ISSN 2449-8955

European Journal of Biological Research

Review Article

Management of fungal plants diseases

Nadia Ghanney[1,2]

[1] National Institute of Agronomy, Tunis, Tunisia
[2] Arid Land Institute, Medenine, 4119, Tunisia
Email: nadia.ghanney@gmail.com

Received: 18 May 2017; **Revised submission:** 30 July 2017; **Accepted:** 14 October 2017

DOI: http://dx.doi.org/10.5281/zenodo.1012350

ABSTRACT

Plant diseases that can affect yield and quality of field crops everywhere around the world are numerous. Fungal parasites are by far the most prevalent plant pathogenic organisms. To develop, all components of the disease triangle must be present. These components are a susceptible host crop, a plant pathogen able to infect the host crop, and an environment that favors disease development. Management practices aiming to reduce plant diseases affect specific components of the disease triangle. They need to be combined to limit more than a single component, an approach known as integrated disease management (IDM). Integrating different tools leads to better disease reduction and decreases selection pressures. Knowing that pathogens are affected by selection pressures when certain individual management practices are over-used, and this can result in new "races" of the pathogen or fungicide-resistant strains of the pathogen being selected. The continual and indiscriminate application of chemical fungicides has caused health hazards in animals and humans due to residual toxicity. Recently, several synthetic fungicides have been banned in the western world because of their undesirable attributes such as high and acute toxicity. Nowadays, biological control is going to be the best alternative strategy for the control of plant diseases. However, other methods in IDM for crop disease control are still necessary in various environmental conditions. Consequently, for economic threshold, other control strategies of IDM besides/with biological control should be also applied to effectively reduce the disease development and the yield loss of crops in the different crop systems.

Keywords: Plant pathogenic fungi; Disease management.

1. INTRODUCTION

During their lifetime, plants are uncovered to fluctuating temperature, humidity, drought or rainfall, soils and nutrients, weeds, insects, nematodes and microorganisms. These components could be beneficial or detrimental to plant health. The disease triangle (Fig. 1), that consists of an interaction between a susceptible plant, a virulent pathogen (usually fungus) and a suitable (conductive) environment for the disease onset, is a classic concept which was formalized in the 1960s by George MacNew [1] to seek out the interrelationship of different factors in an epidemic and to understand how epidemics might be predicted, limited, or managed. It was planned as an experiment tool to presage and control diseases.

More recently, modified versions of the disease triangle concept were defined, including the disease pyramid and tetrahedron, which have 'time' and 'man' as additional factors.

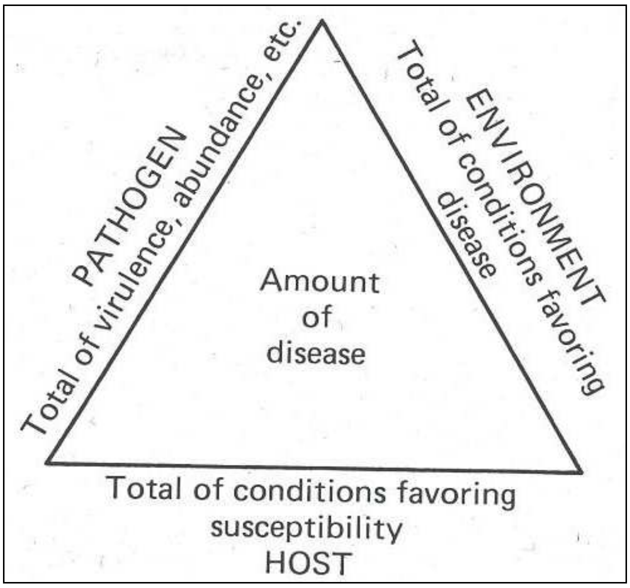

Figure 1. Disease triangle concept.

Today, theoretical and applied plant epidemiologies are advanced fields of research, incorporating the effects of climate change in the control and management of plant diseases.

Bread molds and mushrooms are examples of fungi familiar to all of us. Most of the 100,000 fungus species identified by scientists are only saprophytes and not capable of infecting plants. However, more than 8,000 plant pathogenic species have been identified making fungi the most numerous and economically important class of plant pathogens. The great diversity of fungi and the complex and intricate life cycles of some plant pathogenic species make generalizations difficult.

Plant infection by fungi occurs via a great variety of mechanisms. Some species directly penetrate plant surfaces or enter through natural openings, while others require wounds or injury for infection. During disease development, many species of fungi produces pores which are dispersed by wind, water or by other means. Each spore may cause a new infection resulting in a rapid increase in disease incidence and severity. Some fungi form special resting spores which permit survival for long periods of time (several months or years) in soil or plant debris.

2. FUNGAL DISEASES CONTROL

First of all, it should be noted that among different kinds of pathogens, the greatest losses are inflicted by fungi (42%) followed by bacteria (27%), viruses (18%), and nematodes (13%) [2, 3].

Whether the aim of disease management is to save existing plants or to prevent problems from recurring, we must know "What went wrong?" The diagnosis consists of collecting information on the problem of diseased plants and to fix the cause [4]. Once the cause is determined, it is possible to recommend a solution basing on relevant disease management. The diagnosis of plant problems can involve considerable detective work [5]. Sometimes there is not enough information and other times, the main cause of a problem is hidden by more obvious problems. Success in the diagnosis of plant problems necessarily depends on the amount of knowledge about the triangle of the disease (environment, host and pathogen).

Therefore, the environment may be altered in different ways depending on the disease to be managed. For instance, some diseases require free water for development. In this case, efficient means to reduce free water include morning irrigation, dew removal, reduction in amount and frequency of irrigation. Water manipulation might be wise tool in disease management. Improved drainage and soil conditions by aeration, straw reduction, light conditions manipulations and fertilization regulation might be relevant as steps for reducing damage from particular diseases.

On the other side, disease severity may be underplayed by suitable changes in the crop that is being grown. It is mindless practice to replant the same variety that has been killed by the same pathogen year after year, if there is another option. It is always more suitable, where possible, to use mixture or blends of various varieties, rather than seeding a single kind of crop species. Diversity in a planting almost always raises odds of survival.

The third measure of disease management is depression of the pathogen by applying chemicals which will kill the organism or keep it under threshold of harmfulness. However, most fungicides do not kill fungi, they only prevent growth.

Also, it is important to identify correctly the pathogen, so that a suitable fungicide may be selected. Random choice and application of fungicides without knowledge of the disease cause can make as much harm as good. Using the wrong fungicide wastes money and may worsen the disease as well as causing other negative effects.

3. PREVENTIVE MEASURES

3.1. Cultural practices

Cultural practices usually affect the development of disease in plants by influencing the environment. These practices are intended to make the atmosphere, soil, or beneficial microorganisms convenient to the crop plant, inconvenient to its parasites.

For example, soil solarization process surveys the soil pathogenic organisms efficiently by trapping solar energy under cold frames subjected to direct sunlight (before planting) for sufficient periods so as to raise the temperature of the top layer of soil (to a depth of 10 cm) to 40°-60°C. The control of the soil borne pathogens, especially *Fusarium* species has changed over the last few decades [6]. Application of soil solarization for managing *Fusarium* and *Verticillium* wilt on some crops is performed generally in several countries [7].

The black root rot of tobacco seedlings caused by *Thielaviopsis basicola* were controlled by applying such treatments. Sclerotial viability of *Sclerotium rolfsii* was quickly reduced by more than 95% at 2.5 cm depth in solarized fruit orchards soil, though lowering effects were found in deeper soillayers [8]. However, the major constraints that limit the adoption of soil solarization in practice are relatively longer duration of the process and the climatic dependency. The cost of solarization is relatively low compared with other available alternative; however, it can be a limiting factor depending on the country, the crop type, the production system.

On the other side, organisms that survive in the soil can often be controlled by crop rotations with unsusceptible species, depending on the system. For example, wheat should not be monocropped or grown behind triticale, rye, or barley. Rotating to oats, annual pasture grasses, winter legumes, or a clean winter fallow for 1 to 2 years between wheat crops may be necessary in fields where serious losses to Septoria diseases have occurred [9].

Environmental factors (temperature, water, and organic and inorganic nutrients) significantly affect inoculum production. For instance, warm temperature (solarization) breaks dormancy of sclerotial structures; water may leach growth inhibitors from the soil and permit germination of resting spores; and special nutrients may stimulate the growth of sclerotes that produce inoculum.

3.2. Plant quarantine

A formal regulatory disease control is plant quarantine, the legally enforced stoppage of plant pathogens through regulations made by states concerning the movement of plant materials into them.

3.3. Sample inspection

Another preventive measure to control the diseases is the sample inspection method. Laboratory looks into of a representative sample drawn by the certification agency for the evaluation of germination, moisture content, weed seed content, purity and seedborne pathogens.

4. CONTROL MEASURES

4.1. Chemical control

Pesticides that control plant diseases can be used very differently. It depends on the pathogen to be controlled and the circumstances required for parasitic activities. For example, a water-soluble eradicative spray is applied once to dormant peach trees to remove wintering spores from the leaves, while relatively insoluble protective fungicides are repeatedly applied to the leaves of potato plants to protect them. In addition, systemic fungicides may be used curatively.

Bhuiyan et al. [10] made several studies on the effect of fungicides in inhibition of the *S. rolfsii* mycelial growth. The study used various fungicides as Ridomil, Rovral, Tilt, Dithane, Bavistin, and Provex at different concentrations. At 400 ppm, inhibition of the mycelial growth was 52.9%, 93.88%, 100%, 80.63%, 6.64% and 100%, respectively. The study revealed that Provex inhibited radial mycelial growth totally even at low concentration of 100 ppm.

However, chemical control presents difficulties due to the growing resistance of the strains to the main commercial products. The ideal phytosanitary formula, as for a large number of pathogenic fungi, is far from being found and it is now only possible to limit the damage to an economically tolerable threshold.

The resistance to fungicides is a major cause of poor disease control in fungal pathogens. The development of resistance to fungicides is influenced by complex interactions of factors such as the mode of action of the fungicide, the biology of the pathogen and the crop system. Understanding the fungicide resistance, how it develops and how it can be managed is critical to ensure sustainable control of fungal diseases.

4.2. Biological control

The most logical scope for the environment to the pesticides using for the control of diseases is the use of biological approaches. Biological control is based on the phenomenon that each living entity has an adversary in nature to keep its population in check. Baker and Cook [11] defined biological control as the "reduction of inoculum density or disease producing activities of a pathogen or parasite in its active or dormant state, by one or more organisms, accomplished naturally or through manipulation of the environment, host, or antagonists, or by mass introduction of one or more antagonists".

Biological control can be fulfilled either by introducing bioinoculants or biocontrol agents (BCA) directly into a natural ecosystem or by adopting cultural practices that stimulate survival, establishment, and multiplication of the bioinoculants already existing. The first essay to control a plant disease with microorganism introduced to soil was by Hartley in 1921 [12] where introduction of isolates of saprophytic fungi and one bacterium resulted in significant reduction in severity of damping-off of pine seedlings caused by *Pythium debaryanum* [13].

Bioinoculants are primarily fungal and bacterial in origin. Bioinoculant fungi basically harness through parasitism against plant pathogenic fungi and nematodes [14]. The main genera of biocontrol fungi which have been tried on plant pathogenic fungi and nematodes including *Trichoderma*, *Aspergillus*, *Chaetomium*, *Penicillium*, *Neurospora*, *Fusarium*, *Rhizoctonia*, *Dactylella*, *Arthrobotrys*, *Catenaria*, *Paecilomyces*, *Pochonia*, and *Glomus*. Other types of BCA such as plant growth-promoting organisms have also been examined for disease management [15, 16]. A number of fungi such as *Aspergillus spp*., *Penicillium spp*., and *Trichoderma spp*. have been reported as phosphate-solubilizing microorganisms (PSM), which also suppress plant pathogens. Application of PSM can control soil-borne pathogens such as *Fusarium oxysporum*, *Macrophomina phaseolina*, *Pythium aphanidermatum*, *Rhizoctonia solani* and *Sclerotinia sclerotiorum*.

Trichoderma strains grow rapidly when inoculated in soil because they are naturally resistant to many toxic compounds such as DDT and phenolic compounds [17]. *Trichoderma* strains are efficient in controlling several fungi such as *R. solani*, *P. ultimum* and *S. rolfsii* when alternated with methylbromide, benomyl, captan, or other chemicals.

Disease suppression by bioinoculants might be performed by some mechanisms like fungistatic effects, competition for nutrients, antibiosis, myco-parasitism and stimulation of host defense response.

The practical effectiveness of biological control is clearly succeeded with relevant results *in vitro*. Thus, the need for field productivity of any biological and biotechnological approach should be addressed.

5. INTEGRATED DISEASE MANAGEMENT (IDM)

IDM is defined as: "a sustainable approach to survey diseases by combining biological, cultural, physical and chemical tools in a way that minimizes economic, health and environmental risks". This concept evolved from the original IPM (integrated pest management) [18].

The success and sustainability of IDM strategy [19], especially with resource poor farmers greatly depends on their involvement in helping generate locally specific techniques and solutions suitable for their particular farming systems and integrating control components that are ecologically sound and readily available to them. Training and awareness raising of farmers, disease survey teams, agricultural development officers, extension agents and policy makers remains to be an important factor for the successful implementation of IDM strategies.

6. CONCLUSION

Plant fungal diseases seriously threaten crop production worldwide causing the highest yield losses among those caused by other pathogens. As a result, their management is essential to increase food production. Given the adverse effects of pesticides, bioinoculants offer a potential substitute. Many potentially useful microorganisms are available, such as *Trichoderma spp., Aspergillus niger, Penicillium digitatum, P. anatolicum, Paecilomyces lilacinus, Pochonia chlamydosporia*. These organisms can be applied directly to the soil, as a seed treatment or as a foliar spray to reduce the level of inoculum and the severity of the disease. Commercial formulations of most bioinoculants are available and offer varying degrees of disease control. The overall performance of phosphate-soluble fungi such as *A. niger, Trichoderma spp., Penicillium spp.,* against fungal plant diseases opens the way to commercial exploitation.

TRANSPARENCY DECLARATION

The author declares that has no conflict of interest.

REFERENCES

1. McNew, GL. The nature, origin and evolution of parasitism. In: Plant pathology: an advanced treatise. Horsfall JG, Dimond AE, eds. Academic Press, New York; 1960: 19-69.
2. Rahman Khan M, Arshad Anwer M. Fungal bioinoculants for plant disease management. Microbes and Microbial Technology. Springer New York; 2014.
3. Khan MR, Jairajpuri MS. An overview of nematode infestation in cash crops. In: Nematode infestations field crop (Part 1). Khan MR, Jairajpuri MS, eds. India: National Academy of Sciences; 2010.
4. Krishna Mohan S. Plant disease diagnosis and management; 1998.
5. Sanders PL. Turfgrass diseases: a triangular view of diagnosis and management. 1st edn. WorldCat; 1991.
6. Patel N, Desai P, Patel Ni, Jha A, Gautam HK. Agronanotechnology for plant fungal disease management. Int J Curr Microbiol App Sci. 2014; 3: 71-84.
7. Saremi H, Okhovvat SM, Ashrafi SJ. *Fusarium* diseases as the main soil borne fungal pathogen on plants and their control management with soil solarization in Iran. Afr J Biotechnol. 2011: 10: 18391-18398.
8. Shlevin E, Sagui I, Mahrer Y, Katan J. Modeling the survival of two soilborne pathogens under dry structural solarization. J Phytopathol. 2003; 93: 1247-1257.
9. Hagan AK, Mask P, Gudauskas RT, Collins D. Wheat diseases and their control. Circular ANR. 543; 1990.
10. Bhuiyan M, Rahman M, Bhuiyan K. *In vitro* screening of fungicides and antagonists against *Sclerotium rolfsii.* Afr J Biotechnol. 2012; 11: 14822-14827.
11. Baker KF, Cook RJ. Biological control of plant pathogens. San Francisco, Freeman and Co; 1974.
12. Hartley C. Damping off in forest nurseries. Washington, DC: USDA Bulletin 934; 1921.
13. Baker KF. Evolving concepts of biological control of plant pathogens. Annu Rev Phytopathol. 1987; 25: 67-85.
14. Khan MR. Biological control of Fusarial wilt an root-knot of legumes. New Delhi: Department of Biotechnology, Ministry of Science and Technology; 2005.
15. Papavizas GC. Biological control of soil borne diseases. Summa Phytopathol. 1985; 11: 173-179.
16. Nair MG, Burke BA. A few fatty acid methyl ester and other biologically active compounds from *Aspergillus niger*. Phytochemistry. 1988; 27: 3169-3173.
17. Chet I, Inbar J, Hadar I. Fungal antagonists and mycoparasites. In: The mycota IV: environmental and microbial relationships. Wicklow DT, Soderstrom B, eds. Springer: Berlin, Heidelberg, New York; 1997: 165-184.

18. Overton J. Ecologically based pest management - new solutions for a new century. National Academy Press, Washington DC, USA; 1996.

19. El Khoury W, Makkouk K. Integrated plant disease management in developing countries. J Plant Pathol. 2010: 92: S4.35-S4.42.