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Disease management by organic farming

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Abstract
Organic farming (OF) has significantly increased in importance in recent decades. Disease management in OF is largely based on the maintenance of biological diversity and soil health by balanced crop rotations, including nitrogen-fixing and cover crops, intercrops, additions of manure and compost and reductions in soil tillage. Most soil-borne diseases are naturally suppressed, while foliar diseases can sometimes be problematic. Only when a severe disease outbreak is expected are pesticides used that are approved for OF. A detailed overview is given of cultural and biological control measures. Attention is also given to regulated pesticides. We conclude that a systems approach to disease management is required, and that interdisciplinary research is needed to solve lingering disease problems. Mostly culture, physical and botanicals are used for disease management.

Keywords: Organic farming, disease management, culture method, physical method, botanicals

Introduction

The Concepts and Principles of Organic Farming-

If consumers are asked about organic farming most will characterise it by what organic farmers do not use. Answers will almost certainly include “no pesticides”, “no fertilisers” and “natural” (Zanoli, 2004) [42]. Whilst it is not wrong to describe organic farming in this way, this does not help to understand what principles organic farming is based on and what practices organic farmers do use (Lampkin, 2003) [25]. Organic farming in Europe has a long history and a variety of roots. The ideas and principles underpinning organic farming as a coherent concept go back almost 100 year (King, 1911; Lockeretz, 2007) [18, 28]. The term ‘organic’, was first used in this context in the 1940s, and refers not to the type of inputs used, but to the concept of the farm as an organism (or system in more modern terminology), in which all the component parts - the soil minerals, organic matter, microorganisms, insects, plants, animals and humans - interact to create a coherent and stable whole. Central to the concept is the closing of nutrient cycles and the preference for local resources. Since then, different issues have come to the fore at different times, from soil conservation and the dustbowls in the 1930s (Howard, 1940; Balfour, 1943) [12, 2], to pesticides following Silent Spring (Carson, 1962) [4], energy following the 1973 oil crisis (Lockeretz, 1977) [27], and subsequently to concerns about animal welfare, biodiversity loss, climate change, peak oil, peak phosphate and food security today. These ideas are expressed in the four fundamental principles of organic farming – health, ecology, fairness and care (IFOAM, 2005) [15]. In order to maintain the financial viability of organic systems producers have looked to consumer willingness to pay higher prices for the perceived benefits of organic food. In some cases, this reflected more altruistic environmental, animal welfare and social concerns, but in many cases this reflects more ‘self-interested’ concerns relating to food quality and safety, in particular issues relating to pesticide residues and personal health (for example Aertsens *et al.,* 2009; Hughner *et al.,* 2007) [1, 14]. Science has played, and still does play, a particularly important role in the development of organic farming concepts and its validation, and is central to research on organic farming (e.g. Niggli *et al.,* 2008) [31]. Specific management practices that are part of the organic systems can be adopted by any farmer, whether certified organic or not. It is the combination of these different components/practices with the aim to deliver broad sustainability, health and quality objectives that defines the organic system approach and that delivers a variety of public good benefits (Lampkin, 2010) [24].

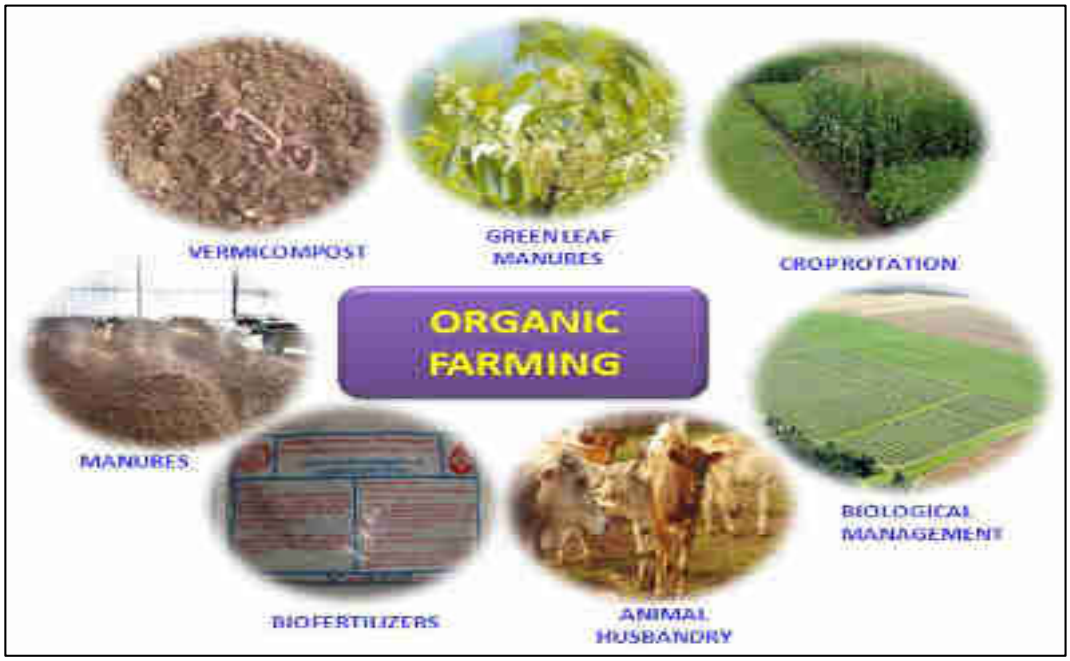
Organisms and they produce symptoms

1. Fungi cause spots, lesions, blights, yellowing of leaves, wilts, cankers, rots, fruiting bodies, mildews, molds, leaf spots, root rots, cankers, and blotches. Fungi are typically spread by wind, rain, soil, mechanical means and infected plant material.

2. Bacteria cause water-soaking, spots, wilts, rots, blights, cankers, exudates, galls, yellowing, leaf spots, watery blotches, wilting. Bacteria are typically spread by rain, mechanical means, planting material, vectors (ex. bacterial wilt of cucurbits spread by cucumber beetle)
3. Viruses cause mottling, leaf and stem distortions, mosaic patterns, rings and stunting. Viruses cause interesting symptoms, some are beautiful. Viruses are spread by mechanical means, vectors and in plant material.
4. Nematodes cause wilting, stunting, yellowing of entire plants. This is because the roots of the plant are infected and the plant is starving or thirsty. Nematodes are spread by soil on equipment or workers boots or on infected plant material.

Disease management strategies in organic farming:-
The organic farming has a hierarchical approach to pest management starting with System-based cultural practices then Mechanical and Physical Practices and finally Material-based (chemical, botanical, elemental) practices.

Cultural Control: Cultural control is your first line of defense.



Organic Farming

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) [26] 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) [37].

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) [38, 17].

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) [16].

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) [33].

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) [6]. Post harvest hot water treatment of mango fruits was able to reduce the incidence of anthracnose (Srinivas *et al.,* 2012) [34].

Sanitation: In vineyards and orchards, diseased branches are pruned away and plant residues are removed from greenhouses. Branches and residues are composted instead of

burned to reduce CO_2 emissions and return carbon to the soil. (Finckh MR *et al.,* 2015) [7]

Soil disinfestation: Several methods of soil disinfestation can be used in OA, namely flooding, soil steaming, solarization, anaerobic (or biological) soil disinfestation, and biofumigation, and are discussed in recent reviews (Gamliel A and van Bruggen AHC. 2015, van Bruggen AHC, *et al.,* 2015) [5, 7]. For soil solarization, moist soil is covered with transparent, UV-resistant plastic and exposed to sunlight for a few weeks (Gamliel, A. and Katan, J. 2012; Gamliel, A. and van Bruggen, AHC. 2015) [8, 9]. Most plant-pathogenic fungi, bacteria, and nematodes, except for some heat-tolerant fungi and viruses, are quite sensitive to increased temperatures (45–55◦C) (Finckh, MR. *et al.,* 2015, Yildiz, A. *et al.,* 2010) [7, 41]. The solarization effect can be enhanced by incorporation of isothiocyanateproducing residues from brassica crops into soil before covering with plastic (Klein, E. *et al.,* 2011; Klein, E. *et al.,* 2012) [19, 21]. For ASD fresh organic material is incorporated into soil, and the soil is moistened and covered by airtight plastic for 3–6 weeks (Lamers, JG, *et al.,* 2004, Momma, N. 2008) [23, 30]. ASD results in the control of many soilborne plant-pathogenic fungi, bacteria, and nematodes, including *Rhizoctonia*, *Fusarium*, *Verticillium*, *Sclerotinia*, *Phytophthora*, *Ralstonia*, *Meloidogyne*, and *Globodera* spp., as well as most weeds (Butler DM, *et al.,* 2012; Goud, J-KC. *et al.,* 2004; Huang, X. *et al.,* 2015; Lamers, JG. *et al.,* 2004 [23]; Messiha, NAS, *et al.,* 2007).

Root-knot and cyst nematodes are sensitive in the upper solarised soil layer (killed at 45 –50 ^{0}C). However, they may survive solarization in deeper soil layers (40 cm). Most plant-pathogenic fungi and bacteria are quite sensitive (45– 55 ^{0}C), except for heat-tolerant species (55 –65 ^{0}C) (Chellemi, DO. *et al.,* 2015 [5]; van Bruggen, AHC. and Finckh, M. 2015 [7]; Klein, E. *et al.,* 2011 [20]; Yildiz, A. *et al.,* 2010 [41]; Noble, R. 2011 [32]) Most plant viruses are inactivated in the range 55 – 70 ^{0}C, and most weed seeds are killed between 50 and 60 ^{0}C, but again there are some exceptions. (Noble, R. *et al.,* 2011) [32]

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. 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-Paani' 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) [40].

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) [22] etc.

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