Bio-fertilizers in wheat: A sustainable approach

Vishal Guleria*, Dr. Gurpreet Singh[2*], Shweta[3]

[1]Department of Agronomy, School of Agriculture,

Lovely Professional University, Jalandhar, Punjab, India, 144411

Lovely Professional University, Jalandhar, Punjab, India, 144411

CSKHPKV, Palampur, India, 176062

Abstract

The paper is being reviewed to study the effect of the different bio-fertilizers on the growth and yield of the wheat as well as to maintain the sustainability at the same time. The different bio-fertilizers which is of economic importance are *Azotobacter, Azospirillum, Phosphate Solubilising Bacteria, Rhizobium.* These bio-fertilizers along with some small amendments increases the plant height, dry matter accumulation number of spikes, grains per spike, length of the root and shoot of the wheat. In addition to the plant growth, these bio-fertilizers also enhance the soil fertility, soil health on the sustainable basis. It is concluded that use bio-fertilizers reduce the need of the chemical fertilizers. Bio-fertilizers are easily available and only required in the small amount and helps in maintaining the soil healthy. The population of the beneficial microorganisms is more when bio-fertilizers are used. The results of this study show that the bio-fertilizers can be a great replacement to chemical fertilizers to get the higher yield on the sustainable basis in relation to the soil and human health.

Keywords: Bio-fertilizes, Wheat, Effects, Yield, Microorganism.

Introduction: - Bio-fertilizer can be defined as the material which consists of living microorganisms, which on application to the soil inhabit the rhizosphere and increase the growth of the plants by promoting the status of the essential nutrients to the plants (Vessey 2003). Bio-fertilizers are one of the important components of the sustainable agriculture for increasing the yield and maintain the soil fertility (Narula et al., 2005). During the last century, with the use of the chemical fertilizers firstly the growth and yield was increased. But as the time passes these fertilizers starts to show the harmful effects on the soil. Nowadays most of the attention has been given to the bio-fertilizers for sustainable yield production (Abd El Humid and Amal, 1994; Abd El- Ghany and Bouthaina, 1994). Importance of the bio-fertilizers is increasing day by day because these are inexpensive, efficient and environment friendly (Kachroo and Razdan 2006). In the developing countries, the use of the bio-fertilizers has been promoted to limit the excessive use of the chemical fertilizers and also to minimise the production expenses (El-Borollosy et al., 2000). Biofertlizers are environmental friendly and less costly and have huge potential for suppying the essential plant nutrients, they also lowers the dose of chemical fertilizers by 25-50% (Vance 1997; Rana et al., 2012). On the sustainability basis, it is very important to incorporate the biofertilizers on the regular intervals with the organic matter in the soil, to maintain the healthy fertile soil (Koopmans and Goldstein 2001).

Wheat (*Triticum aestivum* L.) is one of the major cereal crops in the world and it supply about 20% of the total caloric intake of the whole world population (Reynolds et al., 2011). Wheat is a staple food of India and it is consumed by the 65% population of the India. It is consumed in the different forms like chapatti and bakery products etc. It provides the food security to the India and grows in the all agro-climatic zones. Almost 90% of the wheat growing area lies in the Punjab, Haryana, UP, MP, Gujrat and Rajasthan. In *Rabi* season (2018-2019), from the area of 29.55 million hectare a production of 101.20 million tons had been harvested, with a record productivity of 34.24 q/ha (ICAR-IIWBR, 2019).

The most crucial element for the plant is nitrogen for the proper functioning (Shivay 2007). Even if the nitrogen is most important macronutrient for exploiting the full yield potential of the wheat, but the nitrate pollution is increasing day by day. So, the current demand is to develop the methods which will reduce the nitrate pollution but in the same time do not lower crop yield (Ramesh et al., 2005). It was found that the *Azospirilum sp*. fix the nitrogen while the *Rhizobium sp*. is used as plant growth promoter (PGR) for the wheat (Sharma et al., 2012). Another important nutrient which plays a huge role in various processes like respiration, photosynthesis, energy storage and transformation etc in the living plant cell is phosphorus (Yasmin and Bano, 2011; Solangi et al., 2016). The activity of phosphorus solubilisation is performed by the various Plant Growth Promoting Rhizobium (PGPR) genres i.e. *Enterobacter, Bacillus, Azosprillum* and *Pseudomonas* (Goes et al., 2012; Mehnaz et al., 2010; Tahir et al., 2013). The mineral phosphate is converted into soluble phosphates (primary and secondary orthophosphosphates by these genres due to the creation of organic acids like acetic acid, malic acid, citric acid, oxalic acid (Vessey et al., 2004; Tahir et al., 2013; Solangi et al., 2016). Biofertilizers can also be used in the combination with inorganic fertilizers to enhance the nutrient use efficiency and crop productivity. Distinct range of bacteria consisting species of *Rhizobium, Pseudomonas, Azotobacter, Azospirillum, Bacillus, Burkholderia, Klebsiella, Enterobacter* have shown the capacity to promote the growth of the plant (Bashan et al., 2004). Biofertilizers are able to enhance the productivity by mixing the atmospheric nitrogen in the soil, solubilisation of soil phosphorus or by boosting the plant growth due to the synthesis of plant growth promoting substances and it has very important role in the organic farming (Ram et al., 2014). Biofertilizers contain the microorganisms which help in restoring the natural nutrient cycle of the soil and increase the organic matter. With the use of the biofertilizers, fit and quality plant can be produce and also the sustainability of the soil will be enhanced. As a result, biofertilizers are exceptionally advantageous for enriching the soil fertility, completing the plant needs for the nutrient and getting a healthy produce (Bohme and Bohme, 2006; Jalili et al., 2009; Abedi et al., 2010; Medani and Taha, 2015). Hence, the aim of this study is to access the effect of biofertilizers on the growth and yield of the wheat, their effect on the environment and also on the soil health.

Effect of *Azotobacter* on wheat: - Application of *Azotobacter chroococcum* with humic acid gave the maximum grain and straw yield and also yield attributing characters like plant height , number of tillers per plant, dry weight of leaf, leaf area index etc. It was also observed that the application of arbiscular mycorrhiza (*Glomus mosseae*) and *Azotobacter chroococcum* has considerably increases the dehydrogenase and phosphatise activity in rhizosphere of the wheat. Inoculation of wheat seeds with humic acid or in isolation with *Azotobacter chroococcum* or arbiscular mycorrhiza results in increase in the availability of macronutrients (N, P and K) and some micronutrients like Fe and Zn (Abou- Aley et al., 2009). Inoculation of wheat with *Azotobacter* and yeast results in the highest dry matter accumulation, spike length, number of spikes per m^2, dry weight of shoot, flag leaf area (Ahmed et al., 2011). It was observed that the maximum plant height, number of tillers and dry matter accumulation is found in the wheat when it is treated with the *Azotobacter* over untreated plots. The yield attributing characters like grain weight per plant, length of spike, weight of 1000 grains were also highest in plot treated with *Azotobacter* over no inoculation. The maximum yield was observed in the plots inoculated with the *Azotobacter* (Singh et al., 2013). The highest amount proline and soluble sugar content among the all biofertilizer treatment is found in the plots treated with the *Azotobacter*. The highest yield of the wheat is found in the plots inoculated with the *Azotobacter* and nano Zn-Fe oxide. The combination of *Azotobacter* and nano Zn-Fe oxide also results in the highest carotenoids and chlorophyll contents (Sharifi et al., 2020). It was observed that the maximum nutrient uptake, highest grain quality, protein content and increased productivity is recorded when the wheat seeds are inoculated with *Azotobacter* + green manure + FYM. But the highest net return only gets from the *Azotobacter* + green manure (Ram et al., 2014). It was recorded that the highest grain yield is extracted when the wheat seeds are treated with *Azotobacter*. Inoculation with *Azotobacter* also results in higher dry matter of the crop (Patra and Singh, 2018).

Effect of *Azospirillum* on wheat: - Combined application of the humic acid+ *Azospirillum braselence* results in the higher yield of the wheat. Combined application of humic acid+ *Azospirillum braselence* also results in the lowering the EC of the soil and also decreases the pH of the soil which is due to the activity of microorganisms for decomposing the organic matter and releases organic acids which lowers the pH of the soil. The highest amount of available macronutrients nitrogen, phosphorus and potassium and micronutrients iron, manganese, zinc is observed in the combined application of the humic acid+ *Azospirillum braselence*. While the nutrient concentration (macro and micronutrients) of the wheat plant is also high when treated with combined application of the humic acid+ *Azospirillum braselence* (Alakhdar et al., 2020). *Azospirillum* in combination with N 45 kg/ha and P_2O_5 kg/ha results in the higher grain yield of the wheat. This combination of biofertilizer and inorganic fertilizers results in higher fresh biomass yield, weight of 1000 seeds and number of tillers per m^2 (Amanullah et al., 2012). It was observed that the highest nitrogen uptake by the plant is found in the plots treated with the *Azospirillum* over other treatments and control (Singh et al., 2013). The maximum efficiency of the photosystem II (PS-II) was also observed in the plants whose seeds were inoculated with the *Azospirillum*. The highest activity of the catalase (CAT) enzyme also found in the *Azospirillum* treatment (Sharifi et al., 2020). Treatment of the wheat seeds with the *Azospirillum* results in the maximum plant height, number of spikes per plant, number of grains per spike, weight of 1000 grains, straw yield, grain yield and protein content (Namvar and Khandan, 2013). The application of chicken manure + *Azospirillum braselence* + *Bacillus polymyxa* results in the maximum plant height, highest number of reproductive tillers, number of grains per main head, number of seeds per plant of the wheat plant (Mohammed et al., 2012).

S. No.	Bio-fertilizers	Effect on wheat	References
1	*Azaotobcter*	Increases the dehydrogenase and phosphatise activity, proline and soluble sugar content.	Abou- Aley et al., 2009.
2	*Azospirillum*	Lowers the EC and also decreases the pH of the soil, increase the activity of the catalase (CAT) enzyme.	Alakhdar et al., 2020
3	*Rhizobium*	Cumulative CO_2 evaluation, increase the number of metabolites in the grains.	Sharifi et al., 2020
4	PSB	Increases the root biomass and the root diameter, minerals accumulation and chlorophyll content.	Elhaissoufi et al., 2020

Effect of *Rhizobium* on wheat: Inoculation of the wheat seeds with the *Rhizobium* has significantly increases the mean number of tillers per plant then the number of tillers in the non-inoculated wheat. So, the *Rhizobium* has the positive impact on the number of tillers per plant in the wheat (Phillips and John, 1970). *Rhizobium* inoculation of the wheat seeds also shows a tremendous increase in the maximum number of tillers per plant by 42%, number of grains per spike by 16%, plant height by 13%, grain yield and biological yield by 10% over the non-inoculated treatments (Adnan et al., 2014). Pea *Rhizobium* inoculation of wheat seeds with full dose N, P and K results in the maximum uptake of the nitrogen , phosphorus and potassium by the plant (Adnan et al., 2016). Pea *Rhizobium* inoculation has also results in the cumulative CO_2 evaluation (Yanni et al,. 1997). Single or dual inoculation of the wheat seeds with the *Rhizobium* along P_2O_5 results in the maximum plant height, increase shoot and root length, spike length, leaf protein, leaf sugar content and grain yield (Aftab and Bano, 2008). Co- inoculation of the wheat with *Rhizobium* and *Pseudomonas* strains in combination with P_2O_5 results in the increase in grain yield up to 10%, N and P content of the seed and soil, leaf sugar, leaf protein, grain sugar over the treatment that only treated with P_2O_5 alone (Afzal et al., 2014). Single or dual inoculation of the wheat seeds with *A. brasilense* and *R. Meliloti* results in the higher grain yield than that of untreated plots. *Rhizobium meliloti* along with the 2, 4-D also increases the weight of 1000 wheat seeds (test weight) and the number of seeds per plant (Askary et al., 2009). Highest 1000 grain weight was observed when the full dose of N, P, K or *Rhizobium*+ 1/2N+1/2P was applied to the wheat. Solo inoculation of *Rhizobium* with full dose P to the wheat increases the number of metabolites in the grains (Khan et al., 2009).

Effect of *Phosphate Solubilising Bacteria* on wheat: - It was observed that the highest nitrogen, phosphorus, potassium uptake by the wheat plant is done when treated with recommended dose of fertilisers (RDF)+ PSB+ Vermicompost @1 tonne per ha which ultimately leads to the higher grain yield and better yield attributes. This same treatment also resulted in the increased available nitrogen, phosphorus, potassium content in the soil (Devi et al., 2011). PSB inoculation also affects the roots of the wheat plant; it increases the root biomass and the root diameter as compared to the un-inoculated treatments. With adequate amount of P in the rhizosphere, PSB stimulates the root length, volume and surface area. PSB also enhances the phosphatase activity in the roots which leads to improvement in the root and shoot physiology. Minerals accumulation and chlorophyll content was increased by the PSB inoculation (Elhaissoufi et al., 2020). PSB inoculation along with the rock phosphate significantly increases the shoot height and dry matter and the root dry biomass. PSB+ rock phosphate results in the increased P uptake by the grains, roots and shoot. Available P level is also high in the PSB+ rock phosphate treatment (Kaur and Reddy, 2015). Raw phosphate encourages the activity of the PSB due to which the enzyme activity and soil respiration increases. Due to increase in the soil enzyme activity, plant growth has been supplemented whose results was clearly visible through plant dry weight, number of tillers per plant, nutrient status of the plant and yield (Namli et al., 2017). Application of 40 kg P_2O_5 + PSB + 40 kg sulphur per ha results in the higher grain and straw yield (Patel et al., 2014). Triple interaction of soluble form of PSB, Si and P results in increase in various plants morphological and physiological characters like dry weight of root and shoot, enzymatic activity of CAD, SOD and POD, total uptake of P, K, Si (Rezakhani et al., 2019). Application of PSB strain *B. Cepacia* BAM-6 has a synergistic interaction with Arbuscular Mycorrhizal Fungus (AMF) to promote the growth of the wheat plant. *B. cepacia* BAM-6+AMF increases the seed germination percentage, leaf area, length and dry weight of root and shoot, also yield of the wheat (Saxena et al., 2014). PSB (*P. Fluorescens*) +3.25 ppm of P application results in maximum uptake of phosphorus by the wheat plant after 60 days of growth (Schoebitz et al 2013). Seeds treated with the PSB show the higher number of germination percentage and seedling vigor as compared to the un-inoculated plots (Suleman et al., 2018). Integrated application of the PSB and AMF results in increased dry matter content, plant height, length of spike, number of grains per spike and yield in wheat (Yousefi et al., 2011).

Conclusion: - Bio-fertilizers can be proving a great replacement to the chemical fertilizers because these are easily available, cost effective and can be used over a large area through seed inoculation. As we know that soil health and environment is at risk due to excessive use of the chemical fertilizers. The food that we consume is not healthy because the soil in which it grows is not healthy due over use of the chemical fertilizers. So, to maintain the soil and human health bio-fertilizers can be a great ally.

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