Biological Control to Induced Resistance - A Paradigm Shift in Management of Plant Diseases

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Abstract

The biological world is a vast network of living organisms interacting in their natural environment. In a given ecological niche, the interaction between or among the organisms may be symbiotic, mutualistic, competitive or antagonistic. Plant diseases of economically important crops are very important alone cause 13 to 20% annual loss in production. In India, more than 50% of the crop loss is caused due to soil inhabiting micro-organism. Many fungal genera have been recognized in root disease complex causing seed decay, damping off, root rot, seedling blight, colar rot, crown rot, foot rot and wilt. The conventional method of its control is based on direct elimination of the pathogen but researches are going on in search of non-conventional and eco-friendly management measures that can give good return to growers. Therefore, biological control is getting popularity in the coming era. In this context, *T. harzianum, T. viride*, *Aspergillus niger* AN-27, *C. globosum* and *P. fluorescens* etc, have been used for management of plant diseases. Recently, bio-agents are using as inducers in inducer resistance. Induced resistance is a technique of phyto- immunity has received great attention among the researchers. Various types of biological agents, virulent or avirulent strains of pathogens, plant extracts, crude extracts of bio-agents and chemicals which are not considered as fungicides are used as inducers for induction of resistance in various crops.

Keywords: *Aspergillus niger*, biological agents, plant disease, resistance

1. Introduction

The biological world is a vast network of living organisms interacting in their natural environment. In a given ecological niche, the interaction between or among the organisms may be symbiotic, mutualistic, competitive or antagonistic. The term "biological control" was used in relation to plant pathogen by C.F. Von Tubeuf in 1914. Garrette (1965) defined biological control of plant diseases as "any condition under which or practice whereby survival and activity of a pathogen is reduced through the agency of any other organism (excluding the role of the host and man) with the result that there is a reduction in the incidence of the disease caused by pathogen". Keeping in view the functional relationship between the pathogen, host and environment in the development of disease, Baker and Cook (1974) have given a broader definition of biological control. According to them "biological control is the reduction of inoculumn density or disease producing activities of a pathogen or parasite in its active or dormant state by one or more organism (s) accomplished naturally or through manipulation of the environment, host or antagonist or by mass introduction of one or more antagonist (s).

Plant diseases of economically important crops are very important alone cause 13 to 20% annual loss in production representing $ 50 x 10^9 (James, 1981).The extent of losses is similar in United States though the most advance diseased management technologies are used, (Lewis and Papavizas, 1991). In India, more than 50% of the crop loss is caused due to soil inhabiting micro-organism. Many fungal genera have been recognized in root disease complex causing seed decay, damping off, root rot, seedling blight, colar rot, crown rot, foot rot and wilt (Cook and Baker, 1983). These are the problems persisting in all over the world. The management of diseases can be done through cultural, chemical, biological and use of resistant variety. The conventional method of its control is based on direct elimination of the pathogen but researches are going on in search of non-conventional and eco-friendly management measures that can give good return to growers. Therefore, biological control is getting popularity in the coming era. In this context, *T. harzianum, T. viride*, *Aspergillus niger* AN-27, *C. globosum* and *P. fluorescens* etc, have been used for management of plant diseases.

Recently, bio-agents are using as inducers in inducer resistance. Induced resistance is a technique of phyto-immunity has received great attention among the researchers.

Various types of biological agents, virulent or avirulent strains of pathogens, plant extracts, crude extracts of bio-agents and chemicals which are not considered as fungicides are used as inducers for induction of resistance in various crops (Metraux et al., 1990; Van Loon and Antoniew, 1982; Attitalla et al., 1998; De Cal et al., 1995). The bio-agents like *Pseudomonas fluorescens, Trichoderma harzianum, Aspergillus niger AN 27, Chaetomium globosum* etc. have been successfully used as inducers in induced resistance against several diseases. Successful induction of resistance has been reported in sweet potato (Weber and Stahmann, 1966), cotton (Schnathorst and Mathre, 1966), soybean (Paxton and Chamberlain, 1967), flax (Littlefield, 1969), bean (Rahe et al., 1969) etc. Pre inoculations with avirulent or virulent pathogens induced local resistance against powdery mildew in barley and wheat (Sahashi and Shishiyama, 1986, Schweizer et al., 1989). Resistance in rice plants against *Helminthosporium oryzae* has been reported to be induced by pre-inoculation with the spore suspension of an avirulent race (Sinha and Trivedi, 1969) as well as a mildly virulent race (Sinha and Das, 1972) of the pathogen. Recently some bio control agents are also known to induce resistance in plants in addition to their antimicrobial activities. Nzojiyobiri et al., (2003) reported that rice seedlings pre treated with *Trichoderma harzianum* exhibited moderate resistance against blast and bacterial leaf blight. Pathak et al. (2004) reported that *Pseudomonas* strain GRP3 induced systemic resistance to sheath blight in rice. Biocontrol (antagonistic) potential of *Chaetomium globosum* against the spot blotch pathogen of wheat, *Drechslera sorokiniana* was reported by Mandal et al. (1999).

2. Induced Resistance in Wheat against Spot Blotch through Bio-Agents

Spot blotch of wheat caused by *Drechslera sorokiniana* (Sacc.) Subram & Jain is an important disease of global concern which causes about 3–36% yield losses. (Anon., 1995). High temperature and high relative humidity favor the outbreak of the disease, particularly in South Asia's intensive 'irrigated rice-wheat' production systems. Although biological control of the disease has been attempted as a promising supplement or substitute of chemicals, work on induced resistance against the pathogen is very rare. Biswas et al. (2000) assessed *Chaetomium globosum* as an antagonist for control of spot blotch pathogen (*Drechslera sorokiniana)* in wheat. High antagonistic potential of the fungus was recorded in dual culture. Scanning Electron Microscope *(SEM) showed that the conidia of Drechslera sorokiniana are distorted and mycelium is lysed* by foliar spray of antifungal compounds resulting in reduction of spot blotch disease of wheat. The growth stimulation of wheat seedlings by *C. globosum* have also been observed due to effect of crude extract of *C. globosum*.

In addition to biocontrol property, *C. globosum* also proved to be an inducer of induced resistance in wheat against *D. sorokiniana.* Foliar spray with crude extract of *C. globosum* prior to challenge infection provided protection of wheat plant against spot blotch, showing reduction of disease incidence from 17.90 to 69.70 %. Growth promotion activity of the inducer was also observed in wheat. Shoot and root growth was significantly increased showing involvement of some growth promoting substances. Biochemical analysis of the treated plant prior to challenge infection sensitized the seedlings to produce increased levels of soluble proteins. The maximum content of soluble protein with 34.82 mg g^{-1} of leaf after 72 hrs of treatment was recorded in crude extract treated plant. In addition to proteins, high content of phenol which is an indicator of first stage defense mechanism was also recorded in treated plants. The co-relation co-efficient and regression equation data showed that there was a negative co-relation between disease incidence and soluble protein content (r = -0.4312 to -0.4694). Similarly, negative co-relation was also been observed between disease incidence and total phenol content (r = -0.324 to – 0.3835). Profiling of soluble protein was determined that some new proteins of different molecular weight i.e. *110, 105, 38, 35, and 32* kDa were synthesized due to application of crude extract of *C. globosum*.. *Isolation, purification and characterised the secondary metabolites as Chaetomin, BHT, Mollicelin G, Cochliodinol, Chaetoglobosin A and one isomer of Mollicelin G* from culture filtrate of *C. globosum.*

3. Induced Resistance in Paddy against Brown Spot through Bio-agents

Brown leaf spot caused by *Drechslera oryzae* is considered as important disease of paddy in all rice growing area of India. Several species of *Trichoderma* have been tested against *Drechslera oryza* both *in vitro* and *in vivo*. Seed treatment with *Trichoderma* spp. provides good protection of seed against seed borne infection and also stimulates the germination of seed. The growth promotion effect of *Trichoderma* spp. as seed dresser was supported 26.8-78.7 and 9.2-53.8% increased of shoot length over control -1 (*Drechslera oryzae*) and control – II (healthy) respectively. Foliar spray with spore suspension of *Trichoderma* hampered brown leaf spot lesion formation and protected considereable leaf are from infection showing reduction in leaf spot from 14.6 to 3.2 average lesions per leaf. This may be the manifestation of defense due to application of spore suspension of *T.harzianum* (Kan.). Biochemical analysis of treated leaves exhibited 11.9-85.2 per cent and -10.0 to 66.6 per cent increased of soluble protein over disease and healthy plant respectively. In addition to proteins, high content of phenol which is an indicator of first stage defense mechanism was also recorded in treated plants. It was 3.24 mg/g in *T. harzianum* (Kan.) treated plants and only 1.43 mg/g in healthy leaves. The soluble protein content (r=-0.43 to 0.47) and total phenol content (r = - 0.32 to – 0.38) both showed negative correlation with disease severity (PDI).

4. Induced Resistance in Tomato against Fusarium Wilt through Bio-Agents

Tomato is one of the most valued vegetable crops of the world.

It has a very high nutritive value and also has antioxidant and curative properties. Production of tomato is limited due to various insect pests and diseases. Among these, Fusarium wilt has great economic importance. The conventional method of its control is based on direct elimination of the pathogen but researches are going on in search of non-conventional and eco-friendly management measures that can give good return to growers. Pre-treatment with biotics inducers like *T. harzianum,* (Kan.), *T. harzianum* (Del.), *T. harzianum* (Pant), *T. viride* (Kan.), *T. viride* (Del.), *T. viride* (Pant), *Aspergillus niger* AN-27 (Kan.) *C. globosum* (Del.) and *P. fluorescens* (Del.) provided induced resistance in plant against *Fusarium oxysporum* f.sp. *lycopersici* resulting decline in disease incidence from 100 to 7.69 per cent. Biochemical analysis of treated leaves revealed that the resistance was associated with certain biochemical changes in plant. The soluble protein and total phenol contents were found increased in inducers treated plant. It has also been found that the content of soluble protein and total phenol was varied at different time of interval. Protein profiling by SDS-PAGE revealed that the variable numbers of protein bands were found in inducers treated plants. Soil treated with *T. harzianum* (Kan.) has received the maximum number of 22 bands of protein. The presence or absence of the bands in protein profiling might be responsible for resistance response against *Fusarium oxysporum* f.sp. *lycopersici*. The correlation co-efficient between disease severity with soluble protein and total phenol showed negative correlation representing the values r=-0.6364 and r=-0.7653, respectively.

5. Conclusion

Plant diseases of economically important crops are very important alone cause 13 to 20% annual loss in production. In India, more than 50% of the crop loss is caused due to soil inhabiting micro-organism. The conventional method of its control is based on direct elimination of the pathogen by means of chemical mathods. But this type of disease management has a negative impact on the envioronment. Therefore, biological control is getting popularity in the coming era.

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