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ORIGINAL PAPER

Effect of two species of cyanobacteria as biofertilizers on some metabolic activities, growth, and yield of pea plant

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Abstract Two cyanobacterial species (*Nostoc entophytum* and *Oscillatoria angustissima*) were tested as biofertilizers, substituting the normally used chemical fertilizer, for pea plant. Inoculation of soil with a suspension of each species or a combination of the two species significantly increased the germination percentage and stimulated the other measured growth parameters and photosynthetic pigment fractions of pea. However, the soil inoculation with one cyanobacterial species and the addition of the recommended dose or half the recommended dose of chemical fertilizer were usually more effective and also increased carbohydrate and protein contents of produced pea seeds. However, biofertilization combined with half the recommended dose of the chemical fertilizer was usually more effective than the addition of the full rate of the chemical fertilizer, and this may allow saving 50% of the used chemical fertilizer. The protein profile of the produced seeds showed appearance and disappearance of some protein bands in response to fertilization treatments compared to the control. Blue green algae analyses show that *N. entophytum* fixed more N, produced more exopolysaccharide, and contained more auxin and cytokinin than *O. angustissima*, the latter contained more gibberellins. These data may explain their different influences on growth and yield of pea.

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Introduction

Chemical fertilizers are needed to get good crop yields, but their abuse can be harmful for the environment and their cost can make not economic agricultural products (e.g., Bobade et al. 1992). Thus, attempts have been undertaken to substitute chemical fertilizers with biofertilizers, such as cyanobacteria (blue green algae), which are capable of fixing atmospheric N (Vaishampayan et al. 2001; Sinha et al. 2002; Choudhury and Kennedy 2004; Obana et al. 2007; Asari et al. 2008). In addition, the use of cyanobacteria as biofertilizers can improve plant growth and crop yield since they add organic matter to soil (Zaccaro et al. 1999; Maqubela et al. 2009), thus improving soil structure (De Caire et al. 2000; De Cano et al. 2002; Pandey et al. 2005; Malam Issa et al. 2007; Obana et al. 2007; Maqubela et al. 2009; Saadatnia and Riahi 2009). The positive effect on crop yield was due to their release of various biologically active substances such as gibberellin, auxin, cytokinins (Whitton 2000; Stirk et al. 2002), vitamins, amino acids, polypeptides, antibacterial and antifungal substances and polymers, especially exopolysaccharides (De Caire et al. 1997; De Cano et al. 1997; Zaccaro et al. 1999). Cyanobacteria can also be used for bioremediation since they can take up heavy metals (Zaccaro et al. 2001).

However, cyanobacteria (some species of the genera *Microcystis*, *Nostoc*, *Oscillatoria*, and *Anabaena*) might be harmful as they can synthesize toxic secondary metabolites such as microcystins (Carmichael 1994; Wiegand and Pflugmacher 2005) which can be accumulated in plant tissues and be carried through the food chain (McElhiney et al. 2001).