Integrated Disease Management in Organic Farming: A Review

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ABSTRACT

The paper reviews about the Integrated Disease Management in organic farming. Combined practices are always more effective as the methods adopted compensate each other. Various cultural practices like crop rotation, use of disease free planting material, seed treatment with biocontrol agents, organic amendments, etc are discussed here. The control of crown gall of stone fruit trees (Agrobacterium radiobacter pv. tumefaciens) by avirulent bacteriocin producing Agrobacterium pv. radiobacter strain K84 is one known practical method of biological control on a field scale. Trichoderma spp., Pseudomonas fluorescens, Bacillus subtilis, Penicillium, etc. are some of the known biocontrol agents. Mixed cropping of cotton and moth bean reduced the incidence of root rot of cotton caused by Rhizoctonia solani and Macrophomina phaseolina. India’s rich heritage of agricultural traditions makes it suitable for designing organic farming systems. With greater political will and investment in research, extension and marketing infrastructure, more of this potential could be realized. With increasing demand for organic products in India, certification and regulation of organic sector came into being and thrived. Organic farming sector in India has substantially increased over the course of years. More awareness needs to be created among the farmers for gaining a sustainable livelihood.

Keywords

Integrated disease management, Organic farming, Crop rotation, Biocontrol

Introduction

The health condition of a plant depends to a large extent on the fertility of the soil. When nutrition and pH is well balanced, the plant becomes stronger and is therefore less vulnerable to infection. Climatic conditions, such as suitable temperatures and sufficient water supply, are further factors which are crucial for a healthy plant. If one of these conditions is not suitable, the plant can become stressed. Stress weakens the defense mechanisms of plants and makes them easy targets for pests and diseases. One of the most important points for an organic farmer is therefore to grow diverse and healthy plants. This avoids many pest and disease problems. According to the International Fund for
Agriculture and Development (IFAD), about 2.5 million hectares of land was under organic farming in India in 2004. In India it is estimated that 18 million hectare land is available for organic cultivation in the NE, which can be exploited for organic production. Currently, India ranks seventh in terms of total land (about 2.8 m. ha including wild herb collection area of MP and UP) under organic cultivation and first in number of organic producers (677, 257) in the world (Source: Rice Knowledge Management Portal, Directorate of Rice Research, Hyderabad). Approximately 18 lakhs ha (hectare) of land in NER can be classified as “Organic by Default”. India had brought more than 5.21 million hectare area under organic certification process by 2013- 14 (APEDA).

**What is Integrated Disease Management?**

Integrated Disease Management (IDM) involves all the practices viz cultural practices application of fertilizers, pesticides, fungicides, etc. and use of biocontrol agent to control the plant disease effectively. In the IDM cultural practices are important non-chemical methods to manage the plant diseases. By adopting cultural practices the environment of the pathogen can be modified. Agricultural practices like crop rotation, field fallowing, application of organic amendments are known to reduce the inoculum density of soil-borne pathogens and are the only economical control

**What is organic farming?**

In simple words, it means cultivation of crops in its natural way without application of any artificial control measures such as application of pesticides and chemical fungicides. Organic agriculture can be defined as an integrated farming system that strives for sustainability, the enhancement of soil fertility and biological diversity whilst, with rare exceptions, prohibiting synthetic pesticides, antibiotics, synthetic fertilizers, genetically modified organisms, and growth hormones (Fig. 1).

In other words it means growing crops adjusting the available ecosystem such as checking soil fertility, availability of water, following crop rotation, using green manure compost, etc. It relies on fertilizers of organic origin such as compost manure, green manure, and bone meal and places emphasis on techniques such as crop rotation and companion planting. It is a type of farming where the farmer can use the available resources so that less money is used for farm inputs. Organic farming is gaining momentum in recent years as a sustainable crop and soil management practice especially for the small and marginal hill farmers. It promotes soil health and carbon sequestration and provides multiple ecosystem services including mitigation of climate change. Integrated organic farming system will not only promote organic food production but also reduce dependence on external resources through efficient recycling of on-farm biomass and other resources especially disease management still remains a real challenge. The soil fertility is maintained by returning all the residues to it through composts, thereby, minimizing the gap between nutrient addition and removal from the soil (Chonkar, 2002). The principle of plant nutrition in organic farming is ‘feed the soil not the plant’ (Fig. 2).

**Practices that should be followed in organic plant disease management**

Some important preventive crop protection measures are the following ones:

**Selection of adapted and resistant varieties**

Varieties which are well adapted to the local environmental conditions (temperature, nutrient supply, pests and disease pressure) should be chosen as it allows them to grow healthy and makes them stronger against
infections of pests and diseases. HS 542(Pusa Kiran) is a variety of wheat resistant to stripe
and leaf rust and is recommended for North
Eastern Hills. CAU R3, a short duration paddy
variety and CAU R4, a semi deep water
paddy, released by Central Agricultural
University, Imphal is moderately tolerant to
blast and brown spot of rice and completely
resistant to Rice Tungro virus
(Source:Directorate of Research, Central
Agricultural University, Imphal). In case of
tomato, resistant varieties like Arka Rakshak,
Arka Samrat gives yield upto 18kg/plant.

Selection of clean seed and planting
material and seed treatment with
biocontrol agents

Safe seeds which have been inspected for
pathogens and weeds at all stages of
production should be used. Planting material
should be procured from safe sources. Seed
treatment can be done by protective coating
with biocontrol agents. The control of crown
gall of stone fruit trees (Agrobacterium
radiobacter pv. tumefaciens) by avirulent
bacteriocin producing Agrobacterium pv.
radiobacter strain K84 is one known practical
method of biological control on a field scale.
There are numerous examples of biological
control achieved by protective covering of
seed, rhizomes, tubers, etc. with propagules of
an antagonist (Weller, 1988). Bacillus subtilis,
Pseudomonas spp., Penicillium, Chaetomium
and Trichoderma are often as effective as seed
protectant chemicals such as thiram and
captan. In pre emergence seed rot of pea
caused by Pythium ultimum, the pathogen
derives nutrients for colonization of seed and
subsequent invasion from root exudates
released during swelling of the seed in soil. If
the seed is coated with spores of Penicillium
oxalicum the antagonist exhausts this source
of nutrients before the pathogen could utilize
(Elad and Chet, 1987). Biocontrol agents not
only control the disease but also stimulate
plant growth resulting in better yield. Strains
of Pseudomonas fluorescens and P. putida
applied to potato seed pieces and to sugarbeet
and radish are reported to increase the yield
of potato by 5- 33% of sugarbeet by 4-8 tons per
hectare and root weight of radish by 6- 144%

Use of suitable cropping systems

Mixed cropping systems: Growing a
susceptible crop mixed with a non susceptible
crop is known as mixed cropping. In root rot
of cotton caused by Rhizoctonia solani and
Macrophomina phaseolina it had been found
that incidence of the diseases was reduced
when cotton was grown mixed with moth bean
(Phaseolus aconitifolius), a bushy low height
plant. The latter reduces temperature and
retains high soil moisture due to its shading
effect. In wilt disease of pigeonpea (Fusarium
udum), mixture with sorghum reduces the
disease incidence probably by increasing the
distance between host plants and between
infected and healthy roots, by creating root
barriers between the roots of diseased and
healthy plants, and through toxic root exudates
of sorghum. Mixed cropping reduces the spore
trapping efficiency of the susceptible crop due
to reduced host surface area. If the susceptible
crop is lost to the disease, the other crop partly
makes up for the loss (Singh, 2005) (Fig. 3
and 4).

Crop rotation: In this method, host plants and
non-host plants are rotated in a way that
reduces the inoculum size in the soil. It is the
interposition of 2 or 3 non susceptible crops
between the cultivation of susceptible crops in
the same field and is an effective method for
reducing soil sickness and populations of a
large number of soil borne pathogens such as
Fusarium spp. causing vascular wilt of cotton,
pigeon pea, chick pea, tomato, Verticillium
spp. causing wilt of different crops, Rhizoctonia solani causing black scurf and
stem canker of potato. The pathogens overwinter in crop debris and on the seed. A break of two - three years between susceptible crops will markedly reduce or control these diseases. This rotation break will allow previously infected crop residue to decay in the soil. The suppression of the pathogens through crop rotation may be a result of starvation of the pathogen in absence of the host, toxic effects of root exudates of the intervening crops or due to adverse in soil microflora and fauna enhanced by root exudates and debris of the intervening crops (Singh, 2005) (Fig. 6).

**Green manuring and cover crops:** increases the biological activity in the soil and can enhance the presence of beneficial organisms (but also of pests; therefore a careful selection of the proper species is needed). Creating barriers by non host crops and dead host: Presence of non-host roots creates a barrier between the healthy and infected roots. One of the control measures recommended for bacterial wilt of banana (*Ralstonia solanacearum*) and spreading decline of citrus (*Radopholus similis*) is to destroy the healthy plants around the diseased plants. This checks the movement of the pathogen.

**Decoy crops, trap crops and antagonistic crops:** Decoy crops or cover crops are non-host crops sown with the purpose of making soil borne pathogens waste their infections potential before the susceptible main crop is grown. This is affected by activating the dormant propagules of fungi, larvae of nematodes and seeds of parasitic plants in absence of the host. Trap crops are highly susceptible host crops of the pathogen planted to attract it but destined to be harvested or destroyed before the pathogens completes its life cycle. Such crops are effective in checking the populations of root knot nematode and cyst nematode and some parasitic weeds such as *Orabanche*. Flax (Linseed) is used as a trap crop for *Orabanche ramosa* and *O. aegyptica*. It pinpoints areas of infestation in the field. The parasite damages the linseed plants but does not produce flowering stalks. This eliminates seed of the parasite for the next crop. Antagonistic or enemy crops produce some toxic compounds that directly destroy the nematodes in soil. They are not hosts of the pathogen. Some grasses, certain varieties of mustard, marigold, species of *Crotalaria* and Asparagus have been listed as enemy plants.

**Plant spacing:** Spacing between plants also helps in reducing disease incidence. Due to better ventilation and sunlight the atmospheric humidity in the crop is reduced and those organisms that flourish in high humidity, such as downy mildew are discouraged. Spacing also decreases the chances of contact between diseased and healthy foliage or roots and dissemination of spores and bacterial cells through rain drop splashes. In onion 4-5 inches apart in the row and 12-18 inches between rows should be maintained. Spacing for tomato plants should be between 24-36 inches apart. Straw mulching can also be adopted.

**Use of good water management:** Accumulation of water in a field helps in accumulation of inoculum from other fields. If there is a standing crop it helps in accumulation of toxic substances around the roots and base of the stem and also reduces oxygen supply to roots. These conditions weaken the roots and stem making them liable to easy infection. Drainage is therefore essential to keep the field free from pathogens and making the plants resistant. Excess of soil moisture enhances incidence of several diseases such as damping off. In such diseases, reduced watering helps in checking disease development. Charcoal rot of potato and many other crops (*Macrophomina phaseolina*) is favored by high soil
temperature coupled with dry condition of the soil. In such cases irrigation helps in lowering the temperature and avoiding the disease. In common scab of potato, irrigation to keep the soil continuously wet during tuber formation and development helps in reducing disease incidence. The soil borne pathogens like *Pythium* and *Phytophthora* spread from plant to plant through irrigation water. If the plants are on the main channel they can easily get infected. In such cases care should be taken to irrigate the plants via side channels.

**Hot weather deep ploughing:** In the tropics deep ploughing during summer is of special importance as it exposes the resting structures of the pathogens to hot temperatures and dessication thus reducing their population. In ear cockle disease of wheat, wetting of the soil before summer ploughing causes more rapid destruction of larvae of the nematode as wetting causes swelling of cockles present in the soil releasing the larvae which are then killed by dessication.

**Soil solarisation:** A new system of use of heat to destroy inoculums of pathogens in the soil is trapping of solar heat under a plastic mulch spread over the soil (Fig. 5). In soil solarization, the soil is first wetted and then covered with a thin clear plastic sheet. The trapped heat raises the soil temperature to a level where most pathogen structures including sclerotia, and weed seeds are killed. If the soil is amended with organic matter before solarization the effects are enhanced.

![Fig.1 Organic farming: Basics of organic pests and disease management](image-url)
Fig. 2 Components of organic farming

Fig. 3 Mixed cropping system in plain
**Fig. 4** Mixed cropping system in hill

**Fig. 5** Use of black polythene mulch to control weeds, conserve moisture and reduce soil-borne inoculums

**Fig. 6** Infected plant debris collected and making compost
**Fig.7** Zig-zag or M shaped way of monitoring

**Green manure and organic amendments of soil:** Root diseases are generally less severe in organically than conventionally managed soils through multichannel effects including rejuvenation damaged roots, better and balanced nutrition of the plant and by creating microbial diversity. Decomposition of organic matter in the field produces a number of toxic substances, especially fatty acids. Such substances have a sanitizing effect in the soil by causing death or inhibition of parasitic organisms. Combining organic amendment with soil solarization is a very effective non-chemical approach to management of soil borne pathogens. Heating soils, that have been covered with plastic film and amended with suitable organic materials, actuates a chain of reaction of chemical and microbial degradation, which leads to the generation of toxic compounds in vapor and liquid phases in the soil. The plastic mulch traps the volatile compounds and creates an atmosphere in the soil that enhances degradation of organic matter. At the end of the process the soil contains less pathogens and different microflora which may suppress re-establishment of pathogens (Gamliel et al., 2000). The period of solarization is less for organically amended soils than for non-amended soils. The change in soil texture and fertility resulting from increased humus content helps in better growth and quicker development of roots. This enables the plants to produce new roots to replace diseased and dead roots. The losses are consequently reduced.

**Adjustment of date of sowing:** There are numerous examples where early or delayed sowing of a crop enables it escape critical period of disease incidence. In Northern India, when pea and chick pea are planted early (in October) they suffer heavily from root rot and wilt (a complex of *Fusarium, Rhizoctonia* and
Sclerotium). This is because the high temperature and high soil moisture favour these pathogens. In addition, the early sown crops show much vegetative growth forming a dense canopy which provides high humidity under the plant that favours blight caused by Sclerotinia and also Botrytis gray mold. When these crops are planted late (end of November to December) there is little or no root rot and wilt and incidence of blight and gray mold is also reduced. Dense canopy also favours rapid spread of Ascochyta blight in chick pea. In South India, rice sown from January to June develops no more than 5% leaf blast and 1% neck blast. In July planted crop, the incidence increases to 20% and 25%. Early planted crop reaches the stage of tuberization before the population of vectors reaches the peak in January. The okra yellow vein mosaic virus is not common in crops planted during Feb-March because the vector population is low or absent.

Use of proper sanitation measures and mulching

Remove infected plant parts (leaves, fruits) from the ground to prevent the disease from spreading.

Eliminate residues of infected plants after harvesting

Mulching is also a very effective method to control soil borne inoculums by conserving the moisture.

Compost extract is a fertilizer, but it also can induce plant resistance. For its preparation, mature compost is mixed with water at a ratio of 1:5 to 1:8 (vol/vol: one liter of compost for every 5 to 8 liter of water) and well stirred before it is left to ferment for 3-7 days. One spoonful of molasses can be added per liter of liquid, because this enhances the development of the microorganisms. The fermentation site should be shaded and safe from the rain. After the fermentation period and before the application, the extract is well stirred, then filtered and diluted at a ratio of 1:5 to 1:10.

Plant extracts can be obtained from stinging nettle, horsetail, comfrey, clover, seaweed and others, alone or mixed with marine by-products such as fish waste or fishmeal. Dilutions of 1:10 or 1:5 are used as foliar spray or soil drench.

As a general rule it is recommended to apply compost extracts or teas every 7 to 10 days to prevent diseases from developing and as a way to enhance soil microorganisms.

Monitoring the field: Monitoring the field every 10-15 days is a good practise to check the appearance of disease at initial stage so that appropriate measures can be taken up at the right time. Monitoring should be done in a zig zag manner so that the plants are not disturbed and covers every side of the field (Fig. 7).

Organic farming is a promising avenue for development given the particular circumstances of this region which include possible adverse effects of most modern methods in industry and agriculture on the plains and the abundance of difficult yet fertile tracts of land. Integration of methods of control gives better results. India’s rich heritage of agricultural traditions makes it suitable for designing organic farming systems. With greater political will and investment in research, extension and marketing infrastructure, more of this potential could be realized. With increasing demand for organic products in India, certification and regulation of organic sector came into being and thrived. As a result of its growing importance, organic farming sector in India has substantially increased over the course of years. More awareness needs to be created
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