

Review Article

<https://doi.org/10.20546/ijcmas.2019.811.282>

Integrated Disease Management in Organic Farming: A Review

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ABSTRACT

Keywords

Integrated disease management,
Organic farming,
Crop rotation,
Biocontrol

Article Info

Accepted:
26 October 2019
Available Online:
10 November 2019

The paper reviews about the Integrated Disease Management in organic farming. Combined practices are always more effective as the methods adopted compensates 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.

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 (Chhonkar, 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% (cf. Weller, 1988).

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 inoculums 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 desiccation 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 desiccation.

Soil solarisation: A new system of use of heat to destroy inoculum 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

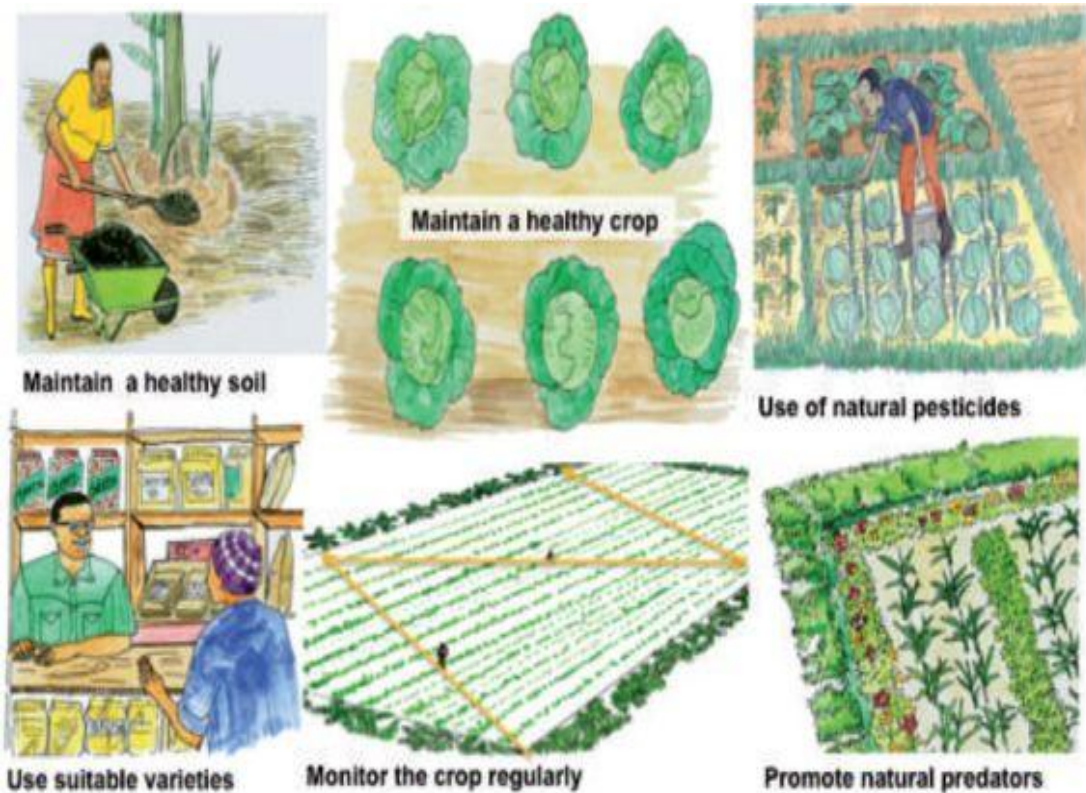


Fig.2 Components of organic farming



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



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

among the farmers for gaining a sustainable livelihood.

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How to cite this article:

Subhalakshmi, T. 2019. Integrated Disease Management in Organic Farming: A Review. *Int.J.Curr.Microbiol.App.Sci.* 8(11): 2440-2449. doi: <https://doi.org/10.20546/ijcmas.2019.811.282>