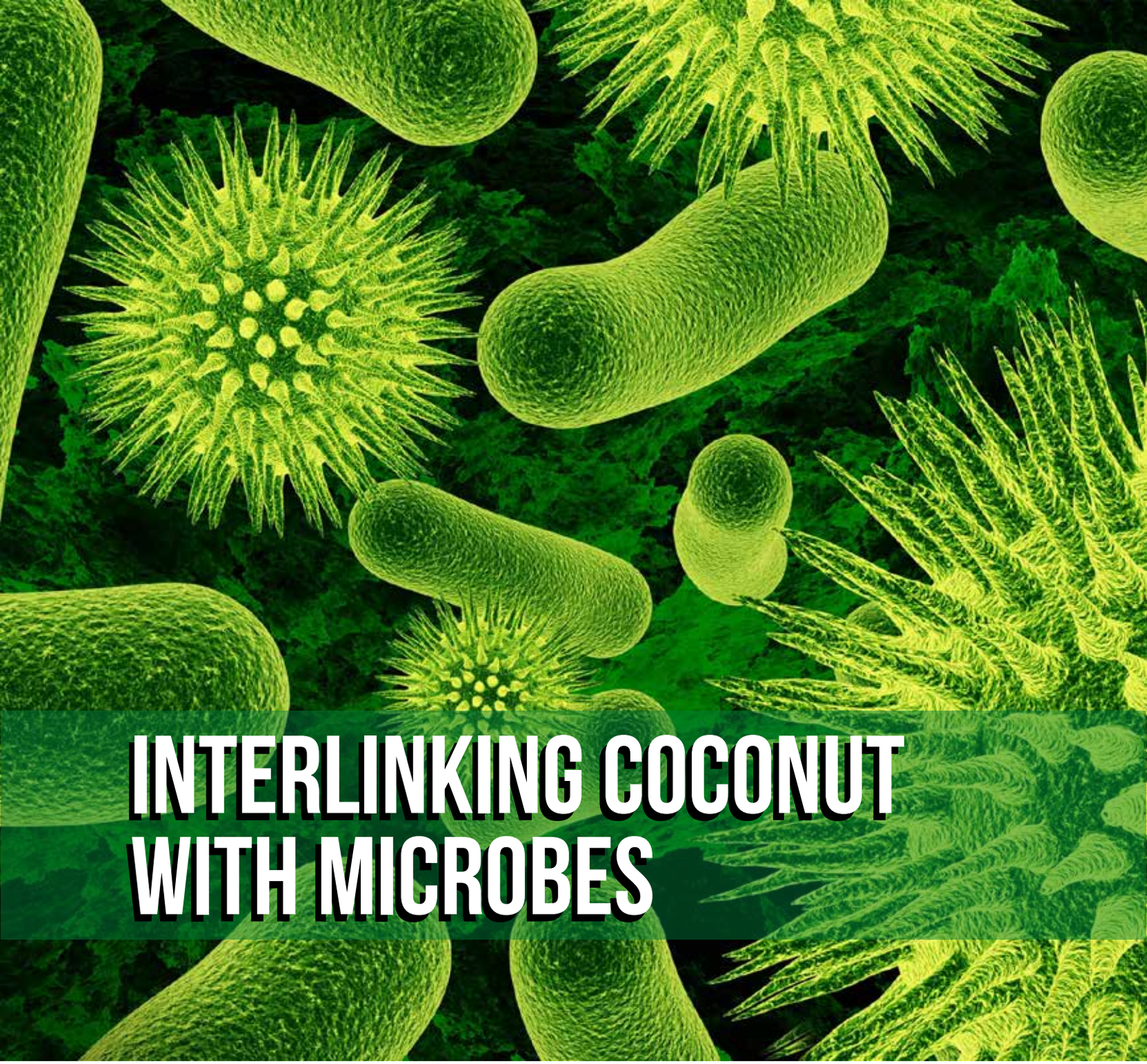

INTERLINKING COCONUT WITH MICROBES

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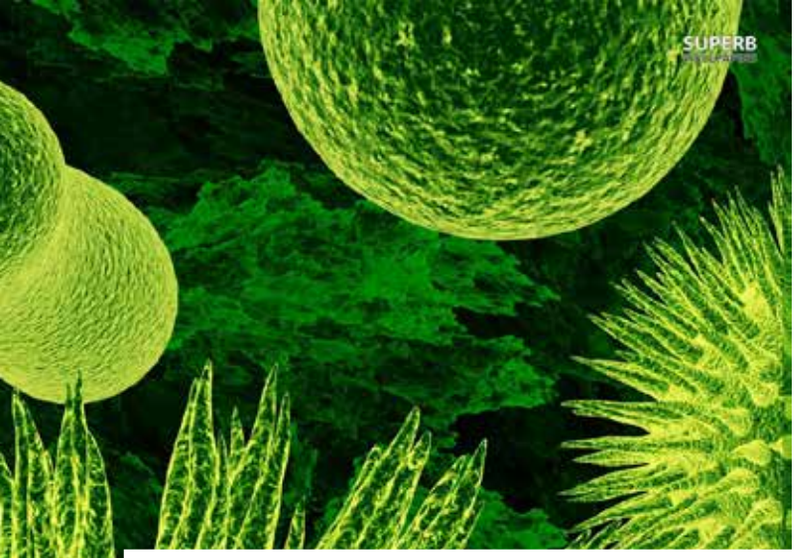
Microbes are organisms that are too small to be seen with naked eye but visible under a microscope. Microbes include bacteria, algae, fungi, viruses and protozoa. Plants and insects literally could not survive without microbes and therefore they form a multitude of relationships with many different kinds of microbes. Some of these relationships are essential and persistent, while others are circumstantial. These microbial interactions can be mutually beneficial, neutral or harmful.

Microbes play a pivotal role in the production and productivity of coconut also. The beneficial microbes enhance the productivity of the palm by increasing the nutrient availability and/or alleviating the biotic and abiotic stresses whereas the pathogenic microbes deteriorate the health of the palms. The Kalpavriksha also provides nutrient rich substrates for the mass multiplication of many beneficial bioagents as well as nutritional mushrooms.



BENEFICIAL MICROBES

Coconut, as like any plants succumbs to biotic and abiotic stresses. Plant bacterial interactions, especially in the rhizosphere determine plant health and soil fertility. Soil microbial investigations are mainly focused on soil management aspects to increase nutrient availability and disease alleviation by microorganisms in plantation crops. Beneficial microbial interactions result in

- Enhanced nutrient mineralization and availability to crops
- Stimulated plant growth
- Enhanced disease suppression
- Improved soil structure

Beneficial microorganisms associated with coconut are broadly grouped as nitrogen fixers, nutrient solubilizers and mobilizers and plant growth promoting rhizobacteria.

Nitrogen fixers are microorganisms which assimilate molecular nitrogen present in the atmosphere to ammoniacal nitrogen, a form available for plants in soil. Biological nitrogen fixation mediated by nitrogen fixing microorganisms is found ecologically and economically viable means to reduce the input of chemical nitrogenous fertilizer. Associative nitrogen fixing bacteria, Azospirillum and Asymbiotic nitrogen fixer, Beijerinckia sp. are found commonly associated with the coconut roots and rhizosphere soil respectively thus contributing enormously to the nitrogen requirement of the crop. Beijerinckia sp., Azospirillum sp., Burkholderia sp., Azoarcus sp., etc. are found effective bio-inoculants for better establishment of coconut nursery seedlings.

Green manures and cover legumes associated with efficient N-fixing strains of Rhizobium when incorporated in coconut basins recorded significant increase in the nitrogen content and are more efficient in terms of yield and stimulation of beneficial microbial activities.

Some heterotrophic bacteria and fungi are known to have the ability to solubilize mineral nutrient like phosphate, potassium, zinc and silicate from insoluble sources and making them available to plants. Pseudomonas sp., Enterobacter sp., Bacillus sp., Micrococcus sp., Corynebacterium sp. and Alcaligens sp. are the phosphate solubilising bacterial encountered in coconut plantation soils. Phosphate solubilising fungi Aspergillus and Pencillium are also found dominant in coconut grown soils. Inoculation of soils with efficient P-solubilising bacteria released more available P from insoluble P sources like rock phosphate.

The symbiotic association between mycorrhizal fungi and the roots by Arbuscular Mycorrhizal (AM) fungi consists of an internal phase inside the root and an external phase (extra radical mycelium (ERM) phase) which can form an extensive network within the soil. Mycorrhizae can increase the surface area of a plant root system helping plants to absorb more water and improving nutrient uptake like phosphorus (P), nitrogen (N), and micronutrients. Coconut cropping system is densely populated with diverse AM fungi. Claroideoglomus, Glomus and Gigaspora are the most commonly present genera. Claroideoglomus etunicatum and Glomus aggregatum are the common species associated with coconut roots. A soil based AMF bioinoculant, 'KerAM' containing Claroideoglomus etunicatum, one of the dominant sp. from coconut rhizosphere has been released, the application of which improves nutrient and water absorption in coconut seedlings.

Plant growth promoting rhizobacteria (PGPR) are known to improve plant growth through its direct or indirect mechanisms. It includes the ability to synthesize hormones like indole acetic acid (IAA), gibberellic acid and cytokinins, and enzymes like ACC deaminase, Most PGPR exhibit antagonistic activity against phytopathogenic microorganisms

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and help inducing systemic resistance in plants against the disease. Several species of Bacillus, one of the dominant genera of coconut rhizosphere are found to exhibit PGPR potential improving the growth of coconut seedlings. Bacterial endophyte Bacillus isolated from coconut roots has shown inhibitory effects against the fungal pathogens of coconut palm. Serratia marcescens and an Enterobacter sp. from coconut rhizosphere possessed multifarious beneficial traits and plant growth promoting potential. One of the best PGPR, Bacillus megaterium from coconut rhizosphere has been released as talc based bio-inoculant 'Kera Probio' for application in nursery seedlings.

Following practices can be adopted in coconut plantations to enhance beneficial rhizosphere microflora

- Bio-priming of coconut seedling with efficient microbial bio-inoculants Recycling of farm wastes in the form of compost or vermicompost
- Application of biofertilizers/PGPR/AM along with farmyard manure or compost
- Basin management with legume cover crops -growing and incorporation of legume crops in coconut basins
- Adopting moisture conservation methods such as mulching with coconut husk, coir dust, coconut leaves, etc. in addition to application organic manures or green manures

PATHOGENIC MICROBES

Microbes causing diseases to plants are called plant pathogens. Coconut palm is susceptible to a number of diseases caused by microbes. Some of them are fatal while others reduce its vigour. Among the diseases affecting coconut palm in India, root (wilt), leaf rot, bud rot, stem bleeding and basal stem rot are the major problems owing to the nature of disease and extent of damage. Some of these diseases can be effectively managed by beneficial microbes known as biocontrol agents.

Root (wilt) and leaf rot are the two diseases prevalent in the southern districts of Kerala. Root (wilt) is a phytoplasmal disease transmitted by insect vectors- plant hopper and lace wing bug. The most obvious and diagnostic symptom of the disease is the abnormal inward bending of the leaflets termed ribbing or flaccidity. Yellowing and marginal necrosis of leaflets are the other associated foliar symptoms The disease also causes several internal changes in the palm. The yield of disease affected palms can be sustained or even improved through adoption of integrated

management practices that involves balanced fertilizer application, soil conditioning with organic manures etc. The resistant/tolerant varieties Kalparaksha (selection from Malayan Green Dwarf), Kalpasree (selection from Chowghat Green Dwarf) and the hybrid Kalpasankara (Chowghat Green Dwarf X West Coast Tall) released from Central Plantation Crops Research Institute (CPCRI) are suitable for cultivation in RWD endemic tracts.

Leaf rot disease, caused by fungi Colletotrichum gloeosporioides, Exerohilum rostratum and Fusarium spp. occurs superimposed on root (wilt) affected palms. About 65 % of root (wilt) diseased palms are affected by leaf rot disease caused by fungi. Normally farmers identify a palm as root (wilt) affected only when the leaf rot sets in. In diseased palms, tiny water soaked lesions appear on spindle leaves which gradually enlarge, coalesce freely leading to extensive rotting. The rotten portions dry up, turn dark brown to black, break and are blown off in the wind. In many cases, the rotten distal portions of leaflet adhere to each other from top to bottom on both sides thereby giving a fish bone appearance. Palms of all ages are susceptible to this disease. Leaf rot causes reduction in photosynthetic area, disfiguration of the palms and reduction in yield apart from attracting a number of insects that feed, multiply and cause further damage. Severity of leaf rot symptom is more during monsoons. The integration of leaf rot management with pest management and general cultivation practices is very effective in improving the health of the palms and thereby increasing the yield. Remove rotten portions of the spindle leaf and the adjacent two innermost fully opened leaves. Apply the solution of the fungicide Hexaconazole 5 EC (2 ml in 300 ml water/palm) or talc based formulation of bio agents Pseudomonas fluorescens or Bacillus subtilis (singly or in consortium @ 50 g in 500 ml of water/palm) are effective for the management of leaf rot disease. In disease endemic areas, treat all palms in the plantation (healthy and diseased) twice a year. To make this operation more economical the treatment should be given along with harvest of nuts before and after the monsoon.

Bud rot is a fatal disease of coconut caused by the fungus Phytophthora palmivora. Symptoms of the disease include withering of the spindle leaf which gradually turns brown and bends down. The affected spindle leaf can easily be pulled out as the basal portion of the spindle is completely rotten emitting a foul smell. Later the inner leaves also fall away one by one leaving only outer whorl of matured leaves in the crown. Ultimately the palm succumbs to the disease with the death of the growing bud. Bud rot disease can be effectively managed by adopting integrated management practices. Removal of dead palms will help to reduce the inoculum load in the plantation and check the fast spread of the disease. Rotten portion of the crown should be destroyed by burning. After removal of the diseased palm, the gaps may be filled by planting good quality coconut seedlings, wherever sufficient space is available. Curative measures have to be adopted when the spindle has just started showing symptoms of withering. Remove the affected tissues completely and treat the wounds with Bordeaux paste 10%. The treated wound should be covered with polythene cover

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to prevent entry of rain water and this protective covering should be retained till normal shoot emerges. In disease endemic areas, spraying using 1% Bordeaux mixture before the onset of monsoon is a very effective prophylactic treatment.

Stem bleeding is a fungal disease that is known to occur in almost all coconut growing regions. The disease is characterized by the occurrence of a dark reddish brown liquid exudation from the longitudinal growth cracks present on the stem bark. The disease can be effectively managed if control measures are adopted in early stages of infection. Apply a paste of talc based formulation of Trichoderma harzianum on the bleeding patches on the trunk. Basin application of T. harzianum enriched neem cake 5 kg per palm basin per year during September- October will reduce the pathogen load in the soil. Since wounds on the trunks predispose the palms to infection, any type of wounding of palms is to be avoided. Care should be taken not to injure the stem base while ploughing the garden with tractor.

Basal stem rot also known as Thanjavur wilt is a very important destructive disease of coconut in Tamil Nadu caused by the fungus Ganoderma sp. The disease can be effectively contained by following an integrated approach with cultural, chemical and biological methods.

KALPAVRIKSHA PROVIDES SUBSTRATE FOR MASS MULTIPLICATION OF BIOAGENTS

The research on better resource management is gaining momentum which emphasizes the need for the maximum residue utilization. Managing agricultural wastes as a sustainable asset not only improves the soil health but increases the farmer's profit also. One of the practical ways to manage agricultural waste is to recycle it for the mass multiplication of biocontrol agents. Coconut water is discarded as an agricultural waste in copra industry. Coconut water which is rich in nutrients supports faster growth of the biocontrol agents. Bacterial biocontrol agents like Pseudomonas fluorescens and Bacillus polymyxa can also be successfully multiplied in coconut water to make the product cost effective. The suitability of mature coconut water for multiplying biocontrol agents like has been studied by different workers. Coconut water has been reported as a low cost liquid medium for the mass production of M. anisopliae, Trichoderma spp. Beauveria bassiana, Paecilomyces fumosoroseus, Verticillium lecanii and Gliocladium virens,.

Coir pith is a byproduct of coir industry. This highly lingo-cellulosic material is rich in potash and micronutrients. Trichoderma sp. is efficient in reducing organic carbon and increasing nitrogen content of coir pith. Pleurotus sajor-caju, Trichoderma sp. and Aspergillus are potent degraders of coir pith. Coir pith amended with coconut water is a medium conducive for mass multiplication of biocontrol agents like Trichoderma. Coir pith is also suitable for the mass production of bacterial antagonists.

TASTY AND NUTRITIONAL MUSHROOMS FROM COCONUT BIOWASTES

A low cost technology has been developed by CPCRI for cultivation of oyster mushroom (Pleurotus spp.) utilizing coconut wastes such as leaf stalk, bunch waste, leaflets, coir pith etc. Mushroom cultivation can be undertaken by women, unemployed youth etc. This technology can not only be the source of income but also provide nutritional security to the family.

All life forms are associated with microbes, the association being positive or negative. Though some of the microbes are pathogenic to the crop, studies on plant- microbe interactions have revealed a great deal of benefits bestowed upon the host by the associated beneficial microbiome. The knowledge on coconut-microbe interaction will help us to streamline the approach and strategies of crop production.