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The Importance of Biofertilizers in Sustainable Production of Wheat : A Review

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ABSTRACT

Wheat (Triticum aestivum L.) is one of the most important and strategic crops in the world. It's grains is a staple human food where bread wheat is the main food of people in many countries approximately 70% calories and 80% protein of human diet is supplied from its consumption. The use of chemical fertilizers (e.g. urea, calcium nitrate, ammonium sulphate, diammonium phosphate etc.) have a great importance for the world's food production as it works as a fast food for plants causing them to grow more rapidly and efficiently. Biofertilizers add nutrients through the natural processes of nitrogen fixation, solubilising phosphorus, and stimulating plant growth through the synthesis of growth promoting substances. They are also environment friendly and responsible for continuous availability of nutrients from natural sources. During the past couple of decades, plant growth-promoting rhizobacteria (PGPR) will begin to replace the use of chemicals in agriculture, horticulture, silviculture, and environmental cleanup strategies. The PGPR are naturally occurring soil bacteria that aggressively colonize plant roots and benefit plants by providing growth promotion. inoculation of crop plants with certain strains of PGPR at an early stage of development improves biomass production through direct effects on roots and shoots growth. The role of biofertilizers for enhancing the productivity of soil by fixing atmospheric nitrogen, or by solubilising soil phosphorus, or by stimulating plant growth through synthesis of growth promoting substances has special importance in organic farming.

Keywords : Wheat (Triticum aestivum L.), Biofertilizers, nitrogen fixation, plant growth-promoting rhizobacteria (PGPR)

I. INTRODUCTION

Wheat (*Triticum aestivum* L.) is one of the most important and strategic crops in the world. It's grains is a staple human food where bread wheat is the main food of people in many countries approximately 70% calories and 80% protein of human diet is supplied from its consumption (Taregh et al., 2011). Wheat grows in temperate climates and represents the staple food for 35% of the world's population and provides more calories and proteins, than any other crop. Annually more than 143.88 million tonnes of chemical fertilizers are used worldwide to increase the yield of crop plants. Despite their efficiency in promoting crop yield, they have proved to be hazardous for soil health as well as for the well being of human and animal populations(Lata et al., 2010). Bio-fertilizers are being essential component of organic farming are the preparations containing live or latent cells of efficient strains of nitrogen fixing, phosphate solubilizing or cellulolytic micro-organisms used for application to seed, soil or composting areas with the objective of increasing number of such micro organisms and accelerate those microbial processes which augment the availability of nutrients that can be easily assimilated by plants. Maintaining soil fertility and use of plant nutrients in sufficient and balanced amounts is one of the key factors in increasing crop yield (Diacono et al., 2013). Nitrogen (N) is the most important nutrient supplied to most non– legume crops ,including wheat. Thus, N supply to the plant will influence the amount of protein, amino acids, protoplasm and chlorophyll formed. Moreover, it influences the cell size, leaf area and photosynthetic activity (Daneshmand et al., 2012, Diacono et al., 2013 and Piccinin et al., 2013). Therefore, adequate supply of N is necessary to achieve high yield potential in crops, N fertilizer is known to affect the number of tiller m^2, number of grains /spike, spike length and weight, 1000 grain weight and grain yield of wheat (Kandil et al., 2011 and Campuzano et al., 2012). biofertilizers involved microorganisms could readily and safely convert complex organic material into simple compounds, they maintain the natural habitat of the soil. Increase crop yield by 20-30%, replaces chemical nitrogen and phosphorus by 25%, and stimulates plant growth. They can also provide protection against drought and some soil-borne diseases (Haas and Defago, 2005). Biofertilizers are cost-effective relative to chemical fertilizers. They have lower manufacturing costs, especially regarding nitrogen and phosphorus use. Chemical fertilizers and their exploitation cause air and ground water pollution by eutrophication of water bodies (Youssef et al., 2014). Conventional, chemically processed fertilizers also subvert the soil ecology, disrupt environment, degrade soil fertility and consequently shows harmful effects on human health (Ayala and Rao, 2002). Hence, the practice of chemical farming put the long-run sustainability of agriculture and the survival of the farming community at risk. In this context, biofertilizers have emer ged as an important component of the integrated nutrient supply system and have great potential to improve crop yields through environmentally better nutrient supplies (Das et al. 2007). This review highlights the role of biofertilizers in modern agriculture, future prospects and aspects based on relevant literature.

Biofertilizers

A biofertilizer (also, bio-fertilizer) is a substance which contains living microorganisms which, when applied to seed, plant surface, or soil, colonizes the rhizosphere or the anterior of the plant and promotes growth by increasing the supply or availability of primary nutrients to the host plant. (Gaur, 2010).

Why biofertilizers?

Biofertilizers are supposed to be safe alternative to chemical fertilizers to minimize the ecological disturbance. Biofertilizers are cost effective, eco-friendly and when they are required in bulk, can be generated at the farm itself. after using 34 years continuously, there is no need of application of biofertilizers because parental inoculums are sufficient for growth and multiplication. They improve soil texture, pH, and other properties of soil (Anonymous, 2012b).

Effect of Phosphate Solubilizing Microorganisms on Phosphorus Uptake, in Rainfed Area

Several soil bacteria, particularly those belonging to the genera Pseudomonas and Bacillus and fungi belonging to the genera Penicillium and Aspergillus possess ability to bring insoluble soil phosphates into soluble forms by secreting acids such as formic, acetic, propionic, lactic, glucolic, fumaric and succinic. These acids lower the pH and bring about the dissolution of bound forms of phosphate. Venkateswarlu et al. (1984) have reported that during the solubilization of rock phosphate by fungi, the pH of the culture was lowered from 7 to 3. Since, phosphate solubilizing micro-organisms , (PSM) proportion in natural microbial population is not more than 1%, hence it is a common practice in several Russian States, European and Asian countries to inoculate soil with PSM to increase P concentration in the soil solution (Taha et al., 1969). Grain yield and biological yield were significantly increased by the treatments and maximum yield was recorded when PSM was used with phosphorus alone or along with organic matter. It is concluded that PSM alone or along with other combinations produced profound effect on grain and biological yield, tillers per m2and seed phosphorus content (Afzal et al., 2005).

Effect of Biofertilizers On wheat Productivity in sandy Soil

Use of soil microorganisms which can either fix atmospheric nitrogen, solubilize phosphate, synthesis of growth promoting substances or by enhancing the decomposition of plant residues to release vital nutrients and increase humic content of soils, will be environmentally begin approach for nutrient management and ecosystem function (Wu et al., 2005) Application of biofertilizer is considered today to limit the use of mineral fertilizers and supports an effective tool for desert development under less polluted environments, decreasing agricultural costs, maximizing crop yield due to providing them with an available nutritive elements and growth promoting substances (Metin et al.,2010). Soil microorganisms are important components in the natural soil sub ecosystem because not only can they contribute to nutrient availability in the soil, but also bind soil particles into stable aggregates, which improve soil structure and reduce erosion potential (Shetty et al.,1994). Many authors have shown the positive effect inoculation of wheat with Azotobacter chroococcum or yeast. (Tawfik and Gomaa 2005; Abbasdokht 2008; Badr et al., 2009; Bahrani et al.,2010). the management of soil organic matter is critical to maintain a sustainable productive organic farming system. biofertilizer possess many desirable soil properties and exert beneficial effect on the soil physical, chemical and biological characteristics. Significant differences were recorded between interactions of cultivars and organic fertilizer, cultivars and biofertilizers as well as organic and biofertilizer for most of yield characters. As for the interaction effect between cultivars, organic and biofertilization, the highest dry matter accumulation in shoot system and spikes and the highest yield and yield components recorded in Gemmiza10 cultivar fertilized with20 m3/fad. and inoculated with yeast and Azotobacter.(Ahmed et al., 2011).

Response of Wheat Growth Parameters to Co-Inoculation of Plant Growth Promoting Rhizobacteria (PGPR).

Biofertilizers, however, are well recognized as an important component of integrated phosphate plant nutrient management for sustainable agriculture like Ca (PO) in calcareous soils. Use of these and hold a great promise to improve crop yield (Marchner, 1995). A group of biofertilizers termed plant growth promoting Rhizobacteria(PGPR) consisting of strains from genera such as Pseudomonas, Azospirillium, Azotobacter, Bacillus, Burkholderia, Enterobacter, Erwinia and Flavobacterium (Rodriguez et al., 1999) Indeed, they produce metabolites such as plant growth regulators that directly promote growth and facilitate nutrient uptake by plants. These bacteria are an important component of the rhizosphere of many plants and are known to colonize the rhizosphere of wheat (Cakmakci et 2006). Saber et al. (2012) showed that biofertilizers significantly reduced P and N fertilizer application without any reduction in wheat yield related parameters. Generally, results of this study revealed that using of biofertilizers especially dual inoculation had effective and significant role in terms of all studied yield characteristics except spike length in given wheat cultivar.

Control of Drought Stress in Wheat Using Plant-Growth Promoting Bacteria

Abiotic stresses such as drought, salinity, and extreme temperature are major causes of declining crop productivity worldwide (Vinocur and Altman, 2005). For instance, drought is expected to cause serious plant growth problems for more than 50 % of the arable lands by 2050 (Ashraf 1994; Vinocur and Altman 2005). Drought stress affects plant–water relationships on both the cellular and wholeplant levels leading to specific and nonspecific phenotype and physiological responses (Beck et al., 2007). Growth reduction under drought stress conditions has been well characterized in several plant species such as barley (Samarah 2005), maize (Kamara and others 2003), rice (Lafitte et al., 2007), and wheat (Rampino et al., 2006). Bacteria-treated plants showed attenuated transcript levels suggesting improved homeostatic mechanisms due to priming. The present study reports on the ability of certain PGPB to attenuate several stress consequences in plants which strongly supports the potential of such an approach to control drought stress in wheat (Wedad et al., 2012).

Response of wheat to biofertilizer inoculation under different levels of weed interference

Weeds are one of the greatest threats to agricultural crop production. They use the soil fertility, available moisture, nutrients, providing shelter for insect-pest and compete for space and sunlight with crop plants which causes yield reduction. Apart from quantitative effects on yield weeds deteriorate the quality of produce through the physical presence of their seeds and debris (Blackshaw et al., 2005; Kolb and Gallandt, 2012; Scursoni et al., 2012). Increasing and extending the role of biofertilizers can reduce the need for chemical fertilizers and decrease adverse environmental effects. They can play a significant role in fixing atmospheric N and production of plant growth promoting substances. Therefore, in the development and implementation of sustainable agricultural techniques, biofertilization has great importance in alleviating environmental pollution and deterioration of nature (Saini et al., 2004; Namvar et al., 2012; Rana et al., 2012).Azotobacter sp. and

Azospirillum sp. are used as biofertilizers in the cultivation of many agricultural crops. The estimated contribution of these free-living N fixing prokaryotes to the N input of soil ranges from 0–60 kg/ha per year (Vessey, 2003). Existence of microbial communities like Azotobacter sp. and Azospirillum sp. in the rhizosphere promotes the growth of the plant through the cycling and availability of nutrients, increasing the health of roots during the growth stage by competing with root pathogens and increasing the absorption of nutrients and water (Vessey, 2003; Zorita and Canigia, 2009; Daneshmand et al., 2012).

Exploring the efficacy of wastewater-grown micro algal biomass as a biofertilizer for wheat

Wastewaters represent rich sources of nitrogen and phosphorus, with promise for use as low-cost media for microalgae.These organisms possess the ability to flourish in diverse types of environments and assimilate such nutrients. Such a method of biomass cultivation is beneficial, as assimilation of nitrogen and phosphorus from such wastewaters can help in recycling this algal biomass as a biofertilizer and, at the same time, reduces the use of chemical fertilizers and sewage disposal (Pittman et al., 2011). The role of algae in agricultural systems as biofertilizers is well known (Prasanna et al., 2012a, b).However, they also have an important role in reducing erosionof soil by regulating the water flow into soils and improving soil fertility, besides playing a role in the reclamation of wastelands, saline soils, etc. (Zhan and Sun, 2012). and biocontrol of agricultural pests (Chaudhary et al., 2012; Prasanna et al. 2014). They also play a key role in the formation of microbiotic crusts (Colica et al.2014) as well as wastewater reatment (Renuka et al., 2015). Wheat is the leading source of protein for human diet, because of its higher protein content than other cereals (rice and maize), but consumes a major share of chemical fertilizers. The deployment of microbial biofertilizers in cereal crops is beneficial, as they not only reduce the use of chemical fertilizers but also improve the overall health and nutritional status of soil (Prasanna et al., 2013). However, no published reports exist on using wastewatergrown microalgae as biofertilizers (Cabanelas et al., 2013).

Effect of Bio-Fertilizer on Yield and Yield Components of Bread Wheat

Increasing and extruding the role of biofertilizer can reduce the need for chemical fertilizers and decrease adverse environmental effects. They can play significant role in fixing atmospheric N and production of plant growth promoting substances. Therefore, in development and implementation of sustainable agricultural techniques, bio-fertilizer has great importance in alleviating environmental pollution (Namvar et al., 2012) reported that the inoculation with bio-fertilization had significant effect on plant height, grain weight/spike, number of spikes/m^2, number of grains /spike, 1000 grain weight, grain and straw yields and crude protein percentage in wheat plants. Hossam El-Din (2007) indicated that the application of farmyard manure at different rates significantly increased yield and its components with increase of farmyard manure rate in all studied characters .He added that the use of organic fertilizer alone was not sufficient to meet the plant requirements of nutrients and application of bio-fertilizer would be necessary to enhance the role of organic fertilizer in reducing of applied chemical fertilizer, production costs and environmental pollution. The objective of this study was to investigate the effect of mineral, organic, and bio-fertilizer on yield and yield components of wheat, to improve wheat productivity and minimizing pollution under soil salinity conditions.

Impact of Zinc Solubilizing Bacteria on Zinc Contents of Wheat

The use of organic soil alterations and microbial culture along with the cautious use of chemical fertilizers can improve biological and physico-chemical properties of the soil, moreover improving the nutrient uptake efficiency. During the current decade, microbial culture proved to be an important component of integrated nutrient application in agriculture and therefore appears a viable potential for efficient use of microorganisms for maximizing crop production. Application of microbes is an vital part of environment friendly justifiable organic agriculture (Bloemberg et al., 200). Ahmad et al. (2016) revealed that wheat treated with Azospirillum, Pseudomonas and hizobiumsignificantly increased zinc contents in different parts of wheat plant at different growth stages. These microbes also facilitate efficient nutrient's uptake which ultimately produce plants of superior quality making agriculture more productive and lesser harmful to environment. It may be concluded from the study that beneficial microorganisms/ bio fertilizers applied in combination could be a better choice for farmers to reduce the use of chemical fertilizers for sustainable crop production.

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