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Survival and Dissemination of Phytopathogenic Bacteria

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Survival of Bacterial Pathogens

Introduction

Natural habitats usually do not provide bacteria the continuity of agricultural crops. With continuous culture perpetuation of pathogen is no problem. Although agricultural practices provide some discontinuity between crops, it is less than that in nature. Uniformity of crop germplasms also favors inoculum buildup and perhaps perpetuation of the pathogens. The growth of most plant pathogens is discontinuous, because of the seasonal effect upon either the pathogen or the host. A successful pathogen must be able to bridge discontinuities, such as the gaps between successive crops and seasons. To reestablish when conditions are again favorable, inoculum must survive. Facultative saprophytes or facultative parasites are not as handicapped by discontinuous growth as are obligate parasites. Discontinuous growth of the pathogen mainly decreases the amount of inoculum (bacteria that cause disease when placed in suitable contact with the host).

The success of a bacterial plant pathogen depends in part on the amount of inoculum (bacterial cells) it produces. Because bacteria have a short generation time, a small amount of surviving primary inoculum can rapidly produce an epidemic. What is the minimum amount of inoculum necessary to initiate disease? Enough for mere survival is not necessarily the answer since transmission to a host is necessary. The source, exit, and transmission of primary inoculum are all necessary for occurrence of disease, for survival, and for continuity of the bacterial species. Establishment of a "curtain" between host and pathogen may be simpler and cheaper during the primary inoculum phase than thereafter.

Plant pathogenic bacteria mostly develop on the host plant as parasites and partly in the plant parts or in soil as saprophytes. They remain alive with restricted activity in association with seed, plant residue, soil, insects, perennial plants, epiphytes and other non-host materials. The survival of phytobacteria are discussed with suitable example hereunder.

I. Survival with seed

Bacteria can survive with seed as cells present in (internally seed borne) or on the surface of the seed (externally seed borne) as well as in (or) on plant debris mixed with seed lot (seed contaminant). Smith (1909) first reported the external and internal mode of transmission of *Pantoea stewartii* in corn.

II. Survival in plant residue

Bacteria can survive in the crop debris left in the field depending upon the weathering of debris. Moreover, plant pathogenic bacteria are the weak competitors and they are highly susceptible to the activities of other microorganism associated with decomposition of crop debris. Species of *Clavibacter* apparently survive for a year (or) more with plant debris in soil. However, burying of plant debris hasten its mortality. But *Pectobacterium carotovorum* sub sp. *carotovorum* survive in plant debris in soil, grows into the rhizosphere or rhizosplane of the host (or) non host and prolong their survival for another 1-2 years. Persistence of bacteria in the plant debris is also decided by soil environment. The survival period of *Xanthomonas axonopodis* pv. *malvacearum* and *Xanthomonas oryzae* pv. *oryzae* is drastically reduced in wet condition.

III. Survival in soil

Soil is the best media that harbors or supports many microorganisms. Plant pathogenic bacteria survive mostly as saprophytes in soil. Buddenlagen (1965) classified the bacterial plant pathogens in soil as

a. **Transient visitors (Soil invaders):** This group contains of species whose population is developed almost exclusively in the host plant and whenever that bacterium reaches the soil, its population decline rapidly and they don't remain important sources of primary inoculum. Most of the *Xanthomonas, Erwinia* and *Clavibacter* fall under this category.
b. **Resistant visitors/Soil inhabitants:** These are the true soil borne pathogens that have maxinum generation in the host. They serve as primary inoculum for the initiation of disease, their population decline gradually in the soil and long term persistence in soil depends upon the presence of host tissue, soil temperature and moisture (e.g. *Rhizobium radiobacter*, *Streptomyces scabies* and *Ralstonia solanacearum* race 1).
c. **Soil saprophyte**: These bacteria have a permanent phase in soil and whose relation to plant disease is only ephemeral (e.g. fluorescent Pseudomonas sp causing soft rot and species of Bacillus pathogenic to plant, survive as saprophyte in the soil).

IV. Survival in perennial host

Perennial host plants are the easy source of survival of pathogenic bacteria in tropical and temperate regions. The perennating pathogens are known to carry over from season to season in the infected plant parts (e.g. *Erwinia amylovora* -fire blight of apple and pear and *Xanthomonas citri* pv. *citri* - citrus canker).

V. Survival as epiphyte

Bacteria can thrive and survive well on the roots, buds, leaves, seed surface and its exudates as epiphyte (e.g.) *Pseudomonas syringae* pv. *syringae* survive as epiphyte in tomato seedling are transmitted to long distance through symptomless seedlings. Similarly *Erwinia amylovora* survive epiphytically on apple buds during its dormancy period.

VI. Survival with insects

Some groups of bacteria are known to have intimate relationship with insects for their transmission. But only few of them have a resident phase in the insect vector for their survival. Among this, mostly species of *Erwinia* / *Pantoea* reside inside the insect vectors. Corn wilt bacterium (*P. stewarti*) is present in the intestinal tract of *Diabrotica undecimpunctata.* The *Pectobacterium carotovorum* subsp. *Carotovorum* (black leg of potato) survives in the intestinal tract of both larvae and adult of seed corn maggot (*Hylemya platura*) in spite of their ability to survive in tubers and soil. The same bacterium also survives internally in *Drosophila melanogaster* (fruit flies) for 2-3 days and externally for 1-2 days.

VII. Survival with non host materials

Most of the farm implements and equipment used in planting, harvesting, intercultural operations, storage act as major site for the survival of bacteria like *Clavibacter sepidonicum*, *Ralstonia solanacearum*, *Xanthomonas axonopodis* py. *malvacearum* and *Pseudomonas syringae* pv. *phaseolicola* for long period.

Dissemination of Bacterial Pathogens

Plant pathogenic bacteria should be dispersed or spread from the source of survival to the host plant or its plant parts for the initiation of disease cycle either by active or passive manner.

Active dispersal

This is the autonomous dispersal of inoculum through soil, seed or vegetative propagative material. Weeds and volunteer crop plants are known as source of survival and transmission of bacteria. Most of the solanaceous weeds harbor *Ralstonia solanacearum* and *Clavibacter michiganensis* and all species of Brassica act as host for *Xanthomonas campestris* pv. *campestris.* Most plant pathogenic bacteria develop primarily in their host and have saprophytic soil borne phase. Bacteria present in the diseased plant reach the soil through plant exudates, rain splash, sprinkler irrigation etc. are carried during crop husbandry with farm implements or machineries and through boot of workers. Infected seeds and vegetative propagative materials act as primary source for the initiation of disease epidemics. For example, seed borne inoculum of *Xanthomonas oryzae* pv. *oryzae* leads to "*kresek phase*" symptom of bacterial blight in paddy nursery. Further, bacterium released from the sown seed may pass into the soil and act as inoculum for further spread. In wheat seed lots contaminated by the presence of infected crop debris with *Anguina tritici* galls facilitate the transmission of bacterium *Rathayibacter tritici*. Citrus canker, crown galls of apple, soft rot of potato, ring rot of potato etc., are some of the common examples under the dispersal by vegetative propagating materials.

Passive dispersal

Unlike fungi, the bacteria do not have the mechanisms for launching themselves into the air and even if motile, their motility is restricted to liquid medium for a snot distance. Hence they are well adapted to the passive dispersal than active dispersal. The agents involved in passive dispersal are water, wind, wind splashed rain water, insects, nematodes, man etc which are discussed hereunder.

1. Water

Water not only act as a medium for dispersal but also helps in the initial establishment of bacterial pathogens in host plant. Washing or spattering effect of rain carries and distribute bacteria from one plant to another, from one part to another, soil and from soil to lower plant parts. Flood irrigation helps the dispersal of bacterial leaf blight (*Xanthomonas oryzae*. pv. *oryzae*) and leaf streak diseases in paddy (*X. o*. pv. *oryzicola*). However, the dispersal of *X.axonopodis* pv. *phaseoli* and *Pseudomonas syringae* pv. *phaseolicola* in beans is aided by sprinkler type of irrigation.

2. Air

Wind cause injury to plant parts whenever they rub against each other and helps in spread of bacteria. Wind disperse some bacterial cells engulfed in water droplets (aerosol) dust, plant debris etc. Bacterial aerosols may be taken up on to the air and dispersed over long distance by air currents. The cells of *Xanthomonas axonopodis* pv. *malvacearum* (black arm of cotton); *X. oryzae* pv. *oryzae* (bacterial blight of rice); *X.citri*. pv. *citri* (canker of citrus); *X. campestris* pv. *campestris* (black rot of crucifers) and *Clavibacter michiganensis* subsp *michiganensis* (bacterial canker of tomato) are predominately disseminated by wind-blown rain splash.

The bacterial cells found in air along with soil particles are easily blown by wind. Depending upon the wind velocity, these particles cause mild injury on plant surface, which facilitate the entry of bacteria. Similar mode of dispersal is observed with *X. axonopodis* pv. *malvacearum* and *Streptomyces scabies*.

3. Insects

Insects with sucking or biting mouth parts frequently transmit bacteria. The most incidental but often intimate biological association of insects can help in the dispersal of bacteria. The insects may get contaminated with the bacterial cells during their routine activities like foraging, nectar or pollen collection transmits bacteria later casually or accidentally. The fire blight bacteria (*Erwinia amylovora*) spread easily by more than 100 species of insects including bees, butterflies, aphids, ants, and wasps etc. which casually visit apple and pear blossoms. Fruit flies that visit the dumped rotten vegetable may act as vector for the transmission of soft rot bacteria.

There are certain cases in which the insects are to be the sole means for the bacterial dispersal. For example, corn wilt (*Pantoea stewarti*) and cucumber wilt (*Erwinia tracheiphila*) are solely dispersed respectively by corn flea beetle and stripped / spotted cucumber beetle by their close biological relationship.

In addition to insects, nematodes are being implicated in the spread of the disease. In wheat, *Rathayibacter tritici (tundu* disease) is unable to produce the symptom in absence of nematode (*Anguina tritici*) which presumably acts as a vector.

4. Man

Man who is solely responsible for the global distribution of many devastating bacterial diseases since other natural agencies normally help in a short distance dispersal. Movement of seed and planting material from one location to another as well as cultural practices adapted by him for raising and harvesting the crop also facilitate easy dispersal of some pathogenic bacteria. We can trace many well known examples of bacterial diseases that spread mainly through improper and neglected quarantine measures. For example citrus canker is introduced into Japan from USA; fire blight of apple from USA to Europe, bacterial canker of tomato from USA to England and bacterial leaf blight of paddy from Japan to India.

The contaminated farm tools and other devices helps in the dispersal of pathogenic bacteria. In potato, the cutting knives contaminated with *Clavibacter michiganensis* dispersed the bacteria from infected tubers to healthy potato seed pieces.