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Potential Use of *Azotobacter chroococcum* in Crop Production: An Overview

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ABSTRACT

Research on *Azotobacter chroococcum spp*. in crop production has manifested its significance in plant nutrition and its contribution to soil fertility. The possibility of using *Azotobacter chroococcum* in research experiments as microbial inoculant through production of growth substances and their effects on the plant has markedly enhanced crop production in agriculture. Being soil bacteria, *Azotobacteria* genus synthesizes auxins, cytokinins, and GA–like substances, and these growth materials are the primary substances controlling the enhanced growth. These hormonal substances, which originate from the rhizosphere or root surface, affect the growth of the closely associated higher plants. In order to guarantee the high effectiveness of inoculants and microbiological fertilizers it is necessary to find the compatible partners, i.e. a particular plant genotype and a particular *Azotobacter* strain that will form a good association.

Key words: *Azotobacter chroococcum*, Inoculant, Microbiological fertilizer, Plant.

INTRODUCTION

Biofertilizers (also known as bio inoculants), the organic preparations containing microorganisms are beneficial to agricultural production in terms of nutrient supply particularly with respect to N and P. When applied as seed treatment or seedling root dip or as soil application, they multiply rapidly and develop a thick population in rhizosphere. The population of *Azotobacter* is generally low in the rhizosphere of the crop plants and in uncultivated soils. The occurrence of this organism has been reported from the rhizosphere of a number of crop plants such as rice, maize, sugarcane, bajra, vegetables and plantation crops, (Arun, 2007). They derive food from the organic matter present in the soil and root exudates and fix atmospheric N (Maryenko, 1964). Biofertilizers can fix atmospheric N through the process of biological nitrogen fixation (BNF), solubilise plant nutrients like phosphates, and stimulate plant growth through synthesis of growth promoting substances and have have C: N ratio 20:1 indicating the stability of the biofertilizer. The isolated culture of *Azotobacter* fixes about 10 mg nitrogen g^{-1} of carbon source under *in vitro* conditions. They are cheaper, low capital intensive besides being eco-friendly. The first species of the genus *Azotobacter*, named *Azotobacter chroococcum* family *Azotobacteriaceae,* was isolated from the soil in Holland in 1901. *Azotobacter* represents the main group of heterotrophic free living nitrogen-fixing bacteria principally inhabiting neutral or alkaline soils. *Azotobacter chroococcum* and *Azotobacter agilis* were studied by Beijerinck (1901). In subsequent years several other types of *Azotobacter* group have been found in the soil and rhizosphere such as *Azotobacter vinelandii*, Lipman (1903); *Azotobacter beijernckii*, Lipman (1904); *Azotobacter nigricans*, Krassilnikov (1949); *Azotobacter paspali*, Döbereiner (1966), *Azotobacter armenicus*, Thompson and Skerman

(1981); *Azotobacter salinestris*, Page and Shivprasad (1991). These nitrogen-fixing bacteria are important for ecology and agriculture. Along with nodular bacteria, *Azotobacter* was considered to be the most extensively studied genus among the saprophytes (Horner *et al.*, 1942). There is a great significance of *Azotobacter chroococcum* in plant nutrition and its contribution to soil fertility.

Production of Growth Substances and Their Subsequent Effects

Growth substances, or plant hormones, are natural substances that are produced by microorganisms and plants alike. They have stimulatory or inhibitory effects on certain physiological-biochemical processes in plants and microorganisms. Brakel and Hilger (1965) showed that *Azotobacter* produced indol-3-acetic acid (IAA) when tryptophan was added to the medium. Hennequin and Blachere (1966) found only small amounts of IAA in old cultures of *Azotobacter* to which no tryptophan was added. Bacteria of the genus *Azotobacter* synthesize auxins, cytokinins, and GA-like substances, and these growth materials are the primary substance controlling the enhanced growth of tomato (Azcorn and Barea, 1975). These hormonal substances, which originate from the rhizosphere or root surface, affect the growth of the closely associated higher plants. Eklund (1970) demonstrated that the presence of *Azotobacter chroococcum* in the rhizosphere of tomato and cucumber is correlated with increased germination and growth of seedlings.). Puertas and Gonzales (1999) report that dry weight of tomato plants inoculated with *Azotobacter chroococcum* and grown in phosphate-deficient soil was significantly greater than that of non inoculated plants. Phytohormones (auxin, cytokinin, gibberellin) can stimulate root development.

Results of a greenhouse pot experiments with onion showed that application of *G. fasciculatum* + *A. chrooccocum* + 50% of the recommended P rate resulted in the greatest root length, plant height, bulb girth, bulb fresh weight, root colonization and P uptake (Mandhare *et al.*, 1998). Elgala *et al.* (1995) concluded that with microbial inoculation rock phosphate could be used as cheap source of P in alkaline soils and that combined inoculation could reduce the rate of fertilizer required to maintain high productivity. A study by Govedarica *et al.* (1993) on the production of growth substances by nine *Azotobacter chroococcum* strains isolated from a chernozem soil has showed that these strains have the ability to produce auxins, gibberelins, and phenols and in association with the tomato plant, increase plant length, mass, and nitrogen content. *Azotobacter chroococcum* produces an antibiotic which inhibits the growth of several pathogenic fungi in rhizosphere thereby seedling mortality (Subba Rao, 2001). Under greenhouse conditions inoculation of *Azotobacter chroococcum* recorded a significant N and P uptake in both seed and stover in Brown sarson over the control (Wani, S A., 2012).

Possibility of Using *Azotobacteria* in Crop Production

Azotobacteria is used for studying nitrogen fixation and inoculation of plants due to its rapid growth and high level of nitrogen fixation. Despite the considerable amount of experimental data concerning *Azotobacter* stimulation of plant development, the exact mode of action by which *Azotobacter* enhances plant growth is not yet fully understood. Three possible mechanisms have been proposed: N_2 fixation; delivering combined nitrogen to the plant; the production of phytohormone-like substances that alter plant growth and morphology, and bacterial nitrate reduction, which increases nitrogen accumulation in inoculated plants. Triplett (1996) concluded that the development of the diazotrophic endophytic association in maize appears to be the most likely route to success in the development of a corn plant which does not require nitrogen fertilization for optimum growth and yield. Yield increased ranges from 2 to 45 per cent in vegetables, 9 to 24 per cent in sugarcane, 0 to 31 per cent in maize, sorghum, mustard etc., on *Azotobacter* inoculation (Pandey and Kumar, 1989). Tandon (1991) estimated the fertilizer equivalent of important biofertilizers. According to the estimate, fertilizer equivalent of 19-22 kg ha^{-1} for rhizobium 20 kg N ha^{-1} for *Azotobacter* and *Azospirillium*, 20-30 kg N ha^{-1} for blue green algae (BGA) and 3 to 4 kg N ha^{-1} of *Azolla.* Dutta and Singh (2002) reported a significant in seed yield (7.86q ha^{-1}) in rapeseed and mustard (var. yella) due to inoculation with *Azotobacter.* Similarly, positive reports on application of *Azotobacter* and *Azospirillum* on the yield of mustard (*Brassica juncea*) are available

(Tilak and Sharma, 2007). According to Das and Saha (2007), combined inoculation of *Azotobacter*, *Azospirillium* along with diazotrophs increased grain and straw yield of rice by 4.5 and 8.5 kg ha^{-1}, respectively.Under green house conditions plant height, leaf number/plant, number of primary and secondary branches/plant, fresh and dry weight of whole plant, number of siliqua/plant, seeds/siliqua of brown sarson increased significantly with *Azotobacter* inoculation than no inoculation with seed and stover yield of 10.107 g pot $^{-1}$ and 22.400 g pot $^{-1}$ respectively (S. A. Wani, 2012).

The challenge to the research community will be to develop systems to optimize beneficial plant-endophyte bacterial relationships (Sturz *et al.*, 2000). In order to guarantee the high effectiveness of inoculants and microbiological fertilizers it is necessary to find compatible partners, i.e. a particular plant genotype and a particular *Azotobacteria* strain that will form a good association.

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