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Disease Management in Organic Farming

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Organic Farming is recognised globally as a priority area in view of the growing concerns on environmental pollution due to increased awareness about the fallouts of the indiscriminate use of agro-chemicals. Demand for safe and healthy food has been increasing with every passing day. The ill effects of plant protection chemicals on the flora, fauna, humans and environment as a whole are the major concerns. Though the use of chemical inputs in agriculture is inevitable to contain dreaded pests and meet the growing demand for food in a populous nation like India, there are opportunities in selected high value fruit and vegetable crops where organic production can be encouraged to meet the domestic and export demand for fresh fruit and vegetables. There are several non-chemical environmentally techniques which can be prudently and strategically incorporated in a well crafted organic production technology module for specific crops. Modification in cultural practices, mechanical destruction of source of inoculum, clean cultivation use of organic amendment and bio-fumigation, developing pesticides of organic origin, encouraging natural biological agents, use of cover and trap crops, use of heat treatment, cold temperature, solar energy etc. can be conveniently used to manage disease incidence below economic injury level. Some of such technologies are discussed briefly in this script.

Introduction

Disease management is an essential component of the commercial farming. Disease tends to reduce the potential production levels of a crop as per its time of incidence and intensity. The disease management interventions need to be taken up at different stages of cultivation of a given crop. The management differs with crop, type of pathogen, source of inoculum, season of cultivation, stage of infection, plant part affected, number of generations of pathogen in a crop cycle, and several other factors. The disease management options and specific recommendations, hence, vary accordingly. Past century has seen development of a number of fungicides and other chemical based pesticides to manage other plant pathogens. Unjustified overuse of chemical pesticides to control various insect pests and diseases over the years has decimated many naturally occurring effective antagonistic microorganisms. Slowly the fight back from the pathogens was evident from the emergence of pesticide resistant strains in the agricultural ecosystems. The scientists realised that the pathogens tend to modify their genetic profiles under heavy pressure of plant protection chemicals. Scientists changed the strategy from 'pest control' to 'pest management'. However, past couple of decades has seen increasing awareness among the farmers and consumers about the futility of some of the highly poisonous chemicals in disease management and their collateral hazards to environment due to their indiscriminate application. Though safer chemicals are being produced in recent times, the stake holders now want to revert to the natural pesticide-free farming based on the organic principles. Managing the ecosystem on an organic farm is very challenging. Most management practices are long-term activities that aim at preventing diseases occurrence, maintenance of biological diversity and improving soil health. Organic cropping system focuses more on the prevention of disease outbreaks rather than managing them after they occur. It advocates dealing with the causes of a disease problem rather than treating the symptoms of the diseases after their occurrence. Further, more than one strategy may be needed for tackling a single pathogen or a group of pathogens and a single set of interventions can target a variety of pathogens. There have been two excellent reviews recently dealing with disease management under organic farming (van Bruggen et al., 2016; van Bruggen and Finckh, 2016) useful for further reading in this regard.

Disease management strategies in organic farming

Occurrence of a disease requires a balanced interaction of host, pathogen, and environment. The disease management strategies under organic farming aim to disrupt this balance and disallow the pathogen to cause disease beyond economic injury level. Pathogens need suitable environmental conditions like humidity, temperature, moisture, host exudates etc to germinate, survive and infect. In absence of these pathogens cannot survive and perish. Most of the strategies described below interfere with the micro-environmental conditions to make them uncongenial for pathogen propagation, multiplication and initiating infection. Further majority of these strategies are specific to particular disease in a crop and hence a combination of strategies based on the crop growth stages and disease cycle need to be integrated as a module for a crop in a particular agro-climatic region.

1. **Growing disease resistant varieties:** For low external input organic farming, resistant crops represent an important alternative to pesticides. Exploiting the diversity and variability in the host genetic constitution for resistance against a pathogen in a crop is the best strategy for disease management without application of hazardous pesticides. It can individually restrict the incidence of a particular disease in a crop. Successful disease establishment depends on the compatible gene for gene interaction between a host and a pathogen. Resistant varieties tend to remain disease free for a long period of time owing to morphological manifestation of their genetic constitution in form of leaf and stem toughness, time of maturity, nutrient content, plant architecture, growth habit which can deter growth of pathogen, their reproduction and host preference. Care need to be taken to include more than on resistant variety in a region to dissipate selection pressure on the pathogen. However this strategy is very specific and tends to tackle only one or two diseases at a time owing to its resistance.

2. **Exclusion of pathogen:** Preventing the potent and viable disease propagules to interact with the host results in reduction in disease incidence. Use of disease-free seeds and planting material would prevent seed borne disease, management of vectors, and *in situ* destruction of soil borne pathogens through soil solarisation or Anaerobic soil disinfestations (ASD) involves the incorporation of fresh organic material in moist soil under airtight plastic for 3–6 weeks, depending on the outside temperature (van Bruggen et al., 2016; Khulbe, 2000).

3. **Application of organic amendments:** Soils with low microbial diversity promote establishment of plant pathogenic organisms. Healthy soil is the mainstay of organic agriculture. Improved soil biological activity is known to play a key role in suppressing weeds, pests and diseases (IFOAM, 1998). Improving soil health through use of cover crops, green manures, animal manures to fertilize the soil not only helps in restricting soil borne pathogens but also maximizes biological activity and maintains long-term soil health. Application of composts and organic amendments tends to increase quantity and diversity of soil microbial diversity and consecutive disease suppressiveness. Organic amendments are biodegradable and are generally available on the farmer's fields. Neem cake used for soil amendment @ 0.25 to 0.5 t/ha contributes significantly in control of nematodes and soil borne pathogens. Soils rich in organic matter are high on soil biodiversity with abundance of beneficial soil microorganisms.

4. **Cultural control:** Cultural control is more like habit of good agricultural practices, which promotes healthy soils and healthy plants. From choosing the date of planting to field sanitation and weed management, the specific cultural measures reduce the initial load of inoculum and favourable conditions for growth of pathogens. Rotations can also be designed to minimize the spread of weeds, pests and diseases. Litterick *et al*. (2002) opined that pest control strategies in organic farming systems are mainly preventive rather than curative. The management of cropped and un-cropped areas, crop species and variety choice and the temporal and spatial pattern of the crop rotations is actually aimed to reduce interaction between susceptible host and virulent pathogen while maintaining a diverse population of beneficial organisms in the field. The development and implementation of well-designed crop rotations is central to the success of organic production systems (Stockdale *et al*., 2000). However, crop rotation can be ineffective if the pathogen is long-lived in the soil with a wide host range. Ensuring good drainage

is essential for disease management. Poor drainage in the fields not only reduces general health of the plant but also allows the pathogen to multiply rapidly. Many pathogens can survive on debris and weeds. Tilling and cleaning of plant residue at the end of the season allows break down of the organic matter, leaving potential pathogens without a host. Moderate fertilization induces steady growth and makes a plant less vulnerable to infection.

5. **Orchard bio-intensification:** The orchard bio-intensification concept envisages habitat modification for beneficial organisms, development of healthy and biologically active soils, maintaining uncultivated lands for diversity of flora and fauna, developing entomophage parks within orchard for food and shelter to diverse beneficial insects, weed strips, hedge rows, wind breaks, inter crops and conservation of insect bio diversity (Singh and Srinivas, 2016).

6. **Physical methods:** Soil solarisation of nursery beds reduces soil borne inoculum. Hot water/steam treatment of seeds/planting material has been successful in many crops (Cohen *et al*., 2005). Post harvest hot water treatment of mango fruits was able to reduce the incidence of anthracnose (Srinivas *et al*. 2012).

7. **Botanicals, essential oils, baking soda, butter milk etc:** Spraying of neem oil, cow urine, *panchgavya*, and fermented butter milk are some of the most predominant methods of controlling pests and diseases by the organic farmers in India. Several researches indicate that application of many plant extracts may reduce incidence of foliar diseases. Application of horticultural grade oils has also proven to reduce disease incidence in many crops. Baking soda has been used to control mildew and rust diseases on plants. Application during hot weather and may though lead to possible phytotoxic effects. Butter milk sprays have been popular against blights, mildew, mosaic viruses and other fungal and viral diseases. Application of soft soap solutions and neem oil against viral vectors like aphids and other sucking insects is also effective. Cow dung ferments like '*Amrit-Paan*i' are widely used by organic farmers for enhancing crop growth and disease management. Such fermented solutions are known to have high bacterial population of cellulose degraders, nitrogen fixers, P-solubilizers, plant growth promoters and antagonists of disease-causing fungi (Venkateswarlu *et al*., 2008).

8. **Application of biocontrol agents:** Microbial bio-control agents isolated from native environments are relatively safe, host specific and do not disturb other biotic systems (Srinivas and Ramakrishna, 2005). They are ideal for both short and long term pest suppression and are also compatible with most other control methods. Their mechanisms of action include competition, antagonism, antibiosis, enhanced nutrient uptake, induction of host resistance (Kloepper *et al*. 1997) etc. Unlike chemical pesticides, they are harmless to humans and other non-target organisms, they do not leave chemical residues on crops, are easy and safe to dispose of and do not contaminate water systems. Commercial bio-fungicides are containing beneficial living organisms are can be locally produced and used for pest management in Organic farming. These are available as powders for seed treatments, as granulars for soil application, and as suspensions for root drenches and foliar sprays. Biological control agents like *Trichoderma* spp, *Pseudomonas* spp and *Bacillus* spp. have proven their worth in managing a range of plant diseases. Some of them have also shown to promote plant growth too.

9. **Application of mineral based fungicides.** Prophylactic sprays of Sulphur are mostly used against plant diseases like powdery mildew, downy mildew and other diseases by preventing spore germination. Copper based fungicides and Bordeaux mixture (Copper sulphate and lime) have been successfully used on fruits, vegetables and ornamentals. Unlike sulphur, Bordeaux mixture is both fungicidal and bactericidal. It is effective against diseases such as leaf spots caused by bacteria or fungi, powdery mildew, downy mildew and various anthracnose pathogens. The ability of Bordeaux mixture to persist through rains and to adhere to plants is one reason it has been so effective. Copper hydroxide and copper oxychloride are accepted in organic farming provided that the number of applications is moderated to prevent copper accumulation in the soil.

Mango under organic mode of cultivation at CHES (ICAR-IIHR), Bhubaneswar

Cultivation of mango (cv mallika) under organic mode at Central Horticultural Experiment Station (ICAR-IIHR) in Bhubaneswar, indicates that there no significant variation in growth pattern of the trees grown in organic system compared to the trees grown using chemical fertilizers. In the experiment different levels of farm yard manure viz., 5 kg, 7.5 kg and 10 kg per plant were provided in different treatment plots. The dosage of the manure was increased by 100 percent of the initial FYM dosage every year. Positive and negative control plots were maintained with recommended dosage of fertilizer (RDF) and no fertilizer, respectively.

Mango orchards are the permanent ecosystems, akin to forest ecosystems, with certain human interventions. However the pest population is not in equilibrium in orchard ecosystems as observed in undisturbed forests. However such natural balance is disturbed in the orchard ecology due to regular cultivation practices especially application of chemical pesticide. Several pests and diseases occur in the organic plots similar to the non-organic plots. However the options for pest management in these plots are limited. Major emphasis is give in bio-intensification of orchards, application of mineral based fungicides, and application of botanicals. For management of foliar leaf spots and anthracnose in leaves and fruits, application of copper based fungicide is done based on the observations of field scouting. The downy mildew disease affecting the inflorescence is managed by application of sulphur based fungicides with prescribed precautions. Field sanitation, proper plant architecture, and application of enriched organic amendment are the mainstay of disease management in the organic mango cultivation. Further, for long term sustainable pest and disease management there is a need to strike a balance for appropriation of various interventions for suppression of pests, which can be achieved through orchard bio-intensification (Singh and Srinivas, 2016).

Disease management in tree crops grown in organic conditions is a challenging task due to limited and unproven options available. Higher powdery mildew and black mildew severity was observed in case of organically grown plants compared to control plants probably due to luxurious growth in the former (Srinivas and Singh, 2011). Different combinations of ecofriendly disease management options were evaluated for their efficiency against powdery mildew and red rust in mango (cv mallika) orchard under organic mode of cultivation at the Station. Treatments viz. Milk (10%), Vermiwash (10%), Cow urine (10%), Neem oil (0.2%). Sulphur (2g/l), and their combinations were imposed in mango plants grown in two nutrient levels (5 kg and 7.5 kg farm yard manure first year basis). The dosage of the manure was increased by 100 percent of the initial FYM dosage every year. Two control treatments of spray with plan water and no spray were also maintained. The disease score of powdery mildew was found to be least in case of the treatments with sulphur and neem oil, while highest disease was observed in treatments with milk and plain water. Incidence of the red rust was least in treatments with sulphur, neem oil and control plots.

There was a marked difference in the incidence of powdery mildew disease among the treatments. The 10 kg treatment plot was relatively free (37.7% incidence) from the powdery mildew disease followed by the negative control plot (34.4% incidence). In contrast highest disease powdery mildew incidence was observed in positive control plots (87.0% incidence) closely followed by 5kg and 7.5kg plots with 76.8% and 76.3% disease incidence. Though it was interesting to note that there was comparatively low and delayed flowering in 10kg and control plots, which also had lower powdery mildew incidence (Srinivas *et al*., 2010). Further the 5kg, 7.5kg and RDF plots contained more trees with inflorescence with higher coverage of the powdery mildew fungus (60% and more area of inflorescence). Based on the data of first three years of experimentation it is concluded that there is no significant negative effect of organic mode of cultivation in the major growth parameters and powdery mildew incidence.

Post harvest losses in mangoes in majority of cultivars due to fruit fly, anthracnose and Non-uniform ripening continue to be a concern in major mango growing area of Odisha (Srinivas *et al*. 2012). Fruit damage due to post harvest diseases in mangoes needs to be minimised to increase the marketability of the harvested mangoes to minimise revenue loss and heavy damage to mango exports within the state. Hot water treatment has been well known method to minimise post harvest losses due to pest and diseases. In a study, different combinations of temperature and fungicidal treatments

were evaluated for their effect in reducing post harvest fruit diseases in the cv. Amrapali, which covers the maximum mango growing area in Odisha. Among twelve treatments imposed, hot water treatment (HWT) in solution of Bavistin (1 gm/lit.) at 52°C for 10 min. (0%) was found to be the best treatment with least anthracnose symptoms, followed by Bavistin (1 gm/lit.) HWT at 46°C for 1hr. (2.5%), HWT at 56°C for 3 min. (4%) and HWT 52°C for 10 min. (5%) after twelve days of treatment. No incidence of stem end rot (SER) was found in the HWT 52°c for 10 min. treatment, HWT with Bavistin (1 gm/lit.) at 46°c for 1hr. and HWT 56°C for 3 min. Effect of treatments on fruit quality parameters were also recorded, which indicated no significant adverse effect of treatments (Srinivas *et al*., 2012).

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