I.J.A.B.R., VOL. 2(4) 2012:784-786 ISSN 2250 - 3579

INTERNATIONAL JOURNAL OF ADVANCED BIOLOGICAL RESEARCH
© 2004 - 2012 Society for Science and Nature (SFSN). All rights reserved
www.scienceandnature.org

Short Communication

TRICHODERMA- A SAVIOR MICROBE IN THE ERA OF CLIMATE CHANGE

Monika Singh* & Sharma, O. P.
*Dept. of Biotechnology, Mewar Institute of Management, Ghaziabad, UP-201002
NCIPM, IARI Pusa, New Delhi-110012

ABSTRACT
Worldwide awareness towards sustainability of food production and inclination to environment friendly technology has led to increase in use of biopesticides as alternatives to chemicals. In India, also share of biopesticide consumption in total pesticide use has shown an increase from 2.5% to 3.7%. A decade back *Bt* use to occupy 70% of total biopesticide production, which has taken a back seat and now over 160 *Trichoderma* formulations are registered in India likewise *Pseudomonas* also paved way. Amongst all biopesticides *Trichoderma*, *Pseudomonas* and *Bacillus* show promise as part of a replacement strategy for seed, soil treatments as well as foliar protectants. Their use as seed treatment has not only resulted in providing protection against seedling diseases but also acted as *Plant Growth Promoting Rhizobacteria (PGPR)*. As on now these two fungi along with *Metarrhizium* and *Beauveria* has proven as boon to organically growing farming community to manage pests across the continent. Use of *Trichoderma* has helped in conserving soil microbial fauna and flora, along with acting as a compost activator which in turned helped soil with increased water holding capacity and decreases soil erosion. It also resulted in lesser dependence on petro derived fertilizers indirectly helping to curb CO_2 emission. According to one study large fraction of carbon is displaced by runoff water leading to emission of 1.1 billion tons of CO_2. Use of biotechnology in transforming *Trichoderma* and *Pseudomonas* to achieve goals has met partial success e.g., CWDE genes from *T. atroviride* inserted into rice genome resulted in high sheath blight (*R. solani*) resistance (Liu *et al.*, 2004). Our field studies supported with laboratory experiments has proved that use of biopesticides can contribute significantly in coping up effect of global warming on field as well as protected cultivation.

KEYWORDS: *Trichoderma,* biopesticide, climate change, pgpr, biological pest management, biocontrol agents.

INTRODUCTION

Trichoderma as biopesticide

Problems with fungicides and soil fumigants such as methyl bromide have let researchers to seek better methods to protect crops against soil borne pathogens. Biocontrol with antagonistic microbes such as fungus *Trichoderma* is one area of research. *Trichoderma* has been used for years for biocontrol of pathogens. A major problem, which is the inability of earlier isolates to effectively colonize plant root system, may have been solved with the development of new strains. Improved strains, application methods and more economical production methods have resulted from a determined research effort. Chemical fungicides such as metalaxyl (Ridomil) or benomyl (Benlate), however, have many drawbacks. They are expensive, cause environmental pollution, and may induce pathogen resistance. Fungicides added to seeds can also cause stunting and chlorosis of young seedlings and results may vary as fungicides are absorbed or inactivated by components of the soil or planting medium (Lumsden and Locke, 1989, Anonymous, 2006). Fungicide treatments can also be toxic to nitrogen-fixing *Rhizobium* spp. bacteria (Harman *et al*., 1981). Some pesticides disturb molecular interactions between plants and N-fixing *Rhizobacteria* and consequently inhibit the vital process of biological nitrogen fixation. Similarly, many studies showed that pesticides reduce activities of soil enzymes that are key indicators of soil health. The applied pesticides may also influence many biochemical reactions such as mineralization of organic matter, nitrification, denitrification, ammonification, redox reactions, methanogenesis etc. However, a few reports reveal some positive effects of applied pesticides on soil health (Hussain *et al*, 2009). Another chemical approach to control of soil pathogens is soil fumigation with agents such as methyl bromide or metam sodium (Vapam). These fumigants are quite toxic, killing most of the micro-organisms and a number of soil insects. Metam sodium is dangerous to transport and use and methyl bromide is harmful to the earth's ozone and its use has been restricted by an international treaty (USEPA, 1993, Anonymous, 2006). Biological control methods have the advantage of being non-toxic to the environment. For the case of soil borne pathogens, seed treatments may cost less than soil treatments because less biomass is required. However, in-furrow treatments with biological agents may now be more effective than seed treatments for some crops. Small scale addition of microbes to container mixes for horticultural use in greenhouses is also promising as amounts needed are less, and conditions can be controlled more exactly (Lumsden and Locke, 1989). Several other bacterial species have been used for biocontrol over the last 30 years. Currently, various *Pseudomonas* spp. bacteria are receiving much attention. Applications to potato seed pieces, sugar beets and radish have significantly increased yields. Because seed treatments with *rhizobacteria* can increase yields, these microbes have been given the name "plant growth promoting *rhizobacteria*" (Burr *et al.*, 1978). *Trichoderma* and other microbials show promise as part of a replacement strategy for toxic fungicides and soil fumigants. Problems such as a lack of rhizosphere competence, which was seen with earlier *Trichoderma* strains, may have been solved by development of newer, more effective organisms. Application and production methods have improved, leading to cheaper, more stable material for use in biocontrol. For some crops, *Trichoderma* spp. and other microbials protect plants just as well as chemical treatments, resulting in improved yields. Though microbial treatments will probably not solve all the problems presented by soilborne pathogens, these methods may soon be ready for implementation on a wide scale in commercial agriculture. Resistance to exogenous and endogenous toxic compounds is one of the keys to the ecological success of *Trichoderma* spp. (Lorito *et al*., 1996). In fact, various strains belonging to these genera are among the most resistant microbes to natural and synthetic chemicals and toxins, and are able to rapidly degrade some of them, including hydrocarbons, chlorophenolic compounds, polysaccharides, and pesticides (Harman *et al*., 2004 and Rigot and Matsumura, 2002). These beneficial fungi are among the first microbes to recolonize the soil after sterilization by methyl bromide, being more tolerant to this chemical than most other fungi or bacteria (Harman *et al*., 2004).

Trichoderma helpful for environment

Controlling the plant diseases by pollution free biocontrol agents are desirable now a days, which are alternative to the chemical pesticides for the control of plant diseases especially the soil-borne (Roberts *et al*., 2005). Among various biocontrol agents of the soil-borne plant pathogens, the fungal bio-control agents are very prominent and reported by various researchers. Among the fungal agents, *Trichoderma* species have been reported to be very effective biological control agents against a number of soil borne diseases (Lewis *et al*., 1998; Wong *et al*., 2002; Ahmed *et al*., 2003; Roberts *et al*., 2005). The efficacy of biocontrol ability of an efficient biocontrol agent depends upon its different mechanisms have been suggested for their biocontrol activity, which include competition for space and nutrients, secretion of chitinolytic enzymes, mycoparasitism and production of inhibitory compounds (Haram *et al*., 1996; Zimand *et al*., 1996; Inam-Ul-Haq *et al.*, 2009).

Biopesticides are less harmless than conventional chemical pesticides and have the advantage of generally targeting one specific pest or a small number of related pests in contrast to broad spectrum chemical pesticides which affect, apart from the pest, other beneficial insects, birds and mammals. They have generally low toxicity levels, decompose quickly and thus do not cause the kind of environmental problems associated with chemical pesticides. Used as part of Integrated Pest Management programs, biopesticides can greatly reduce the use of conventional pesticides without compromising crop yields. It is not right for farmers to have to compromise on yield and profitability as older, more toxic pesticides are getting banned, leaving gaps in their portfolios. Biopesticides now account for $1 billion of the global $40 billion agrochemical market and over the next 10 years the biopesticides, or low-chem., market is expected to grow to $10 billion. Bio-pesticides represent only 2.89% (as on 2005) of the overall pesticides market in India and are expected to exhibit an annual growth rate of about 2.3% in the coming years. In India, so far only 12 types of bio-pesticides have been registered under the Insecticide Act, 1968 (www.cibrc.nic.in).Low cost and biological pest management solutions are becoming increasingly important to producing healthy food and helping farmers grow their crops in a sustainable way (www.agraquest.com).

The first report of tree growth stimulation by application of *Trichoderma* to roots, and is especially important as willow is a major source of wood fuel in the quest for renewable energy. These results also suggest willow trees inoculated with *T. harzianum* T22 could be used to increase the rate of revegetation and phytostabilization of metal-contaminated sites, a property of the fungus never previously demonstrated (Adams *et al*., 2007).

Use of *Trichoderma* has helped in conserving soil microbial fauna and flora, along with acting as a compost activator and thereby improves water holding capacity, improves the physical condition of soils by promoting soil aggregation and preventing crusting, thus, improving water infiltration, plant root penetration and soil aeration, increases the buffering capacity of soils and minimizes the adverse effects of soil acidity and alkalinity Improvement of soil tilth and texture, converting nutrients into readily available forms for plant use.

According to one study large fraction of carbon is displaced by runoff water leading to emission of 1.1 billion tons of CO_2. An application of bavistin and calixin significantly enhanced the microbial activity, as well as availability of nitrate & and available K were found to decrease and significantly increase CO_2 evolution (Khan and Khan, 1987).

Trichoderma and Biotechnology

Research data accumulated in the past few years have produced a completely novel understanding of the way by which these fungi interact not only with other microbes, but especially with plants and soil components. This has opened an avenue of new applications, both in agriculture and biotechnology that exploit the ability of these fungi to change plant metabolism and resistance to biotic and abiotic stresses. In fact, they can be used either to improve crop plant fitness or increase the natural ability of some plants to degrade toxic compounds in soil and waters (Harman *et al*., 2004). Genes present within the fungus family (from *Trichoderma*) enhance the plant host's resistance against other pathogenic fungi. Fungal cell wall degrading enzymes are employed by the transgenic plant cell to destroy an invading pathogenic fungus. Combining the transgenic method with traditional plant breeding technology can be used to express pathogen resistance on a large scale. In an experiment performed by Liu et al. fungal cell wall degrading enzyme genes were isolated from the fungus *Trichoderma atroviride* and inserted into the rice genome via *Agrobacterium*-mediated transformation endochitinase ech42, exochitinase nag70, and exo-1,3--glucanase gluc78 were excised from *Trichoderma atroviride* and were used to prepared plasmids containing different combinations. Inoculation of the plants with *R. solani* resulted in a high sheath blight resistance rate in plants that received the ech42 gene. Plants with the nag70 gene also showed reduced infection. The researchers also found that co-expression of ech42 and nag70 resulted in greater sheath blight resistance when compared to single expression. Inoculation of the plants with *M. grisea* showed increased resistance to rice blast in plants that expressed the ech42 and the nag70 genes. Plants expressing the gluc78 gene showed reduced vigor (due to high glucanase activity) and were not examined (Liu *et al*., 2004 and Lorito *et al*., 1996).

REFERENCES

Adams, P., De-Lei, M. and Lynch, J.M. (2007) *Trichoderma harzianum* Rifai 1295-22 Mediates Growth Promotion of Crack Willow (*Salix fragilis*) Saplings in Both Clean and Metal-contaminated Soil. Microbial Ecology 54(2), 306-313.

Ahmed, A.S., Ezziyyani, M., Sanchez, C.P. and Candela, M. E. (2003) Effect of chitin on biological control activity of *Bacillus* spp., and *Trichoderma harzianum* against root rot disease in pepper (*Capsicum annuum*) plants. European Journal of Plant Pathology 109, 633-637.

Anonymous (2006) Alternative to methyl Bromide: *Trichoderma* seed treatments, Trichoderma Product Information, European Bioremediation.

Burr, T.J., Schroth, M.N. and Suslow, T. (1978) Increased potato yields by treatment of seed pieces with specific strains of *Pseudomonas fluorescens* and *P. putida*. Journal of Phytopathology 68, 1377−1383.

Haram, S.H., Schickler A. and Oppenheim Chet I.(1996) Differential expression of Tr*ichoderma harzianum* chitinases during mycoparasitism. Phytopathology 86, 980-985.

Harman, G.E., Chet I. and Baker, R. (1981) Factors affecting *Trichoderma hamatum* applied to seeds as a biocontrol agent. Phytopathology 71, 569–572.

Harman, G. E., Howell, Viterbo, C.R.., A., Chet, I., and Lorito, M. (2004) *Trichoderma* species-opportunistic, avirulent plant symbionts. *Nat. Rev. Microbiol.* 2, 43-56.

Harman, G. E., Lorito, M., and Lynch, J. M. (2004) Uses of *Trichoderma* spp. to alleviate or remediate soil and water pollution. Adv. Appl. Microbiol. 56, 313-330.

Hussain, S., Siddique, T., Saleem, M., Arshad, M. And Khalid, A. (2009) Impact of Pesticides on Soil Microbial Diversity, Enzymes and Biochemical Reactions, Advances102,159-200.

Inam-Ul-Haq, M., Javed, N., Khan, M.A., Jaskani, M. J., Khan, M. M., Khan, H.U., Irshad, G. and Gowen, S. R. (2009) Role of temperature, moisture and *Trichoderma* species on the survival of *Fusarium oxysporum ciceri* in the rainfed areas of Pakistan, Pak. J. Bot. 41(4), 1965-1974.

Khan, S, Khan, N.N., and Khan F.A. (1987) The influence of Bavistin and Calixin on CO_2 evolution and the major nutrient status (NPK) of the soil. Environ Pollut. 47(2), 115-22.

Lewis, J.A., Larkin R.P. and Rogers D.L. (1998) A formulation of *Trichoderma* and *Gliocladium* to reduce damping-off by *Rhizoctonia solani* and saprophytic growth of the pathogen in soil less mix. Plant Disease 82, 501-506.

Liu M., Sun Z., Zhu J., Xu T., Harman G. and Lorito M.(2004) Enhancing rice resistance to fungal pathogens by transformation with cell wall degrading enzyme genes from *Trichoderma atroviride*. J Zheijang Univ SCI 5(2), 133-136.

Lorito, M., Mach, R. L., Sposato, P., Strauss, J., Peterbauer, C. K., and Kubicek, C. P. (1996a) Mycoparasitic interaction relieves binding of the Cre1 carbon catabolite repressor protein to promoter sequences of the ech42 (endochitinase-encoding) gene in *Trichoderma harzianum*. Proc. Natl. Acad. Sci. U.S.A 93, 14868-14872.

Low-chem. bio-pesticides benefit both consumer and farmer. (www.agraquest.com).

Lumsden, R.D. and Locke J.C. (1989) Biological control of damping-off caused by *Pythium ultimum* and *Rhizoctonia solani* with *Gliocladium virens* in soilless mix. Phytopathology 79, 361–66.

Monte, E. (2001) Understanding *Trichoderma*: Between biotechnology and microbial ecology. Int. Microbiol. 4, 1-4.

Rigot, J. and Matsumura, F. (2002) Assessment of the rhizosphere competency and pentachlorophenol-metabolizing activity of a pesticide-degrading strain of *Trichoderma harzianum* introduced into the root zone of corn seedlings. J. Environ. Sci. Health 37, 201 210.

Roberts, D.P., Lohrke S.M., Meyer S.L.F., Buyer J.S. , Bowers J.H., Baker C.J., Li W, Souza J.T., Lewis J.A. and Chung S. (2005) Biocontrol agents applied individually and in combination for suppression of soil-borne disease of cucumber. Crop Protection 24, 141-155.

Ruocco, M., Lanzuise, S., Vinale, F., Marra,R., Turrà, D., Lois Woo, S., and Lorito, M. (2009) Identification of a New Biocontrol Gene in *Trichoderma atroviride*: The Role of an ABC Transporter Membrane Pump in the Interaction with Different Plant-Pathogenic Fungi MPMI 22(3), 291–301.

Sinha, Bikramjit and Biswas, Indranil, (2009) Potential of Bio-Pesticides in Indian Agriculture Vis-a-Vis Rural Development, India Science and Technology.

Wong, P.T.W., Mead J.A. and Croft M.C. (2002) Effect of temperature, moisture, soil type and *Trichoderma* species on the survival of *Fusarium pseudograminearum* in wheat straw.Australasian Plant Pathology 31, 253-257.

Zimand, G., Elad Y. and Chet I.(1996) Effect of *Trichoderma harzianum* on *Botrytis cinerea* pathogenicity. Phytopathology 86, 1255-1260.