

## ENVIRONMENTAL FRIENDLY DISEASE CONTROL SYSTEMS

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Chemical control of plant diseases is considered as vitally important in sustainable agriculture when referring to significant yield losses in fields due to activities of plant pathogens. Proper handling of chemicals on controlling plant diseases enable pollution free environment. If hazardous chemicals are handled illiterally, chances are not rare that, traces of such chemicals diposit in human bodies causing various abnormalities. Therefore, scientists are presently involved in research on the developing alternative, and safe chemicals, and their application methods. The component of environmentally friendly management systems of plant disease could be outlined as: use of lower doses of chemicals, less toxic fumigants, cultural methods such as soil solarization and soil heating (Katan, 1980; Katan *et al.*, 1976; Pullman *et al.*, 1981), amendment of suppressive soils, flooding, rotations, organic amendmets, fertilizers, integrated control and the use of biological control agents (BCA's).

### **Plant disease control with lower doses of chemicals or integrated control**

In developed countries, biological control systems of plant diseases has often been successful in agricultural systems when applied in conjunction with lower chemical dosages. Onother way to reduce the pesticide use in plant disease control is to alter application rates or frequencies in favor of the host protection- effect of different practices affecting the disease development. Integrated pest management systems are adopted in countries where wasteful and unnecessary use of pesticide were abundant in the past. Use of semiochemicals (*e.g.* Pheromones) is in practice in some countries in combinations with other approaches in the Integrated Pest Management Strategies (IPMS), including pest monitoring for accurate timing of pesticide treatment; use of semiochemicals with host plant resistance and trap crops to manipulate pest behavior and the use of semiochemicals with selective insecticides or biological control agents to reduce the pest population (McDonald, 1995).

Controlled release system of pesticides in soils also an alternative method to avoid contamination of soil water resources. Chemicals used in agriculture are liable for transformation and relocation. Hence, it is required to apply excessive amounts to compensate the losses. Thereby, the controlled release techniques such as immobilization, encapsulation, embedding, clay-polymer beads and pillared-clays are

desirable. Woodward (1988) outlined the methods of immobilization as flocculation, adsorption, cell entrapment and metal-link/chelation processes. As McLoughlin (1994) described, trapping microbial cells in polymers such as alginate or carrageenan or within synthetic gels such as acrylamide may control the level of micro-environment.

### **Biocontrol with introduced microbial inoculants**

Effectiveness of control of plant pathogens with introduced BCAs depends on the application techniques, viz: time and target sites and frequency of application on target organisms. Perhaps, repeated application of the microbial agent may be needed to achieve better results. However, it should be noted that the use of inoculants in soils is restricted by two factors, such as general suppressiveness of soils and economical limitations which also applied to fungicides that are not phloem-mobile. In other words, the BCAs should be either targeted to specific sites on plants that favor activities - e.g. application of *Phlebiopsis (Phlebia) gigantea* on cut surfaces of pine to prevent *Fomes (Heterobasidion) annosus* infection on the cut surface (Rishbeth, 1975) or applied to soils that are particularly receptive where BCA can proliferate (Deacon, 1991). However, as described by McLoughlin (1994), the metabolic activity and adaptability or ecological competence of commercial inoculants appear to be major limitations. Inoculants added as freeze-dried powder, or immediately after suspension of freeze-dried cultures in water are insufficient with number of metabolically active cells- such inoculants cultured overnight before application results improved activity. Commercial microbial inocula also require a high degree of robustness if exposed to heterogeneous habitats where heterogeneity arise due to discontinuity of flow, gas/liquid/solid interfaces, temperature and pH variations, availability of simple and complex substrates, multiple nutrient limitations and competition with indigenous microbial populations, or due to the release of solutes from particulate organic matter or complex polymers which in turn may depend on competing microbial enzyme activities (McLoughlin, 1994).

Siderophore producing microorganisms are effective on biocontrol. Most aerobic and facultative anaerobic microorganisms respond to low-iron stress by producing extracellular, low-molecular-weight (500-1000 daltons) iron (III)-transport agents, which are designated as siderophores (Neilands, 1982). The function of siderophore is to supply iron to the cell (Leong, 1986). Some microorganisms in environments with low levels of iron, have ability to produce siderophores. When such organism is introduced to soil, a competition for iron is created and subsequently, an iron deficit is created to the pathogen. Siderophores are known to play a vital role in biocontrol of many plant pathogenic fungi and bacteria (Neilands, 1984). Sirinivasan *et al.* (1992) revealed that, out of ten *Trichoderma* isolates tested, nine produced siderophores. However little is known about siderophore production

in basidiomycetes except reports by Jellison *et al.* (1990). Low iron composition in wood may allow siderophore producing fungi such as *Trichoderma* to be competitive among the decaying fungi in wood.

Its a challenge to develop economically and practically feasible biocontrol inocula for foliar diseases of field crops. Hyperparasites *Cylindrosporium concentricum* and *Dicyma pulvinata* to rubber plantations in Brazil has resulted in a long term cyclical effect on the black-crust pathogen *Phyllachora huberi* on the foliage. These hyperparasites had destroyed the asci of the pathogen in over 95% of ascostromata within 3-5 months and suppressed the pathogen by 85% in the next flush and subsequently by over 90% in the next flush (Sutton & Peng, 1993). It may be possible to use spore suspensions of *Trichoderma* species with a sugar base such as mollasses to prevent leaf infection in plant nurseries. *Trichoderma* proliferate on the leaf surface using the sugar base. This technique has to be tested thoroughly on experimental basis.

### Suppressive soils

Suppressive soils are described as soils in which diseases fail to develop even though the pathogen is present (McQuilken, 1995). Abiotic factors such as the soil pH or the clay and mineral content or biotic factors such as microorganisms may be associated with suppressive soils. In some reports, incorporation of high level of organic materials including manures and crop wastes, mineral nutrients from aquatic sediments lowered the incidence of *Pythium* damping-off in soils where *Pythium* is introduced. The cause of the suppressiveness was described as the presence of *Fluorescent pseudomonads* and saprophytic *Fusarium* spp. (Lumsden *et al.*, 1987). Transferring samples of suppressive soils into disease conducive soils may be useful in the future in controlling diseases in horticulture.

### Soil solarization

Soil heating process is known as solarization where heat from the sun penetrates a clear plastic sheeting placed on top of moist soil (Katan, 1980), raising the soil temperature to kill pathogens, or weaken the pathogen to such extent that they are attacked by resident antagonists which are tolerant to the accumulated heat. This process has been used successfully to control *Sclerotium rolfsii*, *Sclerotium sclerotiorum* and *Fusarium* spp. in soil. The control is achieved mainly due to microbial colonization and degradation of pathogen propagules which are weakened by sub-lethal heating (McQuilken, 1995). However, this control method could be adapted obviously in such countries where insolation is high.

## **Flooding**

Flooding has been effective on biological control of soil-borne pathogens such as sclerotia of the white rot pathogen (*Sclerotium cepivorum*) of onions (Leggett & Rahe, 1985). The mechanism of control involved microbial degradation of sclerotia. Certain weeds in paddy fields are successfully controlled by increasing the water level (flooding) in the field. Weeds which are not tolerable to high levels of water are destroyed under-water.

## **Fertilizers**

Application of some fertilizers contained ammonium rather than nitrate nitrogen lowers the soil pH which increases the availability of micro-elements and stimulates the soil antagonists. As such, take-all of cereals are suppressed when crops are provided with ammonium nitrogen, and root rot and heart rot of pineapple caused by *Phytophthora cinnamomi* was reduced when applied sulphur to soil for maintaining low pH (Cook & Baker, 1983). Similarly, it was observed in some experimental sites of the Rubber Research Institute of Sri Lanka, where rubber plants were artificially inoculated with the white root disease pathogen, *Rigidoporus lignosus*. The introduced pathogen, poorly or not established at all on roots of rubber plants in sites which were properly manured.

## **Composts/Green manure/Organic amendments**

In some countries in the Asian continent, such as China and Japan, decomposed organic waste have been used to control soil-borne plant pathogens and as organic fertilizers (Hoitink & Fahey, 1986). The control of pathogens is resulted by the activities of microbial population colonized the composted materials. Soil amendments with compost sewage sludge over 4-year period reduced the incidence of lettuce drop caused by *Sclerotinia minor* (Lumsden *et al.*, 1986). In similar cases, root rot of peas, beans and beetroot caused by *P. ultimum* and *P. solani* were reduced as a result of incorporation of such materials in to soil (Schüler *et al.*, 1989). It was also reported that foliar spray of compost extracts obtained from decomposed materials have shown some potential for controlling a number of diseases such as potato late blight and Botrytis grey mould (Weltzien, 1992; McQuilken *et al.*, 1994).

## **Rotations**

The principle behind rotations is based on the reduction of inoculum potential of plant pathogens in soil. This had been a common practice in developed agriculture.

Besides improving the soil conditions, rotations deprive pathogens of their hosts leaving them without a host for a longer period to survive. During this period, the pathogenic propagules may be destroyed as a result of lack of nutrients or being parasitised and lysed by other resident antagonistic organisms.

### Conclusions and future prospects

The factors discussed above are important on manipulation of existing microbial antagonists population in favor of the plant health. Apparently, some of these practices involve the application of huge quantities of organic bio-mass, which is more relevant to low technology agricultural cropping system in developing countries where labour costs are cheaper and costs of effective fungicides are unbearable. In western countries, where agricultural systems are well developed, possibilities of adopting such practices are less, because of expensive labour costs. However, the agronomists in such countries should look for every possible chances to adopt as many of these practices to prevent or delay the onset of pathogen resistance.

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