MANAGEMENT OF FOOT ROT OF BLACK PEPPER
BIOCONTROL STRATEGIES

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Foot rot caused by *Phytophthora capsici* and slow decline caused by *Radopholus similis, Meloidogyne incognita* the plant parasitic nematodes and *P. capsici* are the two important diseases that are causing severe crop losses in black pepper and have become nightmare to pepper planters/farmers.

PHYTOPHTHORA FOOT ROT

Phytophthora affects both the aerial organs like leaves, stems and spike and also roots. The former is called aerial phase and the latter as soil phase of the disease. With the onset of pre-monsoon showers, the soil moisture builds up which triggers the root production and new flush. This also coincides with germination of dormant *Phytophthora* propagules. Infected plants and plant debris in the soil is the primary source of inoculum.

Aerial Phase

Due to direct contact with soil or due to soil splash the initial infection appears as dark brown lesions on tender shoots and leaves at the ground level or lower region of the bush. Later these infected leaves or stems support abundant spores (Sporangia). With the intermittent showers, the disease spreads through splashes to upper region of the bush in a 'ladder like' fashion. This leads to different degrees of defoliation, thus debilitating the vine.

Soil Phase

In the soil phase the disease spreads through soil water in the form of zoospores. The motile zoospores encyst, germinate and infect roots. This results in feeder root infection. Root infection gradually spreads to foot or collar (stem and ground level) region resulting in foot rot. In the presence of root knot and burrowing nematodes, the rotting enhances, leading to fast degeneration of roots, resulting in to death of the affected vine. However *P. capsici* alone can kill the vine.

A positive correlation of soil moisture, rainfall, number of rainy days, RH, low sunshine hours and temperature to disease has been established.

SLOW DECLINE

Plant parasitic nematodes viz. *R. similis, M. incognita* either alone or in combination with *P. capsici* infect the feeder root systems causing severe root rot. This results in foliar yellowing and gradual loss of vigour and productivity of the vine. The nematode damage is particularly high in mixed crop stands of coconut and arecanut since these crops are also infected by the same nematodes.

Soliborne nature of the disease, non adoption of phytosanitation and nursery hygiene, absence of resistant varieties, predominant cultivation of highly susceptible Karimunda variety and continuous wet period for about six months with a heavy rainfall that leaches off any agrochemicals applied, are some of the important factors that affect the successful disease management. However in recent years considerable progress has been made on some of the basic aspects of biocontrol which forms an important component of Integrated Disease Management (IDM). However this biocontrol strategy would be effective only if plant hygiene (Phytosanitation) is strictly observed along with the other important, cultural practices like minimum tillage, better drainage, shade regulation and runner shoot pruning. These are to be strictly adhered to reduce chances of infection in order to make biocontrol effective. Phytosanitation i.e. removal and burning of infected plants along with root system and maintenance of clean nursery stock are the two key factors that would make biocontrol more effective. The technology is simple and eco friendly and needs to be popularised among the farming community.

Why biocontrol?

Biocontrol being ecofriendly and fits into the organic farming very well. This also would reduce the chance of pesticide residues in the product. Soil moisture being ideal in many of the plantations, augmentation with biocontrol agents would further enhance their multiplication. The soil pH in many of the plantations

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being acidic (5.5-6.5) is ideal for the multiplication of *T. harzianum* or *G. virens*.

The biocontrol agents

For disease management in black pepper, cardamom and ginger, organisms (fungi and bacteria) were isolated from the rhizosphere of the respective crops. They were tested against the target pathogens viz. *Phytophthora capsici*, *Pythium aphanidermatum*, *P. vexans* and *Rhizoctonia solani*. Among the biocontrol agents obtained *Trichoderma* spp. *Gliocladium virens*, fluorescent pseudomonads, *Glomus fasiculatum* (VAM) were found highly promising and are used in the disease management both in the field and in nursery management of black pepper, cardamom and ginger. For all purposes native isolates would be more effective and are being used in the programme at IISR.

Production of inoculum of Trichoderma and Gliocladium

At present the efficient isolates are being multiplied on sorghum meal or coffee husk/pulp sterilised in polypropylene bags. Good growth and sporulation are obtained within 10 days after inoculation. Coconut water mixed with coffee husk also did support good growth and sporulation. However large scale production of inoculum is possible with fermenters.

How they act?

Biocontrol agents *T. harzianum* and *G. virens* are soil dwellers and are generally present in soil. By large scale soil application, their high population stability is maintained that would check *P. capsici*. These organisms :

1. Parasitize the pathogen (Hyper-parasitisation) and thus reduce pathogen population.
2. Produce volatile and nonvolatile antibiotics that would suppress the soil borne pathogens.
3. Compete with the pathogen for nutrients and this starves the target pathogen.

Quality standards

Trichoderma inoculum is commercially produced by number of private agencies. Their population level (as cfu-colony forming units) in these formulation should be ensured to be at optimum level. Strict quality control parameters are yet to be laid down.

Production of VAM inoculum (Vesicular arbuscular mycorrihiza) *Glomus faciculatum.*

G. faciculatum cannot be cultured on artificial media and can be multiplied on live roots of grasses. The efficient isolates are multiplied on live sorghum roots. Solarised nursery mixture is filled up in 12" pot and base inoculum consisting of root bits and soil with VAM spores is mixed. Surface sterilised sorghum seeds are sown. When the sorghum plants are 6 week old, the stems are cut off to the base. The root mass is cut into bits. This soil and root bits form the inoculum for further use.

HOW VAM ACTS?

1. Enhances the uptake of nutrients particularly 'P', in 'P' deficient soils.
2. It protects the plant against drought and hence would help in better field establishment.
3. It protects the plant against root pathogens specially *P. capsici* and the plant parasitic nematodes viz., *R. similis* and *M. incognita* in black pepper.

Biocontrol in black pepper can be adopted at three stages, 1. Nursery 2. Preplant application in planting pits 3. Field application.

BIOCONTROL IN NURSERY MANAGEMENT

The disease being soil borne, infection starts right from nursery and the incipient root infection of the rooted cuttings goes unnoticed. Such contaminated nursery stock is the main source of infection and disease spread.

How to produce disease free planting material

i. Conventional Method : Runner shoots of elite cultivars like Panchami, Pournami, Sreekara, Subhakara (varieties released by IISR). Panniyoor I - V (released by KAU) which are preferred sources of planting material, should be kept coiled on a stake to avoid soil contact. This practice should start from October onwards. At the time of planting during February, bundles of three or two node cuttings are made from these runner shoots, washed thoroughly and planted in poly bags kept in thatched nursery sheds ensuring high humidity.

ii. Rapid method of multiplication (single node method): Training the pepper shoots in bamboo splits kept inclined in 45° angle and filled with well decomposed coir dust

accompanied by regular irrigation would ensure rooting at every node. The single node rooted bits are cut and planted in solarised nursery mixture fortified with biocontrol agents.

iii. ***Solarisation of Nursery Mixture :*** Nursery mixture should be disinfected before planting the cuttings. Soil sterilisation being costly, solar energy can be effectively utilised for partial pasteurisation of the nursery mixture. Nursery mixture is moistened and flat beds of 3x1 m with a height of 25-30 cm are made in exposed area. These beds are to be covered with transparent polythene sheet (100-150 gauge) and sealed on all the side with mud plaster. Sun rays that fall on this (solarisation) would raise the soil temperature to 50-55°C. This solarisation be continued for 20-30 days. This practice would eliminate, reduce the pathogens in the soil.

iv. ***Fortification of nursery mixture with biocontrol inoculum :*** The solarised nursery mixture can be mixed with biocontrol inoculum ($3x10^7$ cfu) either of *T. harzianum* or *G. virens* @ 1g/1kg. mixture. Similarly VAM inoculum be added @ 100 cc for 1000 cc of potting mixture. The fortified nursery mixture can be used for raising rooted pepper cuttings.

Vesicular arbuscular mycorrhiza (VAM), *Trichoderma harzianum* and *Gliocladium virens* have been found very effective in suppression of root rot caused by *P. capsici*, *R. similis* and *M. incognita*, the plant parasitic nematodes. VAM ensured abundant root production and good nutrient uptake that would keep the rooted cuttings healthy and robust. The inoculum of these biocontrol agents be mixed with the solarised nursery mixture before filling up the nursery bags. The cuttings raised by this method remained healthy and robust and ensured better field establishment. Rooted cuttings treated with VAM would ensure their further multiplication in the root system of pepper in the field and would check root infection. The technology for multiplication of biocontrol agents is available with IISR.

2. PREPLANT APPLICATION

Biocontrol inoculum of *T. harzianum* or *G. Virens* can be applied @ 50g/planting pit. This can be mixed with 500g of compost or neem cake that is generally applied to the pit before planting. This would protect the cuttings from *P. capsici* infection.

3. FIELD APPLICATION

Biocontrol inoculum of *T. harzianum* or *G. virens* are the two which were found effective against *P. capsici*. The inoculum @ 50g/vine mixed up with 1 kg neem cake or 5-10 kg of FYM is applied around the base of the vine and earthed up from the side without disturbing the base and root system. This operation can be done during May - June period when the soil mixture is good. Second application of inoculum can be given during August. The inoculum also can be mixed @ 50g/51 of water and the same can be used for drenching around the base of the vine.

INTEGRATION OF BIOCONTROL WITH CHEMICAL CONTROL

1. Soil application of copper fungicides like Bordeaux mixture or copper oxychloride are toxic to *T. harzianum* and *G. virens* and hence cannot be combined. However soil application and foliar spraying with potassium phosphonate (AKOMIN) @3ml/1 can be combined with biocontrol since both are compatible.

2. A safe period of 2-3 months be given for the application of biocontrol inoculum where copper fungicides are applied earlier.

3. Phorate and Furadan are also not compatible with biocontrol and hence cannot be combined.

4. Biocontrol application along with fertiliser application can be carried out and no adverse effects were noticed.

However the strategy depends on the organic matter of the soil since organic matter is food base for these biocontrol agents. Hence application of organic amendments like FYM (farm yard manure) neem cake (1kg/vine) poultry manure etc. every year just before the monsoon become important. Organic amendment which support saprophytes like *Trichoderma* and *Gliocladium* were found to check plant parasitic nematodes also. This suppression of root rot pathogens by these biocontrol agents at three different stages as outlined above would ensure optimum health productivity and longevity of the crop if followed up properly.