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Trichoderma as a control strategy of complex late blight disease of potato: A review

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Abstract

Phytophthora infestans, which causes potato late blight, is a very destructive plant disease that can cause significant economic losses in the potato industry. Several strains of The Trichoderma genus might be used as a biocontrol agent and are capable of controlling a wide range of plant diseases in crops. The goal of this work was to find effective Trichoderma isolates against *Phytophthora infestans.* Bioassays *in vitro* between *Phytophthora infestans* and *Trichoderma* isolates showed that the *Phytophthora infestans* colony was active. *Trichoderma* inhibited and overgrew substantially. The antifungal metabolites generated by the isolate HNA14 greatly slowed the *Phytophthora infestans* colony's linear growth. The isolate HNA14 dramatically lowered the disease index, improved plant stem height, and foliar fresh and dry weight in a planta bioassay. Out of all *Trichoderma* strains tested in the field, the *Trichoderma* isolate HNA14 was the most effective against the pathogen and greatly lowered the severity of the condition as compared to the command. Overall, the strategic approach outlined in this research offers an efficient method for a biocontrol agent for potato disease control.

Keywords: *T richoderma* strains, biological control, potato late blight, *Phytophthora infestans*

Introduction

Potato (*Solanum tuberosum*) is the world's fourth most essential food (Powelosn and Randall 1993) [20]. It has the second-highest carbohydrate content after cereal (wheat, rice). [Spooner Amdbarburg 1994] [22]. The Late blight disease was first time reported in India in Nilgiri hills between 1898-1900. In Darjeeling in 1883, it was the first time it was reported in the northern part and subsequently spread rapidly to other adjoining hills. Late blight disease is very destructive and difficult to manage. Consequently, loss due to late blightdisease can reach 100% (Ambarwati, Agus, Hrman, Sumraow 2009) [2]. It is considered a serious threat to global food security, more than $5 billion annually lost worldwide (Katayama, Katsumi 1997) [14]. In India, losses due to the ravages of this disease have been recorded from different parts by several workers. These have been estimated at 20-25% in Punjab, 40-50% in Haryana, 15-50% in U.P., 5-10% in Bihar and West Bengal. *Phytophthora infestans*(Mont) de Bary, which causes late blight in potatoes, is a significant bottleneck in potato production in Ethiopia (Bekele and Yaynu 1996) [4] and other areas of the world (Fry and Goodwin 1997b)[8].*P. infestans* is a pathogenic fungus with different degrees of pathogenicity that exist because this fungus is heterothallic(Purwanti2002) [21]. Within two weeks, in wet conditions it can easily destroy all plant parts of potato (Hooker, 1981; Fry *et al*.,1993) [8, 11].

Disease control has been conducted by using chemical agents but these chemical agents are costly and harmful to the environment (Untung K. 1996) [27]. To build a more effective agricultural environment, biological control is a viable alternative to conventional chemical fungicides in the control of potato diseases. *Trichoderma* spp., investigated as an antagonistic fungus against various plant pathogens (Harman, G.E., 1996)[10].An alternative method known to be very potential to control the disease biologically is antagonistic fungito pathogen *P. infestans*, *Trichoderma* inducses resistance in host plants against potential pathogenic attacks, (Latifah, Kustantinah 2011) [16]. Many crop pathogens are controlled by various species of *Trichoderma*, including Phytophthora species. It suppresses the pathogenic fungi by being hyperparasitic, mycoparasitic, and inducing host plant resistance to potential pathogenic attacks (Sudantha, Kusnarta 2011) [23].

Controlling potato late blight disease by induced resistance of plants with antagonistic fungi *Trichoderma* spp. is part of biological control because it utilizes nonpathogenic

Micro-organisms as aninduced plant resistance. As a result of the resistance affected by inoculation of biological agents, disease symptom decreases, and biochemical factors of the host plant change leading to the plant being resistant todisease-causing pathogens. The induced resistance of plant by biological agents operates by activating thegenetic potential of host plant resistance, if any plant is infected by any pathogen, the defense mechanism within the plant will be activated tobe a protection. Plants defend themselves in two ways; (i) the presence of structural properties that functional physical barriers and inhibit pathogens from entering as well as spreading within plants, and (ii)biochemical responses in the form of chemical reactions taking place in plant cells and tissues so thatpathogens can die or stunt their growth.

Diseases of potato

1) Late Blight-*Phytophthora infestans*, *Alternaria solani*, and *Phoma*spp.. (Van der Waals *et al*., 2001) [28]. 2) Common scab of potato- *Streptomyces scabies*(Thaxter 1892, Lambert and Loria 1989) [25]. 3) Powderyscab-*Spongospora subterranean* (Kim *et al*., 2000) [15]. 4) Wart disease-*Synchytriumendobioticum*, (Obidiegwu *et al*., 2014) [18]. 5) Watery wound rot-*Pythiumultimum*, 6) Potato ring rot-*Clavibacter michiganensis* (cms). 7) Silver scurf-*Helminthosporium solani* (Tiwari *et al*., 2020) [26]. 8) Pink rot-*Phytophthoraerythroseptica* (Taylor *et al*., 2006) [24]. 9) Dry rot -*Fusarium* spp.). 10) Black scurf-*Rhizoctonia solani*. 11) Skin spot of potato-*Polyscytalumpustulans*. 12) Wilt of potato-*Verticillium* sp.13)Charcoal rot- 14) Gangrene of potato - *Phomaexigua* (Giebel and Dopierała, 2004) [9].

Biology of pathogen

Kingdom Cromista (Straminopila), Phylum Oomycota, Class Oomycetes, order peronosporales, Family Pythiaceae.

The majority of Phytophthora species are soil-borne plant pathogens that cause diseases in herbaceous and woody plants, often dicotyledonous. Root rot, basal stem rot, leaf blot, and blight are examples of plant diseases rot in the fruit. Three possible sources of asexual, soil-brone inoculums of *Phytophthorainfestans* spores produced on foliage that fall to the ground (De Bary A. 1863) [6], mycelium that survivessaprophytically on the plant debris (BrefeldO. 1883, de Bruyn, H. G. L.1922, de Bruyn, H. G. L.1926) [5, 7] and mycelium and sporangia that survive on infected volunteer or seed potato tubers (de Bary A. 1863, Murphy 1922, Pasini 1967) [6, 17]. They will infect both cultivated and wild plants all over the world, wreaking havoc on agriculture and disrupting natural forest ecosystems, with some outbreaks reaching epidemic proportions.

The mycelium of fungus is coenocytic, hyaline, branched having simple to club shape haustoria. Sporangiophores originate from internal mycelium and emerge through stomata on the leaves and tubers. These are slender, hyaline, sympodially branched, indeterminate, septate having side branches with swollen bases. Sporangia are formed on the tip of sporangiophore and are hyaline, thin-walled, lemon-shaped, and papillate having up to 30 nuclei. The sporangium turns to the side on maturity and sporangiophore growth continues with characteristic swollen nodes. This fungus is, heterothallic and requires to mating type.

Symptoms

The first symptoms of late blight are seen on the foliage of plant having hydrotic areas with identified margins at the tips or on the margin of the leaflets. These lesions become necrotic and turn brown to almost black. Around the necrotic areas, a chloranemic border develops. The entire leaf may be killed within a couple of days, if moist weather prevails. The infection advances slowly and the affected areas curl and shrivel. They remain limp and soon decay, producing a characteristic offensive odor. The fungus penetrates the host mostly through stomata and the morpho-anatomical characters of the host are reported to be related to resistance

Epidemiology

The initial inoculums are mainly observed on infected tubers. The favorable survival temperature for the pathogen in tubers is found in hilly areas. Where is in plains pathogen cannot survive on infected potato stalks that are buried in the soil for nearly five days. However, in Shimla pathogens were able to survive for about 150 days and in ootacamund for about 40 days. Pathogen can also survive in tomato seed. Also in our country, true seed collected from fruits and berries which are approximately 10 -20 of potato true seed tends to carry the pathogen. But, whether the effective primary source of infection in the hills is of from the potato stalks and true potato seeds are yet to be confirmed. In plain areas, the tuber placed in cold stores or the seed tubers is the initial source of the disease that carries late blight infection. The main factors limiting the development of blight are moisture and temperature and the appearance of the disease is determined by these conditions. The meteorological observations collect the weather data which further helps in forecasting the occurrence of disease. The certain abiotic consideration is rainfall and humidity, temperature, cloudiness, and dew operations. Across the globe, including India, the relationship between p. instant and weather is well understood and utilized for developing disease forecasting models.

Management

Cultural regulation, the use of resistant varieties, chemical control, and advanced disease prevention is the most effective steps. In tropical regions where fungal inoculum is abundant for much of the year, integrating late blight control has long been thought to be one of the best disease management choices.

The first line of defense against late blight of potato is cultural practices. By reducing its survival, reproduction, dispersal, and penetration of the pathogen; cultural practices can be applied to reduce the pathogen population. By eliminating volunteer plants andcull piles, using proper harvesting and storage practices, and applying fungicides when necessary. Avoiding sources of inoculums is a most effective strategy. It is important to keep a clean operation by destroying all cull and volunteer potatoes (Agrios 2005) [3] to avoid bringing in late blight on seed, especially new strains of the pathogen seed sources should be selected carefully. Resistance varieties are available to control late blight By using all these methods we can ignore the pathogen but their effect may be havoc if they get favorable conditions. Fungicides have their residue effect on the environment. Resistance varieties of all crops for all pathogens are not available. Using bio-agents as a control method is a good alternative for disease management. Controlling plant infections with microorganisms as bio agents is a less dangerous strategy.

Biocontrol

The antagonism of several phylloplane microflora of potatoes such as *Trichoderma viride*, *Penicillium viridecatum*, and chromiumbrasilence, while reported *Myrotheciumverrucaria* and *Penicillium auranteogriseum*by Arora in 1999. Epicoccumpupurascens, Stachybotrysatra, and Trichoderma koninis reported by Jindal. Evaluation of the fungal antagonists of potato late blight disease has been done in the greenhouse while with some success mass culture of antagonists and their application on a large scale in fields have been done by Arora (1994) [1]. The biological control of *P. infestans* by using *Bacillus*, *Pseudomonas*, *Rahenella* and *Serratia* is reported by Daayfet. Cultivation of resistant varieties where the disease is common not only ensures the best check of the disease but also reduces the cost of fungicide sprays.

***Trichoderma*:** *Trichoderma* can detect the presence of target fungi and seems to grow tropically toward them, as has been known for many years. (Chet. I., Harman 1981) [10].

***Trichoderma* spp. as opportunistic plant symbionts:** *Trichoderma* is a free-living plant-associated microbe that is strongly beneficial to plants. Mycoparasitism, antibiosis, and competition for nutrients or space, among others, are the major three mechanisms of *Trichoderma* spp. biocontrol, which can work alone or in combination to reduce plant infections. A new generation of models for *Trichoderma* spp. response pathways have recently been proposed (Harman, G. E. Howell).These modern models do not take the place of others, such as inhibition of enzymes required for pathogens to penetrate plant surfaces and competition for nutrients such as those required for pathogen propagules to germinate near planted seeds. It's demonstrated that *Trichoderma* spp. were the very efficient producer of extracellular enzymes, with cellulose. It's known that the enzymes themselves were found to be fungitoxic and mixtures of enzymes were synergistic in their antifungal properties. Different classes of chitinolytic or glucanolytic enzymes from *Trichoderma* are synergistic as are enzymes from different organisms. Genes encoding these proteins have been inserted into plants, where they have been shown to induce resistance to a range of plant-pathogenic fungi.

Table 1: Y Yao, *et al.*, 2016 (29)

S. No.	Crop	Pathogen	*Trichoderma* spp.	Inhibition	Reference	Source
1	Potato	*Phytopathora infestans*	HNQ11	60.4	(Yao et al., 2016)	Potato Tubber
2			HNA14	56.8		Potato Tubber
3			JLC3	54.8		Potato Tubber
4			HNQ7	52.6		Potato Rhizosphere
5			HNQ12	52.3		Potato Tubber
6			LNF9	51.9		Potato Tubber
7			HNN2	48.6		Potato Rhizosphere
8			HNA12	47.7		Potato Tubber
9			HNL2	38.7		Potato Tubber
10			HNS3	31.1		Potato Tubber
11			HNA7	30.5		Potato Tubber

Conclusion
Fungal diseases of potatoes have remained an economically significant disease worldwide. Farmers lose millions of rupees annually due to fungal diseases. Late Blight has got international attention as it constitutes a huge constraint on seed potato production, with considerable indirect effects on trade. The chemical controls are not beneficial to manage the late blight of potatoes. The different species of *Trichoderma* species are added for their biocontrol activity and mechanism against the late blight of potato.

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