Editorial

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Journey of Trichoderma: Plant Stress Amelioration to Nanosynthesis

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The research work focused on the interaction of plant and microbes. Initially investigation has been done in the area of role of *Trichoderma* in abiotic biotic stress tolerance and stress amelioration in plants. The work extended with exploring of microbes for the nanosynthsis of metal nanoparticles and its application in biodegradation, antimicrobial activity against MDR bacteria and phytopathogens. Along with this we have also studied the novel microsatellite markers for *Trichoderma* and *Aspergillus* species in order to elucidate whether it is possible to increase the resolution of existing markers to discriminate between individual strains or whether saturation of discrimination has been reached. This information is of fundamental importance when using microsatellites in future studies on the pathogenicity, ecology, or taxonomy of these species. In *Trichoderma*, twelve polymorphic markers were developed out of which six were from *T. atroviride* and remaining six belong to *T. harzianum.* Similarly, for *Aspergillus* species, we have developed five polymorphic markers for *A. terreus* and similar number of markers was developed for *A. niger* [1,2].

In the field of abiotic stress amelioration activity the work has been investigated on Arsenic (As), a toxic metalloid is among one of the prominent abiotic stresses as it is constantly released in the environment by both natural and anthropogenic activities such as mining, irrigation and spreading of arsenical pesticides and it poses a serious global problem which significantly affects several regions in India as well [3]. Increased levels of arsenic causes various ill effects on plant's metabolic pathways leading to reduced growth and death may also happen [3]. There are different approaches opted by various researchers for bioremediation of agricultural soils and water bodies by the use of Arsenic (As) hyperaccumulator plants among angiosperms and pteridophytes as well as microbes.

Trichoderma a well known fungi helps in plant growth promotion through various direct and indirect mechanisms such as nutrient uptake by mobilising elements such as carbon, phosphorous, nitrogen, sulphur from soil to the plants, through producing siderophores, iron chelating agents and by breakdown of complex carbon sources to simpler forms for the uptake by plants. Their high reproductive ability coupled with efficiency in utilizing nutrients and strong aggressiveness against plant pathogenic fungi make them a preferred PGP fungus for plants in the rhizosphere [1]. One of my studies involved use of *Trichoderma* reesei strain NBRI0716 for As stress amelioration in chickpea under green house conditions [4]. This study exhibited the upregulation of drought responsive genes (*DRE*, *EREBP*, *T6PS*, *MIPS*, and *PGIP*), enhanced proline content and shrunken cortex cells in the presence of Arsenic (As) suggesting that it creates water deficiency in plants and these responses were modulated by NBRI 0716 which provides a protective role to the chickpea plants. NBRI0716 stimulated the production of As reductase enzyme in chickpea which helps in As metabolism. Another study of ours proved that *Trichoderma* methylates inorganic arsenic species to organic species which down-regulates stress responsive genes in the chickpea plants, suggesting Trichoderma helps in amelioration of Arsenic stress in chickpea. So, Trichoderma can be promising microbe for agricultural productivity by modulating plant responses at molecular level as well during abiotic stress.

The technology becomes upgraded as the size of materials became smaller at day by day. Nanotechnology has reaches upto top most position in advancement of technology due to its size in nanometer, increases the surface area of the materials resulting enhances its own activity of materials. Mode of synthesis of materials or particles is basically two types: chemical synthesis and biological synthesis. Rational of my study is basically belongs to biological mode of synthesis, previously the reaction time for the synthesis by greener approach was long, its takes hours to days, which is comparable difference than its counterparts. To solve this problem, we have synthesized the metal Gold nanoparticles from the fungal filtrate of *Trichoderma viride (*MTCC 5661) within a minute [5] and these particles were used for the degradation of water pollutant 4-nitrophenol into less toxic form 4-aminophenol. After the synthesis of gold nanoparticles, biologically regulate the geometry of particles become a mammoth task, we have optimize the physico-chemical parameters viz. reaction time, temperature, pH of the cell free filtrate, salt concentration, concentration of cell free filtrate [6]. We have regulate the interdependency to each other and synthesized five different shape and size of gold nanoparticles and observed the degradation efficacy of same particles for water pollutant 4-nitrophenol into less toxic form 4-aminophenol. With the specificity of nanotechonology, nanoparticles are used for the delivery of targeted gene into host cell. We have enhancing the transformation efficiency of desired gene into competent and non-competent cell by gold nanoparticles. By the property of gold particles and Yoshida effect the rate of transformation become increases [7].

Apart from this we have diversified our area of research by exploring role of nanoparticles for antimicrobial activity. To achieve our target we have synthesized silver nanoparticles by fungal filtrate of *Trichoderma viride* (MTCC No- 5661) of different shape and sizes and applied to treat multidrug resistant bacteria with and without antibiotics [8]. Silver nanoparticles have shown the synergistic effects with antibiotics against pathogenic bacteria. Activity of silver nanoparticles is much higher than chemical one because of coating of metabolites present in fungal filtrate, the main cause of activity enhancer [9].

Future prospects: Now the research is also emphasizing on the preparation of nanoemulsion based on herbs to control phytopathogens as well as human pathogens.

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