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Research Article

DISEASE MANAGEMENT IN ORGANIC AGRICULTURE

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ABSTRACT

Broad management of ecosystem through modification in the cultural practices such as crop rotation, soil quality management through the addition of organic amendments constitute the preliminary defence against the attack of diseases followed by use of the curative methods like use of predators, parasitoids, plant products and ecologically safer chemicals forms the next alternatives of defence against the diseases. Apart from conventional fungicides and microbial biocontrol agents, plant products or extracts have been found effective in organic agriculture. A number of strategies including modification of cultural practices including crop rotation, soil health management, use of disease resistant plants, etc. , use of biological control agents, use of botanicals, entomopathogen, antagonists, microbials and organic pesticides and other permissible pesticides can be taken up for effective management of diseases.

INTRODUCTION

The disease management in organic farming are primarily dependent on preventive measures rather than curative practices which are based on the ecologically safer management methods. The emphasis has been given to maintain the health of the ecosystem thus enabling plant to become resistance to attack by diseases. Broad management of ecosystem through little modification in the cultural practices such as crop rotation, soil quality management through the addition of organic amendments constitute the preliminary defence against the attack of diseases followed by use of the curative methods like use of predators, parasitoids, plant products and ecologically safer chemicals forms the next alternatives of defence against the diseases.

Apart from conventional fungicides and microbial biocontrol agents, plant products or extracts have been found detrimental against a wide range of pathogens (Amadioha, 2003) . Chemicals like salicylic acid, 2, 6-dichloroisonicotinic acid and benzothiadiazole induce systemic acquired resistance in plants (Guleria *et al*, 2005). Execution of systemic acquired resistance is manifested by the expression of genes coding for pathogenesis related (PR) proteins increase in activity of enzymes such as fenil amonya-liyaz and peroxidase and level of fungitoxic phenols (Kagale *et al*, 2004). A number of studies on direct effect of neem leaf and fruit extracts on target pathogens have been reported (Amadioha, 2000). Aqueous leaf extract of *Azadirachta indica* induced resistance in barley against *Drechslera graminea* through biochemical changes in the host plant (Paul and Sharma, 2002). Chemicals applied in the control of disease pollute the atmosphere and affect the properties of medicinal plants. To avoid the hazardous effects of chemicals, natural products of some plant have been found effective to control the disease (Bhatia and Awasthi, 2007). A number of reports are available showing the efficacy of plant extracts especially neem (*A. indica* and *Ocimum sanctum*) showing the antifungal properties (Mesta *et al*, 2009)..

Insect-pest and disease management strategies for organic farming

For ease of understanding and their effective application for management of diseases under organic farming, disease management strategies are classified into following categories:

- Modification of cultural practices including crop rotation, soil health management, use of disease resistant plants, etc.
- Use of biological control agents
- Use of botanicals
- Entomopathogens
- Antagonists
- Microbials

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- Use of organic pesticides and other permissible pesticides.

Modification of cultural practices

Slight modification in the cultural practices can have an impact on the whole ecosystem. These practices can increase the agricultural biodiversity and thus have a greater role to play in the management of pathogens. However, these methods have certain limitations as they have to be planned well in advance and these are preventive in nature rather than curative.

Use of resistant cultivars*:* Plant breeders traditionally have focused on creating disease-resistant varieties. It is important to find out about the mechanism of disease resistance in a crop variety because genetically modified crops (GMOs, transgenic crops) are not permitted in organic production systems. Breeding methods such as introduction and selection, hybridization and selection, pedigree method, backcross method, composite cross, recurrent selection and mutation breeding are followed for development of resistant varieties. Disease resistant hybrids are given in Table 1.

Table 1 Disease resistant hybrids in vegetable crops

Crop	Resistant to	Hybrids
Cabbage	Black rot	Harirani, Kranti, Geetanjali, Bahar, Pragati
	Fusarium Yellows	Harirani, Kranti, Ganesh Gole, Quisto, Viawas
Cauliflower	Black rot	Early Himlata
Okra	YVMV	No.7, No.8, No.10, Panchalik, Adhunik, Tara, Supriya, Uphar, Varsha, Vijay, Vishal
Ridge gourd	Mildews	Surekha
Watermelon	Fusarium wilt	Amrit, MHW-6
Capsicum	TMV	Green Gold, MCPH-II
	TMV & PVY	Indra
Tomato	Fusarium & Verticillium wilt	Ratna, Rishi, Maitri, Manmohan, Lerica
	YVMV	Meenakshi, Menka, Mohini
	Bacterial wilt	Suraksha
	TYLCV	Avinash-II
	Foliar diseases	Akash, Utpan, Ruchi
Chilli	Virus	NS 2302, NS 1820
	Leaf curl	Hybrid No.1
	Anthracnose	Vardhan
	TMV	Kranti, Krishna, Vijli, Agni

Crop rotation*:* Crop rotation is used either to starve the pathogen or to kill it with toxic root exudates. To be most effective, rotations between susceptible crops should be three to seven years. A number of soil borne pathogens like *Fusarium* spp., *Verticillium* spp. and *Ralstonia* spp causing wilts can effectively managed by crop rotation.In fields, where rice-solanaceous crop rotation is followed the severity of bacterial wilt is reduced. In sorghum and pigeon pea mixed cropping helps in reducing *Fusarium* wilt because of toxic exudates of sorghum plant parts which eventually reduces the inoculum load and hence the disease (Satish Chandra and Baiswar, 2007).

Planting time*:* Adjustment of sowing time can also be considered as an effective strategy against disease. It helps in managing disease by avoiding the concurrence of susceptible host and favourable environment. For example, early sown crop escapes blast in rice and turcicum blight in maize. Incidence of chick pea wilt and root rot of pea can be reduced by late planting.

Plant density*:* Decisions about plant densities are influenced more by the growing characteristics of the crop, weed management, and harvest requirements than by disease management. In many cases increasing spacing also helps in reducing disease pressure like in case of sheath blight of rice caused by *Rhizoctonia solani*.

Fertility management*:* Organic production does not allow synthetic fertilizers or sewage sludge. Over fertilized plants may subject to more diseases and become targets of attack. The organic manures create a partial nitrogen stress up to certain period without any negative effects on crop growth and thus induce resistance through intrinsic production of defence compound such as phenols, tannins and lignins that make the leaf toughness and production of more cell wall related structural compounds (Surekha and Rao, 2000).

Antifungal activity among various organic composts has been reported by various workers against soil borne and foliar pathogens. Aqueous extracts of vermicompost and organic compost inhibited the mycelial growth of *Botrytis cinerea, Sclerotinia sclerotiorum, Sclerotium rolfsii, R. solani* and *Fusarium oxysporum f. sp. lycopersici in vitro* (Nakasone *et al*, 1999). Deficiency of certain elements can increase susceptibility of host plants, for example leaf spot of groundnut due to Mg deficiency, wilt of tomato due to Ca deficiency and downy mildew of maize due to Zn deficiency (Singh, 1998). Early blight and charcoal rot of potato can be checked by furrow irrigation.

Water management*:* Irrigation has both direct and indirect effects on population of pathogen. Plants under stress due to drought can be more attractive to pathogen. The need for irrigation is influenced by crop growth and weather rather than the need for pathogen control. Several naturally occurring pathogens, especially insect-pathogenic fungi, provide effective pest suppression when high humidity microenvironments are created. Similarly, in case of potato scab maintaining soil moisture near field capacity during tuber formation protects the crop from scab because of favourable effect of irrigation on bacterial microflora antagonists to *Streptomyces scabies* (Weinbold and Bowman, 1968). Charcoal rot fungus *Macrophomina* species and *Fusarium* spp. cause wilt diseases to those crops which are grown under moisture stress conditions.

Tillage: Infrequent disturbance of soils in natural systems can preserve food webs and diversity of organisms and habitats. The regular disturbance of agricultural soils disrupts ecological linkages and allows adapted pest species to increase. Organic producers usually depend on tillage to control weeds and to prepare the soil for planting. Some practices to reduce tillage in organic systems include zero tillage, ridge tillage, and including a perennial or sod-producing crop in the rotation (Halder *et al*, 2017).

Mulches: Mulching systems include plastic and natural materials. Although, the use of plastic mulch is frequently not allowed by organic certification agencies because it relies on a non-renewable resource. Biodegradeable plastic mulches are being developed and may affect pests in a similar way to that of conventional, non-biodegradeable mulches. Organic farmers often use straw mulch which provides good weed suppression. New systems, such as hydro-mulch may one day supplement

plastic and straw if they are developed with organically allowable components. For now, plastic and straw mulches becoming high in popularity.

Sanitation: Sanitation involves destruction of crop debris, weeds, diseased plant parts which eventually reduces the inoculums load and subsequent the disease. Like in case of leaf blotch of turmeric, removal of infected leaves reduces the disease severity and further spread.

Use of biological control agents

Inundative and inoculative release or applying biological control agents such as insect predators, parasitoids and insect pathogens can have a greater role to play in controlling the insect pests in an insecticide free environment. These agents can be used as curative control methods in case of sudden outbreak in the insect population. Some of the commonly used and potential biological control agents for pest management in organic crop production are given in Table 2.

Table 2 Biological control agents for pest management in organic crop production

Biocontrol agents	Effective against	Crops
Bacteria		
Bacillus thuringiensis	Lepidopteran pests	Cotton, sunflower and vegetables
Entomopathogenic fungi		
Metarhizium anisopliae *Beauveria bassiana* *Verticilium lecanaii*	Lepidopteran and coleopteran Aphids and whiteflies	green house vegetables, cotton, coconut
Insect predators		
Lady bird beetles, *Chrysoperla* spp.	Aphids, whiteflies and mealy bugs	Fruits and vegetables
Insect parasitoids		
Trichogramma spp. *Chelonis blackburni*	Lepidopteran	Sugarcane and tomato
Entomopathogenic nematodes		
Heterorhabditis bacteriophora *Steinernema carpocapsae*	Lepidopterans	Sugarcane and plantation crops
Entomopathogenic viruses		
Nuclear polyhedrosis virus (NPV), Granulosis virus	Lepidopterans	Pulses and vegetables

Source: Kumaranag, *et al*., 2013

Most microbes produce and secrete one or more compound with antibiotic activity. Some examples of antibiotics reported to be involved in plant pathogen suppression (Table 3).

Table 3 Some antibiotics produced by biocontrol agents

Antibiotic	Source	Target pathogen	Disease
Bacillomycin-D	*Bacillus subtilis*	*Aspergillus flavus*	Afflatoxin contamination
Bacillomycin, fengycin	*Bacillus amyloliquefacien*	*Fusarium oxysporum*	Wilt
Xanthobaccin-A	*Lysobacter* spp	*Aphanomyces cochlioides*	Damping off
Gliotoxin	*Trichoderma virens*	*Rhizoctonia solani*	Roor rots
Herbicolin	*Pantoea agglomerans*	*Erwinia amylovora*	Fire blight
Iturin-A	*Bacillus subtilis*	*Botrytis cinerea*, *Rhizoctonia solani*	Damping off
Mycosubtilin	*B. subtilis*	Pythium apha nidermatum	Damping off

Source: Jan *et al*., 2013

A number of bio-control agents like *Trichoderma* spp., *Gliocladium* spp., *Bacillus subtilis*, *Aspergillus niger, Azotobacter chroococcum, Azospirillum lipoforum, Psuedomonas fluorescens* etc. have been exploited in the management of major plant diseases.

Use of botanicals and their mixtures

The use of botanicals for the control of diseases are last options in the organic agriculture, if all the earlier methods are failed. The crude extracts as well as commercial formulations made from plants like neem, pongamia, derris, citrus grass and tobacco that showed efficacy in conventional agriculture for the management of diseases are allowed in organic farming because of their less residual action and ecological safety. A broad array of pest-repellent products, including homemade herbal teas, plant extracts, and fermentation products, and industrial clay and rock powder products (e.g., kaolin) are authorized for use in organic agriculture. Some of the commonly used animal product based concoctions in organic pest management in India are Panchagavya and Dasagavya. The leaf extracts of lemon can display fungitoxic effect against 3 destructive fungal pathogens, i.e. *P. grisea, A. niger* and *A. flavus* inciting the blast disease of rice, collar rot and afla root diseases of groundnut, respectively.

Entomopathogens

Entomopathogens have saprophytic, commensalistic, parasitic or pathogenic association with insect host. Several pathogens including viruses such as nuclear polyhedrosis viruses (NPV) and granulosis viruses, bacteria like *Bacillus thuringiensis*, fungi like *Metarrhizium anisopliae*, *Beauveria bassiana* and *Verticillium* sp. Cause diseases in insects and destroy them. The Nuclear Polyhedrosis Virus (NPV) has a great potential for the management of Helicoverpa and Spodoptera. *Verticillium* as well as *Paceliomyces* sp have wide use in fields infested with nematode problems.

Antagonists (Singh et al, 2007)

The potentiality of suppression of collar rot (*Sclerotium rolfsii*) on sugar beet, lentil and chick pea; damping off (*Pythium graminicolum*) on sugarcane seedlings and brinjal; *Pythium* sp., on pea, tomato and brinjal; sheath blight (*Rhizontonia solanii*) on lentil and chick pea and downy mildew in pearl millet have been demonstrated by soil and seed application of fungal antagonists*, Trichoderma* spp and their strains. Among the bacterial antagonists *Pseudomonas fluorescens* has been found effective in controlling fungal pathogens such as wilt/root *rot Fusarium oxysporum* f.sp. *cubense*, *Pyhtium* spp., *Rhizoctonia solani*, *R. oryzae* and *Sclerotium rolfsii* and bacterial pathogens like *Xanthomonas citri and P. solanacearum* in field tests.

Microbials

Among microbial pesticides, at least 16 microbes have been used in the country. Out of these *Bacillus thuringiensis*, *Trichoderma* species and NPVs are the most accepted products. 25 microbial products including *Bacillus thuringiensis*, *B. sphaericus*, *Trichoderma* species, Beauveria bassiana & NPV are registered with Central Insecticides Board. The Central Insecticides Board has accepted the following microbial products in the schedule of Insecticides Act (1968):

- Entomogenous fungi: *Beauveria bassiana, Verticillium lecanii, Metarrhizium anisopliae, Nomuraea e*tc.
- Antagonistic fungi and bacteria: *Trichoderma* spp., *Pseudomonas fluorescens*, *Bacillus subtilis*, *Gliocladium* spp
- Mycoherbicides
- NPV's and GV's
- Repellents

Use of organic pesticides and other pesticides

Kaolin is naturally occurring clay resulting from the weathering of aluminous minerals with kaolinite as their principal ingredient, such as feldspar. Kaolin is ground to a uniform particle size for application as a water suspension to plant parts. This material is effective against for both insect and disease control. Panchagavya which is prepared by mixing five important ingredients obtained from the cow including urine, dung, milk, curd and ghee along with tender coconut water, sugarcane juice and ripe bananas. The preparation after maturation period is diluted to 3% with water and used as foliar spray. This works well in making plants disease resistant.

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