A Farmer Friendly and Economic IPM Strategy to Combat the Soil Borne Fungal and Root Knot Nematode Diseases Infecting Horticultural Crops

B. K. Goswami[*1], Neetu Singh[2]

Amity Center for Biocontrol & Plant Diseases Management, Amity University, Sector – 125, Noida, U.P.,.India

[*1]bkgoswami@amity.edu; [2]neetusingh21@yahoo.com

***Abstract*– In response to heavy infestations of soil borne wilt and root rot causing fungi along with root knot nematodes both alone and in combination which result in severe damage to wide range of horticultural crops in Western Uttar Pradesh, India. The farmers of the region out of ignorance and also in a notion to get instant results were found to be indiscriminately using toxic chemical pesticides which, in turn, caused heavy damage to the soil, plant and finally to human health by wrecking their immune system. Instances were also gathered about the farmers being compelled to commit suicides due to falling into debt mainly because of high cost farming.**

With the mission to combat the above maladies and also for improving the soil, plant and human health, the authors have successfully carried out an evolved IPM package comprising of safe, cost effective components viz. fungal bioagents, neem oil seed cake, botanicals and VA Mycorrhiza.

Keyword- Meloidogyne incognita; Fusarium oxysporum; Fungal Bioagents; VA Mycorrhiza

I. INTRODUCTION

Through extensive surveys and close interaction with farmers of Western Uttar Pradesh, India during 2008-2010, directly seeded crops like okra, cowpea, cucurbits etc. and the transplantable ones viz. brinjal, tomato, chilli etc. were recorded to be heavily infested with soil borne wilt/root rot causing fungi and root knot nematodes.

Although both the soil borne fungi are capable of causing heavy damage as that of root knot nematode on a wide range of horticultural crops, the latter is known to predispose the hosts for the fungal pathogens causing disease complexes with synergistic effect leading to much more damage to the common hosts (Fig. 1). The disease complex problem was first reported in USA by Atkinson [1] on cotton due to the combined attack of root knot nematode, and the wilt causing fungus on cotton in consequent to which the cotton industry was totally paralyzed. Later several investigators showed the importance of disease-complexes on a wide range of crops round the world due to above soil borne maladies [2], [3], [4].

Patchy tomato field Root-knot nematode Disease- Complex RKN-Wilt Fungus

Fig. 1

It was found that in efforts to get increasingly higher yields, the poor and ignorant farmers were using, exclusively and indiscriminately, very high doses of toxic and expensive chemical pesticides and fertilizers to combat the pests and diseases including root knot nematode. As a consequence of these shortsighted practices, nearly all-conceivable habitats have been polluted, and due to accumulation of toxic residues in food chains, leading to environmental health hazards ruining also the soil fertility, natural biodiversity and health of the consumers including the farmers themselves by wrecking their immune system.

Instances have also been found from accumulated data about the suicides committed by poor farmers due to the extreme economic crisis with high debts arising from exorbitantly expensive chemical pesticides and fertilizers. These chemical based farming has also been reported to make the crops highly susceptible to various maladies leading to tremendous losses in their yields.

As an alternative, thus a farmer-friendly economic IPM package is proposed.

As a remedial approach to existing chemical based practices and in order to combat the above maladies and improve the

soil, plant and human health, an ecofriendly, multi-purpose and cost effective techno-package constituting fungal bioagents, oil seed cakes, botanicals, AM fungus has been used as IPM package.

The proposed techno-package is a first attempt against soil borne diseases to achieve the mission by including all the sustainable components in integrated pest and disease management programme which has also been demonstrated in farmers fields located in Western U.P, India [5, 6].

II. COMPONENTS OF IPM TECHNO-PACKAGE

A. Fungal Bioagents/Biopesticides

1) Trichoderma harzianum:

Trichoderma is an ecofriendly bio fungicide when introduced along with seeds or at root zone protect the seedlings from attack by soil borne pathogens that cause root/collar/stem rots, wilts, damping offs, leaf blights spots etc. and promote healthy growth in early stages of crop. Vigorous growth of biofungicide overshadows the pathogenic fungi, which are overpowered and prevented from infecting the plants [7-9].

2) Paecilomyces lilacinus:

P.lilacinus, also referred to as an '**opportunistic fungus'** being highly pathogenic to eggs and egg masses of root knot nematode is known to infect all the other stages of its life cycle. The fungus entraps the nematode and kills them [10].

In addition to this, both the above fungal bioagents are known to possess enzymes and hormonal properties which play an important role in suppressing the pathogenic microbes and improving the plant health.

3) A Cost Effective Technology for Production of the Core Component:

To achieve the mission for economic upliftment of the rural farmers for mass production of biopesticides (both the fungal bioagents mentioned above) at pilot scale to make them self sufficient in controlling the major soil borne diseases occurring at their own fields. In addition to making them confident in preparing the core component which is proved to be substantially affordable. For the purpose of sterilization, therefore, a simple technology constituting equipments like pressure cooker (approx. 20 $) as a substitute for expensive autoclave (worth 10,000) $ while for maintaining the aseptic condition a simple spirit lamp worth one dollar would serve the purpose of replacing an exorbitantly expensive laminar air flow 20,000 $ which are normally used for the preparation of fungal bio pesticides in lab or commercially. In addition to curbing the expenditure of sterilization and maintenance of the aseptic condition for preparation of the fungal bioagents further economization of our farmer friendly method is also done by using low cost poly propylene bags as substitute of uneconomical conical flasks. Further cut in price is also done by using easily available and affordable agro based starch rich grains in place the semi synthetic medium potato dextrose agar for mass culturing of fungal bio agent

4) Method of Preparation at Farm Level:

In process of mass culturing of fungal bioagents viz. *Trichoderma harzianum*, and *Paecilomyces lilacinus* at farm/village levels by farmers, the following steps were used:

Soak the required amount of starch rich grains (sorghum, maize, rice etc.) in water for overnight in bucket. Transfer the moist grains in autoclavable bags@150-200g and seal each one with cotton thread followed by sterilizing twice in pressure cooker for 35 to 40 minutes. After releasing the pressure, the packets were allowed to cool to room temperature which is ready for inoculation of pre prepared bioagents separately of each species near the flame of the lamp carefully so as to avoid the contamination.

Fig. 2 Easy technology

Inoculated poly bags were kept in ambient temperature for colonization of spore and mycelium of fungal biocontrol agent on sorghum grains for 10-12 days after which they are ready to apply to the fields (Figure 2).

B. Neem Oil Seed Cake

Neem (*Aradirachta indica*), widely used for management of root knot nematodes infecting vegetables and pulses and also soil borne fungi viz wilt, root rot etc [11] combinations of oil seed cake and nematicides in reducing nematode population and improving plant health [12] neem oil seed cake having been recorded to possess nematicidal properties which, together with *Trichoderma*, have been observed to reduce disease incidence on okra victimized by root knot-root rot diseases-complex [13]. Oil seed cake was also reported to enhance the prolification of the spores of *Glomus fasiculatum* [14] thus showing the possibility of integrating fungal bioagents, oil seed cakes and VA mycorrhiza too for better performance of the package against disease complexes.

C. Botanicals

For collection of third management component i.e. local botanicals viz. *Phyllanthus niruri*(Bhumi amla), *Argemone mexicana (Kateli). Ricinus communis(Castor), Calotropis procera(Aak)* etc. grown as weeds. Village farmers would collect, shade dried, powdered and packed in poly bags for use.

These botanicals have been observed to possess nematicidal properties as well, most of which have been successfully tried even under field conditions [15].

D. VA Mycorrhiza a Phosphate Solublizing Biofertilizer

The role of mycorrhiza in management of soil borne diseases is discussed with their mode of action and future perspectives. In recent years VAM bas been proved to be very useful in the management of fungal, root knot nematode and diseases complex caused by both [16] as a "**protectant**"**.** The AM fungus, particularly *Glomus* spp. coupled with oilseed cakes has also been expressed as ideal component of IPM. Thus mustard cake and VA mycorrhiza, *Glomus* sp. were found to be effective in reducing the damage caused by soil borne fungal and plant parasitic nematode diseases on pulse crops [9, 14] (Fig. 3).

Fig. 3

III. APPLICATION TECHNOLOGY OF ABOVE SUSTAINABLE IPM MANAGEMENT COMPONENTS FOR DIRECTLY SEEDED CROP (OKRA)

Through demonstration, application of developed IPM modules was separately imparted to farmers for soil borne fungal and root knot nematode diseases on directly seeded okra.

A. For Soil-borne Diseases (Wilt, Rot Fungi and Root-knot Nematode)

1) Soil Treatment:

Fungal bioagents (*Trichoderma sp.* @ 2 kg/acre + *Paecilomyces lilacinus* @ 2 kg/acre) + Neem/karnaj oilseed cake @ 200 kg/acre + botanical antagonists 20 kg/acre + 5 Kg per acre of AM fungus. Required amount of oil seed cake, botanicals to be applied 10 days prior to sowing followed by irrigation for decomposition while the fungal bioagents to be applied at seed sowing in furrow along with AM fungal chladamydospores.

2) Seed Treatment:

To be done with fungal *Trichoderma sp* @ 80-100 g/1kg + *Paecilomyces lilacinus* @ 8-10 g/1kg with Jaggery as a sticker along with botanicals @ 500 g/kg + neem oilseed cake @ 400 g/kg. Prior to seed sowing required amount of above components is to be dissolved in 500 ml fresh water along with 100 g sticker. The seeds to be coated through proper mixing in above solution.

For the directly seeded module okra cv. Pusa Sawani was selected with trials having been carried out in 10 farmers fields considered to be hot spots for each of which there was heavy infestation of root rot/root wilt causing fungi and also root knot

nematode whose inoculum's level was 8 J/g soil which is much higher than the ETL level of 2 J/g soil .The performance of the evolved package clearly showed excellent improvement in both, productivity as well as quality of okra pods which is represented herewith by the names of the selected acreage farmers (Figs. 4 & 5).

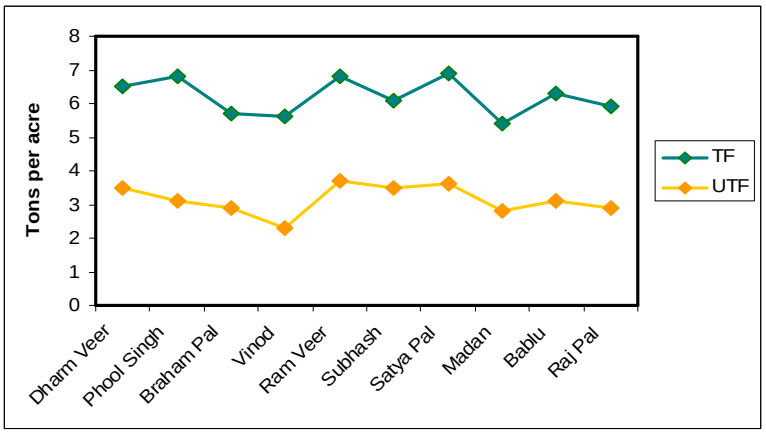

Fig. 4 Performance of IPM Package in Okra fields

Treated field of Okra with IPM package

Okra pods from the treated fields

Fig. 5

B. For Soil-borne Diseases (Wilt/Root Rot and Root-knot Nematode)

1) At Nursery Level:

- Soil treatment: Fungal bioagents (*Trichoderma sp.* + *Paecilomyces lilacinus*) @ 100 g/m^2 + Neem/karanj oilseed cake @ 500 g/m^2 + botanicals 500 g/m^2 applied two weeks prior to sowing.

- Seed treatment: Seeds were sown after treating with a mixture of fungal bioagents powder (*Trichoderma sp.* @ 10 g/kg + *P. lilacinus* @ 10 g/kg) of fungal colonized grains 200 g soil containing 50 AM fungus spores.

2) Bare Root Dip Treatment:

Prior to transplantation of 20-30 days old healthy seedlings in a slurry containing Jaggery @ 50 g+fungal bioagents (*Trichoderma sp 10 g/lit.* + *P. lilacinus* @ 10 g/lit.) + Oilseed cake @ 5%/litre and botanicals @ 5%/lit. were dipped for 30 minutes followed by transplantation.

3) Spot Treatment:

Transplantation of seedlings to the 'hot spots' on ridges prior to which deep ploughing along with application of a mixture of fungal bioagents @ 1 kg + 25 kg summer solarized Farm Yard Manure + 10 kg neem/karanj Oilseed cake in powdered form for one hectare as spot treatment.

Like the performance of the directly seeded representative of the horticultural crops okra the response of the same in case of transplantable crops tomato the treatment was given in three above mentioned phases including bare root treatments and having demonstrated at hot spots of 10 farmers fields. In this case also, as is clear in the fig. a substantial improvement is revealed in the treated plots both in respective of yield as well as quality of fruits respectively (Figs. 6 & 7). In this case the quantity of vit. C was also much more than that recorded in untreated plots.

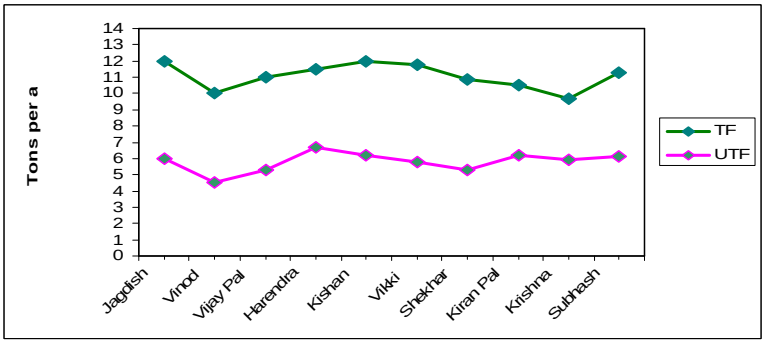

Fig. 6 Performance of the package in respect yield of tomato

Fig. 7 Fresh tomato fruits from treated fields

The performance of IPM Package carried out in 10 farmers' fields of both the crops as presented in Figs. 4 & 6, showed almost consistent result with remarkable deference between treated and untreated fields in respect to quality (5 & 7) and productivity (4 & 6).

IV. ADVANTAGES OF THE PROPOSED IPM PACKAGE

- Protect the crop from nursery till harvest against pests, diseases and disease-complexes caused by root knot nematode and soil borne fungi infecting a wide range of vegetables.
- As all the materials used in preparing packets are natural products (eco-friendly), the packets are safe for use by farmers with zero risk.
- Environmentally safe, much economical than chemical pesticides or other costly contrivances being presently followed.
- It results in making the soil much healthier leaving no residual toxicity and also not disturbing the biodiversity.
- Continuance of the evolved package for more than three crops is expected to improve the soil health to a great extent thus leading to organic farming.

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