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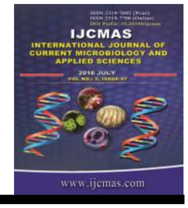

Review Article

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Trichothecene (Trichodermin) Production in *Trichoderma*

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A B S T R A C T

Fungi form an important group of microorganisms comprising of both forms Filamentous and Non-filamentous but mycotoxin production is mostly seen associated with terrestrial filamentous fungi like molds. Symbiosis between plants and endophytes is well known in which symbionts provide shelter to latter and fungi produces some bioactive compounds which play important role in mitigating the effect of pathogens, insectides etc and defend the plant from attack. Toxigenic fungi can produce mycotoxin like Trichothecenes, aflatoxins, rubratoxins, ochratoxins, fumonisins etc. Among them trichothecenes play important role to be used as potential biopesticides. Potentially hazardous concentrations of the trichothecene mycotoxins can occur naturally in cereals and grains.

Introduction

The species of *Trichoderma* are well known for their biocontrol activity against many plant pathogens that cause major problems in the current agricultural scenario (Sharma *et al*., 2011). The major biocontrol process involves antibiosis, providing plant nutrition and mycoparasitism (Janisiewicz and Korsten, 2002). *Trichoderma* species are biofertilizers, that induces plant defense responses, and to enhanced tolerance to abiotic stresses (Shoresh *et al*., 2010; Hermosa *et al*., 2012). There are different species of *Trichoderma* producing bioactive compouns which act as mycotoxins One of them is Trichothecene. It is a sesquiterpenoid derived secondary metabolites synthesized mainly by *Fusarium* other fungal genera like *Trichoderma*, Trichothecium, Stachybotrys (Shentu *et al*., 2014; Wilkins *et al*., 2003). It is known that these sesquiterpenoid compounds are also produced by *Trichoderma arundinaceum* and *T. brevicompactum* which are found harmful to plants and to the animals feeding on infected fodder. Harziandione and trichodermin have been most widely studied antifungal compounds known from long time (Rocha *et al*., 2005; Jin *et al*., 2007;

Degenkolb *et al*., 2008; Cardoza *et al*., 2011; Cole *et al*., 2003), and their biosynthetic pathways have been completely known by now.

Mycotoxins are found to accumulate in plants, and can also lead to the development of (mycotoxicoses) in humans and animals (Janisiewicz *et al*., 2002).

The chemical structure of Trichothecens comprise of a trichothecene ring, which contains an olefinic ring at C-9,10; and an epoxide group of C-12, 12. Trichothecene-are mainly produced by *Fusarium*, *Myrothecium*, *Spicellum*, *Stachybotrys*, *Cephalosporium*, *Trichoderma*, and *Trichothecium* (Shentu *et al*., 2014). These fungi, of the order Hypocreales, are known throughout for there adaptability and colonizing behavior and growth on substrates with a wide range of moisture availability and nutrient content. The genus *Fusarium*, there are species whizh invade important plant pathogens and causes blights,wilts, and ear rots in grains, like wheat, barley, oats and maize (Hermosa *et al*., 2012). The mechanism of action of mycotoxin mainly comprised of toxicity studies showed that trichothecenes inhibit protein synthesis, by preventing peptide bond formation at the peptidyl transferase center of the 60S ribosomal subunit. The polypeptide chain termination may also be inhibited (Jin *et al*., 2007; Degenkolb *et al*., 2008). Trichothecenes were also shown to inhibit protein synthesis in mitochondria (Cole *et al*., 2003) and interaction with protein sulfhydryl groups. The activity of trichothecenes then produces harmful levels of oxidative stress due to generation of free radicals.

Physical and Chemical properties

The trichothecenes are a family of closely related chemical compounds called sesquiterpenoids. There are 200 Trichothecene known. The trichothecene mycotoxins are nonvolatile and have low-molecular-weight (MW 250–550) compounds. Sesquiterpenoids are relatively insoluble in water but highly soluble in acetone, ethyl acetate, chloroform, dimethyl sulfoxide (DMSO), ethanol, methanol, and propylene glycol. The most important mycotoxin is T-2 toxin known for its availability and relatively high toxicity. Extraction of trichothecene from fungas yield yellow brown liquid which on evaporation form a cyrtalline product.Purified trichothecene generally have low vapour pressure, but they do vapourize when heated in organic solvents.

Trichothecene from *Trichoderma*

Trichodermin is known to have stronger antifungal activity against *Saccharomyces cerevisiae*, *Kluyveromyces marxianus*, *Candida albicans*, *C. glabrata*, *C. tropicalis*, and *Aspergillus fumigatus* as compared to antibiotics .To date, more than 200 trichothecenes have been reported and are divided into four types (A–D) according to their chemical structures (Sharma *et al*., 2011). Furthermore, trichodermin had been established a reputation of been a potential role in biological control activity on various soil borne and seed borrne phytopathogenic fungi such as *Botrytis cinerea* and *Rhizoctonia solani*. Yeild of the Trichodermin can be improved from low fermentation units 325 μg/L to high (Jin *et al*., 2007). In order to enable large-scale production, it is very important to look for the factors affecting the yield and optimization parameters in the fermentation conditions in industry. However, the improvement on trichodermin yield in *Trichoderma* using precursor/elicitor has not been reported. There are various gene expression studies conducted by different research groups to understand the biosynthetic pathway of trichothecene in a better way.

The trichothecene biosynthetic gene cluster comprises of set of seven major genes (tri3, tri4, tri6, tri10, tri11, tri12 and tri14) found. In *Fusarium* tri4, tri11 are directly involved in trichothecenes biosynthesis (Cardoza *et al*., 2011). The tri5 gene (encoding the trichodiene synthase),is located outside the gene cluster and is known to be responsible for the first committed step in HA biosynthesis (Cardoza *et al*., 2011). The influence on the trichodermin production as well as the expression levels of three genes, Tbtri4,Tbtri5 and Tbtri11 which are directly involved in trichothecene biosynthesis were investigated.

In recent years, the world is experiencing an increase in awareness of mycotoxin contamination of building materials, grains and air-handling systems. These problems are caused by trichothecenes, which range from relatively simple structures to those with more complex, macrocyclic structures. Based on genetic sequence data the phylogenetic analyses lead to a better understanding of the evolution of trichothecene-producing fungi. Phylogenetic work on the trichothecene gene cluster indicates that , there has been consolidation of *TRI* genes into fewer loci in some fusaria .Newer Researches will contribute the evolution affects of mycotoxin-producing genes. Studying fungal populations and various genetic linkages will also bring a better understanding of how pathogenic fungi spread throughout the world. Comparison of gene sequences from expanding databases may also contribute to identification of trichothecene-related genes that may lead to new control strategies to reduce both crop diseases caused by the fungi and the mycotoxin contamination problems associated with these diseases. Combination of chemical and genetic analysis of trichothecene biosynthesis provide us better understanding of evolutionary mechanisms involved in Trichothecenes.

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