Review Article

Influence of various Bacterial and fungal Strains on Fruit Cuttings: A Review

ABSTRACT

Microbes, especially bacteria and fungi, play a significant role in the plant's multiplication outcome as well as in regulating the success of economic yield. There are some beneficial interactions made by the various fungi and bacteria, such as *Pseudomonas aeruginosa, Bacillus subtilis,* and *endophytic fungi*, which may be responsible for plant vigor, growth, shoot and root development. Bacterial and fungal strains engaged in the uptake, utilization and nutrient transportation in the earth's pores influence the distribution of essential vitamins and minerals for plant development. We may conclude that the influence of various bacterial and fungal strains on fruit cuttings is a complex and multifaceted issue. It is clear that advanced research is obligatory to better understand the precise interactions between different strains and fruit cuttings, as well as to develop strategies for managing and justifying the potential negative impacts. By achieving a deeper and clear understanding of these interactions, we can work towards optimizing health and productivity.

Keywords: *Bacterial and fungal Strains, microbial influence on fruit cutting, bacterial and fungal impact on fruit propagation, fruit cutting*

1. INTRODUCTION

The influence of Bacterial and fungal strains on plant propagation is a significant aspect of agriculture. Bacteria and fungi play a major role in the growth and development of plants. They also affect the overall health, nutrient absorption capacity, and disease resistance of plants. Understanding the interactions between these bacteria and plants is essential to increasing crop yields, advancing sustainable farming practices, and developing improved propagation techniques. Bacterial and fungal strains significantly affect plant proliferation through a variety of methods. Some strains have mutualistic relationships with plant roots, such as mycorrhizal fungi, which facilitate symbiotic plant uptake of nutrients, particularly phosphorus and nitrogen [1]. The general health and vigor of the plants are improved by these beneficial interactions, and this in turn influences how well the plants multiply. However, some strains of bacteria and fungi may be detrimental to plant growth. Pathogenic bacteria and fungi can cause illnesses in plants, causing growth inhibition, reduced yields, or even plant death. It is necessary to comprehend the principles behind pathogen invasion and the evolution of disease resistance in plants in order to propagate healthy crops successfully [2]. Furthermore, Bacterial and fungal strains involved in the breakdown of organic matter or nutrient cycling in the soil, have a significant impact on availability of nutrients meant for plant growth [3]. Besides this, several Bacterial and fungal strains not only directly affect plant health (rooting process) and nutrient availability, but they also promote the development of advantageous microorganisms in the rhizosphere or the soil that surrounds plant roots. This may enhance a plant's overall resilience and capacity to tolerate environmental stressors, which may impact the plant's capacity to spread.

Understanding how different strains of bacteria and fungi affect plant growth is essential to developing sustainable agricultural methods. Research in this field aims to shed light on the complex relationships that exist between microorganisms and plants in order to optimize beneficial interactions and minimize the detrimental impacts of pathogenic strains. By creating techniques for multiplication and promoting the use of helpful microbes, horticulturists and farmers can enhance crop productivity, reduce reliance on chemical inputs, and preserve the long-term health of agricultural ecosystems [4]. This review paper aims at compilation and description of the effects of various Bacterial and fungal strains on fruit cuttings.

2. BACTERIAL STRAINS AND THEIR IMPACT

Different strains of bacteria have significant effects on human health, the environment, and a variety of industrial sectors, including agriculture (plants) [5]. Some of that are described as under-

2.1 *Bacillus subtilis*: *Bacillus subtilis* is a typical aerobic Gram-positive soil bacterium that releases a large amount of enzymes and degrades a variety of substrates so that it may survive under ever changing environments [6]. *Bacillus subtilis* is commonly used in agriculture to treat a wide range of plant diseases. It produces antibacterial substances and catalysts that inhibit the emergence of harmful fungi and bacteria. However, it's direct application in fruit cutting, which often involves manually splitting or cutting fruits, is uncommon.

2.1.1 Impact of *Bacillus subtilis* on plant growth advancement: *Bacillus subtilis*, an effective soil bacterium, encourages plant growth in fruit cuttings by improving access to nutrients and boosting systemic resistance. Its ability to produce growth-promoting compounds while inhibiting harmful pathogens encourages root development, leading in greater plant vigour and fruit yield [7].

2.2 *Pseudomonas aeruginosa*—

Pseudomonas is a genus of rod-shaped, spore-free Gram-negative bacteria. *Pseudomonas* species are known to generate a variety of plant growth-promoting compounds, including indole acetic acid (IAA) and siderophores, which can have a good impact on roots and plant development [8]. Certain strains of *P. aeruginosa* that have the capacity to shield plants from harmful microbes. In addition to combating plant diseases, these strains generate antimicrobial substances that protect cuttings of plants from infections and encourage root development [9].

2.2.1 Phosphate Solubilization: It is commonly recognised that some *Pseudomonas* strains can solubilize phosphate, making it more available to plants. More nutrient availability can help with root production and overall plant growth [10].

2.3 *Lactobacillus plantarum*

Lactobacillus plantarum is one type of lactic acid bacterium. It is known to have relatively little effect on plant cuttings. The majority of research on *Lactobacillus plantarum* in agriculture has been on the potential advantages of utilizing rhizobacteria rather than cuttings to encourage plant growth (PGPR) [11].

2.3.1 Stress Tolerance: Studies have been conducted to determine whether lactic acid bacteria, including *Lactobacillus plantarum*, can help plants become more resilient to stress. Plant cuttings treated during root development may have stronger defenses against environmental stressors [12].

The particular plant species, the surrounding environment, and the general health of the cuttings all affect how effective *Lactobacillus plantarum* [13]. To completely comprehend the potential mechanisms behind the relationship between *Lactobacillus plantarum* and plants, more investigation is also required.

2.4 *Lactobacillus casei*

The following outcomes were recorded when applying *Lactobacillus casei* to plant cuttings:

2.4.1 Enhanced root development: Plant roots grow more quickly when *Lactobacillus casei* is present. It can promote the creation of new roots on cuttings, improving the overall health and growth of the plant [14].

2.4.2 Disease resistance: Studies have demonstrated that the antibacterial qualities of *Lactobacillus casei* may aid in shielding plant cuttings from harmful infections and illnesses. This may make the plants more robust and resilient [15].

2.4.3 Increased nutrient uptake: *Lactobacillus casei* may boost the quantity of nutrients that are accessible to soil-dwelling plant roots. This could lead to improved nutrient absorption and general plant health [16].

2.5 Escherichia coli: *Escherichia coli* is usually associated with food-borne illness and contamination, however not all types are hazardous [17]. Specific types of *E. coli* can have an advantageous impact while cutting fruit. To begin, some not transmissible strains of E. coli release antibiotic compounds that can limit the growth of hazardous bacteria, improving the general safety of the fruits. Furthermore, these microorganisms can help with the inherent fermentation process, resulting in the generation of naturally occurring acids that function as natural additives, increasing the potential for preservation of cut fruits. Furthermore, *E. coli* can help promote the turnover of nutrients by digesting breakdown organic compounds during recycling, which can then be used to sustainably grow agriculture [18]. According to research, certain strains of *E. coli* could be utilized to enhance fruit consistency and flavour through fermentation procedures. However, it is critical to emphasize that stringent quality assurance procedures must be in place to guarantee that only not transmissible genotypes exist during the fruit-cutting process in order to avoid any health hazards. Overall, recognising the advantages of specific strains of E. coli could give rise to novel ways to fruit processing, promoting both safety and efficiency.

Table 1. Fruit growing and the roles played by helpful bacteria

Fruit species	Application effects	References
Banana	Increased height, width, and quantity of leaves in Cavendish banana plants. Fruit development and cluster weight were found to be statistically significantly affected.	[19]
Cherry	Fruit weight variation and increased yield were noted.	[20]
Pear	Increased shoot length and production of Le Conte pear.	[21]
Strawberry	Bacteria applied at 60 mM/L NaCl concentration showed the greatest therapeutic efficacy and good defense against the stress caused by saltwater.	[22]
Sourcherry	In sour cherry, bacteria treatment enhanced shoot length, leaf area, and yield.	[23]
Blueberry	Bacteria (*Bacillus amyloliquefaciens* JC65 and JC65) enhanced the net photosynthesis rate and plant height. Grafted plants produced 14.56% more fruits of a higher grade than the control.	[24]
Blackberry	*Bacillus* genus affected the growth of blackberries in terms of more branches, flowers per cluster and total branches.	[25]

3. FUNGAL STRAINS AND THEIR INFLUENCE:

Fungus strains impact plant proliferation in both helpful and harmful aspects.

3.1 Pathogenic Fungi: Some fungus strains can infect plants and cause illnesses, which lowers the chances of successful replication. These fungi have the ability to infect plant tissues, stunt growth, and ultimately kill the plant [26].

An infestation of infectious fungus in fruit cuttings can harm both the nutritional content as well as the security of the harvest. To begin, pathogenic moulds such as *Botrytis cinerea* or *Monilinia fructicola* can cause obvious rot and spoilage of fruits, resulting in considerable economic losses in the fruit sector. These fungi thrive in damp settings, therefore sliced fruits are especially vulnerable to their proliferation [27]. Furthermore, certain pathogenic fungi create mycotoxins, which can be harmful if ingested, demanding strict surveillance and standard control procedures throughout the fruit cutting process. The growth of mould on cut layers can detract from the entire visual attractiveness of the fruit and negatively affect customer impressions [28]. Furthermore, pathogenic fungus can accelerate deterioration, shortening the life expectancy of cut fruits and raising the risk of cross-contamination. Maintaining strict hygiene procedures, adequate storage conditions, and the use of antifungal agents are critical in reducing the detrimental impact of pathogenic fungus on fruit cuttings and assuring the safety of the finished product.

3.2 *Trichoderma* spp.-- *Trichoderma*, a genus of soil-borne fungus, has received a lot of attention for its wide range of interactions with plants, including mycoparasitism and symbiosis. Besides this, some species of *Trichoderma* are also helpful as biopesticides. It promotes sustainable and ecologically friendly methods by lowering the need for artificial fertilizers and pesticides [29]. These are helpful for improvement in pomegranate cutting establishments due to their growth-promoting and biocontrol properties. It is also established for the bio control of soil borne infections, *Trichoderma* species have been extensively employed [25]. These molds have the capacity to form symbiotic connections with plant roots in addition to encouraging plant growth and enhancing the plant's resistance to stress [30]. Because of these interactions, bioactive substances like enzymes and antibiotics are produced which improve plant health and reduce the frequency of disease [31].

3.3 *Trichoderma*-induced endophytic microbiota stimulates plant immunity through a synergistic mechanism:-

3.3.1 Comparative functions of *Trichoderma:* These are saprophytic fungi that develop quickly on mycelial filaments and have a high degree of environmental adaptation. By becoming entangled in the invasive section of the roots of pathogenic fungi, it can prevent their spread. Moreover, it might take up the nutrients needed for the disease-causing fungi to grow, creating a nutritional deficient environment that prevents the fungi from multiplying and growing [32] (Fig. 1A).

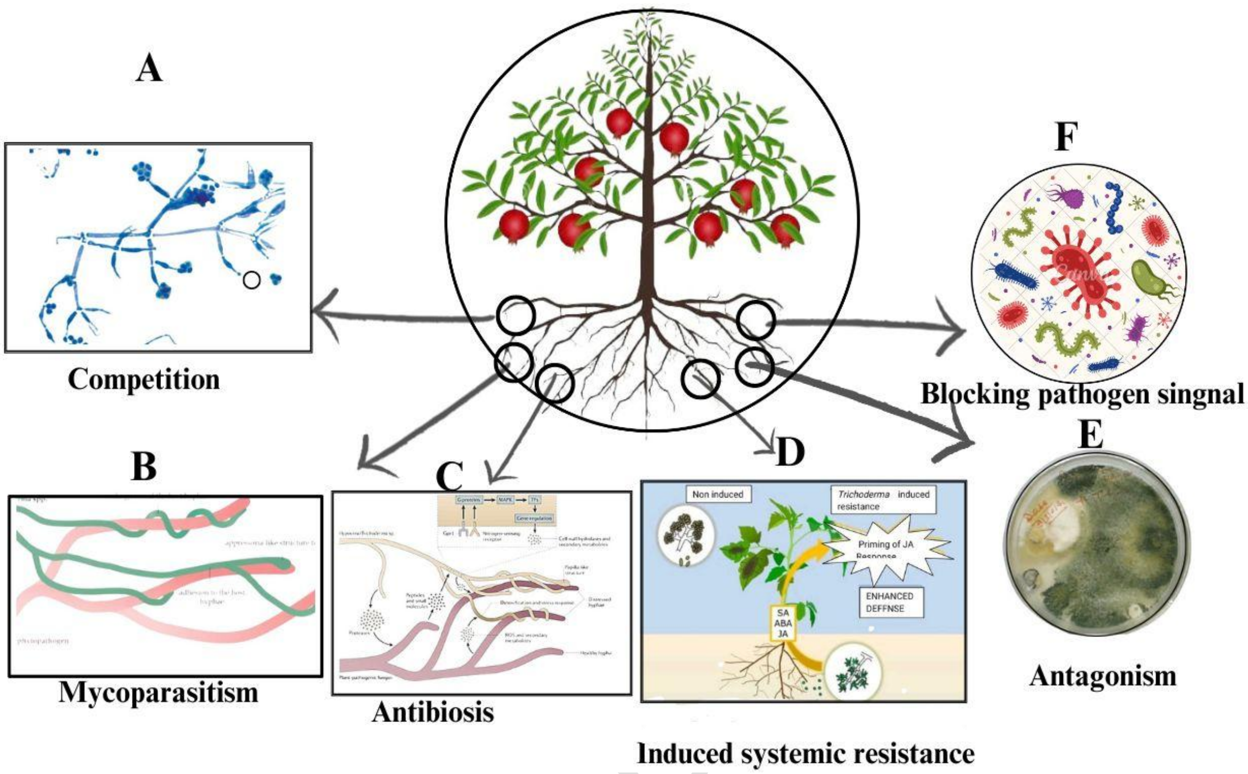

Fig. 1 (A–F) Diagram showing *Trichoderma* mode of action for controlling *fungal* diseases in plants.

3.3.2 Mycoparasitism caused by *Trichoderma*: One of the most important biological controls on *Trichoderma* that exists is mycoparasitism (Fig. 1B). Almost eighteen genera of *Rhizoctonia*, *Phytophthora, Peronospora*, and *Pythium* can be parasitized by *Trichoderma.*

3.3.3 Effect of *Trichoderma* antibiosis: It was revealed that antibiosis refers to *Trichoderma*'s capacity to release compounds that are antagonistic to plant pathogenic fungi, hence impeding their growth [33] (Fig. 1C).

3.3.4 *Trichoderma* induction of systemic resistance: Pests may avoid plants that host may *Trichoderma*. Additionally, it can start the process of crops developing defense mechanisms that shield them.

3.3.5 Antagonism with *Trichoderma*: It was explained that the antagonistic effects of *Trichoderma* are thought to arise from the sequential or simultaneous action of many pathways [34] (Fig. 1 –E, F).

3.4 *Mycorrhizal Fungi*— *Mycorrhizal fungi* have several positive impacts on plant cutting development and survival rates. *Mycorrhizal fungi* are believed to have been widely examined for their impact on horticultural plant developments [35]. Numerous studies have established that *Arbuscular mycorrhizal* symbiosis enhances horticulture yield [36]. *Arbuscular mycorrhizal* fungi (AMF) benefits tree fruit crops by increasing phosphorus

Table 2. Examples of bio control of plant pathogens mediated by beneficial fungi

Name of disease	**Crop**	**Causal agent**	**Biocontrol strain**	**References**
Anthracnose grey mold	Strawberry (*Fragaria ananassa*)	*Colletotrichum acutatum* *Botrytis cinerea*	*T. hamatum* *T. atroviride*	[37]
Brown root rot	Peanuts (*Arachis hypogaea*)	*Fusarium solani*	*T. harzianum*	[38]
Root rot disease	Eggplant (*Solanum melongena L.*)	*Macrophomina phaseolina*	*T. harzianum*	[39]
Wilt	Melon (*Cucumis melo*), Tomato (*Solanum lycopersicum*)	*F. oxysporum and Fusarium oxysporum* f. sp. *Lycopersici*	*T. harzianum and T-78 T. asperellum*	[40] [41]
Fruit rot	Tomato (*Solanum lycopersicum*)	*Rhizoctonia solani*	*T. viride, T. virens* *T. harzianum*	[42]

absorption and resilience to biotic and abiotic stress, making them more resilient than other plant species. Micropropagation plays a crucial role in bioengineering. Micropropagation is a popular method for producing large quantities of hardwood plants that rely heavily on mycorrhizae. Early mycorrhizal inoculation of micro propagated plantlets improved plant survival [43].

3.5 *Penicillium spp.*

Plant cuttings can be affected by *Penicillium* spp., and these species may function as beneficial endophytes. They improve plant growth and health because of their capacity to colonize plant tissues. The impact of different *Penicillium* species can vary depending on the type of plant cuttings and environmental conditions. It was revealed that such harmful effects may be reduced by necessary care and by maintaining proper personal cleanliness [44]. Many species of *Penicillium* are harmful to plant cuttings as they stop the cutting from sprouting and developing into a new plant by causing it to degrade and disintegrate [45].

Penicillium spp., sometimes known as moulds, have various beneficial impacts on fruit cuttings. To begin, certain strains of *Penicillium* assist in the natural decomposition procedure through decomposing down biological material and participating in the decomposition of fruit debris, supporting ecologically responsible discarding techniques. Second, some genera of *Penicillium* release catalysts that aid in the breakdown of complex chemicals, which may improve the extraction of flavours and liquids from fruits during cutting [46]. Furthermore, these molds can serve as biocontrol agents, limiting the growth of hazardous pathogens and lowering the risk of spoiling, hence increasing the shelf life of cut fruits. *Penicillium* spp. are also involved in the formation of a variety of useful metabolites, including organic acids and antibacterial substances, which help to preserve fruit quality. However, it is critical to ensure that the strains employed are non-toxic and suitable for eating. With adequate management and awareness, using the beneficial properties of *Penicillium* spp. can result in creative and sustainable procedures in fruit cutting and processing [47].

3.6 *Aspergillus* spp.

It has following kinds of effects on plant cuttings:

3.6.1 Decomposition: These species help break down organic waste in the soil, which might provide nutrients that may be good for the development of plant cuttings [48].

3.6.2 *Mycorrhizal* associations: Certain *Aspergillus* species have the ability to bind to plant roots and increase the absorption of nutrients and water by the plants [49].

3.6.3 Disease: Damping-off and root rot are two problems that some *Aspergillus* species can produce that are detrimental to plants. Certain diseases might make it difficult for plant cuttings to thrive and survive [50].

3.6.4 Competition: Plant cuttings may not grow and develop as well when they are in competition with one another for nutrients or available space [51].

Aspergillus species can frequently affect plant cuttings in different ways, depending on the environment and the particular species.

Table 3. Beneficial fungi's activities in fruit cultivation

Fruit species	Application effects	References

Banana	Longer branches were observed when treated with AMF and Rhizobacteria.	[52]
Strawbery	Reduced levels of malic acid and pH and higher levels of sugar and anthocyanins were observed when treated with AMF and PGPR	[53]
Pomegranate	*Azotobacter chrococcum* or *Glomus mosseae* combination treatment enhances fruit yield in 5-year-old pomegranate trees.	[54]
Guava	Increased shoot length was obtained when treated with a combination of AMF and *Bacillus megaterium.*	[55]
Citrus	Enhanced growth, improved fruit quality, and improved ion uptake in drought and salinity. Increased soluble sugar and enhanced chlorophyll in foliage as a result of *trifoliate mycorrhizal* inoculation	[56] [57]
Plum	Plants treated with AMF showed increased vegetative growth.	[58]

4. INTERACTIONS BETWEEN BACTERIAL AND FUNGAL STRAINS

Positive effects of fruit cuttings depend on the interactions between bacterial and fungal strains [5]. Fruit crops coexist peacefully with some types of bacteria and fungus. For instance, symbiotic connections between mycorrhizal fungi and plant roots enhance the nutrient-absorbing capacity and general health of the plant. In addition, certain Bacterial strains could be able to convert ambient nitrogen into a form that plants can use, which would increase the amount of nitrogen available for fruit cuttings. Moreover, certain bacteria create antifungal secondary compounds that shield fruit cuttings from hazardous diseases. The complex network of interactions among these microbes eventually creates an ecology that is healthy and balanced around fruit cuttings, providing ideal circumstances for plant development and fruit yield. Gaining knowledge of and using these microbial interactions might lead to more productive fruit farming and sustainable agricultural systems [59].

5. FUTURE DIRECTION

5.1 Examining particular mechanisms that take place during plant-Bacterial or fungal strain proliferative interactions [60]. It revealed that additional research is necessary to determine how these bacteria impact signaling molecules, hormones in plants, gene expression, and other aspects of the development and growth of plants.

5.2 An investigation into the possibility of employing certain strains of bacteria and fungi as biocontrol agents in order to enhance the results of plant multiplication.

5.3 Examining the effects of soil composition, temperature, and humidity on the interactions between strains of bacteria, fungi, and plants during propagation. Understanding how these factors impact the beneficial microbes' ability to promote plant growth could lead to more targeted and effective reproduction methods [61].

5.4 An analysis of the effects on plant health and productivity caused by the Bacterial and fungal strains' long-term growth. It might be necessary to conduct fieldwork and monitor plant performance across several growing seasons in order to fully understand the long-term effects of Bacterial interactions on the development and growth of plants [62].

5.5 Integrating microbial interactions with other plant development management strategies, such as pest control, water management, and nutrient availability [63]. Gaining knowledge of the interactions between various Bacterial and fungal strains and these other elements may lead to more comprehensive and effective plant multiplication promotion strategies [64].

6. CONCLUSION

The investigation of the effects of several bacterial and fungal strains on fruit cuttings indicates complicated interactions between microbial populations and propagation success. Compiled literature studies emphasize the importance of individual strains (both Bacterial or fungal) in either supporting or suppressing the formation of roots, focusing on the significance of a more detailed knowledge of microbial relationships in horticulture techniques.

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