A Review on Current Trends and Future Perspective of Disease management of tomato through PGPB

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ABSTRACT: Tomatoes are the second most widely grown vegetable in the planet. It is vulnerable to more than 200 illnesses caused by a variety of pathogenic fungus, nematodes, bacteria, and viruses during cultivation and post-harvest storage. Despite the fact that a broad variety of chemical pesticides are now available to control plant diseases, continual pesticide application affects not only the nutritional content of tomatoes but also the texture and productivity of soil. Plant growth promoting bacteria (PGPB) are one of the most environmentally friendly, safe, and effective options for the control of tomato diseases and pathogens. A variety of microorganisms are now being utilized as soil or plant inoculants in a variety of plants, including tomato, as a biocontrol agent. These inoculants are growth modulators as well as disease inhibitors. The current paper discusses the biocontrol potential of PGPB strains as well as disease management methods in tomato.

KEYWORDS: Agriculture, Biocontrol, Disease management, Plant Growth Promoting Bacteria (PGPB), Tomato.

1. INTRODUCTION

According to recent estimates, illnesses produced by fungus, nematodes, bacteria, and viruses cause large percentage of vegetable crops to degrade yearly during growth or post-harvest storage. Over thousands of years, this has been one of the main limiting variables affecting food production and human progress. Chemical pesticides have been the standard control tool for disease management in crop and vegetable production for the last 50 years. Continuous exposure to chemical pesticides such as fungicides and weedicides has a negative impact on production, soil texture, vegetable nutritional value, and human health. Because of the dangers of chemically manufactured herbicides and pesticides, disease control via biological methods is a new developing technique that is gaining significance in improving agricultural sustainability [1].

Tomato (Solanum lycopersicum L.) is the world's second most significant vegetable crop, after potato, with projected output of 170 million MT in 2014, with China accounting for 31% of the total, followed by the United States, India, and Turkey. Tomatoes are utilized as a model plant for genetic research on fruit quality, stress tolerance (biotic and abiotic), and other physiological characteristics, in addition to being the most significant vegetable crop in the world. This is well-suited to a broad range of agroclimates, from the tropics to the temperate zones. Currently, infections in the field or postharvest processing are recognized to have a significant impact on tomato output and quality. Without an efficient microbial growth inhibitor, disease development during field or/post-harvest storage and shipping leads in significant economic loss. As a result, a significant need for a long-term strategy to plant disease control exists. In this respect, plant growth promoting bacteria (PGPB) soil or plant microbial inoculants seem to be a viable method for disease control in various crops and vegetables [2]–[5].

1.1. Rhizosphere and plant growth promoting bacteria (PGPB) of tomato:

The root exudates, which include a variety of chemical signals, carbon-containing metabolites such as shedding of root cells, exudation, secretion, and the leakage of sugars, organic acids, and amino acids in the soil matrix, are the most prominent zone for diverse plant–microbial interactions. While most rhizospheric bacteria have no effect on plants, others do have a beneficial or negative influence on the host's growth and health via intricate interactions. Some microorganisms are harmful to plants because they compete for resources or cause illness (soil-borne plant diseases), while others, such as mycorrhizal fungi and PGPB, help their hosts by mobilizing nutrients, promoting growth, improving yield, and decreasing biotic and abiotic stressors [6]–[8].

Rhizobacteria found in plant roots have a variety of beneficial impacts, ranging from direct effects such as phytohormone regulation, phosphate solubilization, and ammonia synthesis to indirect benefits such as antibiotic, siderophore, and HCN production. Pseudomonas, Azospirillum, Azotobacter, Klebsiella, Enterobacter, Alcaligenes, Arthrobacter, Burkholderia, Bacillus, and Serratia are some of the bacteria that promote plant development and function as PGPB. Several plant growth boosting bacteria, such as Pseudomonas fluorescens, Bacillus sp., Azotobacter, Serratia, and Micromonospora, are engaged in both growth promotion and disease control in tomato.

1.2. Important tomato diseases:

More than 200 pests and diseases have been discovered in tomato plants, resulting in direct or indirect output losses. Fungi, nematodes, bacteria, and viruses produce the most serious problems in cereal crops and vegetables, affecting not only their nutritional value but also human health and the economy. Late blight, Sclerotinia rot, Fusarium wilt, Fusarium crown, and root rot are some of the most common fungal pathogen-caused illnesses in tomatoes.

Late blight, produced by the Phytophthora infestans fungus, is one of the most damaging tomato diseases, causing considerable economic loss (20–70%). Another major disease impacting tomato crop production is Sclerotinia rot, which is caused by Sclerotinia sclerotiorum. Fusarium species cause wilt, crown, and root rot diseases in tomatoes, which have been researched extensively.

Fusarium wilt is a vascular disease caused by Fusarium oxysporum that causes large production losses (10–80%) in several tomato-producing nations. The plant foliage becomes yellow and wilts as a result of root rot disease caused by Fusarium and Phytoptora sp., and the plant ultimately dies. The root system is usually affected by Fusarium crown root disease. At the moment, viruses are wreaking havoc on this vital vegetable crop in the field and in greenhouses, and they continue to be significant limiting factors in tomato output. Fusarium sp. is thought to be responsible for around 45 percent of India's tomato production reduction [9], [10].

The nematode causes root knots. Meloidogyne sp. is the other most serious and widespread tomato disease. Nematode not only reduces agricultural production but also renders plants more vulnerable to bacterial and fungal diseases. It reduces tomato yields by 30–50 percent in China. This disease also affects the production of a broad range of vegetables and crops throughout the globe. Effective control methods, on the other hand, have yet to be established.

Bacterial leaf spot is a common bacterial disease produced by Xanthomonas campestris that affects tomatoes. It is extremely damaging in greenhouses as well as in the field, producing output losses of 10–50 percent. Tomato productivity loss has been reported to vary between 10 and 80 percent in India, whereas yearly output loss owing to this illness is 10–20 percent, with some instances reaching 80 percent. Ralstonia solanacearum is one of the most common soil-borne plant diseases, causing bacterial wilt in over 200 plant families, including tomatoes, and reducing their yield. Clavibacter michiganensis infection produces systemic wilting and canker on the stem, as well as blister-like patches on locally affected leaves, resulting in significant economic loss in tomato output throughout the globe. In contrast to wilting, the virulence factor of C. michiganensis plays a significant role during blister development and also promotes local and systemic infection in tomato.

One of the most common viral illnesses of tomatoes is tomato spotted wilt virus, which is one of the most common viral infections that may cause plant mortality. Tomato yellow leaf curl is a viral disease that affects farmed tomatoes in tropical and subtropical areas throughout the globe, causing losses of up to 100%. Tomato yellow leaf curl is one of the limiting issues in tomato output in many areas. Tomato yellow leaf curl virus is caused by a group of Gemini virus species from the genus Begomo virus, all of which are known as tomato yellow leaf curl virus. Pepino mosaic virus is a new virus that has quickly established itself as one of the most serious viral illnesses infecting tomato plants.

1.3. PGPB as a tomato biocontrol agent:

Some pest management researchers have concentrated their efforts on creating synthetic chemical alternatives for pest and disease control. Biological control, often known as biocontrol, is one of these options. The word "biocontrol" refers not only to disease control in plants, but also to disease management during the storage of fruits.

Plant growth promoting bacteria (PGPB) as biocontrol agents (BCA) have a number of advantages over traditional chemical control methods, including the fact that they are environmentally friendly, non-toxic, naturally occurring microorganisms, and their use is not only safe for the environment but also for human health. Another benefit of PGPB as a biocontrol agent is its method of action against pathogens or illnesses, which aids in crop development and yield improvement. The development of antibiotics, cell wall disintegrating enzymes, bio-surfactants and volatiles, as well as the induction of systemic resistance (ISR) in plants, are all key processes implicated in BCA's antagonism. PGPBs are also engaged in competition for space, nutrition, and defensive capacity stimulation.

The majority of research on rhizobacteria's ability to control infections focuses on pathogenic microbes, although they are also efficient against weeds and insects. Many writers have found that PGPB can effectively reduce soil-borne illnesses. A significant number of bacterial strains have recently been discovered and identified in the hopes of being developed as biocontrol agents for tomato illnesses.

1.4. Mechanisms of biocontrol by PGPB:

Competition for resources and space at the infection site, synthesis of metabolites, and modulation of bacterial signaling molecules are all typical disease controls used by BCA (biocontrols). Pathogens are always harmed by the presence and activity of other organisms they come into contact with. The production of molecules like siderophores, which effectively trap iron and deprive the pathogen of this essential element, is the main mechanism of pathogen suppression through nutritional competition. Some bacteria secrete metabolites that impede pathogen development, such as antibiotics, toxins, surface active chemicals (biosurfactant), and cell wall disintegrating enzymes, but their particular metabolites also cause systemic resistance. In many BCA, multiple modes of action are clearly active at the same time. Below is a short discussion of some of the general processes for biocontrol of tomato diseases.

1.5. Antimicrobial metabolite production/synthesis:

Antibiosis is an appealing and successful method of action, as shown by BCA's success in disease reduction, particularly in soil-borne diseases in a variety of crops. In general, BCA produces antimicrobial metabolites, which are a broad collection of low-molecular-weight organic chemicals that inhibit the growth and metabolic processes of other bacteria. For the synthesis of metabolic products, a vast variety of microorganisms, particularly bacterial species, have been employed in recent decades. Some of the metabolites generated by bacterial BCA have wide range action and may kill a variety of bacteria. Bacillus and Pseudomonas species generate a wide variety of antimicrobial compounds that are effective against pathogenic fungus, nematodes, bacteria, helminths, and other microbes.

Secondary metabolites generated by bacteria such as Pseudomonas, Serratia sp., and B. cepecia, such as pyrrolnitrin (3-chloro-4- (20-nitro-30-chlorophenyl) pyrrole, are efficient against a variety of diseases. Another metabolite generated by Pseudomonas fluorescens CHA0, 2, 4-diacetylpholoroglucinol (DAPG), has been extensively used to reduce root-knot in tomato. Pseudomonas sp. produces phenazine, which is effective against the fungus Fusarium oxysporum in tomato. Exogenous and endogenous variables, as such as fertilizers, carbon sources, and minerals, influence antimicrobial metabolite production. The addition of glucose increased DAPG synthesis in Pseudomonas strains, while the addition of phosphate fertilizer inhibited it. 1.6. Cell wall degrading enzyme production:

BCA's main methods for controlling soil-borne pathogens are the production and release of cell wall destroying enzymes. The structural integrity of the target pathogen's cell wall is affected by these enzymes. Cell wall degrading enzymes produced by biocontrol strains included b-1, 3-glucanase, chitinase, cellulase, and protease, which have a direct inhibitory impact on fungal infections' hyphal development, and chitinase and b-1, 3-glucanase lyse chitin, an insoluble linear polymer of a-1, 4-N-acetyl Some biocontrol strains, such as P. aeruginosa and P. fluorescens, have chitinolytic activities that degrade the chitin in the cell wall. The potent biocontrol strain S. marcescens B2 was found to have chitinolytic and antifungal activities against the soil-borne pathogens R. solani and F. oxysporum.

1.6. Induced resistance (IR):

Induced resistance (IR) is described as a boost in a plant's ability to defend itself against a wide range of pests and diseases. The increased resistance is caused by an initiating factor, such as a disease, or by biotic or abiotic stimuli. Induced systemic resistance (ISR) and systemic acquired resistance are the two main forms of IR (SAR). When plants are exposed to biotic stimuli given by numerous PGPB, which are triggered by specific molecules known as elicitors, they develop increased resistance to infections.

Cell wall polysaccharides, salicylic acid, cyclic lipopeptides, signal molecules such as N-acyl-homoserine-lactones (AHLs), phytohormones, ethylene, and jasmonic acid are all examples of elicitors. As shown during biochar amendments, induced systemic resistance in tomato against Botrytis cinerea requires jasmonic acid signaling. The siderophore, pyocyanin, and pyochelin generated by Pseudomonas species have been shown to provide resistance to tobacco mosaic virus in tomato plants. Another research found that root inoculating tomato plants with Micromonospora strains successfully decreased leaf infection by Botrytis cinerea, a fungal disease. Gene expression investigations have confirmed the Micromonospora-induced defensive mechanism in response to pathogen assault. When exposed to pathogens, tomato plants treated with PGPR Micromonospora sp. reacted with a robust and rapid activation of the jasmonate-regulated defensive system.

2. DISCUSSION

To offset the consequences of excessive use of agrochemicals, the need to grow food in a sustainable manner opens the door to the development of new technologies that are not dependent on fossil fuels and are less harmful to ecosystems. Plant growth-promoting bacteria (PGPB) may be a viable alternative to chemical biofertilizers and insecticides for biotic and abiotic stress protection. Bacillus cereus strain “Amazcala” was discovered and named after a bacterial isolation from the roots of the castor bean (Ricinus communis) in this study (B.c-A).

The capacity to solubilize inorganic phosphate and generate gibberellic acid was shown by this isolate (GA3). Furthermore, this bacteria caused substantial increases in tomato plant height, stem breadth, dry weight, and overall chlorophyll content. In preventative disease tests under greenhouse settings, B.c-A also substantially reduced the severity of bacterial canker disease on tomato caused by Clavibacter michiganensis (Cmm). B.c-A may be regarded a PGPB and a helpful agent in Cmm disease management on tomato plants under greenhouse settings, based on our findings.

Sustainable natural resource management may help to provide food security for the world's growing population. PGPB has been shown to have an important function in agricultural management in many studies. However, there is still a knowledge gap underpinning plant–microbe interactions under various stress situations, especially biotic stress. Understanding the rhizosphere ecology that governs pathogen and antagonist dispersion may help improve biocontrol efficacy against phytopathogens.

3. CONCLUSION

Future study will need extensive rhizo engineering based on the successful discovery and separation of new proteins, which may provide a unique environment for plant-microbe interactions. Exploration and application of multi-strain microbial inoculants over a single strain, on the other hand, may be an effective way to suppress illness. Furthermore, genetic changes to improve biocontrol effectiveness may be a new study area for future disease management. Transforming strains with higher amounts of antimicrobials and growth-promoting metabolites, for example, may be a better choice. The addition of ice-nucleating PGPB may boost temperature-dependent activity.

Furthermore, non-symbiotic endophytic PGPB has a limited function in disease control and growth promotion. The use of cutting-edge tools to investigate microbiological, biochemical, and molecular interactions between plants and interacting microorganisms may offer in-depth information for a better understanding of interactions between plants and interacting microorganisms. For example, root colonization by Pseudomonas fluorescens PICF7, an olive root endophyte, induced expression of genes coding for olive lipoxygenase (LOX-2), phenylalanine ammonia lyase (PAL), and acetone cyanohydrin lyase (ACL) in not only the targeted organ (root), but also a broad pattern of plant defense in terms of tissues. To summarize, the next challenge is to enhance the effectiveness and long-term durability of biocontrol in the field. If this problem is addressed, biocontrol effectiveness may be enhanced by using the knowledge to create better screening methods, formulations, and application procedures, as well as novel integrated disease management strategies.

REFERENCES

[1] V. K. Singh, A. K. Singh, and A. Kumar, "Disease management of tomato through PGPB: current trends and future perspective," *3 Biotech*. 2017, doi: 10.1007/s13205-017-0896-1.

[2] K. K. Shrestha and R. Ashley, "Integrated Disease Management of Tomato Late Blight," *Nepal Agric. Res. J.*, 2014, doi: 10.3126/narj.v8i0.11583.

[3] R. J. McGovern, "Management of tomato diseases caused by Fusarium oxysporum," *Crop Prot.*, 2015, doi: 10.1016/j.cropro.2015.02.021.

[4] A. Mansour, L. Al-Banna, N. Salem, and N. Alsmairat, "Disease management of organic tomato under greenhouse conditions in the Jordan Valley," *Crop Prot.*, 2014, doi: 10.1016/j.cropro.2014.03.001.

[5] M. Worku and S. Sahe, "Review on Disease Management Practice of Tomato Wilt Caused Fusarium oxysporum in Case of Ethiopia," *J. Plant Pathol. Microbiol.*, 2018, doi: 10.4172/2157-7471.1000460.

[6] A. Bergna, T. Cernava, M. Rändler, R. Grosch, C. Zachow, and G. Berg, "Tomato seeds preferably transmit plant beneficial endophytes," *Phytobiomes J.*, 2018, doi: 10.1094/PBIOMES-06-18-0029-R.

[7] M. Scagliola, Y. Pii, T. Mimmo, S. Cesco, P. Ricciuti, and C. Crecchio, "Characterization of plant growth promoting traits of bacterial isolates from the rhizosphere of barley (Hordeum vulgare L.) and tomato (Solanum lycopersicon L.) grown under Fe sufficiency and deficiency," *Plant Physiol. Biochem.*, 2016, doi: 10.1016/j.plaphy.2016.06.002.

[8] M. Chanratana *et al.*, "Evaluation of chitosan and alginate immobilized Methylobacterium oryzae CBMB20 on tomato plant growth," *Arch. Agron. Soil Sci.*, 2018, doi: 10.1080/03650340.2018.1440390.

[9] I. M. Hanssen, M. Lapidot, and B. P. H. J. Thomma, "Emerging viral diseases of tomato crops," *Molecular Plant-Microbe Interactions*. 2010, doi: 10.1094/MPMI-23-5-0539.

[10] E. Moriones, S. Praveen, and S. Chakraborty, "Tomato leaf curl new delhi virus: An emerging virus complex threatening vegetable and fiber crops," *Viruses*. 2017, doi: 10.3390/v9100264.