

## Biological management of plant diseases through *Trichoderma*

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**Abstract:** In agriculture, disease management is the measure of reducing disease in crops to increase quantity or quality of harvested yield. The pathogen causing diseases in crops are fungi, oomycetes, bacteria, viruses, viroids, algae, rickettsia like organisms, phytoplasmas, protozoa, nematodes and parasitic plants. Indiscriminate use of pesticides for the past four decades or so has done great harm to vegetation, animals, the environment and humans as a whole. Biological control is now being considered for an increasing number of crops and managed ecosystems as the key method of disease control. Biological control is the use of living organisms to suppress pathogen populations, making them less damaging than they would otherwise be. It can be used against all types of diseases and plant pathogens, but the methods and agents used are different each type of disease. It is particularly desirable because the tactic is environmentally safe, energy self-sufficient, cost-effective, sustainable, and can be readily incorporated into integrated disease management programs. Most biological control methods aim at improving the resistance of the host or favoring microorganisms antagonistic to the pathogen. It eradicates and control the pathogen through the activity of other microorganisms. Biological control measures enhance the activity of microorganisms in soil or at infection site. The antagonism by these organisms may have biocidal or biostatic effect. In biological control, the bio-agents destroy or suppress the pathogen through antagonism (antibiosis, competition, parasitism, and predation). So, in view of harmful effects of chemical pesticides mentioned earlier, application of eco-friendly approaches for managing the crop diseases is essentially required for sustainable crop production. In biological control of plant diseases, *Trichoderma* serves as one of the best bioagents and it found to be effective against a wide range of soil, seed and air borne pathogens.

**Key words:** Antibiosis, Biological control, Competition, Parasitism, *Trichoderma*

**Introduction :** Agriculture is the main source of our food supply to sustain on the earth and it also helps to grow our economy across the world. It is essentially important for ensuring food security, alleviating poverty and conserving the vital natural resource on which the world's present and future generation will be entirely dependent upon for their survival and wellbeing. Agricultural crops are vulnerable to attack number of pests including bacteria, fungi, weed and insects, leading to reduced yield and poor quality of the produce. Most of the plant pathogens, which cause important diseases in cereals, oilseeds, pulses, vegetables, fibres and fruit crops, are seed and soil borne in nature. Monocropping resulted in heavy incidence of soil borne diseases due to build-up of a high inoculum of the pathogen in the same piece of land. It forces the farmers to change either crop or land to reduce the disease intensity. Fungicides play an important role in management of seed borne and air borne pathogens.

However, the soil borne plant pathogens are often difficult to manage with the fungicides and other ordinary methods due to their limitations to perform better against pathogens. In recent years, indiscriminate and expensive use of pesticides has posed a serious problem of pollution in the ecosystem and development of resistance in the pathogens. While the farmer is exemplified by pesticide residues in soil, air, water, food etc., the latter includes phytotoxicity, physiological deformities, diseases, mortality, population changes, genetic disorders, gene erosion, etc. in plant, mammal, avian, insect and other organisms. Therefore, biological control of pathogens has gained importance as component of integrated disease management for sustainable agriculture as it is a long lasting and eco-friendly. Currently, several bio-control agents have been recognized and are available as fungal agents i.e., *Trichoderma* spp., *Gliocladium virens*, *G. roseum*, *Aspergillus niger*, *A. flavus*, *Chaetomium*

*globosum*, *Ampelomyces* spp., *Candida* spp., and *Coniothyrium* spp. and bacterial agents like *Bacillus subtilis*, *B. cereus*, *Pseudomonas fluorescens*, *Agrobacterium radiobacter* etc. (Agrios, 2005). It has been reported to work nicely as antagonists against many fungal plant pathogens *in vitro* and *in vivo* conditions. Among these biocontrol agents *Trichoderma* spp. is one of the most versatile bio-control agents which has long been used for managing the plant pathogenic fungi.

**Trichoderma and its habitat :** *Trichoderma* is a fungal genus that was described in 1794, including anamorphic fungi isolated primarily from soil and decomposing organic matter (Persoon, 1794). *Trichoderma* term has been derived from two words thrix (hair means thread like) and derma (skin). Genus *Trichoderma* is a soil inhabiting green filamentous fungus, which belongs to the division Ascomycota that reproduce asexually. In the early 1930s, *Trichoderma* was introduced as possessing biocontrol ability (Weindling, 1934). *Trichoderma* is an opportunistic, avirulent plant symbiotic fungus which acts as an antagonistic and parasitic fungus against many plant pathogenic fungi and offers protection from phytopathogenic plant diseases. It has been proven in numerous studies that *Trichoderma* spp. are effective biocontrol agents for managing plant disease (Table 1), and currently commercial products of *Trichoderma* are available as biopesticides or soil amendments or as enhancers for plant growth (Papavizas, 1985; Vinale *et al.*, 2008). The efficacy of *Trichoderma* depends on many abiotic parameters such as soil pH, water retention, temperature and presence of heavy metals. The genus *Trichoderma* includes more than 80 species that can be used to control phytopathogenic fungi. Among them; *T. harzianum*, *T. viride*, *T. hamatum*, *T. polysporum*, *T. pseudokoningii*, *T. deliquescens*, *T. aureoviride*, *T. koningii*, *T. lignorum*, *T. reesei*, *T. longibrachiatum* and *T. virens* (formerly *Gliocladium virens*) are considered as most potential biocontrol agents. *Trichoderma* occurrence is worldwide and is commonly found associated with roots, soil and plant debris, forest humus and orchids. Some of the commercially existing bio-control products (Table 2) are also available in the market.

**Mode of action:** *Trichoderma* spp are biocontrol agents and they effective against fungal pathogens causing diseases in plants. In general, it kills or inhibit the growth of pathogen mainly through the three mechanisms as given under.

**Mycoparasitism/ Hyper-parasitism:** The mechanism of mycoparasitism/ hyper-parasitism includes different kind

of interaction like coiling of hyphae around the target organism, penetration, production of haustoria and lysis of hyphae through secretion of intercellular lytic enzymes like glucanase, cellulase, chitinase, protease, lipase etc, which disintegrate the cell wall of pathogen.

**Antibiosis :** Liberation of an antibiotic like substances or other chemical metabolites by the antagonistic fungi viz. *Trichodermin*, *viridin* etc. that are harmful to the pathogen and inhibit or kill their growth.

**Competition:** It is a condition in which there is a suppression of one organism (target pathogen) as the two species struggle for limiting quantities of nutrients, oxygen, space or other requirements.

#### **Application methods :**

**Seed treatment :** Use of 8-10g *Trichoderma* spp. (powder formulation  $2 \times 10^6$  cfu/g) with 50 ml of water (bigger seeds) while small seeds at the rate of 6-8 gram for the treatment of one kg seed before sowing. Apply 5-10 ml *Trichoderma* spp. (liquid formulation) per litre of cow dung slurry for treatment of one kg seed before sowing particularly for cereals, pulses and oilseeds. Shade dries the seeds for 20-30 minutes before sowing is essential. Seed treatment is highly effective against seed and soil borne diseases.

**Soil application :** 1-2 kg *Trichoderma* spp. (powder formulation) or 500-1000 ml (liquid formulation) is added in 25-50 kg farm yard manure (FYM). Mixed thoroughly, cover with jute bag/sugarcane leaves/paddy straw and kept for 2-3 week in shade for proper multiplication. Maintain moisture and mix the mixture in every 3-4 days intervals before broadcasting in the field. Maintain optimum moisture for better multiplication of *Trichoderma* formulations. Apply well decomposed *Trichoderma* based FYM to the field before 15 days of sowing. This mixture can be applied in furrow/pit/pot and at the time of transplanting/sowing. This mixture is sufficient for one acre of land.

**Seed biopriming :** Seed biopriming is treatment of seed with *Trichoderma* formulations (@ 5-10g/kg seed) and incubating under moist and warm conditions until just prior to radicle emergence. After radicle emergence sow the bioprimed seeds in the field. In bioprimed seeds, the germinating conidia of *Trichoderma* form a layer around the seeds. Such seeds tolerate adverse conditions of the soil better than the non-primed seeds. This technique has potential advantages over simple coating of seeds as it results in rapid and uniform seedling emergence. Seed biopriming is beneficial for tomato, brinjal, chickpea, soybean etc crops.

**Table 1: Crop diseases and their management through application of *Trichoderma* spp.**

Crop Name	Disease name	Causative agent	Effective <i>Trichoderma</i> spp.	Mode of application
<b>Cash crops</b>				
Cotton	Root rot	<i>Rhizoctonia</i> sp., <i>M. phaseolina</i>	<i>Trichoderma viride</i> , <i>T. harzianum</i>	Soil treatment
Sugarbeet	Damping off	<i>P. aphanidermatum</i>	<i>Trichoderma harzianum</i>	Seed and soil treatment
	Wilt and root rot	<i>S. rolfii</i>	<i>Trichoderma harzianum</i>	Soil treatment
Sugarcane	Red rot	<i>Colletotrichum falcatum</i>	<i>Trichoderma viride</i> , <i>T. harzianum</i>	Soil treatment and spray
	Root rot, Seedling rot	<i>Pythium graminicola</i>	<i>Trichoderma viride</i> , <i>T. harzianum</i>	Soil treatment
	Wilt	<i>Fusarium moniliformae</i>	<i>Trichoderma viride</i> , <i>T. harzianum</i> , <i>T. longibrachiatum</i>	Soil treatment
<b>Plantation crops</b>				
Coffee	Collar rot	<i>R. solani</i>	<i>Trichoderma harzianum</i>	Seed and soil treatment
Mulberry	Cutting rot	<i>Fusarium solani</i>	<i>Trichoderma viride</i> , <i>T. virens</i> , <i>T. pseudokoningii</i>	Cutting and soil treatment
	Stem canker, die back	<i>Botryodiplodia</i> spp.	<i>Trichoderma viride</i> , <i>T. virens</i> , <i>T. pseudokoningii</i>	Cutting and soil treatment
Rubber	Brown rot	<i>Phellinus noxius</i>	<i>Trichoderma viride</i> , <i>T. harzianum</i> , <i>T. hamatum</i>	Soil treatment
<b>Vegetable crops</b>				
Brinjal	Wilt, damping off	<i>F. solani</i> , <i>P. aphanidermatum</i>	<i>Trichoderma viride</i> , <i>T. harzianum</i> , <i>T. virens</i>	Seed and soil treatment
Radish	Collar rot	<i>Sclerotinia sclerotiorum</i>	<i>Trichoderma viride</i> , <i>T. virens</i>	Soil treatment
	Seedling rot, damping off, seed rot	<i>Pythium</i> sp., <i>R. solani</i>	<i>Trichoderma harzianum</i> , <i>T. hamatum</i>	Seed treatment
Chilli	Root rot	<i>Sclerotium rolfii</i>	<i>Trichoderma harzianum</i> , <i>T. viride</i>	Soil treatment
Tomato	Damping off	<i>Pythium indicum</i>	<i>Trichoderma viride</i> , <i>T. harzianum</i>	Seed and soil treatment
	Seedling wilt	<i>Fusarium oxysporum</i> f. sp. <i>lycopersici</i>	<i>Trichoderma viride</i> , <i>T. harzianum</i>	Seed and soil treatment
Potato	Black scurf	<i>R. solani</i>	<i>Trichoderma viride</i>	Tuber treatment
Pea	Seed and collar rot	<i>Pythium</i> sp., <i>R. solani</i>	<i>Trichoderma harzianum</i> , <i>T. hamatum</i>	Seed treatment
	Wilt	<i>Fusarium oxysporum</i> f. sp. <i>pisi</i>	<i>Trichoderma harzianum</i> , <i>T. viride</i>	Soil treatment
Bean	Seedling rot	<i>Pythium</i> sp., <i>S. sclerotiorum</i> , <i>R. solani</i> , <i>B. cinerea</i>	<i>Trichoderma koningii</i>	Seed treatment
Cauliflower	Damping off	<i>R. solani</i> , <i>P. aphanidermatum</i>	<i>Trichoderma viride</i> , <i>T. harzianum</i>	Seed and soil treatment
Cabbage	Damping off	<i>R. solani</i>	<i>Trichoderma harzianum</i> , <i>T. viride</i>	Seed treatment
<b>Fruit crops</b>				
Banana	Wilt (Panama disease)	<i>F. oxysporum</i> f. sp. <i>cubense</i>	<i>Trichoderma viride</i>	Soil and Rhizome treatment
Apple	White root rot	<i>Dematophora necatrix</i>	<i>Trichoderma viride</i> , <i>T. harzianum</i>	Soil treatment

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Citrus group	Root rot	<i>Phytophthora nicotianae</i>	<i>Trichoderma viride</i> , <i>T. harzianum</i> , <i>T. virens</i>	Soil treatment
Guava	Anthracnose	<i>Colletotrichum gloeosporioides</i> , <i>Pestalotiapsidii</i>	<i>Trichoderma harzianum</i>	Foliar spray
	Wilt	<i>Fusarium oxysporum</i>	<i>Trichoderma viride</i> , <i>T. harzianum</i>	Soil treatment
Mango	Fruit rot	<i>Lasiodiplodia theobromae</i> , <i>Rhizopus arrhinus</i>	<i>Trichoderma</i> spp.	Fruit treatment
Orange	Blue mould	<i>Penicillium italicum</i>	<i>Trichoderma harzianum</i>	Fruit dip
<b>Cereal crops</b>				
Rice	Kernel smut	<i>Tilletia barclayana</i>	<i>Trichoderma viride</i> , <i>T. harzianum</i> , <i>T. virens</i>	Seed/soil/seedling treatment
	Bunt	<i>Neovossia indica</i>	<i>Trichoderma viride</i> , <i>T. harzianum</i> , <i>T. virens</i>	Seed treatment
	Sheath blight	<i>Rhizoctonia solani</i>	<i>Trichoderma viride</i> , <i>T. harzianum</i> , <i>T. virens</i>	Seed, soil, seedling treatment and foliar spray
	Brown spot	<i>Drechslera oryzae</i>	<i>Trichoderma viride</i>	Seed treatment
Maize	Charcoal rot, Banded blight	<i>Macrophomina phaseolina</i> , <i>R. solani</i>	<i>Trichoderma</i> spp.	Seed treatment and foliar spray
Wheat	Root rot	<i>Sclerotium rolfsii</i> , <i>Fusarium oxysporum</i>	<i>Trichoderma harzianum</i>	Seed and soil treatment
	Loose smut	<i>Ustilago segatum tritici</i>	<i>Trichoderma viride</i> , <i>T. harzianum</i> , <i>T. virens</i> , <i>T. lignorum</i> , <i>T. koningii</i>	Seed treatment
	Spot blotch	<i>Drechslera sorokiniana</i>	<i>Trichoderma viride</i> , <i>T. reesei</i> , <i>T. pseudokoningii</i>	Foliar spray
	Take-all	<i>Gaeumanomyces graminis</i> var. <i>tritici</i>	<i>Trichoderma harzianum</i>	Seed treatment
	Karnal bunt	<i>Neovossia indica</i>	<i>Trichoderma viride</i> , <i>T. harzianum</i> , <i>T. virens</i> , <i>T. deliquescens</i> , <i>T. koningii</i>	Seed treatment
Barley	Foot and root rot	<i>Fusarium</i> , <i>Sclerotium rolfsii</i> , <i>Curvularia</i> , <i>Pythium</i> , <i>Penicillium</i> , <i>Aspergillus</i>	<i>Trichoderma viride</i> , <i>T. pseudokoningii</i>	Seed treatment
<b>Pulse crops</b>				
Mung bean	Root rot	<i>Macrophomina phaseolina</i>	<i>Trichoderma viride</i> , <i>T. harzianum</i>	Seed and soil treatment
Pigeon pea	Wilt	<i>Fusarium udum</i>	<i>Trichoderma viride</i> , <i>T. harzianum</i> , <i>T. koningii</i>	Seed and soil treatment
	Seed borne diseases	<i>Alternaria alternata</i> , <i>Curvularia lunata</i>	<i>Trichoderma viride</i>	Seed treatment
Chickpea	Wilt, seed and root rots	<i>Fusarium oxysporum</i> f. sp. <i>ciceris</i> , <i>R. bataticola</i> , <i>Pythium</i> sp.	<i>Trichoderma harzianum</i>	Seed and soil treatment
	Grey mould	<i>Botrytis cineria</i>	<i>Trichoderma</i> spp.	Foliar spray
	Stem rot	<i>Sclerotinia sclerotiorum</i>	<i>Trichoderma harzianum</i>	Seed treatment

Table 1 : Contd.....

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Cowpea	Wilt	<i>F. oxysporum</i> f. sp. <i>ciceris</i>	<i>Trichoderma viride</i> , <i>T. harzianum</i>	Seed and soil treatment
	Charcoal rot	<i>Macrophomina phaseolina</i> ,	<i>Trichoderma viride</i> , <i>T. harzianum</i>	Seed and soil treatment
Lentil	Wilt complex,	<i>R. solani</i> , <i>F. oxysporum</i> , <i>S.</i>	<i>Trichoderma virens</i> , <i>T. viride</i> , <i>T.</i>	Seed and soil treatment
	Collar rot	<i>rolfsii</i>	<i>harzianum</i>	
<b>Oilseed crops</b>				
Groundnut	Collar/root/crown/ stem/pod rot	<i>Aspergillus flavus</i> , <i>S. rolfsii</i> , <i>A. niger</i>	<i>Trichoderma viride</i> , <i>T. harzianum</i>	Soil treatment
	Leaf rust	<i>Puccinia arachidis</i>	<i>Trichoderma harzianum</i>	Foliar spray
	Wilt complex, seed and root rot, stem rot	<i>Sclerotium rolfsii</i> , <i>F. solani</i> , <i>F. oxysporum</i> , <i>R. solani</i> ,	<i>Trichoderma viride</i> , <i>T. harzianum</i> , <i>T. virens</i>	Soil treatment
Mustard	Damping off	<i>Pythium aphanidermatum</i>	<i>Trichoderma viride</i> , <i>T. harzianum</i>	Seed and soil treatment
Safflower	Root rot	<i>Macrophomina phaseolina</i>	<i>Trichoderma viride</i> , <i>T. harzianum</i>	Seed and soil treatment
Sunflower	Blight	<i>Alternaria helianthii</i>	<i>Trichoderma virens</i>	Seed treatment
	Root rot, collar rot	<i>Sclerotium rolfsii</i> , <i>R. solani</i> , <i>Sclerotinia sclerotiorum</i>	<i>Trichoderma viride</i> , <i>T. harzianum</i>	Seed treatment
Sesamum	Blight	<i>Phytophthora</i> sp.	<i>Trichoderma viride</i> , <i>T. harzianum</i>	Seed treatment
	Root rot	<i>Macrophomina phaseolina</i>	<i>Trichoderma viride</i> , <i>T. harzianum</i>	Seed and soil treatment
<b>Spices crops</b>				
Pepper	Collar rot	<i>Phytophthora capsici</i>	<i>Trichoderma viride</i> , <i>T. harzianum</i>	Soil treatment, Drenching
Cardamum	Damping off	<i>F. moniliformae</i> , <i>Pythium</i> <i>vexans</i> , <i>P. aphanidermatum</i>	<i>Trichoderma viride</i> , <i>T. harzianum</i>	Soil treatment, Drenching
	Capsule rot	<i>Phytophthora meadii</i>	<i>Trichoderma viride</i> , <i>T. harzianum</i>	Soil treatment
Coriander	Wilt	<i>Fusarium oxysporum</i> f. sp. <i>corianderii</i>	<i>Trichoderma viride</i> , <i>T. harzianum</i>	Seed and soil treatment
Ginger	Rhizome rot	<i>F. oxysporum</i> f. sp. <i>Zingiberi</i> , <i>Pythium</i> <i>myriotylum</i> , <i>F. solani</i>	<i>T. harzianum</i> , <i>G. virens</i>	Rhizome treatment

**Seed material treatment:** Apply at the rate of 8-10gram *Trichoderma* powder with one litre of water (30 minutes) for the treatment of seed material like sugarcane setts, banana suckers, turmeric, ginger rhizomes and potato tubers before sowing. Shade dries the seeds for 20-30 minutes before sowing is essential.

**Nursery bed treatment:** 500gram *Trichoderma* spp. (powder formulation) mix in 10-15 kg well decomposed FYM/compost/vermicompost and broadcast in a one-acre area at evening time and at proper moisture conditions. 5-10 ml/litre of water *Trichoderma* spp. (liquid formulation) is sufficient for soil drenching.

**Cutting/Seedling's root dip application:** 20-25g *Trichoderma* spp. (powder formulation) or 5-10 ml (liquid formulation) dissolves in one litre of water for about 30 minutes. Dip the cuttings and roots of seedlings in to this prepared suspension for half an hours and transplant

immediately. Root dipping is effective against soil borne diseases.

**Horticultural crops:** Fifty-to-hundred-gram *Trichoderma* formulation mix in sufficient quantity of FYM/ compost/ vermicompost/ field soil and apply the mixture per plant in effective root zone of fruit tree. Doses will change in depending upon age of the plant.

**Foliar application:** 8-10 gram/litre of water *Trichoderma* spp. (powder formulation) or 3-5 ml/litre of water (liquid formulation) spray on diseased plants at cooler hours on 10-12 days intervals.

**Soil drenching:** One-to-two-kilogram *Trichoderma* formulation mix in 200 litre of water and drench the soil in one acre area or 8-10 gm/litre of water in soil in the nurseries from time to time. Maintain optimum soil moisture while applying.

**Table 2: Commercial formulations of *Trichoderma* used in crop disease management in India**

Trade name	<i>Trichoderma</i> strains/species	Manufacturer
Ecoderma	<i>Trichoderma viride</i> + <i>T. harzianum</i>	Morgo Bio-control Pvt. Ltd., Bangalore, India
Trieco	<i>Trichoderma viride</i>	Ecosense labs, India
Tricon	<i>Trichoderma viride</i>	Green Max, India
Biogourd	<i>Trichoderma viride</i>	Krishi Rasayan Export Pvt. Ltd., Solan (HP), India
Trichostar	<i>Trichoderma harzianum</i>	Green Tech, Agro-products, Rajaji Road Coimbatore, India
Gliostar	<i>Trichoderma virens</i>	GBPUAT, Pantnagar, Uttarakhand, India
Monitor	<i>Trichoderma spp.</i>	Agricultural and Biotech Pvt. Ltd. Gujarat, Department of Plant Pathology, MPKV, Rahuri
Tricho-X	<i>Trichoderma viride</i>	Excel Industries Ltd., Mumbai, India
Bioderma	<i>Trichoderma viride</i> + <i>T. harzianum</i>	Biotech International Ltd., New Delhi, India
Bio-fit	<i>Trichoderma viride</i>	Ajay Biotech (India) Ltd., Pune, India
Biocon	<i>Trichoderma viride</i>	Tocklai Experimental Station Tea Research Association, Jorhat (Assam), India
Antagon TV	<i>Trichoderma viride</i>	Green Tech, Agro-products, Rajaji Road Coimbatore, India
Ecofit	<i>Trichoderma viride</i>	Hoechst and Schening Agro. Evo. Ltd. Mumbai, India
Funginil	<i>Trichoderma viride</i>	Crop Health Bioproduct Research Centre, Ghaziabad, Uttar Pradesh, India
Trichogourd	<i>Trichoderma viride</i>	Anu Biotech International Ltd., Bangalore, India
Defence SF	<i>Trichoderma viride</i>	Wockhrt Life Science Ltd., Mumbai, India

**Advantages of application of *Trichoderma*:**

– It is compatible with organic manures and bio-fertilizers. like *Azospirillum*, *Rhizobium*, *Bacillus subtilis*, *Mycorrhizae*, phosphorus solubilizing bacteria and other bio-agents.

– *Trichoderma* strains act against many plant pathogenic fungi (seed, soil-borne) and control the diseases by action of myco-parasitism and antibiosis.

– *Trichoderma* strains play an important role in the bio-remediation of soil that are contaminated with pesticides and herbicides. It has ability to breakdown the pesticides and herbicides residues in the soil. This process is called bio-remediation. *Trichoderma* spp. have the ability to degrade a wide range of insecticides groups like organochlorines, carbamates and organophosphates.

– *Trichoderma* strains decomposes organic farm wastes, solubilizes soil phosphorous and micronutrients, reclaims adverse soil, increases the absorption of nutrients, improve soil fertility and protects soil eco-system.

– It is an eco-friendly, beneficial for environment, safe for users and farming communities. It is effective in organic farming for management of diseases.

– Reduces crop losses, increases plant growth, yield and source of income.

– Reduces the need for harsh and expensive chemical fungicides.

– It increases the rate and percentage of seed germination, root and shoot growth as well as built

systemic resistance of plants to diseases, pests and drought.

**Precautions in use of *Trichoderma*:**

– Do not keep *Trichoderma* treated seeds in direct sun light.

– Do not use *Trichoderma* formulation without organic manure or slurry.

– Don't use chemical fungicide after application of *Trichoderma* formulation for 4-5 days.

– Don't use *Trichoderma* in dry soil, moisture is essential for its growth and survivability.

– Don't put the treated FYM for a longer duration.

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