RHIZOBIUM AND ITS ROLE AS BIO-FERTILIZER IN CEREAL PRODUCTION

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ABSTRACT

Excessive use of chemical fertilizers for greater production of cereals resulted in higher production cost as well as environmental pollution. So, researchers considered an alternative called bio-fertilizers which are cost effective and environment friendly. In bio-fertilizer technology, Rhizobium-legume is most widely important in different countries. Recently, it is found that rhizobia could be able to make an association with graminaceous plants such as rice, wheat, maize, barley, millets and other cereals some time as endophytic without forming any nodule-like structure or causing any disease symptoms. Ability of rhizobia as bio-fertilizer in crop enhancing activity in non-legumes especially cereals would be a useful technology for increased crop yields. They increased plant nutrients accumulation such as P, K, Ca, Mg and even Fe. Therefore, further research in this area would be develop a sustainable strategy for greater and environment friendly cereal production.

Key words: Bio-fertilizer, Cereal, Crop enhancer, Rhizobium, Yield

INTRODUCTION

The United Nations Food and Agriculture Organization (FAO) estimates that the total demands for agricultural products will be 60 percent higher in 2030 than present time. And more than 85% of this additional demand will come from developing countries. For over half a century, the world has relied on increasing crop yields to supply an ever increasing demand for food. World cereal production increased significantly during last two decades. This dramatic increase in world grain production was the result of a 122 percent increase in crop yields. However, this trend of grain production cannot be maintained due to decreasing cultivable land for rapid urbanization. Therefore, vertical expansion for food production is necessary. In order to increase world food production in a sustainable manner, farmers have to use balanced fertilizer timely. One of the most important factors in the generation of high yields from modern rice cultivars is nitrogen fertilizer. That is why farmers are applying high amounts of the fertilizers which is very costly and make the environment hazardous especially when use discriminately. In addition, more than 50% of the applied N-fertilizers are somehow lost through different processes which not only represent a cash loss to the farmers and consequently polluted the environmental (Ladha et al., 1998). Crop scientists all over the world are facing this alarming situation and they are trying to overcome this condition by exploring alternative sources which is cost effective and save the environment. Bio-fertilizer, an alternative source of N-fertilizer, especially rhizobia in legume symbiosis is an established technology. Use of the bio-fertilizers can also prevent the depletion of the soil organic matter (Jeyabal & Kuppuswamy, 2001). Inoculation with bacterial bio-fertilizer may reduce the application of fertilizer-N by increasing N uptake by plants (Kennedy et al., 2004). But most of this technique mainly limited between legume and Rhizobium in symbiotic process, which can fix atmospheric N2. However, biological N2 fixation (BNF) technology can play a vital role in substituting for commercially available N-fertilizer in cereal production thereby reducing the environmental problem to some extent. BNF and its transfer of NH4 activate the growth promotion of associated plants. Nitrogen fixation and plant growth enhancement by rhizosphere bacteria might be important factors for achieving a sustainable agriculture in the future. This is associated with roots and grasses have been recognized as an important component of the nitrogen cycle in a range of ecosystems (Chalk, 1991). In this review, attempt has been made to summarize the current knowledge and information about rhizobial inoculation on cereal production. Information gathered through this review may yield new insights into recent development of rhizobia-cereal interaction.

RHIZOBIUM

Rhizobia are soil bacteria that fix N2 (diazotroph) after becoming established inside root nodules of legumes (Fabaceae). There are several different genera of rhizobia, all of them belong to the Rhizobiales, a probably-monophyletic group of proteobacteria and they are soil bacteria characterized by their unique ability to infect root hairs of legumes and induce effective N2-fixing nodules to form on the roots. They are rod shaped living plants which exist only in the vegetative stage. Unlike many other soil microorganisms, rhizobia produce no spores and they are aerobic and motile. Rhizobia (species of Rhizobium, Mesorhizobium, Bradyrhizobium, Azorhizobium, Allorhizobium and Sinorhizobium) form intimate symbiotic relationships with legumes by responding chemo-tactically to flavonoid molecules released as signals by the legume host. The legume-Rhizobium symbiosis is a typical example of mutualism, but its evolutionary persistence is actually somewhat surprising. Because several unrelated strains infect each individual plant, any one strain could redirect resources from N2 fixation to its own reproduction without killing the host plant upon which they all depend. Symbiotic N2-fixation has been studied widely and exploited as a means of increasing crop yields (Sharma et al., 1993). The fixed N2 is released when the plants die, making it available to other plants and this helps in fertilizing the soil.

CROP ENHANCING ACTIVITY

ROOT STIMULATION FOR WATER AND NUTRIENT UPTAKE

It is well-known that inoculation of cereals with plant growth promoting bacteria (PGPB) resulted in increasing plant/crop growth and yield and acts as bio-fertilizer and bio-enhancer for different non-legumes (Mia et al., 2009). However, there is general agreement that these growth responses were not due to N2 fixation by the bacterium, but were primarily related to the bacterial production of phytohormone, which caused changes in root morphology and physiology that resulted in increased nutrient and water uptake from the soil (Mia et al., 2009). These growth enhancing phenomena are more pronounced in roots rather shoot. Root development is clearly influenced by the phytohormone auxins, which are known to influence a number of plant functions such as promotion of cell elongation and cell division, apical dominance, root initiation, differentiation of vascular tissue, ethylene biosynthesis mediation of tropic responses, and alteration of the expression of specific gene (Wilson & Warren-Wilson, 1993).

PROMOTION OF SHOOT GROWTH

Rhizobium spp. are plant growth promoting rhizobacteria and some are endophytes which can produce phytohormones, siderophores, HCN, solubilize sparingly soluble organic and inorganic phosphates and can colonize in the roots of many non-legumes (Sessitsch et al., 2002). The association increased plant growth at different growth stages such as enhanced seed germination, increased shoot length, leaf chlorophyll content, total dry matter, grain yield, N content and yield attributes (Yanni et al., 1997).

BIO-FERTILIZER ACTIVITY AND YIELD INCREMENT

It has been found from various experimental results that inoculation of Rhizobium in different cereal grains increased yield to some extent. Yanni et al. (1997) and Biswas (1998) reported increased N uptake by rice plants inoculated with rhizobia. This plant response is significant because of its potential importance to sustainable agriculture, especially in cropping systems involving rotations of rice and legumes. It was observed that rhizobial inoculation enhanced stomatal conductance, thereby increasing the photosynthesis rates by 12% in rice varieties where 16% grain yield was recorded. A positive correlation between increased grain yield and photosynthetic rate at zero N-level was also found (Peng et al., 2002). Biswas et al. (2000) reported that inoculation with Rhizobium leguminosarum bv. trifolii E11, Rhizobium sp. IRBG74 and Bradyrhizobium sp. IRBG271 increased rice grain and straw yields by 8 to 22 and 4 to 19%, respectively, at different N rates. Nitrogen, P and K uptake were increased by 10 to 28% due to rhizobial inoculation which also increased Fe uptake in rice by 15 to 64%. This increase might be attributed to changes in many metabolic and physiological processes. Finally, cell viability and electrolyte leakage tests as well as chemical constituents can be used to select drought tolerant cultivars. In the field experiment in rice, R. legunisarum inoculation increased in biomass at vegetative stage in Vietnam condition (Kennedy et al., 2004).

BIO-CONTROL ACTIVITY

Certain mechanisms are postulated towards Rhizobium which may be involved in growth promoting activities, that is, mobilization and efficient uptake of nutrient, enhancement of stress tolerance, solubilization of insoluble phosphate, induction of systematic disease resistance, production of phytohormones, vitamins and siderphores (Mayak et al., 2004; Alikhani et al., 2006). Rhizobium has potential use as bio-control agents and Ehteshamul-Haque and Ghaffer (1993) found that S. meliloti, R. leguminosaram bv. viciae and B. japonicum reduced infection of Macrophomina phaseolina, Rhizoctonia solani and Fusarium spp. in both leguminous and non-leguminous plants. Bacterial biological control agents have been successfully developed for other Rhizobium spp. (Burr & Reid, 1994). In replicated field trials, Rhizobium radiobacter strain K84 has provided effective field control against tumorigenic forms of R. radiobacter that affect stone fruits and many other tree crops (Schroth & Moller, 1976). One of the factors contributing to the success of this bio-control agent is its persistence in the rhizosphere where control is required. The persistence of potential biological control bacteria in the xylem is crucial for activity against the bacteria that cause crown gall disease.

FUTURE PROJECTION AND CHALLENGES

Recent advances in knowledge of symbiotic Rhizobium legume association at the molecular level and the ability of incorporating new genes into cereals through transformation have created excellent prospect to investigate the possibilities for integrating N2 fixing capability in nonlegumes especially in rice (Ladha et al., 1997). Now the challenge is to establish stable Rhizobium-cereal associations and major emphasis should be given for efficient and stable associations including endophytic association. Conditions which give reproducible invasion of lateral root cracks and subsequent intercellular colonization of the roots of rice and wheat by rhizobia at high frequency, provides important information to researchers attempting to extend rhizobial colonization and endophytic N2 fixation to non-legume crops (Webster et al., 1997). Liquid inocula of Rhizobium should be developed for easy handling and foliar spray. Consistency in achieving yield and grain quality will be a big challenge in this technology.

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