fresh cyanobacterial material in 500 ml of distilled water is considered a 1% extract (Shariatmadari *et al.,* 2013). Cyanobacterial extracts were added three times with foliar spray for pots received this treatment.

Standard cyanobacterial inoculum preparation for pot experiment

The standard inoculums of the selected cyanobacterial strains were prepared by inoculating Erlenmeyer flasks (500 ml) containing 250 ml of modified BG11_0 broth medium with a loopfull of 21 days old culture of each ones. Inoculated flasks were incubated at 28-30ºC under continuous illumination (5000 lux) for one month before application in the pot experiment. Inoculum was prepared using a sieved clay soil (as a carrier) just before pot application, by adding 100 ml of homogenous cyanobacterial growth to amounts of 1 kg carrier. Mean number of cyanobacteria (as cfu) in the inoculants were determined using the MPN method as recommended by Cochran (1950). Mean numbers of cyanobacteria was found to be $1.5x10^7$ cfu/ml. The soil-based cyanobacterial inocula (SBI) that were prepared as described by Venkataraman (1972), were inoculated to pots 10 days after wheat sowing at the rate of 10 kg SBI fed^{-1}. The cyanobacterial inoculation was carried out only for pots received this treatment.

Pot experiment

A pot experiment was carried out at the glass house in Faculty of Agriculture, Mansoura University, Mansoura, Egypt during the winter season of (2018) to study the comparison between bio-fertilization as inoculants of the most efficient cyanobacterial strains (that identified as *Nostoc calcicola* and *Anabaena cylindrica* by Zaki (2022) and their extracts as well as tea compost on the growth and yield of wheat. The experiment was arranged as a completely randomized design with three replicates which means three pots for every treatment. Pots with 35 cm height and 30 cm in diameter were filled with 8 kg sandy soil each. Before baking the pots, the soil was thoroughly mixed uniformly with phosphate and potassium fertilizers. The treatments were as recorded in Table (1).

Table 1. List of treatments and abbreviations used in the results

No.	Treatment	Abbreviations
1.	Control 100 (Mineral fertilizer N 100%)	C_{100}
2.	Control 75 (Mineral fertilizer N 75%)	C_{75}
3.	Control 50 (Mineral fertilizer N 50%)	C_{50}
4.	C_{75} + *Nostoc calcicola* + *Anabaena cylindrica*	C_{75}NA
5.	C_{75} + *Nostoc calcicola* Extract + *Anabaena cylindrica* Extract	C_{75}NEAE
6.	C_{75} + *Nostoc calcicola* Extract + *Anabaena cylindrica*	C_{75}NEA
7.	C_{75} + *Anabaena cylindrica* Extract + *Nostoc calcicola*	C_{75}AEN
8.	C_{75} + Compost Tea + *Nostoc calcicola* + *Anabaena cylindrica*	C_{75}TNA
9.	C_{75} + Compost Tea + *Nostoc calcicola* Extract + *Anabaena cylindrica* Extract	C_{75}TNEAE
10.	C_{75} + Compost Tea + *Nostoc calcicola* Extract + *Anabaena cylindrica*	C_{75}TNEA
11.	C_{75} + Compost Tea + *Anabaena cylindrica* Extract + *Nostoc calcicola*	C_{75}TAEN
12.	C_{75} + Compost Tea + *Nostoc calcicole* + *Anabaena cylindrica* + *Nostoc calcicola* Extract + *Anabaena cylindrica* Extract	C_{75}TNANEAE
13.	C_{50} + *Nostoc calcicola* + *Anabaena cylindrica*	C_{50}NA
14.	C_{50} + *Nostoc calcicola* Extract + *Anabaena cylindrica* Extract	C_{50}NEAE
15.	C_{50} + *Nostoc calcicola* Extract + *Anabaena cylindrica*	C_{50}NEA
16.	C_{50} + *Anabaena cylindrica* Extract + *Nostoc calcicola*	C_{50}AEN
17.	C_{50} + Compost Tea + *Nostoc calcicola* + *Anabaena cylindrica*	C_{50}TNA
18.	C_{50} + Compost Tea + *Nostoc calcicola* Extract + *Anabaena cylindrica* Extract	C_{50}TNEAE
19.	C_{50} + Compost Tea + *Nostoc calcicola* Extract + *Anabaena cylindrica*	C_{50}TNEA
20.	C_{50} + Compost Tea + *Nostoc calcicola* + *Anabaena cylindrica* Extract	C_{50}TNAE
21.	C_{50} + Compost Tea + *Nostoc calcicole* + *Anabaena cylindrica* + *Nostoc calcicola* Extract + *Anabaena cylindrica* Extract	C_{50}TNANEAE

Vegetative plant analyses

A sample was collected at 60, 90 and 120 day after wheat sowing, transplanting and the harvest stage. Then, different morphological parameters of plant growth [plant height (cm), root height (cm), number of leaves/plant, number of tillers/plant, number of spikes/plant, fresh weight (g/plant), dry weight (g/plant), root fresh weight (g/plant), root dry weight (g/plant) and weight of 1000-grain (g)] were assessed. A random sample was taken from threshed grains to measure the 1000-grain weight (g). One thousand air dry wheat grains were weighed.

Pigments plant analyses

Chlorophyll a, b (mg g^{-1} F.W) was estimated according to Sadasivam and Manickam (1996). The carotenoids (mg $100g^{-1}$) content was determined spectrophotometer by the procedure postulated by Ranganna (1997). And total Chlorophyll content was estimated in fresh leaves according to Hoel (1998). All the pigments were estimated in fresh leavs.

Chemical plant analyses

N, P and K concentrations in plant tissues were determined according to Gotteni *et al.* (1982). Total Nitrogen was determined using Micro kjeldahl apparatus as described by Jones *et al.* (1991). Total phosphorus was determined colorimetrically as indicated by spectrophotometer (Mousa *et al.* 2018). And total potassium was estimated by using Jenway Flame photometer, Model corning 400 according to the modified method of Peters *et al.* (2003).

Microbiological analysis

Bacterial total counts and total counts of cyanobacteria were determined in soil samples which collected after 60, 90 and 120 day. To enumerate the number of viable bacteria in soil samples, the pour plate method was used (Skerman and Hillard 1967). From each dilution three replicates were prepared. Colony counts of bacteria were counted after incubated for 3 days at 30ºC. The total number of colonies was recorded as cfu (colony forming units) per gram of dry soil.

Method used for cyanobacterial count was the most probable number (MPN) technique using the modified Watanabe medium (Watanabe *et al.* 1951 and El–Nawawy *et al.* 1958). Colonies of cyanobacteria were counted as described by tubes that were incubated at 30ºC under continuous light of 120 cm long white fluorescent lamps intensity of 2500 lux after ten days of incubation.

Statistical analysis

The obtained experimental data were statistically analyzed using COSTAT (2005) software of analysis of variance (Gomez and Gomez 1984). The means were compared using Duncan multiple range test at p= 0.05 as outlined by Snedecor and Cochran (1980).

RESULTS AND DISCUSSION

Nitrogen-fixing cyanobacteria and bacterial rhizosphere soil content

Cyanobacteria strains and total microbial count in soil were varied according to the inoculated *Nostoc calicola* and *Anabaena cylindrica* in Figs. (1 and 2). The count was the highest with inoculation with mixture with 75% nitrogen fertilization + compost tea + *Nostoc calicola* and *Anabaena cylindrica* in soil and extract after 90 days attained the highest number for viable counts 5.01 and 7.63 $X10^3$CFU compared to those recorded by the other tested treatments (Fig. 1). As for the N_2-fixing cyanobacteria found that the highest count was obtained with C_{75}TA after 90 days 3.74 $X10^3$CFU which was near to 60 day 3.44 $X10^3$CFU (Fig. 2).

This result is similar to those repoted by Afify *et al.* (2018) the most active cyanobacteril isolates for nitrogenase activity were Nostoc and Anabaena. Also, El-Sawah *et al.* (2018) found that the highest nitrogenase avtivity (N2-fixing capacity) was due to *Noctoc muscorum*. EL-Zawawy (2019) found that inoculation with mixture cyanobacteria with 60 nitrogen level/fed and 60 days recorded the highest number for viable counts compared to those recorded by the other tested cyanobacteria species.

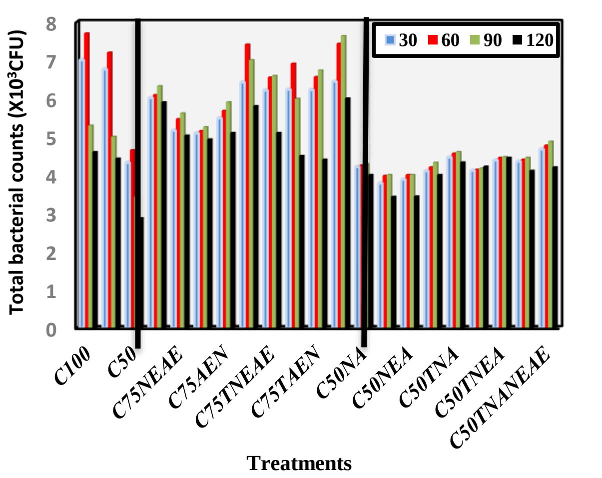

Fig. 1. Total bacterial counts ($X10^3$CFU) in rhizosphere soil affected by *A. cylindrica*, *N. calicola*, their extracts and compost tea comparing with different levels of nitrogen mineralization.

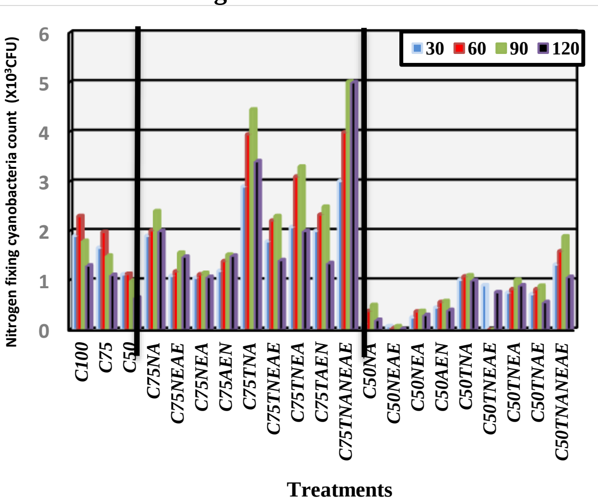

Fig. 2. N_2-fixing cyanobacteria counts ($X10^3$CFU) in rhizosphere soil affected by *A. cylindrica*, *N. calicola*, their extracts and compost tea comparing with different levels of nitrogen mineralization.

Vegetative growth parameters

Data at Table (2) presented the effect of N fertilization rates, compost tea, *Nostoc calicola*, *Anabaena cylindrica* soil and extract addition in solo way or mixed together on plant height of wheat plant through three growth stages (60, 90 and 120 days from planting).

Data in Table 2 revealed that the maximum growth of wheat plant in all growth parameters after 120 days was measured in treated with C_{75}TNANEAE (N 75 % + compost tea + *Nostoc calicola* , *Anabaena cylindrica* soil and extract). The lowest values of all parameters recorded with the treatment C_{50} (N 50%). While, other treatments of N fertilization levels, compost tea enriched with strain and extract *Nostoc calicola* , *Anabaena cylindrica* soil and extract were moderated.

Table 2. Vegetative growth parameters of wheat plants (for 120 days) affected by *A. cylindrica*, *N. calicola*, their extracts and compost tea comparing with different levels of nitrogen mineralization.

Treatments	Plant length cm			Shoot fresh weight g/plant			Shoot dry weight g/plant			No. of leaves/ plant			No. of tiller/ plant		
	60 days	90 days	120 days	60 days	90 days	120 days	60 days	90 days	120 days	60	90 days	120 days	60	90 days	120 days
C_{100}	45.37c	77.61b	83.99d	12.96d	12.96d	27.1d	3.49d d	7.47dd	11.35d	19.00 cde	22.67a-d	13.67abc	4.67abcd	5.00 abc	6.33 ab
C_{75}	39.74f	71.2 e	78.17h	10.63h	10.63h	22.73g	2.75h h	6.04 i	9.86 h	18.00 def	21.33a-g	12.00 cde	4.00 abcd	4.33 abc	5.67 ab
C_{75}	30.13k	59.70i	66.40p	7.31p	7.31 p	14.99n	1.48o o	3.76 q	7.46 p	15.33 h	17.33 h	8.67 g	2.00e	2.67 d	3.00 c
C_{75}NA	43.47d	75.83c	82.15e	12.22e	12.22e	25.79e	3.28e e	7.03 e	10.86e	19.33bcd	22.00 a-e	13.33abc	4.30 abcd	4.67 abc	6.00 ab
C_{75}NEAE	41.94e	73.67d	80.64g	11.47g	11.47g	24.71f	3.07g g	6.58 h	10.51g	18.67 de	21.67a-f	13.00 bcd	4.30 abcd	4.67 abc	5.67 ab
C_{75}NEA	42.6de	74.4cd	81.46f	11.82f	11.82f	25.47e	3.16f f	6.76 g	10.65f	19.00 cde	22.00 a-e	13.00 bcd	4.30 abcd	4.67 abc	6.00 ab
C_{75}AEN	42.82de	74.86cd	81.30f	11.94f	11.94f	25.37e	3.19f f	6.88 f	10.7f	19.00 cde	22.00 a-e	13.00 bcd	4.30 abcd	4.67 abc	5.67 ab
C_{75}TNA	46.46bc	79.38a	85.71c	13.51c	13.51c	28.10c	3.70c c	7.81 c	11.69c	20.67abc	23.00 abc	14.33ab	5.00 abc	5.33 ab	6.67 a
C_{75}TNEAE	46.75b	79.46a	86.07c	13.62bc	13.62bc	28.34bc	3.74c c	7.86 c	11.76c	20.67abc	22.67a-d	14.33ab	5.00 abc	5.33 ab	6.67 a
C_{75}TNEA	47.51ab	80.29a	86.59b	13.86ab	13.86ab	28.76abc	3.82b b	8.01 b	11.92b	21.00 ab	23.33 ab	14.67ab	5.33 ab	5.33 ab	6.67 a
C_{75}TAEN	47.59ab	80.65a	86.87b	13.93a	13.93a	28.97ab	3.85b b	8.06 b	12.00b	21.00 ab	23.33 ab	14.67ab	5.33 ab	5.67 a	6.67 a
C_{75}TNANEAE	48.29a	81.2a	87.43a	14.09a	14.09a	29.32a	3.93a a	8.19 a	12.16a	21.33a	23.67 a	15.00 a	5.67 a	5.67 a	7.00 a
C_{50}NA	34.42i	65.29g	71.60 m	8.67m	8.67m	18.44k	2.02 l	4.75m	8.62 l	16.33fgh	19.67 efg	10.00fg	3.33 cde	3.67bcd	4.67 abc
C_{50}NEAE	32.23j	63.04h	65.61q	8.06 o	8.06o	17.02m	1.81nn	4.36 p	8.07 o	16.00 gh	19.00 gh	9.67fg	3.00 de	3.33 cd	4.00 bc
C_{50}NEA	33.83i	64.48gh	70.93n	8.5mn	8.50mn	17.97kl	1.94mm	4.63 n	8.44 m	16.33fgh	19.33fgh	10.00 fg	3.00 de	3.33 cd	4.67 abc
C_{50}AEN	33.13ij	63.68gh	70.301o	8.28no	8.28no	17.55lm	1.87 n	4.52 o	8.25 n	16.00 gh	19.00 gh	9.67fg	3.00 de	3.33 cd	4.00 bc
C_{50}TNA	37.52h	68.60f	74.90 l	9.80 l	9.79 l	20.87j	2.43 k	5.48 l	9.27 k	17.33efg	20.33d-g	11.00 ef	3.67b-e	4.00abcd	5.00 abc
C_{50}TNEAE	37.25h	68.83f	75.46k	9.91kl	9.91kl	21.13ij	2.47 k	5.57 l	9.36 k	17.33efg	20.33d-g	10.67ef	3.67b-e	4.00abcd	5.00 abc
C_{50}TNEA	38.23gh	69.64ef	76.49j	10.13jk	10.13jk	21.65hi	2.54 j	5.71 k	9.52 j	17.60 d-g	20.67c-g	11.00 ef	3.67b-e	4.00abcd	5.00 abc
C_{50}TNAE	38.48fgh	69.88ef	76.86j	10.25ij	10.25ij	21.84h	2.58 j	5.78 k	9.60 j	17.67d-g	20.67c-g	11.00 ef	4.00 a-d	4.00abcd	5.00 abc
C_{50}TNANEAE	39.08fg	70.47ef	77.46i	10.46hi	10.46hi	22.32gh	2.68 i	5.90 j	9.71 i	18.00 def	21.00b-g	11.33def	4.00 a-d	4.67 abc	5.33abc

C_{100}: 100% N; C_{75}: 75% N; C_{50}: 50% N; A: *Anabaena*; N: *Nostoc*; E: Extract, T: Compost tea. Different letters in each column indicate significant differences between treatments at 5% level of significance

Root parameters

Data at Table (3) presented the root parameters (root length, root fresh weight and root dry weight). The maximum growth of wheat in term of root length was measured in treated with C_{75}TNANEAE (N 75% + compost tea + *Nostoc calicola*, *Anabaena cylindrica* soil and extract) which recorded 12.9 1, 16.47 and 19.23 cm after 60, 90 and 120 days from planting. The next term recorded the highest value with C_{75}TNANEAE (N 75% + compost tea + *Nostoc calicola*, *Anabaena cylindrica* soil and extract) after 90 and 120 days. Concerning the data of root fresh weight in Table (3) it could be revealed that all treatment of nitrogen fertilization rates, compost tea enriched with *Nostoc calicola*, *Anabaena cylindrica* soil and extract were significantly affected in root dry weight during three growth stages (60, 90 and 120 days).

Table 3. Root changes of wheat plants (for 120 days) affected by *A. cylindrica*, *N. calicola*, their extracts and compost tea comparing with different levels of nitrogen mineralization.

Treatments	Root length cm			Root fresh weight g/plant			Root dry weight g/plant		
	60 days	90 days	120 days	60 days	90 days	120 days	60 days	90 days	120 days
C_{100}	11.65 d	15.29 d	17.86 e	1.93 f	1.47 mn	0.63 p	0.81 c	0.98 c	1.08 c
C_{75}	9.45 h	13.06 h	15.63 i	2.53 b	2.02 h	1.02 o	0.42 g	0.67 f	0.79 f
C_{50}	5.51 p	9.19 q	11.84 q	3.41 a	2.76 bcd	1.32 n	0.10 k	0.12 m	0.23 m
C_{75}NA	10.97 e	14.74 e	17.16 f	1.78 g	2.44 e	3.28 d	0.70 d	0.90 d	0.96 d
C_{75}NEAE	10.36 g	14.03 g	16.53 h	1.67 i	2.25 g	3.07 f	0.55 f	0.80 e	0.89 e
C_{75}NEA	10.75 f	14.34 f	16.83 g	1.72 h	2.33 f	3.14 e	0.61 ef	0.85 de	0.93 de
C_{75}AEN	10.63 f	14.42 f	16.94 g	1.74 gh	2.31 f	3.17 e	0.64 e	0.85 de	0.92 de
C_{75}TNA	12.28 c	15.85 c	18.53 d	2.05 e	2.71 d	3.59 c	0.91 b	1.09 b	1.19 b
C_{75}TNEAE	12.37 c	15.98 c	18.63 d	2.07 e	2.73 cd	3.61 c	0.89 b	1.11 b	1.17 b
C_{75}TNEA	12.60 b	16.19 b	18.86 c	2.12 d	2.78 bc	3.69 b	0.94 ab	1.14 ab	1.22 ab
C_{75}TAEN	12.74 ab	16.27 b	19.04 b	2.14 cd	2.81 b	3.71 b	0.95 ab	1.15 ab	1.23 ab
C_{75}TNANEAE	12.91 a	16.47 a	19.23 a	2.18 c	2.87 a	3.78 a	0.97 a	1.18 a	1.26 a
C_{50}NA	7.32 l	10.97 m	13.46 m	1.03 n	1.49 m	1.96 j	0.16 j	0.34 j	0.44 j
C_{50}NEAE	6.59 o	10.22 p	12.74 p	0.88 p	1.31 p	1.71 m	0.14 jk	0.23 l	0.35 l
C_{50}NEA	7.06 m	10.73 n	13.23 n	0.99 n	1.42 no	1.88 k	0.16 j	0.31 jk	0.42 jk
C_{50}AEN	6.85 n	10.46 o	13.04 o	0.93 o	1.37 o	1.79 l	0.15 jk	0.27 kl	0.39 kl
C_{50}TNA	8.53 k	12.24 l	14.66 l	1.27 m	1.78 l	2.45 i	0.28 i	0.53 i	0.62 i
C_{50}TNEAE	8.67 k	12.11 l	14.76 l	1.32 l	1.81 kl	2.43 i	0.27 i	0.54 hi	0.64 hi
C_{50}TNEA	8.91 j	12.48 k	15.05 k	1.36 kl	1.86 jk	2.54 h	0.31 i	0.57 hi	0.69 gh
C_{50}TNAE	9.03 j	12.63 j	15.15 k	1.38 k	1.89 j	2.57 h	0.33hi	0.59 gh	0.68 ghi
C_{50}TNANEAE	9.22 i	12.85 i	15.36 j	1.43 j	1.95 i	2.65 g	0.38 gh	0.64 fg	0.72 g

C_{100}: 100% N; C_{75}: 75% N; C_{50}: 50% N; A: *Anabaena*; N: *Nostoc*; E: Extract, T: Compost tea. Different letters in each column indicate significant differences between treatments at 5% level of significance

Root dry weight was significantly recorded the highest values after 60, 90 and 120 days with treatment of C_{75}TNANEAE (N 75 % + compost tea + *Nostoc calicola*, *Anabaena cylindrica* soil and extract). Increasing shoot and root growth parameters by increasing nitrogen fertilization may be attributed to the important role of nitrogen in nuclic acids, co-enzymes and proteins which reflected to plant development and growth. El-Ayouty *et al.* (2012) reported that combination of cyanobacteria with less chemical fertilizers was potential approach in providing wheat growth. Also, Abou Tahoun *et al.* (2020) showed that the inoculation with cyanobacteria *Nostoc muscorum* combined with 75% N dose significantly attained the superior effect on wheat plant growth parameters.

Pigment content

The data in Table (4) on chlorophyll A ($mg.g^{-1}$) as affected by different levels of nitrogen mineralization with compost tea, *Anabaena cylindrica* and *Anabaena cylindrica* extract revealed that all the treatment were significantly affected on the chlorophyll A content. The maximum chlorophyll A content of wheat leaves was 0.67, 0.81 and 0.79 $mg.g^{-1}$ recorded after 60, 90 and 120 days from planting, respectively were noted with the treatment of C_{75}TNANEAE (N 75 % + compost tea + *Nostoc calicola*, *Anabaena cylindrica* soil and extract). Statistical analysis of data on chlorophyll B showed that the treatments means were significantly ($p < 0.05$) different from one another (Table 4). The significantly maximum content of chlorophyll B was 0.44, 0.53 and 0.51 $mg.g^{-1}$ after 60, 90 and 120 days with the treatment of C_{75}TNANEAE (N 75 % + compost tea + *Nostoc calicola*, *Anabaena cylindrica* soil and extract).

Data on the plant carotenoids content of wheat leaves (Table 4) revealed that the highest mean values of carotenoids content was realized with the treatment of C_{75}TNANEAE (N 75 % + compost tea + *Nostoc calicola*, *Anabaena cylindrica* soil and extract) which scored 0.35, 0.47 and 0.40+ $mg.g^{-1}$.

Table 4. Pigment content ($mg.g^{-1}$) of wheat plants (for 120 days) affected by *A. cylindrica*, *N. calicola*, their extracts and compost tea comparing with different levels of nitrogen mineralization.

Treatments	Chlorophyll a $mg.g^{-1}$			Chlorophyll b $mg.g^{-1}$			Carotenoids $mg.g^{-1}$		
	60 days	90 days	120 days	60 days	90 days	120 days	60 days	90 days	120 days
C_{100}	0.63 c	0.78 c	0.75 d	0.41 d	0.50 e	0.47 d	0.31 e	0.44 e	0.35 d
C_{75}	0.57 f	0.71 g	0.68 h	0.35 h	0.43 i	0.41 h	0.25 i	0.37 i	0.30 h
C_{50}	0.46 m	0.60 m	0.57 o	0.23 p	0.31 q	0.29 o	0.15 r	0.26 p	0.20 p
C_{75}NA	0.61 d	0.76 de	0.73 e	0.36 g	0.47 f	0.45 e	0.29 f	0.42 f	0.34 e
C_{75}NEAE	0.60 e	0.74 f	0.71 g	0.37 f	0.46 h	0.43 g	0.27 h	0.40 h	0.32 g
C_{75}NEA	0.61 de	0.75 ef	0.72 f	0.38 e	0.46 g	0.44 f	0.28 g	0.41 g	0.33 f
C_{75}AEN	0.61de	0.75def	0.72 f	0.39 e	0.47 fg	0.44 ef	0.28 g	0.41 g	0.33 f
C_{75}TNA	0.65 b	0.76 d	0.77 c	0.43 c	0.52 cd	0.49 c	0.33 d	0.46 cd	0.37 c
C_{75}TNEAE	0.65 b	0.796 b	0.77 c	0.43 c	0.51 d	0.49 c	0.33 c	0.46 d	0.37 c
C_{75}TNEA	0.66 ab	0.80 ab	0.77 b	0.44 b	0.52 bc	0.50 b	0.34 b	0.46 bc	0.38 b
C_{75}TAEN	0.66 ab	0.80 a	0.78 b	0.43 b	0.53 ab	0.50 ab	0.34 b	0.47 ab	0.39 b
C_{75}TNANEAE	0.67 a	0.81 a	0.79 a	0.44 a	0.53 a	0.51 a	0.35 a	0.47 a	0.40a
C_{50}NA	0.50 j	0.66 j	0.62 l	0.28 l	0.36 n	0.34 l	0.19 n	0.30 m	0.24 l
C_{50}NEAE	0.49 l	0.63 l	0.60 n	0.26 o	0.34 p	0.32 n	0.17 q	0.29 o	0.22 o
C_{50}NEA	0.5 jk	0.65 jk	0.61 m	0.28 m	0.26 r	0.34 lm	0.18 o	0.3 mn	0.23 m
C_{50}AEN	0.49 kl	0.64 kl	0.61 m	0.27 n	0.35 o	0.33mn	0.17 p	0.30 n	0.23 n
C_{50}TNA	0.55 hi	0.69 i	0.66k	0.32 k	0.40 m	0.38 k	0.22 m	0.34 l	0.27 k
C_{50}TNEAE	0.54 i	0.69 i	0.66k	0.33 k	0.40 lm	0.38 k	0.22 l	0.34 l	0.27 k
C_{50}TNEA	0.55ghi	0.70hi	0.67 j	0.33 j	0.41 jk	0.39 j	0.23 k	0.35 k	0.28 j
C_{50}TNAE	0.56 gh	0.70hi	0.67 j	0.33 j	0.41 kl	0.39 ij	0.23 k	0.36 k	0.28 j
C_{50}TNANEAE	0.56 fg	0.71gh	0.68 i	0.34 i	0.42 j	0.40 i	0.24 j	0.36 j	0.29

C_{100}: 100% N; C_{75}: 75% N; C_{50}: 50% N; A: *Anabaena*; N: *Nostoc*; E: Extract, T: Compost tea. Different letters in each column indicate significant differences between treatments at 5% level of significance

Application of nitrogen directly increased the chlorophyll content and leaf surface area resulting in increased photosynthesis process leading to more sugar formation (Dikshit and Paliwal, 1989). Nitrogen nutrition influences the content of photosynthetic pigments, the synthesis of the enzymes taking part in the carbon reduction, the formation of the membrane system of chloroplasts, etc. (Mengel and Kirkby, 1996). Verma *et al.* (2004) recorded that the N content in the third leaf and chlorophyll a content increased with increasing nitrogen rate. Chlorophyll is essential for leaf photosynthesis, and its content in wheat leaves reflects their photosynthetic capacity (Hlavacova *et al.,* 2018). Nitrogen affects and participates in chlorophyll synthesis (Gaju *et al.,* 2014). Moderate nitrogen fertilizer application has been shown to increase leaf chlorophyll content, which promotes the growth of aboveground parts, such as leaves, and thus leads to an increase in biomass (Yang *et al.,* 2017 and Tian *et al.,* 2020).

Ördög (1999) showed that cyanobacterial contain a special set of biologically active compounds including plant growth regulators, which can decrease senescence and transpiration and increase the content of leaf chlorophyll. In this respect, Pereira *et al.* (2009) found that the use of bio-fertilizers based on local strains of cyanobacteria was effective to increase the nitrogen use efficiency in rice. It seems reasonable to suggest that, significant increase in photosynthetic pigments a result of bio-fertilizer treatments may be due to the role of nitrogen in the increase of photosynthetic activity of the chloroplast.

Nitrogen, phosphorus and potassium content in shoot, root and in straw & grain

The data of nutritional status of plant (at 60, 90 and 120 DAS) are presented Table (5) in shoot, Table (6) in root and Table (7) in straw & grain respectivly, as affected by nitrogen mineralization with compost tea, *Nostoc calicola*, *Anabaena cylindrica* soil and extract. From observed data found that all treatments significantly affected in N, P and K percent in shoot during the three stages. In Table (5) the highest mean values of N, P, K were obtained with the treatment of C_{75}TNANEAE (N 75 % + compost tea + *Nostoc calicola*, *Anabaena cylindrica* soil and extract) which recorded 2.93, 3.48 and 2.55% for N, 0.34, 0.30 and 0.18% for P and 1.72, 2.39 and 1.65% for K after 60, 90 and 120 days. And in Table (6) showed the values of N, P and K percent in root as affected by nitrogen mineralization with compost tea, *Nostoc calicola*, *Anabaena cylindrica* soil and extract. Regarding the varietal differences, the data showed that all treatments significantly affected the root content of NPK and the different application from all treatments increase the nutritional root content. From the data found the highest value recorded with the treatment of C_{75}TNANEAE (N 75 % + compost tea + *Nostoc calicola*, *Anabaena cylindrica* soil and extract). At the same time, data in Table (7) showed a significant ($P\leq 0.05$) predictable improvement in N, P and K concentration in both straw and grain of wheat. The increment obtained by the best interaction was with the treatment of C_{75}TNANEAE (N 75 % + compost tea + *Nostoc calicola*, *Anabaena cylindrica* soil and extract) which recorded 1.95, 0.25 and 1.92% in straw and 0.38 and 2.94% in grain for P and K%, while N content recorded the highest value with C_{75}TNEAE (2.99%).

Table 5. Nitrogen, phosphorus and potassium content (%) in shoots of wheat plants (for 120 days) affected by *A. cylindrica*, *N. calicola*, their extracts and compost tea comparing with different levels of nitrogen mineralization.

Treatments	N			P			K		
	60 days	90 days	120 days	60 days	90 days	120 days	60 days	90 days	120 days
C_{100}	2.69 d	3.23 c	2.37 d	0.31 d	0.42 e	0.27 d	2.63 d	3.17 d	2.50 d
C_{75}	2.25 h	2.82 g	1.97 h	0.25 h	0.36 i	0.22 h	2.21 h	2.78 h	2.06 h
C_{50}	1.48 n	2.02 n	1.30 o	0.16 p	0.25 o	0.15 o	1.29 o	1.95 o	1.22 p
C_{75}NA	2.54 e	3.14 d	2.24 e	0.29 e	0.40 f	0.25 e	2.50 e	3.07 e	2.35 e
C_{75}NEAE	2.42 g	3.02 f	2.12 g	0.28 g	0.38 h	0.24 g	2.38 g	2.93 g	2.25 g
C_{75}NEA	2.50 ef	3.07 ef	2.20 ef	0.28 f	0.39 g	0.25 f	2.44 f	2.99 fg	2.30 f
C_{75}AEN	2.48 f	3.09de	2.18 f	0.29 f	0.39 fg	0.25 fg	2.46 ef	3.01 ef	2.31 ef
C_{75}TNA	2.80 c	3.34 b	2.46 c	0.33 c	0.43 d	0.29 c	2.80 c	3.30 c	2.59 c
C_{75}TNEAE	2.81 c	3.37 b	2.47 bc	0.32 c	0.43cd	0.29 c	2.78 c	3.32 bc	2.62 c
C_{75}TNEA	2.87 b	3.43 a	2.51 ab	0.33 b	0.43bc	0.29 b	2.85 b	3.36abc	2.68 b
C_{75}TAEN	2.89ab	3.44 a	2.53 a	0.33 b	0.44ab	0.29 b	2.87ab	3.38 ab	2.7 ab
C_{75}TNANEAE	2.93 a	3.48 a	2.55 a	0.34 a	0.44 a	0.30 a	2.91 a	3.42 a	2.74 a
C_{50}NA	1.84 k	2.35 k	1.59 l	0.20 l	0.30 m	0.18 l	1.72 l	2.39 l	1.65 m
C_{50}NEAE	1.70 m	2.22 m	1.49 n	0.18 o	0.28 n	0.16 n	1.59 n	2.23 n	1.50 o
C_{50}NEA	1.79 l	2.30 kl	1.56 lm	0.20 m	0.30 m	0.18 l	1.69 l	2.36 lm	1.59 n
C_{50}AEN	1.75 l	2.26lm	1.52mn	0.19 n	0.29 n	0.17 m	1.64 m	2.30 m	1.55 n
C_{50}TNA	2.11 j	2.64 ij	1.82 jk	0.23 k	0.33 l	0.20 k	2.00 k	2.64 jk	1.88 kl
C_{50}TNEAE	2.09 j	2.62 j	1.80 k	0.23 k	0.33 l	0.20 k	1.97 k	2.61 k	1.87 l
C_{50}TNEA	2.16 i	2.68 ij	1.88 i	0.24 j	0.34 k	0.21 jk	2.06 j	2.69 ij	1.92 jk
C_{50}TNAE	2.17 i	2.70 hi	1.86 ij	0.24 j	0.35 k	0.21 j	2.09 j	2.69 ij	1.94 j
C_{50}TNANEAE	2.21 hi	2.75 h	1.94 h	0.25 i	0.35 j	0.22 i	2.15 i	2.72 hi	1.997 i

C_{100}: 100% N; C_{75}: 75% N; C_{50}: 50% N; A: *Anabaena*; N: *Nostoc*; E: Extract, T: Compost tea. Different letters in each column indicate significant differences between treatments at 5% level of significance

Table 6. Nitrogen, phosphorus and potassium content (%) in roots of wheat plants (for 120 days) affected by *A. cylindrica*, *N. calicola*, their extracts and compost tea comparing with different levels of nitrogen mineralization.

Treatments	N			P			K		
	60 days	90 days	120 days	60 days	90 days	120 days	60 days	90 days	120 days
C_{100}	1.64 c	2.51 e	2.18 c	0.25 e	0.33 d	0.25 e	1.91 d	2.40 e	2.20 e
C_{75}	1.33 g	2.14 i	1.88 f	0.21 i	0.29 h	0.21i	1.56 i	1.98 i	1.77 i
C_{50}	0.79 m	1.48 p	1.26 m	0.13 q	0.19 q	0.14 q	0.91 q	1.26 p	1.04 p
C_{75}NA	1.56 d	2.43 f	2.09 d	0.24 f	0.32 e	0.23 f	1.80 e	2.30 f	2.09 f
C_{75}NEAE	1.44 f	2.31 h	2.01 e	0.23 h	0.30 g	0.22 h	1.70 h	2.16 h	1.96 h
C_{75}NEA	1.47 ef	2.34gh	2.05de	0.23 g	0.31 f	0.23 g	1.77 f	2.23 g	2.02 g
C_{75}AEN	1.49 e	2.36 g	2.04 e	0.23 g	0.31 fg	0.23 g	1.74 g	2.21 g	2.003g
C_{75}TNA	1.76 b	2.60 d	2.28 b	0.26cd	0.34 c	0.26cd	1.99 c	2.55cd	2.31 d
C_{75}TNEAE	1.74 b	2.62cd	2.27 b	0.26 d	0.34 c	0.26 d	2.01 c	2.53 d	2.33 cd
C_{75}TNEA	1.80 a	2.66bc	2.31 b	0.27bc	0.35 b	0.26bc	2.06 b	2.59bc	2.39 ab
C_{75}TAEN	1.81 a	2.68ab	2.32 b	0.27 b	0.35ab	0.26 b	2.08ab	2.62 b	2.37 bc
C_{75}TNANEAE	1.83 a	2.71 a	2.37 a	0.27 a	0.35 a	0.27 a	2.11 a	2.76 a	2.43 a
C_{50}NA	1.05 j	1.77 n	1.53 j	0.16 m	0.24 m	0.17 m	1.25 m	1.58 m	1.37 m
C_{50}NEAE	0.93 l	1.68 o	1.44 l	0.15 p	0.22 p	0.16 p	1.14 p	1.43 o	1.23 o
C_{50}NEA	1.00 k	1.76 n	1.49 jk	0.16 n	0.23 n	0.17 n	1.21 n	1.52 n	1.33 m
C_{50}AEN	0.96 l	1.71 o	1.47 kl	0.16 o	0.23 o	0.16 o	1.18 o	1.48 n	1.28 n
C_{50}TNA	1.22 i	2.02lm	1.75 i	0.19 l	0.27 kl	0.19 kl	1.44 l	1.83 l	1.62 l
C_{50}TNEAE	1.31 g	1.99 m	1.73 i	0.19 l	0.27 l	0.19 l	1.43 l	1.80 l	1.60 l
C_{50}TNEA	1.21 i	2.04 kl	1.80 h	0.20 k	0.28 j	0.20 j	1.50 k	1.90 jk	1.69 jk
C_{50}TNAE	1.27 h	2.07 jk	1.82gh	0.20 k	0.27 jk	0.20 jk	1.47 k	1.88 k	1.67 k
C_{50}TNANEAE	1.30gh	2.11 ij	1.85 fg	0.20 j	0.28 i	0.20 i	1.53 j	1.94 ij	1.73 ij

C_{100}: 100% N; C_{75}: 75% N; C_{50}: 50% N; A: *Anabaena*; N: *Nostoc*; E: Extract, T: Compost tea. Different letters in each column indicate significant differences between treatments at 5% level of significance

The highest mean values of N, P, K percent recorded with nitrogen fertilization may be return to the elements availability for plant and improving root growth, hence increasing the absorbing area of root, these results were consistent with finding of El-Sobky and Desoky (2016) resulted that *Anabaena* and spraying with *Anabaena* extract and mineral nitrogen fertilizer significantly increased N, P, and K content of shoots of rice plant.

Results of Abed EL-Rasoul *et al.* (2004) and Mussa *et al.* (2003) indicated that spraying nitrogen fixing bio fertilizers individually significantly increased N, P, and K concentration by grains and straw over the control treatments (without spraying bio-fertilizers) confirmed increasing the nutrient concentration by wheat grain and straw in response to the use of cyanobacterial as an activator bio-fertilizer separately. In this respect, El-Sobky and Desoky (2016) suggested significant differences among bio-fertilizer treatments in N, P, and K content while the best result of bio-fertilizer was obtained for treatment inoculated with *Anabaena* and spraying with *Anabaena* extract treatment followed by that inoculated with *Anabaena* treatment.

Table 7. Nitrogen, phosphorus and potassium content (%) in straw and grains of wheat plants (for 120 days) affected by *A. cylindrica*, *N. calicola*, their extracts and compost tea comparing with different levels of nitrogen mineralization.

Treatments	Straw			Grains		
	N	P	K	N	P	K
C_{100}	1.81 c	0.23 e	1.78 d	2.70 d	0.36 e	2.73 d
C_{75}	1.58 g	0.20 i	1.56 h	2.60 f	0.31 i	2.39 h
C_{50}	1.13 n	0.14 p	1.09 o	2.64 ef	0.22 o	1.68 o
C_{75}NA	1.76 d	0.22 f	1.72 e	2.65de	0.34 f	2.64 e
C_{75}NEAE	1.69f	0.22 h	1.64 g	2.88 b	0.33 h	2.52g
C_{75}NEA	1.72e	0.22g	1.67 fg	2.90 b	0.334g	2.57f
C_{75}AEN	1.73e	0.22g	1.69 ef	2.95a	0.34fg	2.59 ef
C_{75}TNA	1.87b	0.24d	1.85 c	2.96 a	0.37 d	2.84 c
C_{75}TNEAE	1.89b	0.24cd	1.86 bc	2.99 a	0.37cd	2.86 bc
C_{75}TNEA	1.92a	0.24bc	1.88abc	2.02 k	0.37bc	2.89abc
C_{75}TAEN	1.93a	0.24 b	1.89 ab	1.91m	0.38 b	2.90ab
C_{75}TNANEAE	1.95a	0.25 a	1.92 a	1.98 kl	0.38 a	2.94a
C_{50}NA	1.32k	0.17m	1.34 l	1.94lm	0.26m	2.05 l
C_{50}NEAE	1.24m	0.16 o	1.25 n	2.27 ij	0.24 n	1.92 n
C_{50}NEA	1.29kl	0.17m	1.32 lm	2.25 j	0.25m	2.03lm
C_{50}AEN	1.27lm	0.16 n	1.29 m	2.30 ij	0.25 n	1.98 m
C_{50}TNA	1.48 j	0.18 l	1.48jk	2.32 hi	0.29 l	2.27 jk
C_{50}TNEAE	1.47 j	0.19 l	1.46 k	2.36 h	0.29 l	2.25 k
C_{50}TNEA	1.5 ij	0.19 k	1.50 ij	2.70 d	0.29 k	2.31 ij
C_{50}TNAE	1.51 hi	0.19 k	1.50 ij	2.60 f	0.30 k	2.31 ij

C_{100}: 100% N; C_{75}: 75% N; C_{50}: 50% N; A: *Anabaena*; N: *Nostoc*; E: Extract, T: Compost tea. Different letters in each column indicate significant differences between treatments at 5% level of significance

Yield parameters

Results in Table (8) indicated the effect of inoculation under nitrogen fertilization with compost tea on weight of 100 grain g. Results revealed that with increasing nitrogen fertilization the weight of 100 grain increased especially under inoculation *Nostoc calicola*, *Anabaena cylindrica* soil and extract and compost tea. While the highest mean values recorded with C_{75}TNANEAE (N 75% + compost tea + *Nostoc calicola*, *Anabaena cylindrica* soil and extract) and scored 5.94 g followed by C_{75}TAEN (N 75% + compost tea + *Anabaena cylindrical* extract+ *Nostoc calicola*) and scored 5.84 g with low significant effect.

While, the results in Table (8) illustrated the effect of nitrogen mineralization with compost tea, *Nostoc calicola*, *Anabaena cylindrica* soil and extract on weight of straw g/plant. On average the maximum weight of straw 13.64 g/plant was obtained with the application of C_{75}TNANEAE (N 75 % + compost tea + *Nostoc calicola*, *Anabaena cylindrica* soil and extract) over the other treatments.

Effect of inoculation with *Nostoc calicola*, *Anabaena cylindrica* through soil or spraying with *Anabaena cylindrica* extract either alone or in combination with the application of nitrogen fertilization and compost tea on weight of spike g is given in Table (8). Data showed significant differences among bio-fertilization and N fertilization with compost tea. On the average maximum weight of spike (4.17 g) was obtained with C_{75}TNANEAE (N 75 % + compost tea + *Nostoc calicola*, *Anabaena cylindrica* soil and extract).

According to the individually or combination application between nitrogen mineralization with compost tea, *Nostoc calicola*, *Anabaena cylindrica* soil and extract on the number of grain/spike in Table (8). The highest increase was obtained with C_{75}TNANEAE (N 75% + compost tea + *Nostoc calicola*, *Anabaena cylindrica* soil and extract) treatments.

Table 8. Yield parameters of wheat plants (at 120 days) affected by *A. cylindrica*, *N. calicola*, their extracts and compost tea comparing with different levels of nitrogen mineralization.

Treatments	100 grain weight (g)	Straw weight (g/plant)	Spike weight (g)	No. of grain/spike
C_{100}	5.59 d	11.75 d	3.82 c	70.67 bc
C_{75}	4.68 g	8.98 g	3.22 f	60.00 e
C_{50}	3.03 n	4.24 o	2.39 l	42.00 h
C_{75}NA	5.30 e	10.96 e	3.63 d	67.67 cd
C_{75}NEAE	5.07 f	10.49 f	3.46 e	64.67 d
C_{75}NEA	5.21 e	10.66 f	3.53 de	66.00 cd
C_{75}AEN	5.19 e	10.58 f	3.55 de	66.33 cd
C_{75}TNA	5.75 bc	12.64 c	3.99 b	72.67 ab
C_{75}TNEAE	5.70 c	12.75 c	3.97 b	73.00 ab
C_{75}TNEA	5.82 b	13.16 b	4.04 b	73.67 ab
C_{75}TAEN	5.84 ab	13.29 b	4.08 ab	74.00 ab
C_{75}TNANEAE	5.94 a	13.64 a	4.17 a	76.00 a
C_{50}NA	3.75 k	5.96 k	2.73 i	51.33 fg
C_{50}NEAE	3.47 m	5.10 n	2.56 k	48.33 g
C_{50}NEA	3.67 kl	5.67 l	2.68 ij	50.67 g
C_{50}AEN	3.57 lm	5.36 m	2.61 jk	49.00 g
C_{50}TNA	4.31 ij	7.73 j	3.02 h	56.00 ef
C_{50}TNEAE	4.27 j	7.82 j	3.02 h	55.67 ef
C_{50}TNEA	4.39 i	8.25 i	3.11 fgh	57.67 e
C_{50}TNAE	4.41 i	8.12 i	3.08 gh	58.00 e
C_{50}TNANEAE	4.56 h	8.58 h	3.18 fg	58.67 e

C_{100}: 100% N; C_{75}: 75% N; C_{50}: 50% N; A: *Anabaena*; N: *Nostoc*; E: Extract, T: Compost tea. Different letters in each column indicate significant differences between treatments at 5% level of significance

Additionally, using cyanobacteria strain found an increase yield component, this result is similar to those repoted by Karthikeyan *et al.* (2007) and El-Zemrany (2017) who reported the effects of inoculant cyanobacteria strains on wheat involving (single or in combination) showed visible differences in terms of the appearance of plants. This was accompanied by enhancement in plant height, dry weight and grain yield of wheat crop. Therefore, plant growth stimulation, in terms of plant height, dry weight and grain yield in pot culture experiment can be attributed to Indole Acetic Acid -like compounds and photoheterotrophic/ heterotrophic abilities of the cyanobacteria strains, as observed in our earlier studies.

CONCLUSION

Application of inoculation with two cyanobacterial strains, their extracts and compost tea under three doses of inorganic nitrogen increased Nitrogen-fixing cyanobacteria and bacterial rhizosphere soil content, plant growth parameters and yield of wheat plant. And from root biovolume and shoot length were taken as index for the plant growth promotion activity of the tested strains (Hauka *et al.,* 2012). Therefore, it would be recommended to apply these strains of cyanobacteria in bio-organic farming (Zaki *et al.,* 2021).

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تأثير شاى الكمبوست وكذلك سلالات السيانوبكتيريا ومستخلصاتها على نمو وإنتاجية نبات القمح

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الملخص

تم إختبار إمكانية إستخدام شاى الكمبوست والتلقيح بسلالتى من السيانوبكتيريا (*Anabaena cylindrica* و *Nostoc calcicole*) ومستخلصاتهما لتحسين نمو وانتاجية نباتات القمح تحت ظروف الصوبة الزجاجية. المعاملات منفردة أو كخليط مع جرعات من السماد النتروجينى المعدنى كانت هى الرئيسية فى الدراسة المقدمة0 وقد أشارت النتائج المتحصل عليها خلال ثلاثة مراحل من نمو النبات (60 - 90- 120 يوم من الزراعة) إلى وجود فرق معنوى من معاملة لأخرى وسجلت النتائج أن هناك معنوية فى نمو النبات الخضرى وأيضا فى المحصول وكذلك فى محتوى العناصر (النتروجين والفوسفور والبوتاسيوم) فى المجموع الخضرى والجذرى والقش بالأضافة إلى محصول الحبوب وذلك مع المعاملة C_{75}TNANEAE (N 75 % + compost tea + *Nostoc calicola*, *Anabaena cylindrica* and extracts) (سلالاتى السيانوبكتيريا + شاى الكمبوست + 75% من الجرعة الموصى بها من التسميد النتروجينى) 0 كما أشارت النتائج إلى أن معاملات التسميد الحيوى أظهرت زيادة فى أعداد البكتيريا الحية فى التربة بالإضافة إلى زيادة أعداد سلالاتى السيانوبكتيريا المستخدمة وذلك مع المعاملة C_{75}TNANEAE بعد 60 يوم من الزراعة فى كلتا الحالتين . لذلك توصى الدراسة من خلال النتائج التى تحصلنا عليها بإمكانية إستخدام لقاح السيانوبكتيريا الثنائى ومستخلصاته وشاى الكمبوست فى وجود 75 % من معدل النيتروجين الموصى به لتحسين نمو و إنتاجية نبات القمح .