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REVIEW

Trichoderma: a potential bioremediator for environmental clean up

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Abstract Environmental awareness has resulted in development of regulatory measures that aim to straighten past mistakes and protect the environment from future contamination and exploitation. However, much consideration and research needs to go into the decision-making process for an effective clean up of a particular contaminated site. Each technology developed has its advantages and limitations for the treatment of specific contaminants. Bioremediation and phytoremediation in association with microbes are innovative technologies having a potential to alleviate numerous environmental pollution problems. Owing to its dominant presence in contaminated sites, the application of the fungi in bioremediation is well documented. The genus *Trichoderma* is genetically very diverse with a number of capabilities among different strains with agricultural and industrial significance. It is also tolerant to a range of recalcitrant pollutants including heavy metals, pesticides, and polyaromatic hydrocarbons. This review presents an updated overview of application of *Trichoderma* for biological or phytobial remediation of environmental contaminants.

Keywords *Trichoderma* · Bioremediation · Heavy metals · Agrochemicals · Poly aromatic hydrocarbons (PAHs)

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Introduction

Trichoderma is a genus of soil inhabiting, teleomorph-bearing filamentous fungi belonging to Hypocreales order of the Ascomycota division. The genus *Trichoderma* is genetically very diverse with a number of capabilities among different strains with agricultural and industrial significance (Azevedo et al. 2000; Harman et al. 2004a; Chulalaksananukul 2008; Ahamed and Vermette 2009; Contreras-Cornejo et al. 2009; Lorito et al. 2010). It has attained a special position in the field of agriculture as a potent biocontrol agent besides being a plant growth promoter and improves soil fertility due to its disease suppressiveness and composting ability (Harman et al. 2004a; Contreras-Cornejo et al. 2009; Lorito et al. 2010). *Trichoderma* has found application in industrial production of enzymes, paper and pulp treatment, and food industry (Ahamed and Vermette 2008; Nguyen et al. 2008; Singh and Singh 2009). Reports are available for its potential application to remediate soil and water pollution (Kredics et al. 2001; Harman et al. 2004b; Ezzi and Lynch 2005). Its use has also been demonstrated in preparation of biofilms in the field of nanotechnology (Maliszewska et al. 2009; Vahabi et al. 2011).

Ability of *Trichoderma* to attack soilborne plant pathogens mediated by mycoparasitism and antibiosis is well documented (Howell 2003; Harman et al. 2004a; Lorito et al. 2010). It is an efficient plant growth promoter which is due to its rhizosphere competence (Rigot and Matsumura 2002), ability to produce or induce hormone production in plants (Harman et al. 2004a; Contreras-Cornejo et al. 2009; Lorito et al. 2010), release of nutrients from soil (Altomare et al. 1999, Harman et al. 2004a, b), and enhance development of root system architecture (Contreras-Cornejo et al. 2009; Harman et al. 2004b). *Trichoderma* increases