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Bacteriophage: An emerging bioagent in eco-friendly management of bacterial plant diseases

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Introduction:

Diseases incited by bacterial plant pathogens are responsible for major economic losses to agricultural and horticultural production. Chemical-based management with bactericides has been extremely difficult because few effective bactericidal formulations are available in the market. Copper has been used more extensively than any other chemical for the management of bacterial plant diseases. However, copper resistance is present in many plant pathogenic bacteria and is associated with plasmid-borne and chromosomal resistance. Antibiotics (streptomycin) have also been used as part of a management strategy for various bacterial diseases. As a result of extensive use, streptomycin-resistant strains became prevalent, which resulted in reduced disease management efficacy of bacterial spot of tomato and bell pepper, fire blight of apple and pear, and many other bacterial plant pathogens. More recently, systemic acquired resistance (SAR) plant inducers have been used and have shown some success against bacterial diseases of tomato and bell pepper, Xanthomonas leaf blight of onion, and fire blight of apple. These inducers also may have some negative effects on yield in certain plant species. Plant inducers have been ineffective for disease management in some path systems. Bacteriophage-based control of bacterial plant diseases is an emerging niche area of research as a part of the biological management of crop bacterial diseases. A wide range of strategies (prevention of development of phage-resistant mutants, proper selection of efficient phases, the timing of phage application, maximizing chances for interaction between phage and target bacterium, overcoming adverse factors in phyllosphere on phage persistence, development of solar protestants to increase phase bio-efficacy and delivery of phages in the presence of phage-sensitive bacterium) has been utilized to increase management efficacy. Phages are utilized as a component in developing integrated disease management strategies along with SAR inducers, a virulent strains, copper-based fungicides. Owing to their increased efficacy and contribution to sustainable agriculture, phage-based products are likely to gain a bigger share in the bactericide market in the near future.

Bacteriophage:

A bacteriophage (from 'bacteria' and Greek *phagein* 'to eat') is any one of a number of viruses that infect bacteria. Bacteriophages are amongst the most common biological entities on Earth. The term is commonly used in its shortened form, phage. Typically, bacteriophages consist of an outer protein capsid enclosing genetic material. The genetic material can be ssRNA, dsRNA, ssDNA, or dsDNA (i.e ss- single-stranded and ds- double-stranded) along with either circular or linear arrangement. The most striking form of phage infection is that in which all of the infected bacteria are destroyed in the process of the formation of new phage particles. This results in the clearing of a turbid liquid culture as the infected cells lyse. When lysis occurs in cells fixed as a lawn of bacteria growing on a solid medium, it produces holes or areas of clearing, called plaques. These represent colonies of bacteriophage. The size and other properties of the plaque varies with individual viruses and host cells. Since the early 1990s, various approaches were attempted to improve the competitive advantage of phage's in the environment in order to improve their efficacy including prevention of development of phage-resistant mutants, proper selection of efficient phages, the timing of phage application, maximizing chances for interaction between phage and target bacterium, overcoming adverse factors in phyllosphere on phage persistence, development of solar protect ants to increase phase bio-efficacy and delivery of phage's in the presence of phage-sensitive bacterium.

Management of Bacterial Plant Diseases:

Mallman and Hemstreet (1924) isolated the 'cabbage- rot organism', *Xanthomonas campestris* pv. *campestris*, from rotting cabbage and demonstrated that the filtrate of the liquid collected from the decomposed cabbage inhibited *in vitro* growth of the pathogen. The following year, Kotila and Coons (1925) isolated bacteriophages from soil samples that were active against the causal agent of blackleg disease of potato, *Erwinia carotovora* subsp. *atroseptica*. They demonstrated in growth chamber experiments that co-inoculation of *E. carotovora* subsp. *atroseptica* with phage successfully inhibited the pathogen and prevented

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the rotting of tubers. These workers also isolated phage's against *E. Carotovora* subsp. *carotovora* and *Agrobacterium tumefaciens* from various sources such as soil, rotting carrots, and river water. Thomas (1935) treated corn seeds that were infected with *Pantoea stewartii*, the causal agent of Stewart's wilt of corn, with bacteriophage isolated from diseased plant material. The seed treatment reduced disease incidence from 18 to 1.4 percent isolated eight phages active against the pathogen, screened them for host range and lytic ability and selected a lytic phage with the broadest host range for disease control trials. Biweekly spray applications of the phage suspension in producing orchards significantly reduced bacterial spot incidence on fruits used a mixture of three phages for controlling fire blight on apple blossoms and achieved significant (37%) disease reduction. Effectively controlled the disease in greenhouse and field experiments with a mixture of four host-range mutant phages active against the two predominant races of the pathogen, *X. Campestris* pv. *vesicatoria*. Tanaka *et al*. (1990) reduced tobacco bacterial wilt by co-application of an avirulent strain of *R. solanacearum* with a phage that was active against both the virulent and avirulent strains. Svircev *et al*. (2006) reduced the fire blight of pear with the co-application of an antagonistic epiphyte, *Pantoea agglomerans*, and a phage that lysed both the antagonist and the pathogen, *Erwinia amylovora* .

Conclusion and Future Perspectives:

Application of bacteriophages for managing bacterial plant diseases, is an emerging field with great potential. The concern about environment-friendly sustainable agriculture and the rise of organic crop production necessitates improvements in biological management strategies, including the use of bacteriophages against bacterial plant pathogens. On the other hand, the lack of knowledge about the biology of phage–bacterium–plant interaction and influencing factors hinders progress in the field. Much research in these areas is needed before phage's can become effective and reliable agents of plant disease management. Hence Phage's can be used effectively as part of integrated disease management strategies.

References:

Coons GH, Kotila JE (1925) *Phytopathology* 15:357–370

Flaherty JE, Jones JB, Harbaugh BK, Somodi GC, Jackson LE (2000) *Hortic Sci* 35:882–884

Kotila JE, Coons GH (1925) *Michigan Agri Exp Stn Tech Bull* 67:3–29

Mallmann WL, Hemstreet CJ (1924) *Agri Res* 28:599–602

Manulis S, Zutra D, Kleitman F, Dror O, David I, Zilberstaine M, Shabi E (1998) *Phytoparasitica* 26:223–230

Saccardi A, Gambin E, Zaccardelli M, Barone G, Mazzucchi U (1993) *Phytopathol Mediterr* 32:206–210

Schnabel EL, Fernando WGD, Meyer MP, Jones AL, Jackson LE (1999) *Acta Hortic* 489:649–654

Svircev AM, Lehman SM, Kim WS, Barszez E, Schneider KE, Castle AJ (2006) Proceedings of the Ist international symposium on bio control of bacterial plant pathogens. *Die Deutsche Bibliothek – CIP-Einheitsaufnahme*, Berlin, Germany, pp 259–261

Tanaka H, Negishi H, Maeda H (1990) *Ann Phytopathol Soc Jpn* 56:243–246

Thayer PL, Stall RE (1961) *Proc Fla Hortic Soc* 75:163–165

Thomas RC (1935) *Phytopathology* 25:371–372

Zaccardelli M, Saccardi A, Gambin E, Mazzucchi U (1992) *Phytopathol Mediterr* 31:133–140