Secondary Metabolites of Microbials as Potential Agrochemicals

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Abstract

Microorganisms especially bacteria and fungi are promising sources of structurally diverse and potent secondary metabolites. Many of these bioactive compounds are used as microbial pesticides. There is a continuing demand for novel bioactive compounds for management of devastating pathogens of crops, which are insensitive or less sensitive to existing chemical pesticides. These are being introduced in new scenario of crop protection and currently several beneficial microorganisms are the active ingredients of a new generation of microbial pesticides. Microbes contain a virtually untapped reservoir of pesticides that can be used directly or as templates for synthetic pesticides. Several beneficial microorganisms have been foundto be the active ingredients of a new generation of microbial pesticides or the basis of many natural products of microbial origin. Numerous factors have increased the interest of the pesticide industry and the pesticide market in this source of natural products as pesticides. The potential bioactivity evident from the overview on secondary metabolites of microbes presented above brings out clearly their potential for use in pest control. Being environment friendly and less toxic to nontarget pests, these microbial pesticides emerge as a potential option for pest management and hence they can be exploited as a skeleton for the synthesis of new strategies.

Introduction

Agriculture has been a means of livelihood and a source of food since the dawn of human civilization. About one third of the total crop yield is lost due to insect pests, pathogens and weeds. The introduction of DDT in 1945 followed by the use of various other synthetic chemical pesticides has played a key role in the increase of agricultural productivity and protection of crops from pests and diseases. However, the indiscriminate use of synthetic pesticides leads to serious problems like pesticide residues in food products, environmental contamination and development of resistance in target organisms (Fig. 1). Use of chemical pesticides has developed an urgent need to look for an alternative method for pest control. There are many approaches used to minimize the application of agrochemicals (Fig. 2). The use of microbial pesticides employing microorganisms or their by-products seems to be one of the best alternatives.

Microbial Pesticides

Microbial pesticides comprise of microorganisms such as bacterium, fungus or virus as the combat weapon. The preference of using bio-pesticides over synthetic chemicals has been widely accepted for several reasons.

Microbial pesticides -Advantages

They are degradable and their toxicity to non-target animals and humans is extremely low. Their ecological advantages are that they tend to be highly selective, infecting or killing a very narrow range of target pests. Another important advantage of bio-pesticides is their lower resistance in the target pest populations.

Main classes of secondary metabolites

Bacterial secondary metabolites

- **Phenazine**
  - Pyocyanin -*Pseudomonas aeruginosa*.
- **Polyketides**
  - Avermectin - *Streptomyces avermitilis*.
- **Non ribosomal peptides**
  - Polymyxin - *Paenibacillus polymyxa*.
- **Ribosomal peptides**
  - Bacteriocins microcin V - *Escherichia coli*.
- **Alkaloids**

- Tetrodotoxin - *Pseudoalteromonas*

Fungal secondary metabolites

- **Polyketides**
  - Strobilurins - *Strobilurus tenacellus*
  - Griseofulvin - *Penicillium griseofulvum,*
- **Non ribosomal peptides**
  - Cephalosporin C -*Acremonium chrysogenum*
- **Terpenes**
  - Fumagillin -*Aspergillus fumigatus*

Rawat and Kumar (2023) observed that the immobilization of second-stage juveniles (J2) by the fungus *P. florida* was found inversely proportional to the time period of incubation. Whereas, the trapping of J2 by the fungus *P. florida* and the time period of incubation was found directly proportional. It was found that the paralysis of J2 decreased with the increase in dilutions of cultural filtrate. The overall increase in growth parameters of tomato and decrease in reproduction parameters of *M. incognita* was found in the treatment where 60g GM and 100g SMS was used per 2 kg of nematode infested soil.

Hohenbuehelia reniformes and *Pleurotus salmoneostramineus* showed the ability to immobilize and consume the pinewood nematode, *Bursaphelenchus xylophilus.* They also investigated the nematode-trapping ability of the most effective nematode scavenger, *P. salmoneostramineus.* Nematode-trapping structures with abundant toxin droplets were observed on the surface of the mycelia, and more than half of the inoculated nematodes were immobilized by this strain within 24 h. The nematophagous activity of this strain was greater than that of the well-known nematophagous species, *P. ostreatus* (Ishizaki *et al.*, 2015).

Perumal *et al.* (2023) isolated entomopathogenic fungi from Palamalai Hills (India) using insect bait method. *Metarhizium majus* (MK418990.1) was identified using biotechnological techniques. Bag-formulated fungal conidial efficacy (2.5×10^3, 2.5×10^4, 2.5×10^5, 2.5×10^6, and 2.5×10^7 conidia/ml) was evaluated against third instar larvae of *Spodoptera frugiperda* at 3, 6, 9, and 12 days of treatment. Study suggested that higher concentration (2.5×10^7 conidia/ml) of *M. majus* was efficient to cause 100% mortality at 9 days post treatment. Further investigation into enzymatic responses revealed that at 3 days post *M. majus* conidia exposure (2.5×10^3 conidia/ml), insect enzyme levels had significantly changed, with acid and alkaline phosphatases, and catalase enzymes significantly reduced and superoxide dismutase enzymes significantly raised relative to the control.

The endophytic fungus strain 0248, isolated from garlic, was identified as Trichoderma brevicompactum, from its culture extracts bioactive compound T2 was extracted which was identified as 4β-acetoxy-12,13- epoxy-Δ(9)-trichothecene (trichodermin) by spectral analysis and mass spectrometry. Trichodermin has a marked inhibitory activity on Rhizoctonia solani, with an EC50 of 0.25 µgmL(-1). Strong inhibition by trichodermin was also found for Botrytis cinerea, with an EC50 of 2.02 µgmL(-1). However, a relatively poor inhibitory effect was observed for trichodermin against Colletotrichum lindemuthianum (EC50 = 25.60 µgmL(-1)). Compared with the positive control Carbendazim.

Madhavi *et al.* (2011) studied compatibility of *Trichoderma viride* with 25 pesticides *in vitro*. Among six seed-treatment chemicals tested, *T. viride* showed a high compatibility with the insecticide Imidacloprid (7.6cm mycelial growth), followed by Mancozeb (6.3cm) and Tebuconazole (3.7cm). Contact fungicides, *viz.,* Pencycuron and Propineb were found to be fully compatible with *T. viride.* Among the 10 herbicides also tested, the fungus was highly compatible with Imazathafir (9.0cm) followed by 2,4-D Sodium salt (8.9cm) and Oxyfluoforen (6.5cm) while being totally incompatible with systemic fungicides like Carbendazim, Hexaconazole, Tebuconazole and Propiconazole.

Yashaswini *et al.* (2022) reported that *Bacillus sp.* an endospore-forming phyllosphere bacteria isolated from *Amaranthus spp.* showed antagonistic activity against *R. solani in vivo* (Dual culture plate assay and detached leaf assay) *and in vitro* (Greenhouse experiment) studies. Treatments included foliar spray on leaf blight susceptible red amaranthus variety Arun with cell suspension of bacterial isolates and the recommended fungicide Mancozeb (0.2%), pathogen inoculated control and absolute control. *Bacillus* sp. AL3 obtained from the red amaranthus variety Arun exhibited 44.5 % disease suppression over the pathogen inoculated control. Foliar spray with the recommended fungicide, mancozeb (0.2%), performed poorly in suppressing the disease compared to foliar application of bacterial cell suspension except for a single strain.

Conclusion

The unscrupulous use of chemical pesticides has led to widespread contamination of water, food and environment. Hence the use of microbial pesticides employing microbes or their by-products has found a potential role in the pesticide market. Microbes contain a virtually untapped reservoir of pesticides that can be used directly or as templates for synthetic pesticides. Several beneficial microorganisms have been found to be the active ingredients of a new generation of microbial pesticides or the basis of many natural products of microbial origin. Numerous factors have increased the interest of the pesticide industry and the pesticide market in this source of natural products as pesticides. The potential bioactivity evident from the overview on secondary metabolites of microbes presented above brings out clearly their potential for use in pest control. Being environment friendly and less toxic to nontarget pests, these microbial pesticides emerge as a potential option for pest management and hence they can be exploited as a skeleton for the synthesis of new strategies.

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