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Managing plant disease by managing soils

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Meeting the food grain demand of ever growing global population is the big challenge to agriculture sector. Plant disease significantly reduces the production of food crops besides affecting the quality adversely. Losses associated with plant diseases in yield reduction ranging from slight to catastrophic depending upon varying factors. Literature review highlighted that an average yield loss of 42 % from the six most important food crops. It is vital to manage plant diseases to avoid the yield loss, which helps to meet the food grain demand in simple means. In other way, disease management is helping us to meet the food grain demand of increasing population under shrinkage of cultivable area.

Soil borne disease is a serious concern in plant disease management as eradication of pathogen from soil is so difficult. Hence, it is most essential to establish a healthy soil condition to avoid soil borne pathogen. There are multitudes of options available to control the soil pathogens by farmers. This paper elucidates the control of soil borne pathogens lucidly by adopting suitable soil management measures.

Soil borne pathogen can be controlled by varying means. Reducing the population of plant pathogen suppresses the plant diseases and hence, all disease management aims at decreasing plant population in agricultural environment. This can be achieved by increasing beneficial and other general microbial population so that harmful pathogen proportion can be decreased this in turn reduces the contact of pathogen with plant. In other way, introduction of antagonistic microbes is also helpful which control pathogen directly. These antagonistic microbes compete with pathogens for nutrients, water and space as a result growth of pathogen is restricted and disease development curtailed. Alternatively, in specific cases, antagonistic microbes produce antibiotics which kill the pathogen directly. Predatory microbes directly kill the pathogens. Antagonistic microbes usually exhibit multiple mechanisms as described above.

Soil management for pathogen reduction : Altering soil physical, chemical and biological conditions influences the plant pathogens. Soil pathogen control aims at establishing adverse soil condition for pathogenic microbes so that it does not favour pathogens and significantly reduces plant disease development. A disease suppressive soil is one in which the level of disease that develops on plants grown in that soil is lesser compared to the plants grown in other soils under similar conditions. Most of the soils have some disease suppressive properties. The phenomenon of disease suppressive soil should be thought of on a continuum from low to high levels of suppression rather than being disease suppressive or conducive. In many cases the disease suppressiveness of soil is decided by presence and activity of microorganisms. Bacteria, fungi, and soil borne fauna are responsible for collectively change the suppressiveness of a soil.

There are two types of disease suppression *viz.*, general and specific suppression. In general suppression, it is hypothesized that reduction of disease is due to the non-specific increase in the activity of the microbial community. General disease suppression is connected to the population and kinds of soil organism presences, soil

type and fertility status. The actual mechanism by which reduction in disease occurs is due to the nutrient competition, induced resistance, parasitism, and direct inhibition.

In case of specific suppression, the disease suppression is associated with the increase in specific microbial community such as parasitic, predatory and antagonistic microbes in soil. In this case, the antagonistic microorganisms respond to the pathogen as it serves as energy source for antagonistic microbes. The utility of biological controlling agents such as *Pseudomonas florescens, Tricoderma viridi*, etc. falls under specific disease suppression.

Following are some of the management practices that can increase disease suppressive properties of soils.

Addition of organic matter : Addition of organic matter in soil has beneficial effect on managing soil borne diseases. Addition of organic matter amendments can be done by incorporating crop residues, manures, peat moss, by-products of agro-industries (sawdust, chips, bark, bagasse, rice hulls and biosolids). Numerous reports are available to support the reduction is disease levels owing to the incorporation of organic matter into the soil.

The mechanism of disease reduction is so complex process. It act as a source of energy for microbes and thus by increases the soil microbial activity and population. This suppresses the soil borne pathogens and reduces root diseases considerably by means of competition or parasitism, the release of compounds that are toxic to the pathogens, and the stimulation of the host plant's disease defense system.

It also enhance the activity of beneficial microbes which helps to increase soil available nitrogen and phosphorous. Due to this, plant growth and resistivity to plant pathogen is enhanced to a considerable extent. A study on the effects of organic amendments on potato early dying disease informs that higher levels of soil organic matter decreased the disease level which is attributed to the increased nutrient holding capacity, water infiltration, and decreased soil crusting. The disease reduction is also because of the enhanced beneficial microbes such as *Pseudomonas putida*, *Trichoderma* spp. and others.

Specific kind of organic matter releases toxic compounds that inhibit or kill pathogens. The incorporation of sudan grass reduces nematode and fungal diseases in lettuce and potato due to the release of cyanoglucosides. The population of soil borne fungi such as *Fusarium oxysporum*, *Rhizoctonia solani* and *Verticillium dahliae* can be appreciably reduced by the incorporation of broccoli residues in soil which is due to the release of glucosinolates.

Numerous evidences are available for the positive influence of soil amendments in controlling foliar diseases in plant. Incorporation of paper mill residues in soil reduced the intensity of foliar disease in cucumbers and snap beans. Similarly, cannery waste is capable to decrease bacterial spot on tomato fruit. This might be due to the higher nutrient uptake, healthy plant nutrient status and acquired disease resistance such as Systemic Acquired Resistance (SAR) or Induced Systemic Resistance (ISR).

In many cases addition of organics not necessarily decrease the disease level in plant. Further, effectiveness of organic amendments varies with varying edaphic and climatic conditions. In fact, in certain situations, organic matter amendments increased the disease incidence. It might be due to the types and quality of organic matter, presence of contaminants in organic matter. Besides this, the physical, chemical, and biological condition of the soil, weather condition and type of crops is also determines the disease intensity while incorporating organics in soil.

Soil solorization : Soloarization is considered to be one of the best approach in reducing microbial population. Exposing soil dwelling spores to sunlight to kill the living pathogen is essential in case of soil borne pathogens. This is why summer ploughing is carried out by farmers if the crop is infected any root diseases in the previous season. This uplifts the spores living inside the soil to surface where it is killed by the scorching sunlight. This helps to reduce the inoculum load and hence disease is suppressed to a desirable extent.

Maintaining apt soil moisture condition : Excessive and prolonged moisture condition favours collar rot and damping off in many crops whereas prolonged dry soil condition encourages root rot and termite infestations.

Hence, soil needs to be kept under proper moisture condition so that these diseases can be avoided. Keeping soil moisture condition just below maximum water holding capacity is ideal for crop growth and reducing these kinds of pathogens. Excessive moisture needs to be reduced through suitable drainage provision depending upon the soil and drainage conditions. Dry soils should be irrigated to avoid prolonged dry condition with in soil.

Amendments for adverse soil conditions : Fungi in general grow profusely under acidic soil conditions and owing to this reason, fungal diseases are more predominant in acidic soils. Reducing soil acidity and bringing to neutral conditions nullifies this issue. Based on this principle, liming of soil is encouraged to reduce potato scab disease under acidic soils. In contrast, bacteria survive well under alkaline conditions and hence reduction in alkalinity helps to manage bacterial diseases suitably. Application of neem cake is beneficial in suppressing many pathogens as it has antimicrobial properties. Similarly many other useful plant products can also be applied.

Good sanitation practice : Maintaining healthy soil healthy conditions helps reducing disease incidence. Soil dwelling pathogens that are survived from the previous infested crop debris, is the source of inoculum which cause disease in plants. Hence, this source of inoculum must be removed suitably through proper sanitation measures such as removing, composting, and burying of infested crop debris. Burying crop debris restricts the pathogen spread by wind or splashing rain besides. This is applicable and effective for foliar pathogens and not applicable for soil borne and root-infecting pathogen as these are well adapted to live under adverse soil conditions. Sanitation is general disease suppression measures which can be considered as a preparatory control measure and not be as a prophylactic control measure.

Exploitation of biological control agents : Enhancing antagonistic microbes helps specific disease suppression. *Rhizoctonia* causes damping off and kills young seedlings under low temperatures and moist soil conditions. The antagonistic fungus *Trichoderma viridii* attacks mycelial stands of *Rhizoctonia* and cause death by dehydrating them. It can be applied as soil application or seed treatment in general.

Suitable crop rotation : Crop rotation is one of the measure which helps to reduce pathogen in a natural way. Planting a non-suitable host in a cropping sequence helps to reduce the population of pathogen in soil. Rice-pulses cropping system is suitable system which not only helps to reduce soil pathogen from rice crop but also increase the fertility levels of the soils too.

Crop rotation is not effective for managing all kinds of plant pathogens. Specific pathogens can able to thrive for longer time even without host crop whereas certain pathogenic organism invades the weed plants. Saprophytic pathogen lives over the organic matter and hence lives in soil for years together. Under these conditions, crop rotation is not helpful to reduce disease suppression.

Conclusion : Pathogen in soil causes plant disease which leads to reduction of microbial biodiversity especially beneficial organisms. The growth of pathogen in soil is controlled by the physical chemical and biological properties of the soil besides the general weather conditions, crop type and other factors. Soil borne diseases can be suitably controlled by managing soil conditions in such a way that it does not favour pathogenic organism. Addition of organic matter, suitable inorganic amendments, altering moisture conditions, soil solorization, enhancing beneficial organisms are some of the measures that creates apt soil condition for disease suppression. This is one of the natural means to control plant diseases which helps to sustain soil quality by the reduced usage of fungicides.

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