Plant Archives Vol. 21, Supplement 1, 2021 pp. 2401-2407 e-ISSN:2581-6063 (online), ISSN:0972-5210

Plant Archives

Journal homepage: http://www.plantarchives.org
doi link : https://doi.org/10.51470/PLANTARCHIVES.2021.v21.S1.392

THE RESPONSE OF BIO-FERTILIZERS TO THE PRODUCTION POTENTIAL OF CEREAL CROPS

Dipak P. Gite[1], Prakash A. Gite[2] and Mayur S. Darvhankar[1*]
[1]School of Agriculture, Lovely Professional University, Phagwara (Punjab), India
[2] Dr. Punjabrao .Deshmukh .Krishi.Vishvavidyalaya. Akola (M.S.), India
*Corresponding author - mayur.21878@lpu.co.in

ABSTRACT

The land is a limited resource. Due to the increase in population; it is necessary to increase crop yield from the viewpoint of food security. The sole use of inorganic fertilizers may create an imbalance in soil health by the reduction in crop yield. For sustainable crop production, it is necessary to balance the soil health using organics and bio-fertilizers along with the optimum use of chemical fertilizers. Bio-fertilizers are important in the nutrient management of crops because of their role in nutrient supply leading to reduce the use of chemical fertilizers. The use of Bio-fertilizers is a cost-effective and eco-friendly technology in crop production which is gaining importance in crop production the commonly used biofertilizers are azotobactor, azosprillium, PSB, VAM fungi.

***Keywords* :** Bio-fertilizer, Grain yield, Growth, Production

Introduction

The sole use of inorganic fertilizers with suboptimal doses of organics deteriorates soil fertility leading to a reduction in crop production and its sustainability. For sustainable crop production, it is necessary to use organics and bio-fertilizers consistently leading to improvement in soil biota for the transformation of organics in available nutrients and essential soil enzymes important to crops. Mohammadi and Sohrabi (2012) stated that soil microorganisms play important role in physical, chemical, and biological processes. Bio-fertilizers are the products containing viable cells of different microorganisms essential for plant growth. Nutrients in the soil are available through elemental transformations, solubilization, fixation, and other mechanisms. Bio-fertilizer helps to supply N and P through fixation and solubilization respectively and acts as a supplement to inorganic fertilizer in an eco-friendly manner. In cereals, azotobactor is generally used in wheat and maize which is a non-symbiotic and contributes 20-25kg N ha^{-1}. Phosphorous solubilizing bacteria (PSB) can solubilize 20-30% of insoluble phosphate and increases yield up to 20 %. (Kachroo and Razdan, 2006). Other bio-fertilizers like azosprillium and vesicular-arbuscular mycorrhiza (VAM) fungi also improves plant growth and production by fixing and solubilizing phosphorous (Tarafdar and Rao, 1997).

Classification of Bio-fertilizers

A) N-Fixing Bio-fertilizers.

1. Free-living: Azotobactor, Clostridium, Anabaena, Nostoc.
2. Symbiotic: Rhizobium, Frankia.
3. Associative symbiotic: Azosprillium.

B) P- Solubilizing Bio-fertilizers.

1. Bacteria: Bacillus megaterium var. phosphaticum, Bacillus circulans, Pseudomonas striata
2. Fungi: Penicillium spp. , Aspergillus awamori.

C) P-mobilizing Bio-fertilizers

1. Arbuscular mycorrhiza : Glomus sp. , Gigaspora sp.
2. Ectomycorrhiza : Boletus sp., Amanita sp.
3. Orchid mycorrhiza: Rhizoctonia solani

D) Bio-fertilizers for micronutrients.

1. Silicates and Zinc solubilizer: Bacillus sp.

(source: www.Krishisewa.com)

Bio-fertilizers application

1. Seed treatment
2. Seedling root dip treatment
3. Soil application

Bio-fertilizers in cereal crops

Cereal crops are grown on a large scale for food and energy throughout the world. Cereals are stapled food crops and reach in CHO's, proteins, vitamins, minerals, etc. In India, important cereal crops are rice, wheat, maize, sorghum, pearl millet, etc. are grown on a large scale. The use of biofertilizers in these crops is beneficial for increasing production by reducing the cost of nutrient management. The role and importance of biofertilizers in cereal crops have been reviewed by some authors and presented below.

Effect of bio-fertilizers on wheat production

Agrawal *et al.* (2004) reported that at 80 DAS, about 72.03% N uptake was increased over the control due to Azotobacter inoculation and it was at par with treatment of 20 kg N ha^{-1} alone in wheat. Azotobacter alone and 20 kg N ha^{-1} were statistically at par in affecting the nitrogen content in grain and straw of wheat. Inoculation alone increased about 37.97, 39.17, and 37.37 % P uptake over the control in the grain, straw, and total yield of wheat respectively; whereas, potassium uptake was 95.25, 43.23, and 44.81%

respectively. Ram and Mir., (2006) stated that both biofertilizers, i.e. Azospirillum and Azotobacter, significantly enhanced all the growth parameters and grain and straw yields over the control. The combined application of Azospirillum + Azotobacter showed significant improvement over their individual application. Dileep and Ravinder, (2006) conducted an experiment at Jammu to study the effect of biofertilizers on wheat crop And observed that Azotobacter + Azospirillum in a 1:1 ratio was found to be effective in increasing the growth, yield attributes, and yield of wheat crop to significant levels. It also resulted in higher NUE. Prasanna *et al.* (2008) stated that the application of vermicompost in combination with BGA biofertilizer (biofertilizer + vermicompost + N40 P30 K30) has resulted in a significant increase in Nitrogenase activity. They also reported that inoculation with Azotobacter + BGA resulted in the highest value of chlorophyll (1.19 $\mu g\ g^{-1}$ soil).

Katiyar *et al.*, 2011, reported that the inoculated wheat seed by Azotobacter increased the yield up to 1.92–2.0 % as compared to a non-inoculated seed. Similarly, Ahmed *et al.*, 2011 also reported that azotobacter plays a very important role in the growth of plants especially it improves the yield of wheat. The yield of wheat increases when it was inoculated with yeast + Azotobacter with 20 m^{-3} fad. The combined application of Azospirrillum, Azotobacter significantly increases the spikes, no of tillers, grain weight, grain size, spikelet per plants, spike length, etc, therefore the use of 75 % mineral nitrogen and biofertilizer with Azospirrillum and Azotobacters increases all the growth character in wheat (Chauhan *et al.*, 2011).

Kaushik *et al.*, 2012 stated that Inoculation of Azospirillum plus PSB significantly recorded 23.2 and 11.9, 21.6 and 9.9, 32.3, and 15.7 % higher grain and straw yield and net returns over control and Azospirillum respectively in wheat crop. Minaxi *et al.,* 2013 also reported a significant increase in growth, yield, and nutrient uptake by wheat due to PSB and VAM fungi. A significant increase in seed yield was also recorded by 92.08% over control.

Singh *et al.*, 2016 reported that Azotobactor and PSB inoculation, being at par caused significant improvement in the growth and yield attributes of wheat over the control. It was also reported that the co-inoculation of Azotobactor and PSB further increase the growth and yield attributes of wheat over individual inoculation.

Kumar *et al.*, 2017 concluded that the Rhizobacterial inoculation in wheat crop either alone or in a consortium of different combinations significantly increased the growth and yield of the wheat crop as compared to the mock-inoculated controls. In both the field and pot trials, the combination of Rhizobacterial isolates was found to be more effective as compared to single inoculation. Mukhtar *et al.*, 2017 reported that biogas sludge and enriched soil-based P biofertilizers showed the highest phosphate solubilization activity. It has increased the growth of the wheat by 20.13% and 15.51% as compared to non inoculated controls using biogas sludge and enriched soil-based P biofertilizers respectively.

Sanjay Mahato and Asmita kafle (2018) conducted a pot experiment on wheat and reported that inoculation of azotobactor only increased 16.05%-19.42% grain yield over control; while with other fertilizers, the increase was of range 19.42-63.1% increase over control. The increase in yield was 23.3% with only chemical fertilizers NPK @120:80:80 kg^{-1} respectively over control so azotobactor can be used as a biofertilizer when it is used along with FYM and chemical fertilizers (NPK).

Trichoderma shows a slight increase in the plant height, panicle weight, number of grains, grain yield, biological yield, and biomass yield over control; while rooting length, number of leaves, tiller number, panicle number, panicle length highlight the negative impact of Trichoderma on the wheat plant. Trichoderma shows antagonism with inorganic fertilizer. In most of the parameters, more is the inorganic fertilizer with Trichoderma, higher is the antagonism. When Trichoderma and NPK are accompanied with farmyard manure, most of the growth and yield parameter shows the highest value, but the yield was slightly higher than NPK alone treatment. This finding indicates that while sowing seed, the use of Trichoderma with FYM and NPK may not improve the yield over NPK to a greater extent. Hence it is indicated that Trichoderma viride can be a growth promoter and be used as a biofertilizer. Mahato *et al.* (2018)

Effect of bio-fertilizers on maize production

MEENA *et al.,* 2013 reported that maize Grain yield was increased with increasing levels of nitrogen, and a maximum grain yield of 4.3 Mg/ha was obtained by use of 150 kg N/ha with FYM @ 5 t/ha and Azotobacter inoculation. Significant uptake of nitrogen, phosphorus, and potassium was recorded under the application of 150 N kg/ha over the control. Protein content in maize grain increased significantly by conjoint use of organic manure and biofertilizers with each level of nitrogen application, over application of each nitrogen level alone.

Umesha *et al.*, 2014 reported that the treatment (T_{13}) having recommended dose of NPK +Azotobacter chroococcum + Bacillus megaterium + Pseudomonas fluorescence + enriched compost has shown the highest plant height at 30, 60, 90 days after sowing and at harvest (120 days) (31.70, 180.93, 186.07 and 188.13 cm respectively). The highest total dry matter production at harvest (375.80 g) and yield parameters like Weight of cob (207.63 g), Grain yield per plant (158.93 g), Grain yield per ha (54.53 q) and Test weight of seeds (33.10 g) was also found highest in this treatment and available nutrient content in the soil after crop harvest i.e., nitrogen (185.40 $Kg\ ha^{-1}$), phosphorous (38.83 $Kg\ ha^{-1}$) and potassium (181.47 $Kg\ ha^{-1}$) was also found highest in the same treatment combination.

Amin Farnia and Hamidreaza Torkaman (2015) conducted an experiment on maize with three treatments of N fertilizers (Nitroxin, Nitrokara, and azot barvar 1) and P biofertilizers (Phosphate barvar 2, biosuperphosphate, and Phosphatin) with control for them. Results showed that the effect of N fertilizer, P fertilizer, and interaction between them on all traits was significant instead of the number of rows per cob and harvest index. The comparison of the mean values showed that the Nitroxin phosphate barvar 2 treatment had the highest cob weight, cob length, and biomass. However, the combined application of Nitroxin and Biosuperphosphate treatment had the highest 1000 grain weight and grain yield. Also, a single application of Nitrokara had the highest number of rows per cob. A single application of Biosuperphosphate biofertilizer had the highest number of row per cob and HI. The final results of this study reviled that application N and P biofertilizers increased yield and yield components of maize.

Two field experiments were conducted at Sudan University of Science and Technology, College of Agricultural Studies, The Demonstration Farm, Shambat, during two successive winter seasons of 2011/2012 and 2012/2013 under irrigation conditions to study the effect of bio-fertilizer (Effective Microorganisms, EM) on two maize (*Zea mays* L.) cultivars for some growth and yield characters using a split-plot design with four replications. The liquid bio-fertilizer levels were (Zero, 06.25, 12.5, 18.75, and 25.00 L/Ha) corresponding to F1, F2, F3, F4, and F5 treatments. The two maize cultivars were HUDAIBA (HD) and MUGTAMA45 (MG). The results revealed that Plant height, stem diameter, leaf area, 100-grain weight, and grains number per cob were increased due to the increase in the level of bio-fertilizer. Also, the aforementioned characters were significantly increased for HD cultivar particularly under the application of F4 and F5 levels. Further, the highest grain yield was obtained from the application of an F4 dose to the two cultivars in both seasons. This high response of the two maize cultivars to bio-fertilizer could be of great value in using it in maize nutrition in Sudan. (Obid *et al*., 2016)

Gao *et al*., 2020 carried out a field experiment on maize and the Seeds were treated with Azotobacter chrocoocum, arbuscular mycorrhizal fungi (AMF), Bacillus circulans, biogas slurry, humic acid (HA), and their combination aiming to increase the growth and yield of maize and to reduce the need for chemical fertilizers. The results showed that the combined application of the biofertilizer mixture (Azotobacter chrocoocum, AMF, and Bacillus circulans) with organic fertilizers enhanced maize growth, yield, and nutrient uptake. Moreover, bio-organic fertilization has improved the soluble sugars, starch, carbohydrates, protein, and amino acid contents in maize seeds. Additionally, the bio-organic fertilization caused an obvious increase in the microbial activity by enhancing acid phosphatase and dehydrogenase enzymes, bacterial count, and mycorrhizal colonization levels in the maize rhizosphere as compared with the chemical fertilization. Additionally, the bio-organic fertilizers have improved α-amylase and gibberellins (GA) activities and their transcript levels, as well as decreased the abscisic acid (ABA) level in the seeds as compared to the chemical fertilizers. The obtained results of bio-organic fertilization on the growth parameters and yield of maize recommend their use as an alternative tool to reduce chemical fertilizers.

Effect of bio-fertilizers on rice production.

A field experiment was conducted by Karmakar *et al*., 2011 to evaluate the various components of the integrated plant nutrient system on transplanted rice in the plateau region of Jharkhand during wet seasons of 2006 to 2008. Combined application of 50% of recommended dose through chemical fertilizers and 25 % N through farmyard manure along with insitu green manuring and blue-green algae improved growth and yield attributing characters increased yield of rice variety Lalat (19.3%) as compared to that of recommended fertilizer dose. Increase in nutrient uptake (21.4, 29.0 and 16.9 % of N, P, and K, respectively) and improvement of the soil physico-chemical properties like organic carbon (0.34 to 0.44%), available N (220.3 to 254.0 kg ha^{-1}), P (21.2 to 25.8 kg ha^{-1}) and K status (153.0 to 159.0 kg ha^{-1}) were also recorded. The maximum net return (Rs 22160 ha^{-1}) and benefit-cost ratio of 2.23 were also noted under the combined nutrient application.

Azospirillum inoculation increased the rice yield significantly by 1.6–10.5 g $plant^{-1}$ (32–81% increase) in greenhouse conditions (Mirza *et al*., 2000; Malik *et al*., 2002). However, in field conditions, the estimated yield increase was around1.8 t ha^{-1} (22% increase) as reported by (Balandreau 2002).

Studies conducted at the IRRI showed that rhizobium inoculation increased the growth and yield of rice, and N, P, and K uptake by rice plants significantly (Biswas *et al*. 2000a, 2000b).

Naher *et al*., 2016 experimented and showed that N and P (50%) with biofertilizer (10 t ha^{-1}) increased the number of tillers (29), panicle length (28 cm), weight of 1000 grain (21.31 g), and produced the highest grain yield (7.26 t ha^{-1}). There was no significant difference found among the N, P (75%) with biofertilizer (5 t ha^{-1}) and N, P (50%) with biofertilizer (10 t ha^{-1}) treatments for plant height, number of panicle $plant^{-1}$, and harvest index (%). The application of biofertilizer with beneficial microbes improved the leaf chlorophyll, plant nutrient uptake, and grain protein content in rice. Hence, the use of chemical N and P fertilizer can be minimized by 50 percent and improve rice yield with the supplement of 5 ton ha-1 of bio-organic fertilizer**.**

A field experiment was carried out to evaluate the feasibility of inoculating rice seedlings with biofertilizers (Azospirillum and Trichoderma) in order to reduce the use of chemical inorganic nitrogen (N) fertilizer on rice variety BU D han 1. The plant performances were better when 25% less inorganic N was applied with Trichoderma and the combined application of Trichoderma and Azospirillum. Plants contained the highest chlorophyll concentrations when they were treated with 75% N + Trichoderma. Considering the yield attributes, 75% N + Trichoderma, and 75% N + Trichoderma + Azospirillum performed similar to the control. The grain yield of rice was similar to the recommended dose even with 25% less N application. The application of Trichoderma resulted in a higher yield, followed by a combined application with Azospirillum. Results revealed the greater scope of applying biofertilizer (Trichoderma) to supplement chemical N fertilizer with an optimum yield of rice (Haider Iqbal Khan 2018).

Effect of bio-fertilizers on sorghum production

A field experiment was conducted at College Farm, Navsari Agricultural University, Navsari (Gujarat) during the rabi season of the year 2017-18 to study the "Effect of fertilizer levels, bio compost and biofertilizer effect on yield and yield attributes of fodder sorghum. Twelve treatment combinations consisting of three levels of fertilizer, two levels of bio compost, and two levels of biofertilizer were tried in a factorial randomized block design with three replications. The result showed that among different treatment combinations, the application of 100% RDF with bio compost and biofertilizer significantly registered maximum green and dry fodder yield, plant height, and stem girth. While, in interaction maximum plant height, green and dry fodder yield was recorded in 100% RDF with biofertilizer which was statistically at par with 75% RDF with biofertilizer (Chauhan *et al*., 2019).

A pot experiment was carried with biofertilizers of N2-fixers (A. chroococcum + A.brasilense), P-dissolvers (*Bacillus megaterium*), and K-dissolvers (*Bacillus circulans*) for sorghum (Sorghum bicolor) grown on a light clay torrifluvent soil. Different combinations of such N_1, P_1, and K_1 biofertilizers were compared with the N_0, P_0, K_0 non-addition which gave 15.2 g pot^{-1}. All additions giving one or more or all of the 3 biofertilizers caused a positive response. Ranges of % increase were: 63 ($N_1 P_0 K_0$) to 81($N_1 P_1 K_0$) for yield; 63 ($N_0 P_0 K_1$) to140 (N_1, P1, K_0) for N uptake; 88 (N_1,P_0,K_1) to 224 (N_1,P_1,K_1) for P uptake and 69 (N_0,P_1,K_0) to 130 (N_0,P_0,K_1) for K uptake. When given singly (solely), the percentage increase caused by any of the 3 biofertilizers was higher than when given in presence of any or both of the others (i.e. interaction effects). For yield, increases of 63, 67, and 65 % occurred due to a sole application of N, P, and K biofertilizers respectively. Main (average) increases were 13, 14, and 12 % for each biofertilizer respectively (irrespective of presence or absence of the others). The average increase by one was greater in absence of each of the others, and generally non-effective in presence of the other. Similar patterns occurred regarding uptake of N, P, and K. The interactions among the 3 biofertilizers were evident. An indication of competition among the microorganisms could have taken place. Practical implications indicate that biofertilizers could be used to decrease total dependence on chemical fertilizers. Ali *et al*. (2015)

Akhtar *et al*. (2020) conducted an experiment and concluded that all the treatments enhanced the growth, yield, and quality attributes but the maximum improvement was recorded by the combined application of chemical and biological fertilizers. Application of N @ 60 kg ha^{-1} + P @ 35 kg ha^{-1} + PSB @ 1.25 kg ha^{-1} + Biozote @ 1.25 kg ha^{-1} showed an increase of 12.45%, 78.11%, 34.4%, and 25.38% in plant height, green fodder yield, grain yield and crude proteins over the control respectively. The results of the current study are very promising regarding the combined use of chemical and bio-fertilizers to improve the productivity of sorghum crop.

The combination of PGPR-mix (Azospirillum, Azotobacter, Bacillus) with hydrogels as bio-organic fertilizer and CMC as carriers has promoted the growth of the roots, shoots, and vigor index of in vitro sorghum germination, as well as increased the root length, shoot length, and total dry weight of sorghum seedlings in pots containing sterile sand. The best result of in vitro experiment (root length = 8.67 cm; shoot length = 12.6 cm, and vigor index = 2127.00) was obtained by sorghum seed inoculated with a single PGPR inoculant (A. lipoferum) with a carrier of CMC. The root length, shoot length and total dry weight of the highest sorghum seedlings were obtained by PGPR-mix inoculants without carriers (46.5 cm, 12 cm, and 0.477 g), PGPR-mix with a carrier of CMC (48.67 cm, 15.67 cm, and 0.431 g), and PGPR-mix with a carrier of hydrogel (48.67 cm, 15 cm, and 0.430 g). S Widawati and Suliasih 2020

Verma *et al*.,(2014) showed that the growth parameter like plant height, number of leaves, fresh weight of leaf, fresh weight of stem, fresh weight of the plant, LAI, dry matter accumulation on leaf, stem, and plant, leaf stem ratio, and CGR were significantly higher in T10 (100% RDN @ 60 kg ha^{-1} + Azotobacter +Azospirillum) as compare to other treatments and it was at par with T9(100% RDN @ 60 kg ha^{-1}+Azospirillum) and T8(100%RDN @ 60 kg ha^{-1} + Azotobacter). Among all the treatments, T10 (100% RDN @ 60 kg ha^{-1} + Azotobacter + Azospirillum) recorded significantly higher green and dry fodder yield over other treatments and it was at par with T8(100% RDN @ 60 kg ha^{-1} +Azotobacter) and T9 (100% RDN @ 60 kg ha^{-1}+ Azospirillum) and it may be due to cumulative effect of the higher value recorded by this treatment for most of the yield contributing characters. The combination of inorganic fertilizer with biofertilizers significantly increased the overall growth and development of the sorghum plant.

Effect of bio-fertilizers on pearl millet production

Choudhary R.S., Gautam R.C (2005) conducted an experiment for 2 years (2002 and 2003) to evaluate the effect of nutrient management practices on growth and yield of pearl millet [*Pennisetum glaucum* (L.) R. Br. emend. Stuntz.]. Nutrient-management practices comprised the control, 30 kg N/ha + 20 kg P_2O_5/ha, 60 kg N/ha + 40 kg P_2O_5/ha, 5 tonnes FYM/ha + bio-fertilizer (Azotobacter + vesicular-arbuscular mycorrhizae), 10 tonnes FYM/ha + bio-fertilizer (Azotobacter + VAM), 30 kg N/ha + 20 kg P_2O_5/ha + 5 tonnes FYM/ha + bio-fertilizer, 30 kg N/ha + 20 kg P_2O_5/ha + 10 tonnes FYM/ha + bio-fertilizer and 60 kg N/ha + 40 kg P_2O_5/ha + 10 tonnes FYM/ha + bio-fertilizer in randomized block design with three replications. The total rainfall received during the Kharif season of 2002 and 2003 was 405.5 mm and 823.0 mm respectively. Application of 60+40 kg/ha of N + P_2O_5 along with 10 t FYM/ha and biofertilizer gave significantly higher grain yield and N, P uptake by pearl millet than control and FYM (5 or 10 t/ha) + biofertilizers use.

The diazotrophic bacteria namely: *Pseudomonas fluorescens, Azotobacter chroococcum, Azospirillum lipoferum, and Acetobacter diazotrophicus*, one fungus: *Trichoderma viride* alone and in combinations were treated to the pearl millet seeds @ 10-20 g kg^{-1}, followed in randomized block design with three replications. The results proved that combined inoculation of all these bio-inoculants enabled to enhance the plant height (163.54 cm), dry weight (91.15 g), length of the ear (31.27 cm), grain yield (3.01 t ha^{-1}), and stover yield (10.77 t ha^{-1}) of pearl millet crop, while least results obtained in the control. Singh *et al*. (2016).

Togas *et al.,*(2017) conducted an field experiment having eight treatments of fertilizers /manures (Control, RDF (60:30:0), FYM @ 12 t/ha, FYM @ 6 t/ha + ½ RDF, vermicompost @ 5 t/ha, Vermicompost @ 2.5 t/ha + ½ RDF, Poultry Manure @ 4 t/ha, Poultry Manure @ 2 t/ha + ½ RDF) and two treatments of microbial inoculation (without inoculation and with Azotobacter) thereby making sixteen treatment combinations were tested in randomized block design with three replications. The recommended dose of fertilizer for pearl millet was 60 kg N and 30 kg P2O5/ha. Results indicated that seed inoculation with Azotobacter significantly increased plant height, dry matter accumulation, total number of tillers, chlorophyll content effective tillers, ear length, grains/ear, test weight, grain, stover and biological yield, protein content, total uptake of N, P and K and their concentration in grain and stover. The seed inoculation with Azotobacter was found economical fetching the highest returns (29615/ha).

To study the beneficial effect of biofertilizers on the performance of pearl millet (*Pennisetum glaucum* L.) a field experiment was conducted in randomized block design during the rainy (Kharif) season of 2014 at Sam Higginbottom University of Agriculture, Technology and Sciences, Allahabad, India. Seeds of pearl millet were treated with diazotrophic bacteria namely- *Pseudomonas fluorescens, Azotobacter chroococcum, Azospirillum lipoferum, Acetobacter diazotrophicus*, and one fungus-*Trichoderma viride* @ 10-25 g kg^{-1} alone and in combinations. The combined treatment with all the bio inoculants enhanced the grain yield (44%), nutrient uptake (N by 79.9% and P by 87.9%), and grain quality (Protein by 58.9% and carbohydrate by 17%), single inoculation was also found profitable over the control (Un-inoculated). Therefore, inoculation of pearl millet seed with different biofertilizers could produce pollution-free and healthy (better quality) food for an increasing population and may able to reduce chemical fertilizer application without any significant reduction in grain yield. Singh *et al*. (2018).

Savita *et al*. (2019) conducted an experiment having Twelve treatments i.e. T1(Control), T2 (Seed treatment with Biomix), T3 (Foliar spray of Azotobacter isolate JFS5 @ 108cfu ml^{-1} at 15 DAS), T4(Foliar spray of Azotobacter isolate JFS5 @ 108cfu ml^{-1} at 30 DAS), T5[RDF (40 kg N + 20 kg P_2O_5 ha^{-1})], T6[75 % RDF (30 kg N + 15 kg P_2O_5 ha^{-1}], T7(T5 + seed treatment with Biomix), T8(T5 + foliar spray of Azotobacter isolate JFS5 @ 108cfu ml^{-1} at 15 DAS), T9(T5 + foliar spray of Azotobacter isolate JFS5 @ 108cfu ml^{-1} at 30 DAS), T10(T6 + seed treatment with Biomix), T11(T6 + foliar spray of Azotobacter isolate JFS5 @ 108cfu ml^{-1} at 15 DAS), T12(T6 + foliar spray of Azotobacter isolate JFS5 @ 108cfu ml^{-1} at 30 DAS) were laid out in RBD in three replicates. The combined application of biomix along with RDF (recommended dose of fertilizer) increased the protein content in grain over the control up to the extent of 16 percent. N content, Nand P uptake in grain was significantly increased in treatment T7 [T5 + seed treatment with Biomix] then T1- control. The N and P uptake ranged from 28.41-59.01 and 4.30-9.70 kg/ha among different treatments with the maximum with T7. The highest protein yield recorded with the combined application of biomix along with RDF (T7) was 107.8 and 17.3 percent higher over control (T1) and RDF (T5), respectively.

Conclusion

This study showed that the bio-fertilizers are very important for the crop growth and yield of the crops. It maintains the soil health, improves plants nutrition, increases the organic matter content and also maintains the soil p^H. The use of bio-fertilizers by farmers is useful for increasing the outcome from the crops and helps for increasing farmer's income.

References

Aditi, C.; Tripathi, S.; Singh, N. and Saini, L. (2019). Effect of fertilizer levels, biocompost and biofertilizer on growth and yield attributes of fodder sorghum (*Sorghum bicolor* (L.) Moench). Journal of Pharmacognosy and Phytochemistry, 8(6), pp.617-620.

Afzal A, Asghari B. (2008). Rhizobium and phosphate solubilizing bacteria improve the yield and phosphorus uptake in wheat (*Triticum aestivum* L.). International Journal of Agriculture and Biology. 10:85-88.

Akhtar, S.; Bashir, S.; Khan, S.; Iqbal, J.; Gulshan, A.B.; Irshad, S.; Batool, S.; Ahmad, N. and Rizwan, M.S. (2020). Integrated usage of synthetic and bio-fertilizers: an environment friendly approach to improve the productivity of sorghum. Cereal Research Communications, pp.1-7.

Ali, S.; Hamid, N.; Rasul, G.; Mehnaz, S. and Malik, K.A. (1998). Contribution of non-leguminous biofertilizers to rice biomass, nitrogen fixation and fertilizer-N use efficiency under flooded soil conditions. In Nitrogen Fixation with Non-Legumes (pp. 61-73). Springer, Dordrecht.

Amin F, Hamidreaza T. (2015). Effect of Different Biofertilizers on Yield and Yield Components of Maize (*Zea mays* L.). Bull.Env.Pharmacol. Life Sci.; 4(4): 75-79.

Banayo, N.P.M.; Cruz, P.C.; Aguilar, E.A.; Badayos, R.B. and Haefele, S.M. (2012). Evaluation of biofertilizers in irrigated rice: Effects on grain yield at different fertilizer rates. Agriculture, 2(1): 73-86.

Beyranvand H, Farina A, Nakhjavan S, Shaban M. (2013). Response of yield and yield components of maize (*Zea mays* L.) to different biofertilizers. International Journal of Advanced Biological and Biomedical Research. 1(9):1068-1077.

Bocchi, S. and Malgioglio, A. (2010). Azolla-Anabaena as a biofertilizer for rice paddy fields in the Po Valley, a temperate rice area in Northern Italy. International Journal of Agronomy, 2010.

Choudhary, R.S. and Gautam, R.C. (2007). Effect of nutrient-management practices on growth and yield of pearl millet (*Pennisetum glaucum*). Indian Journal of Agronomy, 52(1): 64-66.

Dhar DW, Prasanna R, Singh BV. (2007). Comparitive performance of three carrier based blue algal biofertilizers for sustainable rice cultivation. Journal of Sustainable Agriculture. 30(2):41-50.

Singh, D.; Raghuvanshi, K.; Chaurasiya, A.; Dutta, S.K. and Dubey, S.K. (2018). Enhancing the Nutrient Uptake and Quality of Pearlmillet (*Pennisetum glaucum* L.) through Use of Biofertilizers. Int.J.Curr.Microbiol.App.Sci. 7(04): 3296-3306.

Gao, C.; El-Sawah, A.M.; Ali, D.F.I.; AlhajHamoud, Y.; Shaghaleh, H.; Sheteiwy, M.S. (2020). The Integration of Bio and Organic Fertilizers Improve Plant Growth, Grain Yield, Quality and Metabolism of Hybrid Maize (*Zea mays* L.). Agronomy, 10: 319.

Kachroo, D. and Razdan, R. (2006). Growth, nutrient uptake and yield of wheat (*Triticum aestivum*) as influenced by biofertilizers and nitrogen. Indian Journal of Agronomy. 51 (1): 37-39.

Kader MA, Mian MH, Hoque MS. (2002). Effects of Azotobacter inoculants on yield and nitrogen uptake by wheat. Journal of Biological Science. 2(4):259-261.

Karmakar, S.; Prakash, S.; Kumar, R.; Agrawal, B.K.; Prasad, D. and Kumar, R.; (2011). Effect of green manuring and biofertilizers on rice production. ORYZA-An International Journal on Rice, 48(4): 339-342.

Khan, H.I. (2018). Appraisal of biofertilizers in rice: To supplement inorganic chemical fertilizer. Rice Science, 25(6): 357-362.

Kumar, V. and Ahlawat, I.P.S. (2004). Carry-over effect of biofertilizers and nitrogen applied to wheat (*Triticum aestivum*) and direct applied N in maize (*Zea mays*) in wheat-maize cropping system. Indian Journal of Agronomy, 49(4): 233-236.

Mahato, S.; Bhuju, S. and Shrestha, J. (2018). Effect of trichodermaviride as biofertilizer on growth and yield of wheat. Malays. J. Sustain. Agric, 2(2): 1-5.

Mahato, S. and Kafle, A. (2018). Comparative study of Azotobacter with or without other fertilizers on growth and yield of wheat in Western hills of Nepal. Annals of Agrarian Science, 16(3): 250-256.

Mandal, R.; Begum, Z.N. and Islam, S. (2011). Effect of cyanobacterial biofertilizer on the growth and yield components of two HYV of rice.

Meena, M.D.; Tiwari, D.D.; Chaudhari, S.K.; Biswas, D.R.; Narjary, B.; Meena, A.L.; Meena, B.L. and Meena, R.B. (2013). Effect of biofertilizer and nutrient levels on yield and nutrient uptake by maize (*Zea mays* L.). Annals of Agri-Bio Research, 18(2): 176-181.

Minaxi, Saxena, J.; Chandra, S. and Nain, L. (2013). Synergistic effect of phosphate solubilizing rhizobacteria and arbuscular mycorrhiza on growth and yield of wheat plants. Journal of Soil Science & Plant Nutrition. 13(2).

Mishra, U. and Pabbi, S. (2004). Cyanobacteria: a potential biofertilizer for rice. Resonance, 9(6): 6-10.

Mohamed, M.F.; Thalooth, A.T.; Elewa, T.A. and Ahmed, A.G. (2019). Yield and nutrient status of wheat plants (*Triticum aestivum*) as affected by sludge, compost, and biofertilizers under newly reclaimed soil. Bulletin of the National Research Centre, 43(1): 31.

Monem, M.A.A.; Khalifa, H.E.; Beider, M.; Ghandour, I.A.E. and Galal, Y.G. (2001). Using biofertilizers for maize production: response and economic return under different irrigation treatments. Journal of Sustainable Agriculture, 19(2): 41-48.

Mukhtar, S.; Shahid, I.; Mehnaz, S. and Malik, K.A. (2017). Assessment of two carrier materials for phosphate solubilizing biofertilizers and their effect on growth of wheat (*Triticum aestivum* L.). Microbiological research, 205: 107-117.

Naher, U.A.; Othman, R.; Panhwar, Q.A. and Ismail, M.R. (2015). Biofertilizer for sustainable rice production and reduction of environmental pollution. In Crop production and global environmental issues (283-291). Springer, Cham.

Naher, U.A.; Panhwar, Q.A.; Othman, R.; Ismail, M.R. and Berahim, Z. (2016). Biofertilizer as a supplement of chemical fertilizer for yield maximization of rice. Journal of Agriculture Food and Development, 2(0): 16-22.

Namvar, A. and Khandan, T.; 2013. Response of wheat to mineral nitrogen fertilizer and biofertilizer (*Azotobacter* sp. and *Azospirillum* sp.) inoculation under different levels of weed interference. Ekologija, 59(2).

Narula, N.; Kumar, V.; Singh, B.; Bhatia, R. and Lakshminarayana, K. (2005). Impact of biofertilizers on grain yield in spring wheat under varying fertility conditions and wheat-cotton rotation. Archives of Agronomy and soil science, 51(1): 79-89.

Obid, S.A.; Idris, A.E. and Ahmed, B.E.A.M. (2016). Effect of bio-fertilizer on growth and yield of two maize (*Zea mays* L.) cultivars at Shambat, Sudan. Sch. J. Agric. Vet. Sci, 3(4): 313-317.

Orona-Castro, F.; Lozano-Contreras, M.G.; Tucuch-Cauich, M.; Grageda-Cabrera, O.A.; Medina-Mendez, J.; Díaz-Franco, A.; Ruiz-Sánchez, E. and Soto-Rocha, J.; (2013). Response of rice cultivation to biofertilizers in Campeche, Mexico. Agricultural Sciences, 2013.

Reynders, L. and Vlassak, K. (1982). Use of Azospirillum brasilense as a biofertilizer in intensive wheat cropping. Plant and Soil, 66(2): 217-223.

Rose, M.T.; Phuong, T.L.; Nhan, D.K.; Cong, P.T.; Hien, N.T. and Kennedy, I.R.; (2014). Up to 52% N fertilizer replaced by biofertilizer in lowland rice via farmer participatory research. Agronomy for sustainable development, 34(4): 857-868.

Roychowdhury, D.; Mondal, S.; Banerjee, S.K. (2017). The Effect of Biofertilizers and the Effect of Vermicompost on the Cultivation and Productivity of Maize - A Review. Adv Crop Sci Tech 5: 261.

Saadatnia, H. and Riahi, H. (2009). Cyanobacteria from paddy fields in Iran as a biofertilizer in rice plants. Plant Soil Environ, 55(5): 207-212.

Sahu, D.; Priyadarshani, I. and Rath, B. (2012). Cyanobacteria–as potential biofertilizer. CIBTech J Microbiol, 1(2-3): 20-26.

Savita *et al*. (2019). Effect of Biofertilizers on Quality and Yield of Pearl Millet Under Rainfed Condition. International Journal of Agriculture Sciences, ISSN: 0975- 3710 & E-ISSN: 0975-9107, 11(20): 9145-9148.

Singh, D.; Raghuvanshi, K.; Pandey, S.K. and George, P.J. (2016). Effect of biofertilizers on growth and yield of pearl millet (*Pennisetum glaucum* L.). Res. Environ. Life Sci, 9(3): 385-386.

Singh, M.P.; Kumar, P.; Kumar, A.; Kumar, R.; Diwedi, A.; Gangwar, S.; Kumar, V. and Sepat, N.K. (2016). Effect of NPK with biofertilizers on growth, yield and nutrient uptake of wheat (*Triticum aestivum* l.) in western Uttar pradesh condition. Progressive Agriculture. 16(1): 83-87.

Singh, R.R. and Prasad, K. (2011). Effect of bio-fertilizers on growth and productivity of wheat (*Triticum aestivum*). International Journal of Farm Sciences, 1(1), pp.1-8.

Subashini, H.D.; Malarvannan, S.; Kumaran, P. (2007). Effect of biofertilizers (N- fixers) on the yield of rice varieties at Punducherry, India. Asian Journal of Agricultural Research. 1: 146-150.

Togas, R.; Yadav, L.R.; Choudhary, S.L. and Shisuvinahalli, G.V. (2017). Effect of Azotobacter on growth, yield and quality of pearl millet. Journal of Pharmacognosy and Phytochemistry, 6(4): 889-891.

Tarafdar, J.C. and Rao, A.V. (1997). Response of arid legumes of VAM fungal inoculation. Symbiosis, 22: 265-274

Umesha, S.; Srikantaiah, M.; Prasanna, K.S.; Sreeramuiu, K.R.; Divya, M. and Lakshmipathi, R.N. (2014). Comparative effect of organics and biofertilizers on growth and yield of maize (*Zea mays*. L). Curr. Agri. Res. Jour, 2(1): 55-62.

Vaishampayan, A.; Sinha, R.P.; Hader, D.P.; Dey, T.; Gupta, A.K.; Bhan, U. and Rao, A.L. (2001). Cyanobacterial biofertilizers in rice agriculture. The Botanical Review, 67(4): 453-516.

Ventura, W.; Mascariña, G.B.; Furoc, R.E. and Watanabe, I. (1987). Azolla and Sesbania as biofertilizers for lowland rice. Philipp. J. Crop Sci, 12: 61-69.

Verma, N.; Swarnkar, V.K. and Das, G.K. (2014). Effect of Organic and Inorganic Sources of Nitrogen with

Biofertilizer on Forage Sorghum [*Sorghum bicolor* (L.) Moench]. Biosciences, p.986.

Widawati, S. (2018). The effect of plant growth promoting rhizobacteria (PGPR) on germination and seedling growth of *Sorghum bicolor* L. Moench. In IOP conference series: earth and environmental science (Vol. 166, No. 1, p. 012022). IOP Publishing.

Wijebandara, I.; Dasog, G.S.; Patil, P.L. and Hebbar, M. (2010). Response of rice to nutrients and bio fertilizers under conventional and system of rice intensification methods of cultivation in Tungabhadra command of Karnataka. Karnataka Journal of Agricultural Sciences, 22(4).