CULTURAL APPROACHES FOR DISEASE MANAGEMENT: PRESENT STATUS AND FUTURE PROSPECTS

J. Katan

Department of Plant Pathology and Microbiology, The Robert H. Smith Faculty of Agriculture, Food and Environment, The Hebrew University, Rehovot 76100, Israel

SUMMARY

Cultural practices (CPs) can be harnessed for the management of foliar and soilborne diseases by creating an environment which is favorable for the crop and unfavorable for the pathogen. Certain CPs, e.g. flooding and sanitation, are used mainly for pest control while others, e.g. irrigation, can be used for both crop management and pest control. Some CPs, e.g. deep plowing, crop rotation, flaming sanitation, soil solarization and biofumigation, are used as preplanting measures, whereas others, e.g. water and mineral nutrition management, tillage, and alteration of soil temperature, are used both pre- and post-planting. Special plastic covers can be used in protected agriculture to manipulate insect behavior, thereby reducing infestation. CPs are potential components in integrated pest-management programs.

Key words: biofumigation, crop rotation, fertilizer, irrigation, sanitation, solarization.

INTRODUCTION

Crops in greenhouses are typically under monoculture. This results in a rapid buildup of populations of pathogens, arthropods pests, weeds, etc. The accumulating plant residues that remain in the soil or on the greenhouse structure make the sanitation task more difficult. A similar situation exists in crops in the open field when monoculture is adopted.

To manage a pathogen, the disease cycle can be interrupted at any stage: in the absence of the host, at planting, during plant growth and afterwards. This can be achieved by manipulating the biotic and abiotic environments. Any technology for disease management has to fulfill a variety of requirements: effectiveness of control, environmental, social and economic acceptability, technological feasibility and if possible, a long-term effect. This is also true for CPs for disease management.

CULTURAL PRACTICES FOR DISEASE MANAGEMENT

Since the dawn of history, CPs have been the main or only techniques available for reducing the incidence of soilborne diseases and pests. Numerous observations and long experience served to generate practices for pest control through trial and error, which in the end became traditions. For example, the use of crop rotation is one of the oldest means of suppressing soilborne pathogens. The Robigalia, a festival in Roman times, was connected with rust of wheat. In 1660, a law was passed in France requiring the eradication of barberry bushes because of conclusive evidence that rust of cereals was most prevalent in their vicinity (Stakman and Harrar, 1957). The rise of modern plant pathology in the 19th century provided a scientific basis for the systematic development of disease control and the elucidation of the mechanisms involved. However, the concomitant development of powerful and effective chemicals for control in the last few decades has resulted in declining interest in CPs for disease control. Nevertheless, renewed interest in this issue has recently emerged, especially since CPs do not involve pesticides.

The definition of CP in the context of disease control is complicated. We suggest classifying CPs into three categories (Katan, 1996):

1. CPs which are usually applied for agricultural purposes that are not related to crop protection, such as fertilization and irrigation. They may or may not have positive or negative side effects on disease incidence.
2. CPs which are used solely or mainly for disease control, such as sanitation for the eradication of plant residues and flooding.
3. CPs which are used for both agricultural purposes and disease control, such as crop rotation, grafting, composting and flooding.

It is difficult to draw clear distinctions between these categories. For example, planting date, irrigation and plowing can be adjusted to escape or avoid disease. Traditionally, composts have been used primarily to improve plant nutrition and soil structure, but it is now realized that they can suppress soilborne pathogens (Hoitink and Fahy, 1986).
When analyzing the potential of CPs as tools for the management of soilborne diseases, the following should be determined (Palti and Katan, 1997):
1. level of disease reduction
2. economic and technological feasibility of the method
3. conditions under which disease reduction occurs (epidemiological aspects)
4. reproducibility of disease reduction by the CP
5. possible long-term effects
6. mechanisms of disease reduction, which should be investigated since they may provide tools for improving the method.

There are CPs, e.g. crop rotation or deep plowing, which are implemented only as preplanting measures, while others, e.g. adjusting mineral nutrition, can be implemented as either pre- or postplanting measures.

There are many publications related to CPs for disease management. One book (Palti, 1981) is dedicated in its entirety to the subject.

**PREPLANTING CP CONTROL MEASURES**

**Crop rotation.** Neglecting crop rotation results in the enrichment of pest populations, the accumulation of toxic substances, the depletion of mineral nutrients, degradation in soil fertility and destruction of soil structure. Crop rotation deals with plant health in general rather than with controlling a specific disease, although a certain crop sequence might be more effective in reducing the incidence of a specific disease than others. It can also be regarded as insurance against the rise of unknown pathogens (Bruehl, 1987; Katan, 2003).

**Deep plowing.** In tomatoes, the incidence of the southern blight disease was lower after deep plowing (25 cm depth), compared with shallow tillage by means of a harrow (Worley et al., 1966). Deep plowing results in exposure of propagules to elevated temperatures and physical killing of the pathogen. This can be regarded as dry soil solarization. Summer plowing was effective at reducing populations of cyst nematodes and increasing wheat yield (Mathur et al., 1987).

**Flooding.** This practice somewhat resembles soil disinfection. The harmful effect on soilborne pests may be related to lack of O₂, increased CO₂ or various microbial activities under anaerobic conditions, e.g. production of substances that are toxic to the pathogen (Bruehl, 1987). This practice was known in ancient civilizations in the Near and Far East. A classical case of control on a large scale was demonstrated with the Panama wilt disease of bananas caused by *F. oxysporum* f. sp. *cubense* (Stover, 1962). Flooding also apparently destroys *Pseudomonas solanacearum*, and the nematode *Radopholus similis* (Stover, 1962). Long-term summer soil flooding, with or without paddy rice culture, decreased populations of *Verticillium dahliae* and the incidence of *Verticillium* wilt in cotton, and increased yields (Pullman and DeVay, 1982).

**Fire and flaming.** Hardison (1976) defined this approach as thermosanitation and described many examples of controlling diseases by fire and flaming. The basic idea (which was established long ago) is to achieve thermal killing of the pathogens’ resting structures. This can be done by either burning the dry plant residues in the field or flaming the residues with special equipment; the latter approach provides more controlled heating. Although temperatures may reach high levels (500°C or more), inoculum reduction will depend on the duration of the heating process and on the depth of the heat’s penetration into the soil. Burning of rice stubble and straw is common practice throughout the world.

**Sanitation.** The two principal aims of sanitation are to prevent the introduction of inoculum, by whatever means, into the field, greenhouse, farm or community, and to reduce or eliminate the inoculum that is already present at these sites (Palti, 1981). This can be achieved by flooding, flaming, solarization, plowing, chemical treatments to destroy resting structures, mechanical removal of residues, controlling alternate hosts (weeds, volunteer plants), roguing (removing diseased plants from host populations), pruning and other means.

**Additional preplanting CP measures.** These include: soil solarization (Gamliel and Katan, 2009), adjusting planting date to avoid the disease, adjusting crop density, biofumigation, namely, incorporation of organic amendments which produce toxic volatiles under plastic mulch, and others (Palti and Katan, 1997).

Plasticulture, and the use of special plastic or net covers in protected agriculture, are providing new options for reducing insect infestation by adversely manipulating their behavior. UV-absorbing polyethylene films or nets eliminate most of the light spectrum in the range of 280-380 nm. This results in reduced infestation of crops by a variety of insect pests. These optical barriers affect the insects’ orientation and navigation and can play an important role in pest management. Colored polyethylene soil mulches reduced infestation by *Bemisia tabaci* and infection of tomato by *Tomato yellow leaf curl virus* (Antignus, 2000). Thus, the development of technologies to produce plastic films with specific spectral properties will facilitate the use of “optical means” of interfering with the vision and behavior of insects (Antignus, 2010).

**PRE- AND POSTPLANTING CP CONTROL MEASURES**

These include: irrigation and water management,
weed control to eliminate alternate hosts, herbicides which reduce diseases, tillage, alteration of soil temperature, and use of fertilizers, manure or compost. There are many examples of successful reductions in disease incidence or severity using the appropriate CP, and no attempt is made here to cover them all.

Irrigation strongly affects both foliar and soilborne diseases (Rotem and Palti, 1969). It alters the moisture content of the soil and consequently influences its aeration and temperature, and these, in turn, affect the incidence of diseases through their impact on biotic and abiotic processes in the soil or foliage. Irrigation also affects disease incidence indirectly due to changes in the agricultural regime, such as intensification of cropping, and changes in the date of sowing and growing seasons (Katan, 1996). Irrigation alleviates the water stress which predisposes the plants to certain diseases. Water stress had a predisposing effect on the severity of Phytophthora root rot in safflower (Dunniway, 1977) and on disease caused by Macrophomina phaseolina (Ghaffar and Erwin, 1969), and an adequate irrigation regime reduced disease incidence.

CONCLUDING REMARKS

Every CP should be evaluated as a potential tool for disease control, or be modified to prevent disease increase. A thorough familiarity with the ecology and plant husbandry of the particular crop is absolutely essential for disease control: appropriate modifications of innovations in crop husbandry practice have furnished the foundations of success in all types of crop cultivation (Garrett, 1970).

Integrated management is less convenient, but it reduces the risks and hazards stemming from the use of a single method of control. There is increasing interest in CPs for disease control that can replace the use of pesticides, and that can be integrated into pest-management programs.

REFERENCES


