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BIOLOGICAL CONTROL OF PLANT DISEASES

By

S. B. CHATTOPADHYAY

In recent times, biological approaches towards control of plant diseases are gaining momentum in view of technical and economic limitations of different methods adopted in protection of plants against ravages of diseases and pests, apart from toxic hazards and environmental pollution in many cases. The problem of suitable, and cheap direct control measures, chemical or physical, is very acute in case of soil borne pathogenes.

With the advent of chemicals in the field of plant protection, application of the same is now considered to be first line of defences, rather than a component of management system. Main reasons for leaning heavily on chemical methods are (i) they are less complicated for the growers to use than non-chemical methods, which need an understanding of pathogenesis, initimate knowledge of pathogen and assosciated factors ; (ii) results are often immediate and spectacular ; (iii) reluctance, at least partially, on the part of biologists to become more intimately involved in the problem of growers and disease development in the field which are needed to evolve suitable nonchemical methods. Consequently the field of plant protection has been left to the advocates of chemicals and their aggressive salesmen.

Net work of living population is in a state of dynamic equilibrium in relation to both physical environments and biotic communities. Presence of any living organism—autotrophic or heterotrophic in a givien place or time is determined by (a) being evolved or introduced thereto (b) presence of (i) proper physical environment (ii) mutually beneficial other organisms, (iii) food (living and nonliving) for survival, (c) absence or inhibition of action of disease producing organisms pests or other causes of extinction. Plants in their wild state are supposed to be adjusted against diseases and pests. It however does not signify that plants have not succumbed to the attack of these harmful organisms in the past. Pressures from attack of diseases and pests have tended to select or evolve forms resistant to them, in other words, a system of adaptation developed under a stable agro-ecosystem. But due to changes in the environ ment and other pertinent factars particularly those introduced by men in course of cropping with consequent interference on stable ecosystem have created such conditions that biological balance is upset and pathogens become aggressive in nature. Chemical treatments, however desirable they may be, produce large abrupt changes causing wide fluctuation in population of pathogens, but ecosystem is rendered unstable.

In case of soil borne pathogens, biological approach is considered necessary for two major reasons, namely (a) soil has a fairly stable biotic community and ecological environment and (b) soil-borne pathogens are difficult to eliminate effectively and economically by chemical methods.

Biological approach in plant pathology differs from that in entomology in objectives as well as methods. Biological control of insects has been largely through predators and parasites, which are actively mobile, find their own target insects and operate on the basis of a single parasite or predator against a single target insect. Biological control of plant pathogens is aimed to be achieved primarily through antibiosis and competition. Antagonists are largely nonmobile and passive, rarely makes direct contact with pathogen, function in an indirect manner and often operate in mixed groups rather than individuals. Due to the fundamental differences, concept of density dependency (repressive environmental factors intensify as population increases and relax as it declines, stabilizing the population) may have limited application in biological control of plant pathogens. Success in control of plant pathogens by non chemical methods has been attributed to direct action of pathogen than biological control, Biological control, of plant pathogens as conceived in insect pests, has been considered to be empirical, unreliable and inextensible. (Baker and Cook, 1974).

In plant pathology biological control has been defined as the reduction of inoculum density or disease-producing activities of a pathogen in its active or dormant state by one or more microorganisms, accomplished naturally or through manipulation of environment, host, or antagonist or by mass introduction of one or more antagonists (Baker and Cook, 1974).

In this context it may be relevant to mention existence of certain soils which are inhospitable to some plant pathogens. They cannot establish themselves in such soil, even if they establish, they fail to produce the disease or they may get established and incite the disease, but diminish in virulence or pathogenicity with continued culture of the crop. Such soils have, in general, been ignored by plant pathologists, but they have been noted for years for species of *Fusarium, Rhizoctonia*, *Phytophthora* and probably others. Reinking and Manns (1933) showed clear cut existence of soils 'tolerant' and 'intolerent' to *Fusarium oxysporum f. cubense*, incitant of panama disease of banana in Central America. These have been taken advantage by growers in selecting fields for new plantings of susceptible varities. Walker and Snyder (1933) noted this phenomenon in Wisconsin for pea wilt caused by *Fusarium oxysporum f. pisi*. Causes of tolerance or intolerance in soils have not been fully explored. Suppressiveness of these soils have been ascribed to the properties of lysis of germ tubes of *Fusaria* (Cook, 1969; Burke, 1965). Smith and Snyder (1972) showed presence of more bacteria in such soils. Resistance of soils is however lost by steaming in some cases (Nelson, 1950). Behaviour on the part of the soil is not due to presence of any specific soil bacteria but total bacterial population and their activity near the germ tube causing lysis by preempting nutrients and oxygen and elaboration of metabolic wastes or both.

Suppressiveness of soil in many cases may be assosciated with (a) high content of organic matter; (b) high calcium level (3000-4000) ppm. with calcium tied up in organic recycling; (c) PH 6. 0-7. 0; high levels of ammonium and nitrate nitrogen also involved in the organic cycle; (e) adequate levels of phosphate; (f) very high populations of many microorganisms, and (g) relatively high magnesium content.

Neither factor alone probably does not contribute much, but collectively they are responsible for checking growth or pothogenicity of soil borne pathogen.

Farmers were aware of the beneficial effects of organic amendments of soil, as measure of checking activity of soil borne pathogens. Organic manures are known to stimulate high populations of soil microorganisms. Hence early attempts to use soil microorganisms in practical biological control were through organic amendments which initiate increase in dormancy of propagules of soil borne pathogens and their eventual digestion by microorganism. This process has been ascribed due to increase in soil fungistasis which is non-specific in origin and involves the sum total of intensified activity of the complex microbial community rather than any specific group, which may lead either to liberation of toxic metabolites or competition for food-(Adams *et al* 1968 a, b).

Cover and legume crops, particularly green legumes if they are ploughed under the soil have been considered as a practical method of elimination or reduction in activity of soil borne plant pathogens. Biological activity, particularly of soil is intense in response to such amendment or incorporation of organic matter as leguminous residues are rich in available nitrogen and more complex substrates are needed for microbial growth. Propagules of *Phytophthora cinnamomi* have been found to germinate in response to amendments by leguminous crop, only to terminate in lysis (Zentmyer, 1963). Ammonia is also released from such substrates during decomposition, temprorarily increasing soil PH. The changes in PH along with other accompanying changes, possible accumulations of nitrites or availability of mineral nitrogen are known to bring complex shifts in biological balance and may also lead to production of fungistatic substances with the net result that suppression of pathogens takes place and consequent decrease in disease severity.

One of the classical example of control by biological means is that of potato scab (causal organism *Streptomyces scabies*) by green manuring. *Bacillus subtilis* is considered to be involved in the mechanism. Though this bacterium can grow in soil with or without green manuring, antibiotic effect against the causal organism of scab was much more pronounced in soil amended with green manures(Weindhold and Bowman, 1968).

Control of *Fusarium solani f. phaseoli* incitant of root rot of bean by incorporation of barley straw into the soil has been ascribed to immobilisation o inorganic nitrogen by the incorporated organic matter with the consequence of nitrogen needed by the pathogen for growth and parasitism is not available to it (Cook and Watson, 1969). However organic amendment has its own limitations and may not give desired result as noticed in case of control of bacterial wilt (*Pseudomonas solanacearum var. asiaticum*) of eggplant in certain parts of West Bengal. More research is needed in this direction before a generalisation can be made in case of control of soil borne pathogens by biological means through organic amendment.

In some cases, fumigation of soil with methyl bromide, carbon disulphide, not benomyl compounds, results in stimulation of activity of *Trichoderma viride* as a result root rot by pathogenic fungi is considerably brought down. Thus biological activity is stimulated following fumigatlon which has a differential effect on soil microflora. (Saksena 1960). Control of nematodes has been hieved or is qeingaimed at through use of trap or inhibitory plants, but this has not stimulatep any research on control of soilborne microorganisms.

Soilborne pathogens are well adapted to the different elements of the environment, abiotic or biotic and they can adjust themselves to changes in environment. Hence they may not be easily suppressed by manipulation of the enviro nment, on the otherhand they have the capacity of utilizing any advantage, however small, the surroundings may offer. Soilborne pathogens are well adaptible and have capacity of adjustment with environmental changes, hence they are often difficult to eliminate. Though there have been substantial data indicating correlation of certain characteristics of soil with relative prevalence of a parti cular pathogen, it does not however signify that suppression may be achieved through manipulation in that direction. It may also be pointed out that surface layer of the soil contains most organic substances. It is the zone of maximum microbial activity, hence maximum antagonistic effect towards pathogens is noticed. Pathogens are often capable of growing above or below this zone and thus avoid or escape microbial antagonism.

Viewed in this context, diverse mechanism may be developed depending on the ecology of the pathogen. *Sclerotium rolfsii* is highly aerobic and tends to attack plants at soil line or above. Growth rate of mycelia is particularly sensitive to higher concentrations of carbon dioxide, which may be due to greater microbial activity, hence a mechanism of antogonism and biological control can be evolved in this direction.

Inability of *S. Rolfsii* to attack plants below surface layer is due to greater concentration of carbon dioxide (Griffin and Nair, 1968).

Soils rich in organic matter and nitrogen have been reported to produce ethylene than infertile soils. These soils which are reported to be biologically active produce more ethylene necessary to maintain fungistatis in soil (Smith, 1973). Production of ethylene is related to greater microbial activity In an indirect manner. It has been shown that in biologically active soils, after depletion of oxygen be aerobic soil microflora, under anaerobic conditions *Closteridium* produces ethylene, whether other microorganisms are involved in production of ethylene are not known. However fungistatis is related to nutrient status and abundunce of nutrients can override the fungistasis (Baker and Cook, 1974). It well-watered soil, *Helminthosporim sativum* is limited in its pathogenic activity, at least partly dueto increased microbial activity particularly if the soil is amended with organic matter (Colbaugh,1973). Aquatic Phycometes have well adaptability hence escape effects of microbial antogonism. Many isolates of *Rhizoctonia solani, Phythium ultimum* and *Phytophthora parasitica* remain more localized within or on basal parts of the host and thus more exposed to the antagonistic action of secondary soil invaders. *Rhizoctonia solani* is however well adapted to diverse situations including capability to continue as saprophytes over long periods, and often from mycorrhizal strands resistant to antagonistic actoin of many other organisms (Harley. 1969).

Vast majority of antagonistic organisms in the soil are saproyhytes. Pathogen after germination of the propagule is exposed to antogonism, hence time spent by the pathogen in the rhizosphere or rhizoplane, particularly in the mycelial stage is a contributory factor in determining successful microbial antagonism and consequently biological control. Biological control of plant diseases is in reality putting saprophytes against pathogens, as the former are broadly adapted to the environment and capable of deriving nutrition from wide range of substrates and more quckly so than plant pathogens, being much less specialised and exacting in nutrients. It has been observed that the more specialised is the pathogen, the more restricted are conditions under which it can cause disease and more susceptible it is apt to be to antagonistic microorganisms (Garrett, 1970).

Antogonists in biological control of plant pathogens include fungi, actinomycetes, bacteria, viruses etc. Soil bacteria being effective as scavangers play more important part in microbial antagonism through competition, where as actinomycetes are ineffecient scavangers, but are excellent producers of antibiotic substances. Fungi are effective in competition and hyperparasitism and some are antibiotic producers. Bacteria are normally more effective in rhizosphere, and bacteria, actinomycetes and fungi can be effeciently operative when growing on organic debris or crop residues harbouring pathogen in host free period.

Viruses occur in a number of fungi. They are reported to cause commercial loss in mushrooms (Holling and Stone, 1971). They are transmitted through hyphal anastomoses, fusion of germ tubes with mycelia and to a limited extent by mites. It has not yet been possible to transmit them mechanically, a factor which constitutes a limitation to their possible use in biological control. Virus infection in fungi causes hyphal leakage, decrease growth rate and virulence of pathogen Lapierre (in Annonymous, 1973) reported presence of viruses in *Sclerotium eepivorum, Verticillium, Fusarium roseum, F. oxysporum, Penicillium* spp. Spire, (in Annonymous, 1973) added *Pythium stoloniferum, Diplocarpon rosae, Ustilago maydis, Alternaria tenuis, Fusarium moniliforme, Helminthosporium* *maydis, H. oryzae* and *Pyricularia oryzae*. In microbial antogonism through competitive mechanism, oxygen, nutrients and possible space are important. According to Clark and Paul (1970) in top layers of soil, where plant pathogens are likely to be active, lack of oxygen or anaerobiosis is not uncommon and in microbiologically active soils, it may be a limiting factor. Similar situation may be experinced in root zone, if rhizosphere organisms are exceptionally active. The more quickly can the competitors exhaust oxygen supply, the more important they are in biological control.

Noemally pathogenic fungi are comparatively slow to germinate and resume growth and are sensitive to fungistasis. Greater microbiological activity would result in quick depletion of nutrients, hence when pathogenic fungi are ready to germinate, they are likely to face nutrition starvation. Thus unfavourable competition for food may result in lysis of germ tubes; preventicn of penetration of pathogen into host tissue. Growth near host plants through preemption of nutrients would require rapid absorption as such nutrients become available. Amendments high in C/N Ratio can be used for causing deficiency of nutrients under ideal conditiors, besides rapid microbial decomposition of the plant refuse and other organic amendments can cause anaerobiosis. Hence effect is two fold. Leguminous refuse and organic amendment are specially effective in this direction.

Wcindling (1932, 1934) showed that *Trichoderma viride* was antagonistic to other fungi and were found to produce antibiotics - gliotoxin and viridin, which were stable in acid solution. He also noted that acidification of seed beds of Citrus favoured inhibition of *Rhizoctonia solani* by *Trichoderme viride*. Antibiosis has distinct advantages, inasmuchas, toxic substances produced may easily diffuse and operate where pathegens are present. Physical contact between pathogen and antogonists is not necessary.

Besides antibiotic substances may remain operative even after death of the antagonist. Production of antibiotics however requires abundunce of nutrients and hence antibiosis is operative in soils rich in nutrients They are however limitations in this approach of biological control. Antibiotics may be degraded in the soil or become inactive due to sorption.

In this context it may be mentioned that a number of arthropods have been reported to secrete volateile substances which are fungistatic and fungicidal. (Roth, 1961), *Scaptocoris divergens*, a soil burrowing hemipteron has been found to produce substances fungistatic or fungicidal to *Fusarium oxysporum f.* sp. *cubense*, *F. oxysporum f.* sp. *lycopersici*, *Sclerotium rolfsii*, *Botrytis cinerea*, bactericidal to *Pseudomonas solanacearum* and nematicidal to *Meliodogyne incognita* (imonin, 1961). The toxic material is a mixture of seven aldeydes, two furans, and two quinones and secreted when disturbed, (Roth, 1961). This is another form of antibiosis which may prove useful.

Inoculation of seeds with microorganisms before planting in non-treated soil has been studied in USSR and his apparently increased yield and control of root patnogens. These findings have lately been confirmen in Rothamsted Experimental Station, England (Brown *et al*, 1964, Brown 1972, 1974) and in Commonwealth Scientiffic and Industrial Research Organization, Austitiatia. Selected organisms can thus be introduced into the soil. Exact mechanism is not known, though number of plausible factors have been enlisied. In control of root pathogens, inhibition of parasitic microorganisms reducing plant growth and producing other symptoms or mullification of toxins they might produce is considered to be plausible mechanisms. Chang and Kommedahl (1968) obtained fairly good control of seedling blight of corn bp *Fusarium reseum f.* sp. *cerealis* by seed inoculation with *Chaetomium globosum* or *Bacillus subtitis*—38-40%, as compared to 62% with mercury treatment of seeds. Tveit and Moore (1954) found resistancc of Brazilian oats to *Helminthosporium victoriae* as due to natural presence of *Chaetomium globosum* and *C. cochloides* on the seed coat, hot water treatment of these seeds make them amendable to attact by *H. victoriae*.

It may be stated in conclusion that biological control of soil borne pathogens offers promise but has not redeived the attention it deserves. Earlier works show numerous possibilitics which need to be worked out for practical for practical feasibility through sustained research.

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