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Effects of Cyanobacterial Inoculation on the Growth and Yield of *Triticum aestivum* L. var. Deva K9117

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Abstract

The exponential growth in human population is become a serious concern in terms of their nutritional requirements. For the solution of this problem several methods and technologies have been adopted like development of high yielding varieties with improved agricultural practices. These varieties require more chemical fertilizers for the maximum production but excessive utilization of these chemical fertilizers may cause the deficiencies and infertility in the agricultural soils. So there is need to replace these chemical fertilizers with biological fertilizers due to their environmental sustainability. The utilization of cyanobacteria as bio-fertilizers are an eco-friendly, easily manageable and self-regenerating process which improve the nutrient status as well as health of soil. In addition to biological nitrogen fixation they also produce several growth promoting substances. During the present investigations we have adopted an experimental research approach to examine the effects of cyanobacteria (inoculation of live *Anabaena fertilissima* C.B. Rao and *Nostoc linckia* Bornet ex Bornet & Flahault isolates collected from river Ganga at Kanpur, U.P, India) as bio-fertilizer in *Triticum aestivum* L. var. Deva K9117 on the basis of average height of plants, weight of grains and number of grains/spike. The observations showed significant changes/improvements in growth and productivity of *Triticum aestivum* L. var. Deva K9117. The inoculation of *Anabaena fertilissima* C.B. Rao (100 ml) increased the 19.81% grains/spike, 9.86% weight of grains and 7.91% height of plants while inoculation of *Nostoc linckia* Bornet ex Bornet & Flahault (100 ml) increased the 19.36% grains/spike, 7.27% weight of grains and 5.64% height of plants over the control. The most considerable finding of the study was the mixture of *Anabaena fertilissima* C.B. Rao+*Nostoc linckia* Bornet ex Bornet & Flahault (60:40) increased 24.32% grains/spike, 15.09% weight of grains and 10.09% height of plants over the control.

1. Introduction

Increasing demand of food and fodder has enhanced the excessive utilization of chemical fertilizers, pesticides, insecticides and herbicides to gain maximum yield of agricultural crops. Commonly modern agricultural practices depended on the nitrogenous chemical fertilizers. Due to massive application of agro-chemicals in agricultural practices the agricultural lands are losing their fertility. These agro-chemicals directly or indirectly pose serious health problems in human and other domestic animals. Thus, it is urgent need to investigate the probable alternatives of nitrogen fertilizers with microbial origin. In this way some microorganisms like bacteria and cyanobacteria (Blue-green algae) have ability to fix atmospheric nitrogen.

The cyanobacteria include about 150 genera and 2,000 species ranging from unicellular, colonial and filamentous forms (Vincent, 2009). Cyanobacteria are gram-negative and oxygen evolving photosynthetic prokaryotic organisms and are most successful and oldest life forms of the planet. They acquire almost all kinds of habitats ranging from freshwater, marine and terrestrial environments and also in extreme habitats where other organisms cannot survive (Tripathi *et al*., 2007; Nagarajan *et al*., 2012; Whitton, 2012). Generally, it is believed that heterocyst bearing filamentous cyanobacterial species possesses the nitrogen fixing ability (Granhall and Henriksson, 1969) but some non-heterocystous cyanobacteria also capable to fix atmospheric nitrogen (Kallas *et al*., 1983). Cyanobacteria play an important role due to their capability in crop production as promising biofertilizers, soil conditioners and plant growth promoters (Ashraf *et al.,* 2013; Kaushik, 2014; Singh *et al*., 2014; El-Beltagy *et al*., 2016). Cyanobacteria also produce growth promoting substances such as amino acids, auxins, gibberellins, cytokinins (Sood *et al.,* 2011). All these compounds enhance the availability of nutrients in soils for up taking by crop plants (Mader *et al.,* 2011). Thus, cyanobacteria are potential candidates for the enhancement of growth and productivity of crops. The present investigations aimed to examine the role of cyanobacteria in the growth and yield of *Triticum aestivum* L. var. Deva K9117 on the basis of average height of plants, average weight of grains and average number of grains/spike.

2. Material and Methods

2.1. Collection, identification, isolation, purification and culturing of cyanobacteria

The cyanobacterial samples were collected from river Ganga at Kanpur, by using 20μ mesh size plankton net. Collected samples were observed under compound research microscope and identification of different genera and species of cyanobacteria have been made by using standard texts and monographs *i.e.* Desikachary (1959); Prescott (1962) etc. on the basis of their structures and measurements. Pure cultures of *Anabaena fertilissima* C.B. Rao and *Nostoc linckia* Bornet ex Bornet & Flahault have been made in modified Chu 10 media (Stein, 1973).

The fragments of these forms have been taken on clean slide and separated with the help of sterilized needle and transferred into culture tube containing sterilized culture media. For the removal of eukaryotic contaminants cyclohexamide (1 ml L^{-1}) added into culture media. The pure cultures of these cyanobacteria have been obtained by serial dilution method. The cultures of these isolated and purified cyanobacteria have been maintained in BOD incubator at 25±2^{0}C under 350-400 foot candles light intensity with 16 hours light period and 8 hours dark period.

2.2. Effects of cyanobacterial inoculation on Triticum aestivum L. var. Deva K9117

Sterilized seeds of *Triticum aestivum* L. var. Deva K9117 sown in the four cemented pots, filled with autoclaved 10 kilogram uniform soil in each pot. The soil was collected from the agricultural fields of local Kanpur city. Ten healthy grains of *Triticum aestivum* L. var. Deva K9117 were sown in per pot. After germination, number of plants has reduced to five healthy plants per pot. The experiments have been performed in following conditions to investigate the cyanobacterial potential as biofertilizer in agriculture-

Pot 1- Served as control *i.e.* no inoculation of cyanobacteria

Pot 2- 100 ml of live *Anabaena fertilissima* C.B. Rao (*AF*) was inoculated into the pot.

Pot 3- 100 ml of live *Nostoc linckia* Bornet ex Bornet & Flahault (*NL*) was inoculated into the pot.

Pot 4- 100 ml of live *AF* + *NL* (60:40) was inoculated into the pot.

These experiments have been carried out in natural environmental conditions during the November, 2013 to March, 2014. The observations and results have been made on the basis of average number of grains/spike, weight of grains and height of plants. The plants were irrigated with water when soil began to dry.

3. Results and Discussion

Utilization of Cyanobacteria as bio-fertilizer is an eco-friendly, easily manageable input forming perpetually self-regenerating systems which improve the nutrient status as well as health of soils. In addition to biological nitrogen fixation, cyanobacteria are also useful for crop plants by producing various growth promoting substances. A lot of workers have observed enhancement in seed germination, growth of root and shoot, weight of grains and protein content of *Triticum aestivum* L. (Mishra and Kaushik, 1989; Singh and Trehan, 1973) and seed germination of *Triticum aestivum* L. (Gupta *et al*., 1967). Growth promoting substances such as gibberellins (Singh and Trehan, 1973), cytokinins (Rodgers *et al*., 1979), auxins (Ahmad and Winter, 1968) and abscisic acids (Marsalek *et al*., 1992) have also observed from cyanobacteria. Some workers observed that they also have the ability to produced vitamins (Venkataraman and Neelakantan, 1967; Misra and Kaushik, 1989), amino acids (Watanabe, 1959), antibiotics and toxins (Metting and Pyne, 1986).

We have used experimental research approach to examine the effect of cyanobacteria as biofertilizer in the *Triticum aestivum* L. var. Deva K9107 on the basis of average height of plants, weight of grains and number of grains/spike. These experiments have been made in four cemented pots filled with autoclaved soil in natural environmental conditions. The detailed results have been shown in Table 1 while summary in Table 2 and Figure 1. Results shown in tables and chart contain the information about average number of grains/spike, average weight of grains and average height of plants. According to Table 1-2 and Figure 1 the application of *Anabaena fertilissima* C.B. Rao were increased the 19.81% grains/spike, 9.86% weight of grains and 7.91% height of plants over the control while the application of *Nostoc linckia* Bornet ex Bornet & Flahault were increased the 19.36% grains/spike, 7.27% weight of grains and 5.64% height of plants over the control. The application of *Anabaena fertilissima* C.B. Rao were increased the 0.37% grains/spike, 2.42% weight of grains and 2.02% height of plants over the application of *Nostoc linckia* Bornet ex Bornet & Flahault.

Table 1: Effects of cyanobacterial inoculation on the growth and yield of *Triticum aestivum* L. var. Deva K9107 (Detailed)

Experiment No.	Number of grains/spike					Average weight of grains of each plant (mg)					Height of plant (cm)				
	P1	P2	P3	P4	P5	P1	P2	P3	P4	P5	P1	P2	P3	P4	P5
Pot 1(Control)	46	46	42	42	46	40.3	41.2	39.8	38.9	40.5	96.5	96.7	98.5	97.6	98.2
Pot 2(*AF*)	54	52	54	54	52	44.5	44.2	43.7	43.2	44.9	104.5	105.5	105.8	104.8	105.5
Pot 3 (*NL*)	52	52	50	52	54	42.5	42.9	43.5	43.5	42.9	102.3	103.5	103.4	102.8	103.7
Pot 4 (*AF+NL*)	56	56	54	56	54	46.5	45.7	46.4	46.8	45.6	107.5	107.9	106.5	108.2	106.6

Table 2: Effects of cyanobacterial inoculation on the growth and yield of *Triticum aestivum* L. var. Deva K9107 (Summarized)

Experiment No.	Average number of grains/spike	% Increased over control (grains/spike)	Average weight of grains (mg)	% Increased over control (weight of grains)	Average height of plants (cm)	% increased over control (height of plants)
Pot 1(Control)	44.4	-	40.14	-	97.50	-
Pot 2(*AF*)	53.2	19.81	44.10	9.86	105.22	7.91
Pot 3 (*NL*)	53.0	19.36	43.06	7.27	103.14	5.64
Pot 4 (*AF+NL*)	55.2	24.32	46.20	15.09	107.34	10.09

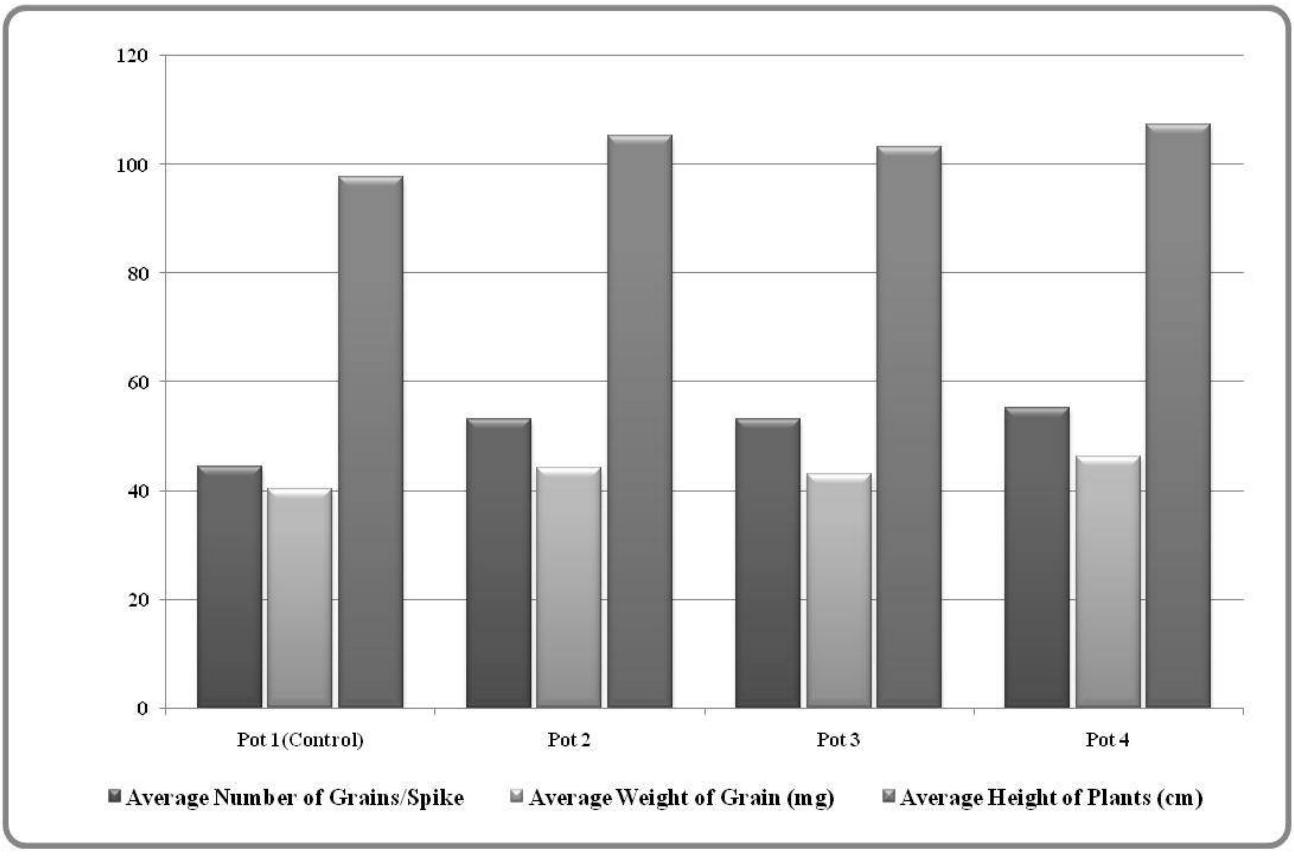

Fig. 1: Effects of cyanobacterial inoculation on the growth and yield of *Triticum aestivum* L. var. Deva K9107

The application of *Anabaena fertilissima* C.B. Rao+*Nostoc linckia* Bornet ex Bornet & Flahault (60:40) were increased the 24.32% grains/spike, 15.09% weight of grains and 10.09% height of plants over the control. The application of *Anabaena fertilissima* C.B. Rao+*Nostoc linckia* Bornet ex Bornet & Flahault (60:40) were increased the 3.75% grains/spike, 4.76% weight of grains and 2.01% height of plants over the application of *Anabaena fertilissima* C.B. Rao and 4.15% grains/spike, 7.29% weight of grains and 4.07% height of plants over the application of *Nostoc linckia* Bornet ex Bornet & Flahault.

According to above mentioned results and analysis we have recorded significant changes/ improvements in the growth and productivity of *Triticum aestivum* L. var. Deva K9107. The mixture of live *Anabaena fertilissima* C.B. Rao+*Nostoc linckia* Bornet ex Bornet & Flahault have provided the maximum 24.32% grains/spike, 15.09% weight of grain and 10.09% height of plants over the control and also over the single application of *Anabaena fertilissima* C.B. Rao and *Nostoc linckia* Bornet ex Bornet & Flahault. Conclusively, it can be said that cyanobacteria were cost effective, easily available and alternative to chemical fertilizers which can efficiently promote the growth and yield of several crops.

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