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BIOTIC FACTORS : A NEW DIMENSION IN PLANT PATHOLOGY

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In the process of infection of plants by pathogenic organisms, a number of factors are encountered which have been conveniently grouped under host, pathogen and environment. In recent years. it has been appreciated that a pathogenic organism or entity in nature does not exist alone in isolation whatever may be the habitat, soil, water, air or host surface. It exists as a member of biotic community in association with others in a state of biological equilibrium-a fact which has been clearly understood by entomologists in cases of damages caused by insects. At present biological equilibrium has been upset due to a number of factors which include cultivation practices, application of agricultural chemicals toxic to pathogens. That the biological equilibrium has been disturbed and there has been changes in members of biotic community wherein pathogens are present is evident from the appearance of new diseases, minor diseases gaining importance. Hence to the conventional three groups of factors, a new dimension has to be added namely biotic factors.

Our concept on influence of biotic factors in plant pathology has emerged largely from studies on soil inhabiting and soil invading fungi and actinomycetes affecting growth and development of plants and inciting diseases in them in many cases. Study has gradually been extended to leaf surfaces, air and other substrates. Biotic factor in plant pathology has become an extensive subject of study, because of diverse manifestations namely microbial interactions as synergism, antagonism including competition, overgrowing, hyperparasitism, mycoparasitism, rhizosphere, aerosphere and phyllosphere effects, multiple infections, soil fungistasis, vectors, self inhibition, stimulation of spore germination and interactions between pathogens and other organisms.

In this paper, it is not the intention to review the entire subject, but an attempt has been made to highlight some pertinent and important aspects.

In soil plant pathogens have to struggle with other soil microorganisms for their successful existence and parasitic activity. This struggle may be for space, food, oxygen or defence against metabolites of other microorganisms. Most root surfaces are covered by soil which contain numerous beneficial or harmful microorganisms including pathogenic fungi. Intense activity presumably takes place in the rhizosphere which includes not only the root surface, but also the soil immediately adjacent or surrounding the same. Hence the microorganisms present on the surface of roots and in the immediate vicinity in the soil are likely to exert influence on infection of roots by pathogenic organisms. This is evident from the fact that though the roots, particularly the younger ones, rootlets and root hairs do not have any special protective covering like wax, hairs, cutin etc. and they are supposed to be very vulnerable to attack of disease inciting organisms, but in nature this often does not take place due to effect of microorganisms in the rhizosphere. One of the well known cases is that of Flax wilt caused by *Fusarium oxysporum* f. *lini* (Timonin, 1941) where resistance of cultivar Bison has been ascribed to secretion of greater quantity of hydrocyanic acid which apparently favoured growth of saprophytic fungi suppressing the growth of pathogen, in comparison to susceptible cultivar Novelty which produced traces of HCN and encouraged growth of pathogens.

Protection due to antagonistic effects of other microorganisms, particularly *Trichoderma viride* has been reported in root disease of pine caused by *Fomes annosus* (Risbeth, 1950). Eatson and Rigler (1946) suggested that immunity of monocotyledons to Texas root rot fungus *Phymatotrichum omnivorum* is due to microbial activity on the root surface.

The hyphal lysis of fungi in soil is often brought about due to action of antagonistic microorganisms which has been ascribed to production of antibiotics or cell wall degrading enzymes. Recently Ko and Lockwood (1970) working with *Cochliobolus victoriae, Glomerella cingulata,* and *Fusarium solani* have concluded that mycelial lysis of these fungi in soil is caused by activation of β-D glucosidase and chitinase within the mycelium, rather than by enzymes produced by the microorganisms in the soil. This activation is supposed to be due to deficiency of nutrients brought about by saprophytic soil microorganisms, since lysis usually occurs under conditions of deficient nutrients or declining nutrient levels.

Role of soil amendments in encouraging the development of antagonistic microorganisms and eventual control of plant pathogens has been discussed by Garrett (1956).

Beneficial effects of mycorrhizas have always been ascribed to nutritional factors. That mycorrhizal fungi may also have a protective role in affording protection against soil borne root infecting fungi has been pointed out by Zak (1964). He suggested that the protective action of mycorrhizal fungus may be due to utilization of surplus carbohydrates and other nutirents, thus reducing the attractiveness to pathogenic organisms, also acting as a physical barrier and protecting rhizospheric microorganisms. The suggested actions have been corroborated from experimental studies on mycorrhizal fungi of pine roots by Marx (1969, 1969a), and Marx and Davey (1969).

Term 'Phyllosphere' was proposed by Last (1955) and Ruinen (1956) to denote the leaf surface and adjacent area, the actual leaf surface being designated as phylloplane. On leaves and other aerial parts of plants a number of epiphytic microorganisms colonise. These may be macrosoopic forms e. g. lichens, liverworts, mosses, even ferns, etc. which are normally noticed on plants in rain forests or microbes like algae, fungi and bacteria. These epiphytic organisms may be normal inhabitants of phyllosphere or may be casual visitor, comparable to soil invaders in case of soil borne fungi, these casual visitors normally grow on plant debris or moribund plant parts, and may accidently be present in the phyllosphere. Some organisms may be brought down from aerosphere by action of rains. Many pathogens live on the plant surface. Accounts of the leaf microflora have been given by Leben (1965), Last and Deighton (1965), Ruinen (1961, 1963) and Preece and Dickinson (1971). There is an ecological succession, first bacteria colonize on actively growing tissue, then fungi come later.

Among leaf inhabiting bacteria *Pseudomonas* spp. and *Xanthomonas* spp. are prominent and many of them are parasitic on plants. They are capable of utilizing simple sugars which are present in the exudates. Besides non-parasitic bacteria and nitrogen fixing bacteria *(Beijerenecia)* may be present on the leaves and in stomatal cavities. Yeast like fungi, particularly members of Sporobolomycetaceae and Cryptococcaceae are commonly present. Many Hyphomycetes are also present on the leaf surface particularly in the declining and senescence stages of plants. They become parasitic often weak ones in many cases. They include *Cladosporium herbarum, Alternaria tenuis, Epicoccum nigrum, Aurebasidium (Pullularia) pallulans* (which has a yeast like phase) and less frequently *Botrytis, Fusarium, Helminthosporium* and *Penicillium* and unidentified mycelial fungi—the last one often becomes parasitic on leaves of many plants, causing partial drying of leaves under suitable conditions (Butler, 1918). Many of these are however common constituents of aerial microflora. Spores of many other fungi e. g. rusts, powdery mildews, downy mildews are also deposited on the leaves.

Under humid conditions and shade, lichens and algae may be present. Of the latter, *Cephalurous* spp. are often responsible for inciting diseases in economically important plants like tea, litchi. In tropical areas, large number of epiphytic fungi particularly belonging to Ascomycetes such as members of Micropetalaceae, Chaetothyriaceae may be present.

Warm, humid conditions as present in our country favour microbial epiphytes, which may be present more frequently on the lower leaf surface. There may be variations in the composition of epiphytic microflora depending on the species of the plants, age of the leaves, season and climatic conditions.

There may be two possible ways in which microbial members of phyllosphere act. These normally develop on exudates of leaves which normally contain nutrients for growth of saprophytes. Where exudates are secreted profusely and environmental conditions are favourable these grow rapidly. These sapropeytes may interfere with growth of the parasitic forms, being better utilizers of exudates and competitors for food, thus they deprive the pathogenic ones of the essential requirements in the initial stages of infection. Many leaf epiphytes have been reported to produce antibiotics in culture, whether such production can take place in nature on the leaf surface is not precisely known. There are however reports of reduction in incidence of the disease, when saprophytic forms were introduced into the plants. Grosse (1959) reported decreased infection of cherry leaves by *Pseudomonas morsprunorum* by saprophytic bacteria. Wood (1951) reported partial control of lettuce grey mould *Botrytis cinerea* by antagonistic microorganisms. These epiphytes may also act as physical barriers to the attack of pathogenic organisms. It has been suggested that the epiphytes may induce defence reactions which may be effective against infection of pathogens.

Study of interections between epiphytes and pathogens on and near plant surface may yield valuable informations which may be utilized in control of pathogenic diseases, particularly airborne diseases. This may be possible through modification of cultural practices which will encourage growth and development of epiphytic microflora, many of which will be antagonists inhibiting or interfering with process of infection by pathogens. Such reactions may institute as first line of defence. This aspect has assumed particular significance, when control of infection of aerial parts by use of chemicals is now considered to be attended with toxic hazards and environmental pollution. Besides it is not also known application of chemicals is how far interfering with number and compoaition of epiphytic microflora and saprophytes and thereby increasing chances of infection.

Surface microflora of seeds have been investigated by a number of workers. Experimental findings of Simmonds (1947) and Ledingham, Sallans and Simmonds (1949) have shown presence of a large number of microflora on seeds of wheat. They were inhibitory to common seed borne pathogen *Cochliobolus sativus* and could control the disease under certain conditions. It is possible that control of some seed-borne pathogens by soaking or moistening the seeds is partly due to activation of microorganisms present on the seed surface. There is considerable evidence that epiphytic microorganisms on germinating seeds can give some degree of protection against pathogens. This aspect needs further investigations.

Antagonism usually noticed between different microorganisms when they occur in associations has been mostly studied in rhizosphere. It also occurs on the leaf surface, may be to a much less extent, because of much less variation in microflora and conditions may not always be conducive for such antagonism which is often limited.

Apart from antagonism, hyperparasitism has been ohserved to be widespread in nature in fungi. It has been noticed in both obligate and facultative parasites. Biological control has been successfully used to control pests, but little attempt has been made to control pathogens. The use of hyperparasitic and antagonistic fungi in disease control has been investigated to a limited extent. It has not yielded very promising results, but needs further investigation. One problem with hyperparasites is that both hyperparasite and host pathogen tend to remain in a biological equilibrium in nature, unless conditions are created in which the shifting of equilibrium will be in favour of hyperparasite favourable results are not likely to be achieved. This aspect also needs further investigation.

Hyperparasites are found in most groups of fungi and many of these which attack fungal pathogens belong to Ascomycetes and Fungi Imperfectae. Mycoparasites can be classified into several groups on a nutritional basis. Distinction between hyperparasitism and antagonism is sometimes not very distinct. It is contended that they occur together. *Papulospora stoveri* parasitises *Rhizoctonia solani.* also produces toxic effect on it before contact (Warren, 1948). *Trichoderma* which attacks *Rhizoctonia solani* also produces antibiotics. Devolopment of fungal structure is inhibited by hyperparasites e. g. sclerotia formation of *Claviceps purpurea* is inhibited by *Cerebella (Epicoccum)* sp. Hyperparasitism as a possible disease control measure has been reviewed by Boosalis (1964), Boosalis and Mankau (1965), Madelin (1968) and Barnett (1963).

Vectors of many plant diseases may be affected by microorganisms. Predaceous fungi can appreciably reduce the number of nematodes under favourable conditions and might play role in reduction of nematode transmitted viruses and fungi. Little is known of interactions between fungi and viruses and between microorganisms and virus transmitting insect vectors. These aspects need to be studied to find out new avenues of biological control.

Self inhibition of germinating spores has been noticed in many fungi. Germ tubes often grow away from other germ tubes. This has been explained as self inhibiting effects. The phenomenon has been mostly reported in obligate parasites. It is anticipated that this may occur in facultative parasites. Self inhibition has been attributed to trimethyl amine (Forsyth, 1955) to glutamic and aspartic acids (Wilson, 1958). Fatty substances are considered to play an important part in germination of spores. It is considered that inhibitory substances may be produced from these. It has been observed that self inhibitory effects may be eliminated to a large extent by washing of spores. The biological significance of these inhibitors is not clearly understood. The specificity and the elucidication of the chemical structure of the substances involved need to be investigated. Pritchard (1965) reported that the inhihitory substances from the unedospores of one species of rust may inhibit germination in other species, but they were not present in aeciospores nor in teliospores of *Ustilago nuda*.

Germination stimulants, such as pelargonaldehyde and certain other aldehydes and some phenolic compounds, notably coumarin stimulate germination. Little is however known of these stimulants. Some has been extracted from uredospores and they appeai to be nonspecific.

Germination of spores is the first step in pathogenesis. Inhibitory and stimulating substances which greatly affect germination are expected to play a significant role in the infection process of pathogens. They need further sutdy for their probable origin and significance.

Investigations on the role of biotic factor in plant pathology visavis control of plant diseases merit consideration in the wake of extensive use of fungicides for seed and soil treatment and for protection of foliage and fruits. Entomologists have paid serious attention to the biotic factors and control of harmful insects by biological means. In plant disease control, some attempts have been made to control soil borne pathogens and these have met success to some extent. In other cases, there is exclusive dependence on chemical methods of control. Greater use of biological approach towards control of seed and airborne diseases Is essential in the present day context of toxic hazards of pesticides, environmental pollution and effect of these chemicals on microflora and biological balance.

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