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Interactions of phyllosphere microorganisms

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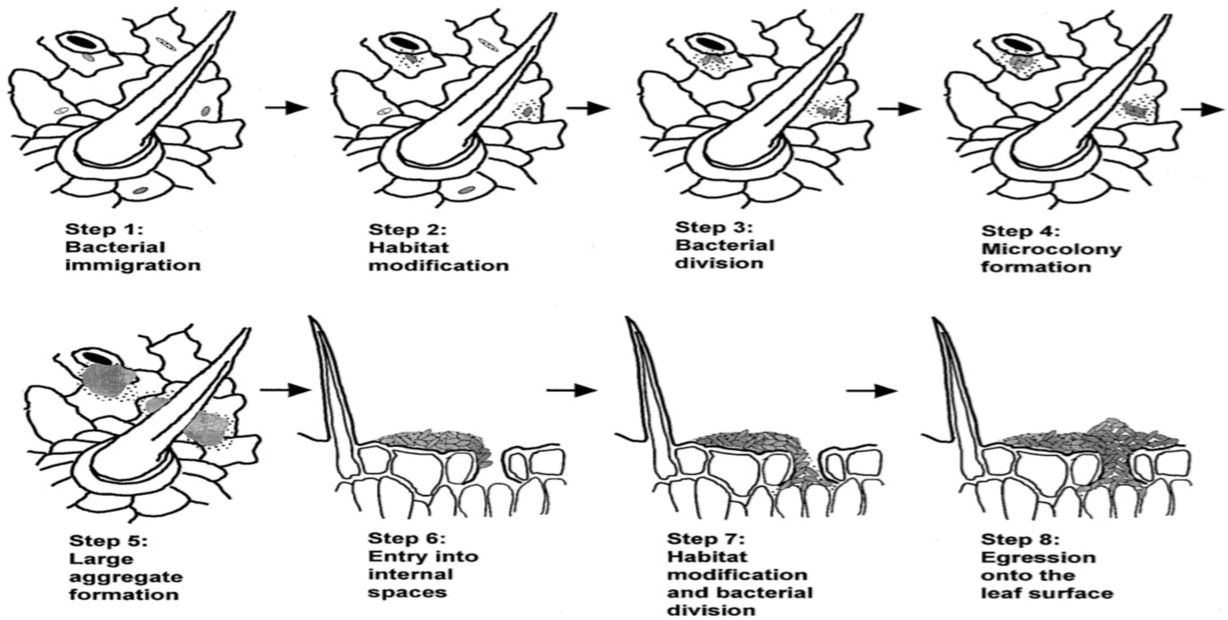
Abstract: Phyllosphere microorganisms play a crucial role in plant health and ecosystem dynamics through complex interactions among bacteria, fungi, and their host plants. These interactions can be mutualistic, pathogenic, or neutral, influencing nutrient cycling, disease resistance, and plant growth. Recent studies have delved into the ultimate effects of environmental factors, such as climate and land use, on microbial community composition and function. Understanding these interactions offers insights into agricultural practices and ecological stability, highlighting the potential for harnessing phyllosphere microorganisms in sustainable management strategies.

Introduction: Phyllosphere microorganisms have extensive interactions with each other, including competition for nutrients and their ecological niche, direct inhibition, and indirect inhibition. There are three types of interactions affecting the assembly of phyllosphere microorganisms:

1. Plant−Microorganism
2. Microorganism−Microorganism
3. Microorganism−Herbivore−Plant

Colonization of Bacteria:



Distinct phyllobacterial species probably colonize leaves in different ways. Due to the similarities among bacteria in their requirements for growth and survival, however, the colonization strategies of these distinct species must contain at least some common elements. Based on the concept a general model of leaf colonization that represents how many of these bacteria including foliar pathogens colonize leaves. This model is illustrated in above figure and involves the following steps.

Step 1. Bacteria arrive on the leaf surface via airborne, waterborne, or vector deposition and are randomly distributed across the leaf surface, usually in the form of individual cells or small clumps of cells.

Step 2. While some of these cells may enter into the leaf via openings such as stomata or hydathodes, many of those on the surface modify their local environment. This may occur by mechanisms such as enhancing nutrient release from the plant leaf and producing extracellular polysaccharides.

Step 3. The bacteria that can modify their environment divide, and their increased cell numbers facilitate further habitat modification. Those surface bacteria that do not modify their environment have a lower probability of survival.

Step 4. Bacterial multiplication results in the formation of a microcolony. This microcolony may be either homogeneous, if it contains only progeny from a single cell, or heterogeneous, if other cells are incorporated into it. Heterogeneity may result from immigration subsequent to multiplication, envelopment of one or more neighboring cells into the microcolony, or convergence of microcolonies. If incorporation of a cell into a microcolony enhances its ability to multiply or survive, such incorporation would be an important process in community development.

Step 5. The microcolonies develop into large aggregates that, like the microcolonies themselves, may be either homogeneous or heterogeneous in bacterial composition.

Step 6. At least for foliar pathogens, the bacteria enter into the internal spaces of the leaves. High density growth in aggregates may facilitate ingress by density or growth stage dependent gene induction that results in phenotypes that aid in ingress.

Step 7. The bacteria multiply in the leaf intercellular spaces, aided by their ability to modify the intercellular habitat.

Step 8. The bacteria egress onto the leaf surface. This egression may be mediated or enhanced by water-soaking or canker or lesion formation.

The relationships between microorganisms and also with their hosts include,

i. Competition
ii. Commensalism
iii. Antibiosis
iv. Mutualism
v. Parasitism

Mutualism: Interaction where two organisms benefit each other without affecting each other. In phyllosphere, the benefits provided by plant are space, nutrients and some secondary metabolites, the advantages provided by phyllosphere microorganisms are production of harmones which helps in growth and give them fitness, resistance to biotic and abiotic stresses.

Commensalism

It is a interaction where one obtains benefits from other without either harming or benefiting the latter. Example: Biofilm formation: initial colonizer helps other microorganisms to attach.

Antibiosis

It is an antagonist association between an organism and metabolic substance produced by another. Example: *Pseudomonas* and *Bacillus* spp. produce secondary metabolites and antibiotics which are antagonist to many fungal pathogens.

Parasitism

It is a relationship in which one organism, the parasite, lives on or within body of another organism i.e, host, harming it, and possibly causing death. Example: most pathogenic fungi

Ouorum sensing:

Quorum sensing (QS) is a bacterial cell–cell communication process that involves the production, detection, and response to extracellular signaling molecules called autoinducers (AIs). Processes controlled by QS include bioluminescence, sporulation, competence, antibiotic production, biofilm formation, and virulence factor secretion. Gram-positive bacteria use **autoinducing peptides (AIP)** as their autoinducers. Gram-negative bacteria produce **N-acyl homoserine lactones (AHL)** as their signaling molecule. Quorum sensing in *P. syringae* B728a is important for epiphytic fitness by inducing EPS production and indirectly desiccation.

For the bacteria to use quorum sensing constitutively, they must possess three abilities: secretion of a signaling molecule, secretion of an autoinducer (to detect the change in concentration of signaling molecules), and regulation of gene transcription as a response. This process is highly dependent on the diffusion mechanism of the signaling molecules. QS signaling molecules are usually secreted at a low level by individual bacteria. At low cell density, the molecules may just diffuse away. At high cell density, the local concentration of signaling molecules may exceed its threshold level, and trigger changes in gene expression.

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