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Microbial Metabolites in Plant Disease Management

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India is known as growing economic giant but the benefits of this progress are mostly confined to urban or semi-urban areas. Agriculture, the backbone of Indian economy, contributes to overall economic growth of the country and determines standard of living for more than 50 per cent of Indian population and contributes 14.4 per cent in GDP. Modern agriculture is evolving through agricultural innovations and farming practices and helping farmers to increase efficiency and reduce requirement of natural resources like water, land and energy necessary to meet world's food, fuel and fibre needs. More than 65% of the population in the country lives in rural areas and depends on agriculture and related avenues for their sustenance. Hunger and poverty persists because of lack of work opportunities, thus inadequate income for farming communities. Indian agriculture, basically characterized as a means of subsistence, is changing fast as per market demands both domestically and international. Modern high input mono cropping based intensive agriculture has resulted in loss of biodiversity, outbreaks of pests and diseases, degradation of soil and water, which has ultimately led to stagnating agricultural production and productivity. Climatic changes are becoming a major factor in the present scenario (Kumar, 2013). The crop yield losses, on field and during post harvest period, caused by pests, diseases and weeds are of paramount importance. The crop losses due to pests, diseases and weeds are approximately assessed to be ranging between 10 to 30% of crop productions. If we consider, on average, crop loss of 20%, and the present gross value of our agriculture produce as Rs, 7 lakh crore, the loss comes to Rs. 1,40,000 crore, which is colossal (Kumar and Gupta, 2012). Even if we could save 50% by using plant protection, it will add Rs. 70,000 core additional income to our farmers. At a same time, when all of us are concerned about National Food Security, can the country afford these losses? Various type of direct and indirect losses caused by plant diseases include, reduced quality and quantity of crop produce, increased cost of production, threat to animal health and environment, limiting the type of crops/varieties grown, loss of natural resources and less remunerative alternatives adopted. In order to combat the losses caused by the plant diseases, it is mandatory to define the problem and seek solutions, At the biological level, the requirements are for fast and accurate identification of the causal organism, accurate estimates of the severity of diseases and its effect on yield, and identification of its virulence mechanisms. Plant diseases caused by pathogenic microorganisms such as bacteria, fungi and virus can be controlled so as to protect plants from being infected with the help of certain microorganisms inhabiting rhizosphere, endosphere and phyllosphere (Mathivanan *et al.*, 2008) Biological control is an eco-friendly and effective means of reducing or mitigating plant diseases through the use of natural enemies i.e., microorganisms. These microbe-based agro agents are used as either whole

organism or their metabolites. Interestingly, some of the microbial metabolites that are used in plant disease control programme are of great importance. Microbial secondary metabolites are low molecular bioactive compounds synthesized during a subsequent production stage (idiophase) of microbial growth. The secondary metabolite production is controlled by special regulatory mechanisms in microorganisms, as their production is generally repressed in logarithmic phase and depressed in stationary growth phases. It is commonly observed during microbial interaction of antagonistic microorganisms and pathogens.

Sources of Secondary metabolites

Actinomycetes : Actinomycetes are powerful producers of a broad range of secondary metabolites with a variety of biological functions, including substances that are significant for agriculture and medicine. Between 1988 and 1992, more than 1,000 secondary metabolites from actinomycetes were identified. The majority of these substances are made by different *Streptomyces* species. Actually, it has been reported that *Streptomyces* is the source of roughly 60% of novel pesticides and herbicides. Many of the antibacterial, antifungal, nematicidal, and herbicidal chemicals that actinomycetes have developed are employed in agriculture. Several species of actinomycetes belonging to the genera *Streptomyces*, *Actinoplanes*, *Actinomadura*, *Micromonospora*, *Streptosporangium*, *Streptoverticillium* and *Spirillospora* have been successfully used as potent antagonists against various phytopathogens. *Streptomyces* is the dominant genera among actinomycetes known to produce numerous types of antibiotics, of which, many of them, for example, validamycin and kasugamycin have been commercialized as fungicides (Mathivanan *et al.*, 2008).

Bacteria : Within the prokaryotic group, microorganisms from the genera *Bacillus* and *Agrobacterium*, Numerous plant diseases have been effectively treated with *Burkholderia*, *Enterobacter*, *Erwinia*, *Lysobacter*, *Pseudomonas* and *Serratia* as biological control agents. *Bacillus* and *Pseudomonas* are two of these unicellular bacteria that produce a lot of antibiotics. Numerous metabolites, including phenazines, are produced in large quantities by fluorescent pseudomonads (FPs). Antimicrobial metabolites of *Bacillus* spp. have been used against plant diseases (Kavitha *et al.*, 2005). *Bacillus* spp. are found to produce many antibiotics such as Zwittermycin-A, Bacillomycins, Fungicin, Kanosamine, Rhizocticin C, Iturins and Saltavalin and are also capable of producing thermostable antimicrobial peptides.

Fungi : A number of fungal genera namely, *Ampelomyces*, *Aspergillus*, *Coniothyrium*, *Penicillium*, *Phlebiopsis*, *Gliocladium*, *Sporodesmia*, *Laetisaria*, *Talaromyces*, *Tilletiopsis*, *Trichoderma*, *Trichothecium* and non-pathogenic *Fusarium* are known to produce biologically active secondary metabolites that are having potential in controlling plant pathogens.

Microbial secondary metabolites in plant disease management

It has been discovered that microbial metabolites of bacterial, fungal, and actinomycetes antagonists can stop the growth of a number of phytopathogens. secondary metabolites generated by the following are some types of microbes:

Siderophores : Siderophores, the iron-binding molecules produced by many rhizobacteria were responsible for inhibition of many phytopathogens. Examples of siderophores produced by BCAs are pyoverdinin and pyochelin, which have been reported to contain antimicrobial activity on their own. However, in most of the studies, the Siderophores have been reported to inhibit the pathogens by iron competition only. Siderophore-mediated biocontrol potential of *Rhizobium meliloti* against *Macrophomina phaseolina*, causal agent of charcoal rot of groundnut has been demonstrated (Arora *et al.*, 2001).

Viridin : Viridin has been first described in 1945 as an antifungal metabolite of the fungus *Gliocladium virens* (*Trichoderma virens*). This compound has been detected in other *Trichoderma* species such as *T. koningii*, *T. viride* and *T. virens* and prevents the germination of spores of *Botrytis allii*, *Colletotrichum lini* and *Fusarium caeruleum* (MIC of 0.003–0.006 lg/ml), *Penicillium expansum*, *Aspergillus niger* and *Stachybotrys atra* (6 lg/ml).

Azole compound : Recently, the disease-control potential of an azole chemical produced by *B. licheniformis* MML2501 against *M. phaseolina*, the cause of dry root rot in groundnuts,

was thoroughly described. With the exception of *R. solani*, the purified azole molecule has remarkable antifungal efficacy against a variety of soil-borne fungal phytopathogens (Prashanth, 2007).

Koningins : A series of complex pyranes named koninginins A–E and G have been discovered in some species of *Trichoderma*. Koninginin D has also affected growth of other soil-borne plant pathogens such as *Rhizoctonia solani*, *Phytophthora cinnamomi*, *Pythium middletonii*, *Fusarium oxysporum* and *Bipolaris sorokiniana*.

Phenazine-1-carboxylic acid (PCA) : Phenazine-1-carboxylic acid (PCA) It has been reported from *P. fluorescens*, *P. chlororaphis*, *P. aeruginosa* and *P. putida*. PCA has been reported to inhibit fungal pathogens such as *Gaeumannomyces graminis* var. *tritici*, *Pythium* sp., *Rhizoctonia solani*, *Polyporus* sp., *Sarocladium oryzae*, *Macrophomina phaseolina*, *Pestalotia theae*, various species of *Colletotrichum* etc. and bacterial pathogens, *Actinomyces viscosus*, *Bacillus subtilis* and *Erwinia amylovora* etc.

Pyrrolnitrin (PRN) : Pyrrolnitrin (PRN) has been reported from *P. aureofaciens* and *P. fluorescens*. PRN has been found to be active against a wide range of fungi belonging deuteromycota, ascomycota and basidiomycota. Hence, PRN is widely used as fungicide in agriculture. PRN producing *Burkholderia cepacia* showed a broad-spectrum antifungal activity towards phytopathogenic fungi including *R. solani*.

Hydrogen cyanide (HCN) : It is the strongest volatile substance that many soil bacteria make. It has been demonstrated that the HCN generated by antagonistic fluorescent pseudomonads (FPs) exhibits excellent antifungal action against phytopathogens. HCN in *P. fluorescens* CHA0 was essential in suppressing the take-all disease of wheat produced by *G. graminis* var. *tritici* and black root rot of tobacco caused by the fungus *Thilaviopsis basicola*. The protective properties of HCN generated by *P. aeruginosa* against *Meloidogyne javanica*, the tomato root-knot worm, have been amply demonstrated by Siddiqui *et al.* (2003).

Future Perspectives of Microbial Metabolites in Plant Disease Control

High throughput screening methods are revolutionizing the discovery of novel metabolites of microbial origin with novel bioactivities (Zhang *et al.*, 2007). However, the successful use of this advanced technology in identifying novel agroactive metabolites is yet to be followed vigorously. This would save the time required for discovering and developing agroactive molecules into a commercial scale. Microbial metabolic engineering is another field where the generation of well-characterized parts and the formulation of biological design principles in synthetic biology are laying the foundation for more complex and advanced engineering of synthetic microbial metabolism. Mapping out the regulatory networks that govern microbial metabolism through metabolic system biology research is never easy. In metabolic engineering, on the other hand, metabolic pathways, networks, and regulation information in databases are combined with microbial genomic information to develop genomic engineering techniques that are implemented to maximize the microbial production of metabolites. The world has become greener in recent years, and environmental safety is seen as a crucial concern in every way. Even though synthetic chemicals like fungicides provide adequate control over plant diseases, their toxicity to the environment, persistence in the environment, and development of resistance have compelled us to focus more on microbial metabolites for a variety of applications, including the control of plant diseases. Furthermore, structural analyses are crucial for the initial screening process to determine whether the compounds are unique or not. The creation of an extensive database that contains the structures of every purified metabolite in connection with its function is necessary for these kinds of investigations. Even though there are a lot of these structural databases available right now, the importance of structure and function has not yet been taken into account.

Conclusion

We can conclude that employing the microbial metabolites produced by antagonistic bacteria to biologically control plant diseases is an appealing alternative to chemically created pesticides. Their uniqueness and lack of persistence made it possible to handle plant diseases in an environmentally benign manner and allow us to grow crops in an organic manner

without endangering the environment. Additionally, the production of plant protection compounds using these microbial metabolites as lead molecules opens up new opportunities for manufacturers and entrepreneurs. The identification of novel agroactive metabolites using more recent scientific techniques, including microbial metabolic engineering, has not yet been actively pursued.

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