L04 - Alternative methods for plant protection against diseases.

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The welfare of plants is of particular interest to those most directly concerned with the growth of plants and the manufacture and distribution of plant products. Most importantly, however, the welfare of plants should be of concern to every one of us as growers of plants for food or pleasure, as individuals concerned with the beauty and safety of our natural environment and, particularly, as consumers of plants and of the endless series of products derived from plants.

The growth and yield of plants depend on the availability of nutrients and water in the soil where they grow and on the maintenance within certain ranges of such environmental factors as light, temperature, and moisture. Plant growth and yield depend also on protecting the plants from parasites. Plant pathogens, unfavorable weather, weeds, and insects pests are the most common causes of reduction or destruction of plant growth and production.

A plant is healthy or normal when it can carry out its physiological functions to the best of its genetic potential. Whenever plants are disturbed by pathogens or by certain environmental conditions and one or more of these functions are interfered with beyond a certain deviation from the normal, then the plants become diseased.

A plant disease results from the interaction of a host and a pathogen as influenced by a favorable environment – the disease triangle. This figure illustrates one of the paradigms in plant pathology; that is, the existence of a disease caused by a biotic agent absolutely requires the interaction of a susceptible host, a virulent pathogen, and an environment favorable for disease development. Conversely, plant disease is prevented upon elimination of any one of these three causal components. The general principles of plant disease control (exclusion, eradication, protection, immunization, therapy, regulation and escape) are essentially based on the knowledge of how a disease occurs and change over time and space, i.e. the epidemiological approach.

The principle of **exclusion** includes all practices that prevent the entrance of a pathogen in an area not yet infested; the **eradication** includes the elimination of a pathogen from a previous infested area; the **protection** principle consists on the deposition of a protecting barrier (usually chemical) covering the susceptible surface of the plant before the arriving of the pathogen inoculum; the **immunization** principle is based on the selection/development of plants resistant or immunes to the pathogen; the **therapy** aim at the stop of the progress of a already established infection; the **regulation** principle comprise the practices that modify the environmental condition and turn it unfavorable for the disease development; and, the **escape** principle can be defined as the prevention of the occurrence of a disease by the selection of season or area of planting when or where the pathogen is inefficient, rare or absent.

Although these principles are known since a long time, the plant protection in modern agriculture is largely dependent on the use of pesticides. This approach is extremely attractive, since it is simple, can be programmed (calendar, e.g.) and do not require profound knowledge of the basic process of the agroecosystem and the pathosystem for its application. In the other hand, the intensive use of pesticides in the agriculture is not sustainable over a long time and carries several environmental and public health concerns. On this context, the searching for environmental friendly, healthy and economically acceptable strategies and methods for reduce or eliminate the pesticide dependency on plant protection became a challenger task.

In a strict sense, "alternative methods" for plant disease control, in counterpoint of the use of synthetic pesticides, include the use of plant extracts, aqueous extracts of organic matter, products resulting from the fermentation of organic materials ("biofertilizer"), salts and diluted acids (e.g. bicarbonates, acetic acid), organic substances (e.g. milk) and biological control agents. However, in order to achieve the above stated "epidemiological approach", this concept should be enlarged to include other practices such as physical and cultural methods that contribute to the maintenance of the plant health.

Several alternative methods of diseases control feasible to be used in medicinal and aromatic plants cultivation are available and will be discussed.

Control of damping-off and soilborne pathogens

Damping-off and root rot diseases occurs worldwide and affect seeds, seedlings, and roots of almost every cultivated plant. Losses vary considerably with soil moisture, temperature and other factors. In many instances, poor germination of seeds or poor emergence of seedlings is the result of damping-off infections in the pre-emergence stage. Older plants infect with root rot pathogens may have their development retarded considerably, and their yields may be reduced drastically. Several fungal pathogens are involved in damping-off and root rot diseases, including *Pythium* spp., *Phytophthora* spp., *Rhizoctonia solani*, *Fusarium* spp., and others.

The alternative methods for control of these diseases include:

Soil and substrate disinfestation by solar energy

- Soil solarization

The method consists in covering the humid soil with a transparent plastic film, in pre-planting, over a period of intense solar radiation (variable for each region) for at least 30 days. The control of the pathogens propagules, weeds seeds and nematodes are resulting of several mechanisms, including physical stress and microbiological activation in soil.

- Solar collector

A solar collector for substrate disinfestation was developed by the Embrapa Environment and the "Instituto Agronômico de Campinas". The equipment substitutes satisfactorily the methyl bromide use for substrate disinfestation. The solar collector is simple, easy to use and cheap. Complete information on how to construct and use the solar collector can be find at http://www.cnpma.embrapa.br/download/circular_4.pdf.

Fermented organic materials ("biofertilizer", compostea, aqueous extracts)

The aerobic or anaerobic fermentation of organic matter (such as cattle manure, cereals bran, etc.) produce a rich biofertilizer, that can be used for nutritional and/or disease control purposes. Besides the inorganic nutrients, the biofertilizer contains a huge microbial community (especially bacteria and actinomycetes) that produces antibiotics, hormones and other antifungal compounds. The biofertilizer can be added to the soil or substrate by irrigation at pre- or post-planting stages. Considering the possibility of the presence of fecal coliforms in the biofertilizer made with animal excrements, it should not be used in post-planting of direct consumption vegetables.

Biological control agents

Fungal antagonists, especially those of the genera *Trichoderma* and *Gliocladium*, can be used to reduce the soilborne pathogens population. These antagonists control the pathogens by competition for space and nutrients, direct parasitism and antibiosis. Better results are achieved when the use of the antagonists is associated with other methods, for example, soil disinfestation followed by recolonization by the antagonists.

Control of the powdery mildews (*Oidium*) diseases

Powdery mildews are probably the most common, conspicuous, widespread, and easily recognizable plant diseases. They affect all kinds of plants and are characterized by the appearance of spots or patches of a white to grayish, powdery, mildewy growth on young plant tissues, or of entire leaves and other organs being completely covered by the white powdery mildew. The symptoms are most commonly observed on the upper side of the leaves. The powdery mildews seldom kill their hosts but utilize their nutrients, reduce photosynthesis, increase respiration and transpiration, impair growth, and reduce yields, sometimes by as much as 20 to 40 percent.

The alternative methods for control of these diseases include:

Crude milk

The crude milk sprayed weekly at 10 to 20 % (milk:water, v/v) can control efficiently the powdery mildew on several crops. This mode of action include the formation of a biological film on the leaf surface and the inhibitory effects of the salts present in the milk. Complete information on how to use crude milk to control oidium diseases can be find at http://www.cnpma.embrapa.br/download/comunicado_14.pdf

Salts

As stated above, salts have inhibitory effects on the powdery mildew development. Thus, the pulverization of diluted salts, such as sodium bicarbonate, monossodical glutamate and others can exert control of the disease. Caution should be taken with the possibility of phytotoxicity of some salts to more sensitive plants.

"Biofertilizers"

The liquid phase of the biofertilizer diluted to 10 to 20% (biofertilizer:water, v/v) and sprayed weekly is efficient in control the powdery mildew. Caution should be taken when using biofertilizer on direct consumption vegetables parts, to avoid biological contaminations.

Control of general foliar pathogens

The foliar spots and blights caused mostly by fungi affect numerous hosts and are quite diverse. The diseases cycles and controls of these diseases are quite similar, however. Nevertheless, considerable variability may exist among diseases on different hosts or when the diseases develop under different environmental conditions. Most foliar fungal pathogens reproduce by means of conidia (asexual spore), and, in some instances, by ascospores (sexual spore). On the infected areas, numerous spores are produced that spread to other plants by wind, wind-blown rain, water, and insects and cause more infections. In most cases these fungi overwinter and reproduce in fallen leaves or other plant debris. For some diseases, use of disease-free seed or removal and destruction of contaminated debris or both may be the most important control method.

The alternative methods for control of these diseases include:

Cultural practices and regulation of irrigation

Most of the foliar pathogens require high relative humidity and free water to cause infection. Thus, the irrigation, especially in greenhouse seedlings should be regulated to avoid excess of humidity for long periods of time. A nutritional balance, avoiding excess of nitrogen is another important measure to not predispose the plants to pathogen attack. As several pathogens can survive and multiply on plant debris, the sanitation practices (removal of dead tissues and plants, disinfestation of used pots and benches, etc.) should be taken regularly.

Biological control agents

Some biological control agents (including bacteria and fungus) are reported to be effective on the control of specific foliar diseases, especially in nursery and greenhouse cultivations. Unfortunately, there are only few commercial products available. Among then, includes products based on *Trichoderma* spp. and *Clonostachys rosea* for control of necrotrophic pathogens (such as *Botrytis cinerea*); *Ampelomyces quisqualis* for control of oidium diseases; *Bacillus subtilis* for control of some biotrophic pathogens (such as rusts and mildews).

"Biofertilizers"

In the same way as for the oidium diseases, the liquid phase of the biofertilizer diluted to 10 to 20% (biofertilizer:water, v/v) can be used to control general foliar pathogens. The efficacy of the treatment, however, varies with the pathosystem.

Plant extracts

Plant extracts are reported to be effective against some plant pathogens. Among than, there are several medicinal and aromatic plants extracts traditionally used by organic farmers. Several receipts can be found at the Web sites of organic agriculture.

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