Mucormycosis epidemic and biosecurity concerns of biocontrol agents in the cropping system

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Rhino-orbital infection by mucorales in COVID-19 patients with compromised immunity gained attention last year. This is the opportunistic invasion of the blood vessels by fungal hyphae[1]. Mucorales, are ubiquitous saprophytic fungi found in the soil and decaying plant materials. They are widely used in the biological control of pests and also in fermentation of food. It is a matter of serious concern that the saprophytic fungi turned into an opportunistic pathogen. 'Entomophthorales' in Zygomycetes, the same class to which the mucorales belong, has been recently reported to be pathogenic to humans, similar to *Conidiobolus coronatus* and *Basidiobolus ranarum*[2].

Microorganisms have been widely used for the control of diseases, pests and weeds of crop plants for many decades. Biological control and biopesticides have become synonymous with sustainable crop production and natural farming. Microbes like *Trichoderma*, *Beauveria*, *Metarhizium*, *Bacillus* and *Pseudomonas* are common in this list. For the management of plant diseases, about 300 fungal antagonists belonging to 13 classes and 113 genera are used. *Trichoderma* is the genus with greatest number of biocontrol agents, i.e. 25. It has been used against several plant fungal diseases[3]. In addition, *Aspergillus*, *Candida*, *Fusarium*, *Penicillium*, *Pichia*, *Pythium*, *Talaromyces* and *Verticillium* also comprise of many antagonistic agents. The State Agricultural Universities and crop-based institutions in India have a Trichoderma formulation of their own, and they recommend it for almost all the crops as a part of the package of practice. Not only in India, the global trend of sustainable agriculture is based on *Trichoderma*.

Trichoderma are 'rhizosphere competent'. They achieve this competitive advantage through fast growth, competitive saprophytic ability, mycoparasitism (using weapons like cell wall degrading enzymes and proteins) and antibiosis where they release chemicals and metabolites for restricting the growth of other microbes. Is it replacing just the pathogen or all the beneficial microbes involved in hundreds of other activities in the soil? If the farmers incorporate different *Trichoderma* populations in the soil or spray them on the leaves, soon they will replace the rhizosphere and phyllosphere microbes. What will be the long-term impact or ramifications of this so called 'sustainable strategy'? There exists only a thin line between a symbiotic microorganism and an opportunistic pathogen. The 'ear rot of maize' caused by *Trichoderma afroharzianum* is a warning. The risk is not limited to the rhizosphere and plant pathosystem-dwellers like mycorrhizae and non-target microbes. There were reports in the last century about widening spectrum of opportunistic *Trichoderma* species in immunocompromised patients. In the last decade, increasing number of case reports of human diseases caused by *Trichoderma* species like skin and lung infections, allergic sinusitis, peritonitis of hosts mainly with impaired immune system has been recorded, with the most recent one on human mycoses caused by *Trichoderma bissettii* originating from agricultural environments[4].

While introducing a biocontrol agent to an ecosystem, a detailed study of the non-targeted effect of the biocontrol agent is necessary. Are we doing it religiously whenever we recommend *Trichoderma* application to a new ecosystem? The concern is applicable to all biocontrol agents. Beauveriosis in the silk-worm industry and chalkbrood in honey-bee colonies are some events from the past where biocontrol went wrong.

Assessing the impact on the native microbial world is an insurmountable task as we do not know the millions of flora live in a handful of soil. Still it is imperative to keep a watch with all possible technologies to avoid any future ecological disaster. The risks posed as direct attack and indirect effects on non-target organisms, including humans, autonomous dispersal or deliberate/inadvertent human-assisted dispersal to a new area, changing equations between a biocontrol agent and a native species under the present climate change scenario need surveillance and assessment before pushing a sustainable biocontrol product into the mainstream. Periodic surveillance of the native microbes population and biocontrol agents after release is as important as pre-release risk assessment. There is a need for dedicated research on risk and impact assessment of introduction of a biocontrol agent into a new environment.

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