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Use of Bacteria in Improving the Productivity of Citrus: A review

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Abstract

Citrus trees (Citrus spp.) being the world's most popularly known fruits, the excessive use of synthetic fertilizers in citrus trees poses a threat to human health and the environment. By improving crop productivity through integrated fertilization, citrus orchards maximize profits, increase plant resistance to biotic stresses, and conserve natural resources maintaining soil ecological equilibrium is imperative to the bacterial community. Rhizobacteria can be used in a variety of ways to promote plant development, including their ability to promote plant nutrition and health. This study thus sought to determine the extent to which bacteria can exert a positive influence on citrus development alternatively, bacterial inoculation influences yield without causing any type of damage consequently, biofertilizer commercialization has been accelerating in recent years, with companies and products being offered every year. Several benefits are provided by organic and biofertilizers, including increased nutrient availability in soils, increased tree productivity, improved fruit quality, better soil properties, increased rhizosphere microflora populations, and improved plant tolerance to biotic and abiotic stresses. Environmental conservation, in particular, is aided by organic and biofertilizers. The purpose of this review is to summarize a group of research studies showing that microbes can act as plant probiotics in fruit and horticulture crops, which are important sources of food and should be included in balanced diets.

Keywords: *Citrus, bacteria, microorganisms, biofertilizers, inoculation, plant probiotics.*

Introduction

Citrus is one of the most commercially important crops in the world. These fruits are grown and sold all around the world. Nursery trees are essential to starting a citrus grove, and Swingle citrumelo and Rangpur lime are the most commonly budded rootstocks of citrus [33]. In the formative years of citrus plants, the growing medium is inoculated with helpful microbes to facilitate their growth. Bacteria that promote plant growth are found in a wide range of species. They stimulate plant growth and may even shorten the growth cycle. Thus, it is possible to use these organisms as a means of accelerating citrus tree development, enhancing dry mass production, and thus saving nursery time [42]. In addition, they may offer the chance to reduce agricultural input usage, which could improve the sustainability of citrus farming economically as well as environmentally.

There are 5 - 17% the total root surface occupied by plant growth-promoting rhizobacteria (PGPR) in the rhizosphere [18]. There are several genera being investigated, including Bacillus, Pseudomonas, Azospirillum, and Rhizobium. Microbes help with the propagation of seeds, the emergence of seedlings, and the growth of plants [5]. There have been many studies examining the link between bacterial strains and an increase in crop production. Additionally, a large number of studies provide evidence that biofertilizers not only increase yield but also improve plant nutrition and result in higher crop quality [4]. Microbes associated with plants called plant probiotics have many benefits [17, 41]. A plant probiotic is a bacterium that promotes a plant's health when it is fed at the proper dose [23]. These microbes are also members of the Plant Growth Promoting Rhizobacteria (PGPR) bacteria group, which improves the nutritional value of plants and the quality of crops through their ability to colonize

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roots, direct or indirect. [8].

Plants benefit most from efficient and specific PGPR, as this is the best way to achieve this. Thus, it is imperative to understand the intricate links between plants, microbes, and the environment. A plant's exudates and inorganic mineral concentrations can influence bacterial growth and establishment **[51].** Thus, plant populations are affected by the development of ecosystems developing a better understanding of the interactions and mechanisms of biofertilization will enable improvements in plant quality. To avoid problems with human or environmental health, it is also important to verify that the microorganisms in biofertilizers are not harmful **[43].** It is widely recognized that biofertilizers are an important tool in biological control methods in citrus orchards to reduce pests and pathogens, produce more healthy fruits, and create a healthier ecosystem. As safer substances can partly replace agrochemicals that have caused environmental and health problems, they could play a role in providing a healthy agricultural commodity [48].

Sustainable horticultural crop production systems require organic and bio-fertilizers since organic and bio fertilizers can improve soil health, increase yields, and improve fruit quality while maintaining environmental sustainability **[21]**. The use of organic and biofertilizers is imperative to improving soil characteristics and maintaining crop output for horticulture crops in an integrated fertilization system **[31].** As a result, organic and biofertilizers release nitrogen slowly, resulting in an increase in fruit size as a result of enhanced nitrogen release for nutrition during the fruit growth period. As a result of the biofertilizer, peel water content increases and potassium is more readily absorbed by the fruit, thus increasing the water content of the fruit pulp [11].

This review aims to augment the nutritional value of fruits and horticulture crops by applying plant probiotic bacteria as nutritional value enhancers.

Discussion

It will not be easy to determine which combination of organic and bio fertilizers, in conjunction with mineral fertilizers, will maximize production, improve fruit quality, and protect the environment through this study. Further research is needed to determine which combination of fertilizers will be most beneficial to citrus orchards [27].

According to **[36]**, Plant nutrition is greatly influenced by interactions between roots and soil microbiota by synthesizing plant hormones (auxins and gibberellins), fixing nitrogen, saturating inorganic phosphate, and mineralizing organic phosphate, plants benefit from soil microorganisms promoting plant growth.

Synthetic fertilizers

When these fertilizers are used excessively, various issues arise, including soil fertility loss, groundwater pollution, and environmental pollution, all of which have an impact on crops. This calls for the development of alternative, more environmentally friendly fertilizers that will enhance horticulture production, maintain soil health, and prevent soil erosion [49].

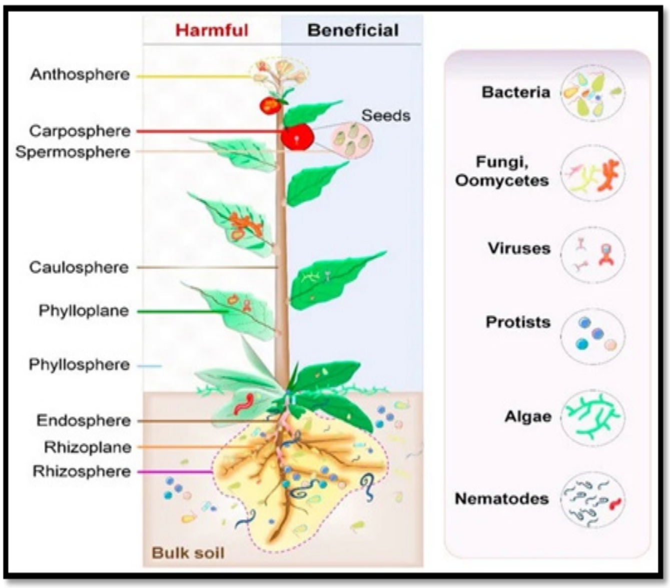


Fig No. 1: Harmful and beneficial effects of synthetic and organic fertilizers respectively

Hazard effects of synthetic fertilizers

Figure 1 denotes the harmful effects of synthetic fertilizers on the plant. The indiscriminate use of synthetic fertilizers has greatly impacted agriculture and the environment for decades [7, 32], including: Pollution and contamination of the soil and groundwater exterminate rhizosphere microorganisms and friendly insects reduce soil fertility increase plant susceptibility to pathogens, causing health problems.

The need for bacterial culture in citrus orchards

Figure 1 denotes the beneficial effects of organic fertilizers on plants. Citrus cultivations aim to

Table No. 1: Use of different types of bioagents on citrus crops to improve productivity.

Sr. No.	Bio-agent	Citrus Species	Response	Reference
1.	VAM and Azotobacter	Sweet Orange (*Citrus sinensis* L.)	Producing more fruit of higher quality and increasing productivity	Rana *et al.,* (2020)
2.	Lactobacillus, Saccharomyces Rhodopseudomonas	Murcott tangerine (*Citrus reticulata*)	Improving leaf mineral content of trees and increasing tree productivity	Fikry *et al.,* (2020)
3.	Azotobacter, PSB, and VAM	Acid lime (*Citrus aurantifolia* Swingle)	Quality control of fruit	Kumar *et al.,* (2020)
4.	Biofertilizers	Valencia orange (*Citrus sinensis*)	The mineral content of leaves increases with increased in productivity.	El-Badawy, (2017)
5.	Azotobacter and VAM	Lemon (*Citrus limon)*	Increasing the quality of fruit	Ghosh *et al.,* (2017)
6.	Azotobacter	Lemon (*Citrus limon)*	The enhancement of fruit quality	Khehra and Bal, (2016)
7.	VAM	Orange (Citrus sinensis) Mandarin (*Citrus reticulate*)	Increasing the mineral content of leaves and increasing vegetative growth	Xiao *et al.,* (2014)
8.	Pseudomonas fluorescens	Navel orange (Citrus sinensis)	Improve leaf mineral content and tree productivity	Shamseldin *et al.,* (2010)
9.	VAM, Azotobacter, Azospirillum, Bacillus circulans	Balady mandarin (*Citrus reticulata*)	Improved mineral content in the leaves and increased tree yield	Amin *et al.,* (2009)
10.	Azotobacter and VAM	Acid lime (*Citrus aurantifolia*)	Improve the quality of the fruit and increase the productivity of the plants.	Bhandari *et al.,* (2018)
11.	VAM, PSP, and Azospirillum	Nagpur mandarin (*Citrus reticulata*)	Improving the mineral content of the leaves and fruit of trees	Hadole *et al.,* (2015)

optimize their organic and biofertilizer inputs in a variety of ways. Some of these efforts include boosting plant growth and productivity, improving plant resistance to abiotic stresses such as drought, high temperatures, salinity, and so forth. The organic fertilizer also enhances plant health and increases their ability to tolerate biotic stresses such as Citrus Leaf Miners (Phyllocnistis citrella) damage, citrus canker [44], and nematodes[1], Adapting it to an integrated management plan could be beneficial for citrus groves. A variety of horticulture crops appear to benefit from their use in integrated fertilization systems. A recent study states that a greater emphasis is placed on producing healthy fruit crops, including citrus [3].

Organic fertilizer and horticultural orchard

Plant vigor, tolerance to both biotic and abiotic stresses, and fruit quality may be improved more effectively with organic fertilizers than synthetic ones [44], Improve soil health, enhance soil physical and chemical properties, increase citrus productivity, produce healthy, chemical-free fruit, safeguard human health, and fetch better crop prices using organic fertilizers [19]. Organic fertilizers have wide range of beneficial effects on soil and crops, such as enhancing the capacity to hold water, buffering soil capacity can be improved, making nutrients more available, the release of plant growth-stimulating hormones, controlling pathogens/pests to reduce damage, enhancing resistance to abiotic stresses.

Citrus and organic fertilizers

Table 1 explains the use of different bioagents on citrus plants to improve their productivity. To increase the efficiency of citrus production, organic fertilizers are needed, which provide a cost-effective solution to reducing the use of synthetic agrochemicals and preserving natural resources at the same time [13], In citrus orchards, organic fertilizer is therefore used to produce healthy fruits by lessening or eliminating the use of synthetic chemical fertilizers. However, organic liquid fertilizer is thought to be an excellent method of encouraging citrus growth, promoting soil health, and increasing the activity of microbes. [27].

Didifferent roles of organic fertilizers in citrus orchards include:

Provide numerous macronutrients and micronutrients for optimal absorption. Increase the production of biomass from citrus plants. The rhizosphere must be stimulated to maintain microflora. Provides microflora with a means of using bacteria that secrete enzymes.

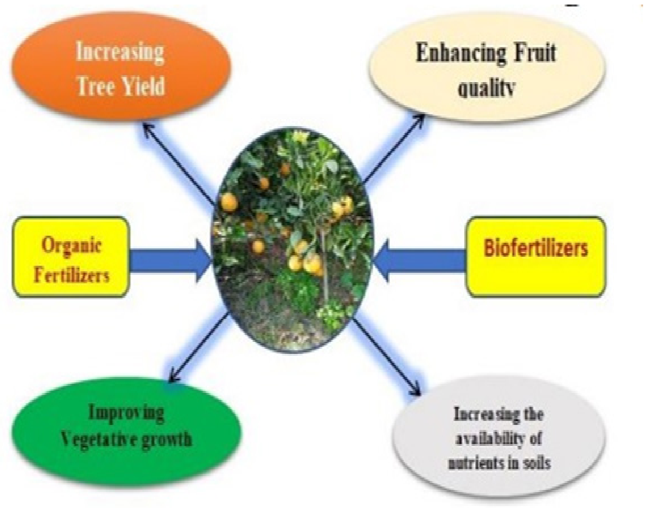


Figure No. 2:- Role of organic fertilizers on plants

Figure 2 denotes the role of organic fertilizers in fruit crops. Using organic and bio fertilizers in citrus production has several advantages, including better fruit quality and soil nutrient availability, a reduction in pollution, and the preservation of ecological balance. Citrus orchards that use organic fertilizers will conserve the soil and improve the quality of the fruit, thereby generating economic sustainability. Citrus production can therefore be increased by using organic fertilizers while protecting the environment at the same time [27].

Citrus and bio fertilizers

Nitrogen-fixing

There are mainly three types of Nitrogen fixing bacteria *viz.* Free-living bacteria (nonsymbiotic) such as Azotobacter, Associative Symbiotic as Azospirillum and Symbiotically like Rhizobium and Frankia.

Inoculant organisms that fix nitrogen in the atmosphere and convert it to organic nitrogen compounds that can be utilized by plants are nitrogen-fixing organisms (NFOs). The release of growth hormones from them results in a greater yield and superior fruit quality by promoting cell division and cellular expansion. Due to their ability to reduce inorganic nitrogen fertilizer use, citrus growers are paying close attention these days to nitrogen-fixing bacteria. This results in lower costs and better-quality fruits [25] on (Citrus limon (L.) Burm.) cv. Baramasi; increase tree yield of sweet orange (Citrus sinensis L.) cv. Mosambi [34]; [39] on Washington navel orange (Citrus sinensis [L.] Osbeck); and **[9]** on Acid lime (Citrus aurantifolia Swingle); reduced nitrate and nitrite residue in fruit juice of Washington navel orange [14].

Phosphorous Solubilizing Microbes

Insoluble phosphorus molecules can be hydrolyzed by Phosphorous Solubilizing Microorganisms (PSM), including Pseudomonas and Bacillus, and are then soluble, which plants can digest, resolving the phosphorous deficit environmentally, economically, and effectively. Fruit quality and productivity are improved by using PSM in citrus orchards [28], As a result of this, soluble P becomes available for root uptake, as well as IAA and GA3 are generated [37] Additionally, the nitrogen fixation process is increased [24].

Phosphorous Microbes

A study shows that hyphae of vascular arbuscular mycorrhiza (VAM) are more effective at stimulating citrus growth and nutrient uptake in citrus plants than those from a standard mycorrhizal fungus[2]. Plants stricken with VAM exhibit increased tolerance to stress through an enhanced intake of nutrients and an improved transport of water, leading to increased plant growth [46], *Poncirus trifoliata* seedlings infused with VAM grew taller, had more leaves, greater stem diameter, and more dry matter. Additionally, it reduced iron-chlorosis symptoms by enhancing chelate reductase activity in the roots and by accumulating both active and total iron in the leaves. [47].

Plant growth promoting rhizobacteria

In the rhizosphere, plants grow most quickly when they have an abundance of beneficial microbes known as plant growth-promoting rhizobacteria (PGPR) [35].

Plant effects of PGPR are categorized as the first biofertilizer which improves plant growth by mobilizing insoluble nutrients, solubilizing elements

Table No. 2: Different species of bioagent used in different species of citrus

Sr. No.	Bio agent	Crop	Scientific Name
1.	Bacillus circulance, B. poylmyxa, B. megatherium, Candida spp, Trichoderma spp	Valencia orange tree	*Citrus sinensis*
2.	Azotobacter spp., Arbuscular Mycorrhiza	Lemon Tree	*Citrus limon Burm*
3.	Azotobacter spp	Sweet Orange Trees	*Citrus sinensis*
4.	Arbuscular Mycorrhiza	Sour Orange seedlings	*Citrus aurantium*
5.	Bacillus circulans, B. megaterium, Azotobacter chroococcum	Balady Mandarin Trees	*citrus reticulata*
6.	Azospirillum spp., Bacillus megatherium	Navel Orange Tree	*Citrus sinensis*
7.	Azospirillum spp., Arbuscular Mycorrhiza	Rough Lemon seedlings	*Citrus jambhiri Lush.)*
8.	Nitrobin (N-fixing bacteria), Phosphoren (P-dissolved bacteria)	Mandarin varieties Trees	*Citrus spp*
9.	Azospirillum Lipoferum	Navel orange tree;	*Citrus sinensis*
10.	Azotobacter spp	Kinnow Mandarin	*Citrus reticulata*
11.	Arbuscular Mycorrhiza	Trifoliate Orange seedling	*Poncirus trifoliata*
12.	Azotobacter chrocoocum, Bacillus megatherium var phosphaticum	Bitter Orange Seedlings	*Citrus aurantium*
13.	Azospirillum lipoferum, Bacillus megaterium, Bacillus circulans	Washington Navel orange trees	*Citrus sinensis*
14.	Cyanobacteria, Azolla	Valencia orange Trees	*Citrus sinensis*
15.	Spirulina plantensis Algae	Balady lime tree	*Citrus aruntifollia*
16.	Azotobacter spp.	Eureka Lemon Trees	*Citrus limon (L.) Burm)*
17.	Arbuscular Mycorrhizal	Kinnow Mandarin Tree	*Citrus reticulata*
18.	Azotobacter spp.	Valencia orange Tree	*Citrus sinensis*
19.	Bacillus. velezensis, Pseudomonas aeruginosa	Pan-lime seedlings and trees	*Citrus aurantifolia*
20.	Azospirillum brasilense, Pseudomonas fluorescence	Washington Navel orange	*Citrus sinensis*

like zinc and phosphorus in the rhizosphere, and producing phytohormones such as cytokinins and auxins [29]. The second one is bio pesticides which by producing hydrolytic enzymes and antibiotics, Rhizobacteria can combat harmful species, including bacteria, fungi, and nematodes [49, 29].

Biofertilizers used in various citrus cultivation

With references to the research paper of Abobatta et al., (2019) [2] Citrus Research Department, Horticulture Research Institute, Agriculture research center, Egypt.

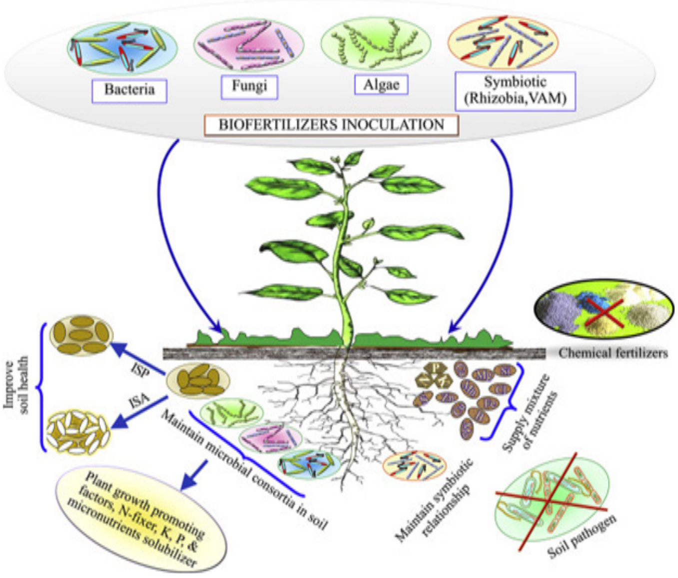
The table 2 reflected the information about the information of different bioagents used in variety of species of citrus. To promote tree growth and productivity, it is an effective strategy to inoculate citrus orchards with biofertilizers, particularly mycorrhizal, at different growth stages. Using biofertilizers also promotes citrus growth since they provide a wide variety of nutrients to the soil, improve their absorption, and facilitate their utilization. They can also alter the pH of the soil and secrete organic materials into the rhizosphere [40].

Mechanism of biofertilizers

Biological fertilizers boost plant growth by altering the entire microbial community in the rhizosphere, either directly by producing nutrients and hormones (such as plant hormones and nutrients), or indirectly by strengthening the plant's defenses by enhancing systemic resistance, limiting the growth-inhibiting effects of soil pathogens [10].

It is true that there are a variety of explanations for how biofertilizers produce growth stimulation effects on plants which are not fully understood but include, for instance, the use of micronutrients. Plants are stimulated to produce or to accumulate hormones, Fixation Nitrogen non-symbiotically and Solubilize complex nutrients forms such as Dolomite, Feldspar, Phosphate, and other nutrients.

Figure No. 3: Mechanism of biofertilizers on plants



Direct mechanisms

Abiotic biofertilizers increase plant growth in two ways: either by increasing the availability of nutrients (nitrogen, phosphorus, siderophore, potassium solubilizers, and other minerals) or by increasing the production of phytohormones [12].

Nitrogen fixation or atmospheric nitrogen to be fixed, biofertilizers are necessary. Various microorganisms are capable of fixing nitrogen

Symbiotic N2 fixing bacteria the Rhizobiaceae family contains several species of bacteria capable of fixing nitrogen in leguminous crops, as does Frankia spp., which is associated with a non-leguminous woody plant.

Non-symbiotic N2 fixing organisms among the free-living organisms that fix nitrogen by association or endophyte mechanisms are cyanobacteria, Azospirillum, Azotobacter, Gluconoacetobacter, Diazotrophicus, and Azocarus.

Indirect mechanism

The biocontrol method is considered a safe and effective method of citrus orchard management, which does not negatively affect fruit quality and is safe for both humans and the environment. Increasing systemic resistance to soil pathogens and limiting the negative effects on plant growth **[45].** Controlling citrus canker is a negative impact on the growth and productivity of different cultivars of citrus throughout the world when citrus canker disease appears in different citrus orchards. At present, using biocontrol agents to combat canker disease is a better strategy since they are safer for consumers and the environment, and they usually do not affect the quality of the fruit **[30].** Control citrus canker disease, scientists are using antimicrobial agents, such as Pseudomonas protegens and Bacillus amyloliquefaciens. Controlling citrus canker disease may be possible through the use of microbial antagonists like Pseudomonas protegens and Bacillus amyloliquefaciens **[30].**

Siderophore production

This profitable crop, Citrus, is susceptible to iron chlorosis, caused by Fe3+ converting to insoluble forms of hydroxides and oxyhydroxides in alkaline soil, making it inaccessible to plants for a variety of reasons. Azotobacter vinelandii, Bacillus megaterium, Bacillus subtilis, Pantoea allii, and Rhizobium radiobacter are bacteria that produce siderophore, but Bacillus megaterium may be useful in the treatment of lime chlorosis during citrus cultivation under alkaline conditions. Siderophore is also produced in moderate amounts by Bacillus subtilis and Azotobacter vinelandii **[15].**

Phytohormone production

In biofertilizers, many phytohormones stimulate citrus growth by increasing nutrient uptake, increasing photosynthesis, controlling plant cell division and size, as well as increasing prolin production. There have been many studies that have found that inoculated plants with this bio-fertilizers release various phytohormones, including cytokinin's, gibberellin, indole acetic acid, auxin, and ethylene. Thus, biofertilizers play a vital role in improving the productivity and quality of citrus plants and their fruits **[53].**

Arbuscular mycorrhizae and citriculture

Abiotic stress tolerance is significantly improved with Arbuscular Mycorrhizae in the presence of extreme climate conditions. This significantly improves citrus performance under these conditions. Citrus plants exposed to abiotic stresses have shown that AM has mitigating effects on them, and recent scientific studies have described ways in which AM enhances citrus tolerance and supports growth performance by increasing chlorophyll levels, improving water and nutrient absorption, controlling osmosis, storing antioxidants, accumulating osmolytes in plant tissues, and synthesizing essential oils **[22].**

Conclusion and Future Research Perspective

A green fertilizer containing plant probiotic bacteria increases the nutritional value of fruits and vegetables, as opposed to chemical fertilizers. The switch from chemical fertilizers to probiotic bacteria-based products is, therefore, a highly effective option for reducing chemical fertilizer abuse while ensuring the safety of food. Several studies have demonstrated that the application of green products increases crop production, minimizes disease and insect damage, and boosts plant nutrition. To increase the use of biofertilizers, however, several changes are needed. The goal is to ensure that commercial products are produced with bacteria that are not harmful by putting in place more efficient quality control methods. Be successful in the environmental arena, green products must be constructed with transporters that function reliably.

The examples discussed in this review illustrate about how plant probiotic bacteria can improve plant growth, increase yield and impact some food quality indicators when used as biofertilizers. Studies have shown that probiotic plants can form a connection with fruits and other horticulture crops, leading to an increase in beneficial to plant as well as for human health. Despite the constant expansion of the bacterial fertilizer market, the effects of these commercialized strains of bacteria on plants and food quality criteria are still unknown. Therefore, more research is needed to determine how various types of bacteria can improve food quality. An agricultural method aimed at producing high-quality fruits and vegetables which could benefit from a better selection of plant probiotic bacteria.

In addition to boosting the concentration of vitamins, flavonoids, and antioxidants in fruits and vegetables, probiotic bacteria have also been shown to enhance the quality of fruits and vegetables. Additionally, bacterial inoculants may improve functional food components such as flavor, color, and texture research on metabolomics that compares fruits and vegetables grown with and without probiotic bacteria may lead to better results in the future regarding food crops' quality.

References

[1.] Abd-Elgawad, M. M. (2020). Managing nematodes in Egyptian citrus orchards. *Bulletin of the National Research Centre*, 44, 1-15.

[2.] Abobatta, W.F. (2019). Arbuscular Mycorrhizal and Citrus growth. *Acta Scientific Microbiology* 2(6): 14-17.

[3.] Aji, T. G. (2020). Nutrition management in conversion-to-organic citrus orchard in the Indonesian citrus and subtropical fruits research institute. *In IOP Conference Series: Earth and Environmental Science*, 484(1), 012057.

[4.] Ahemad M, Kibret M (2014) Mechanisms and applications of plant growth promoting rhizobacteria: current perspective. *J King Saud Uni-Sci* 26: 1–20.

[5.] Ahmad F, Ahmad I, Khan MS. (2008) Screening of free-living rhizospheric bacteria for their multiple plant growth promoting activities. *Microbiol Res*; 163:173-81.

[6.] Aiman, K.A. Mohamed, Z., Mohamed, M. M. A. and Mohamed. M. E. (2009). Is it Possible to Compensate the Annual Fertilization in Mandarin Orchards by Using the Bio-fertilizers. *Assiut J. of Agric. Sci.*, 40 (4): 37-68.

[7.] Bankole, S., O., Akala, A., O. and Adegboyega, D., A. (2019). Potential Significance of Beneficial Microbes for Sustainable Soil Management and Plant Utilization. *Acta Scientific Microbiology* 2.6: 88-95.

[8.] Bashan Y, de-Bashan LE (2005) Bacteria/ plant growth-promotion, In: Hillel D, Editor, *Encyclopaedia of Soils in the Environment*, Oxford: Elsevier, 103–115.

[9.] Bhandari,J. Kanpure, R.N., Singh, O.P., Kachouli, B. and Patidar, D.K. (2018). Effect of organic and inorganic nutrient sources on growth, yield and quality of Acid lime (Citrus aurantifolia Swingle). *International Journal of Chemical Studies*, 6(1): 1635-1639

[10.] Daniel Y, Tariku A. (2019) Components, mechanisms of action, success under greenhouse and field condition, market availability, formulation and inoculants development on biofertilizer. *Biomed J Sci & Tech Res.*;12(4).

[11.] Debnath, S, Rawat, D., Mukherjee, A., Adhikary, S. and Kundu, R. (2019). Applications and Constraints of Plant Beneficial Microorganisms in Agriculture, Rhizosphere and Soil Microbes - *Utilization in Agriculture and Industry Under Current Scenario*

[12.] Elavarasi P, Yuvaraj M, Gayathri P. (2020) Application of bacteria as a prominent source of biofertilizers. *Biostimulants in Plant Science*

[13.] El-Badawy, H. E. M. (2017). Partial substitution of Valencia orange chemical fertilization by bioorganic fertilization conjoint with algae extract foliar spray. *Middle East Journal of Applied Sciences*, 7(4): 1016-1030.

[14.] El-Migeed, M.M.M, Saleh, M. and Mostafa, E.A.M. (2007). The beneficial effect of minimizing mineral nitrogen fertilization on Washington navel orange trees by using organic and biofertilizers. *World Journal of Agricultural Sciences*, 3:80 - 85.

[15.] Ferreira CMH, VilasBoas AM, Sousa CA, (2019). Comparison of five bacterial strains producing siderophores with ability to chelate iron under alkaline conditions. *AMB Expr*.;9:78.

[16.] Fikry, A. M., Abou Sayed Ahmed, T.A.M., Mohsen, F.S. and Ibrahim, M.M. (2020). Effect of Nitrogen fertilization through inorganic, organic and biofertilizers sources on vegetative growth, yield and nutritional status in Murcott Tangerine trees. *Plant Archives*, 20 (1):1859-1868.

[17.] Flores-Félix JD, Silva LR, Rivera LP, Marcos-García M, García-Fraile P, Martínez-Molina E, et al. (2015) Plants Probiotics as a Tool to Produce Highly Functional Fruits: The Case of *Phyllobacterium* and Vitamin C in Strawberries. *PLoS ONE* 10(4): e0122281.

[18.] Gray EJ, Smith DL. (2005) Intracellular and extracellular PGPR: commonalities and distinctions in the plant-bacterium signaling processes. *Soil Biol Biochem*; 37:395-412

[19.] Hameed, A., Fatma, S., Wattoo, J. I., Yaseen, M. and Ahmad, S. (2018). Accumulative effects of humic acid and multinutrient foliar fertilizers on the vegetative and reproductive attributes of citrus (Citrus reticulata cv. kinnow mandarin). *Journal of Plant Nutrition*, 41(19): 2495- 2506.

[20.] Hadole, S.S., Waghmare, S. and Jadhao, S. D. (2015). Integrated use of organic and inorganic fertilizers with bioinoculants on yield, soil fertility and quality of Nagpur mandarin (Citrus reticulata Blanco). *International Journal of Agricultural Sciences*, Vol.11 No.2 pp.242-247 ref.12

[21.] Hazarika, T. K. and Aheibam, B. (2019). Soil nutrient status, yield and quality of lemon (Citrus limon Burm.) cv. 'Assam lemon'as influenced by bio-fertilizers, organic and inorganic fertilizers. *Journal of Plant Nutrition*, 42(8): 853-863.

[22.] He JD, Dong T, Wu HH, (2019) Mycorrhizas induce diverse responses of root TIP aquaporin gene expression to drought stress in trifoliate orange. *Sci Hortic*.;243:64–69.

[23.] Islam MT, Hossain MM (2012) Plant probiotics in phosphorus nutrition in crops, with special reference to rice, In: Bacteria in Agrobiology: Plant Probiotics, *Springer Berlin Heidelberg*, 325–363.

[24.] Kalayu G. (2019) "Phosphate Solubilizing Microorganisms: Promising Approach as Biofertilizers", *International Journal of Agronomy*, vol.2, 7 pages.

[25.] Khehra, S. and Bal, J.S. (2016). Influence of combined use of organic, inorganic and biological sources of nutrients on fruit quality in lemon. *International Journal of Agriculture, Environment and Biotechnology*, IJAEB: 9(1): 85-88

[26.] Kumar, T.R., Kumar, G.P., and Kumar, R.S. (2020). Integrated use of organic and inorganic fertilizers with bio -inoculants on physicological characteristics of Acid Lime (Citrus Aurantifolia Swingle). *Plant Archives*, 20(1):1769-1772.

[27.] Martínez-Alcantara, B., Martínez-Cuenca, M. R., Bermejo, A., Legaz, F., and Quinones, A. (2016). Liquid organic fertilizers for sustainable agriculture: Nutrient uptake of organic versus mineral fertilizers in citrus trees. *PLOS ONE*, 11(10):1-20

[28.] Maklad, M. and Elkhawaga, A. (2013). Effect of combination between Bio and chemical fertilization on vegetative growth, yield and quality of Valencia orange fruits. *Journal of Suez Canal University*, 1: 269-279.

[29.] Martínez-Viveros, O., Jorquera, M. A., Crowley, D. E., Gajardo, G. M. L. M. and Mora, M. L. (2010). Mechanisms and practical considerations involved in plant growth promotion by rhizobacteria. *Journal of soil science and plant nutrition*, 10(3): 293-319.

[30.] Michavila G, Adler C, De Gregorio PR (2017). Pseudomonas protegens CS1 from the lemon phyllosphere as a candidate for citrus canker biocontrol agent. *Plant Biol*.; 19:608–617.

[31.] Pathak, D.V., Kumar, M., and Rani, K. (2017). Biofertilizer Application in Horticultural Crops. In Microorganisms for Green Revolution; *Springer: Berlin/Heidelberg, Germany*, pp. 215– 227.

[32.] Pindi, P. K. and Satyanarayana, S.D.V. (2012) Liquid microbial consortium a potential tool for sustainable soil health. *J Biofertil Biopestici* 3:124. pp.1-9

[33.] Prado RM, Rozane DE, Camarotti GS, Correia MAR, Natale W, Barbosa JC, (2008). Nitrogênio, fósforo e potássio na nutrição e na produção de mudas de laranjeira 'Valência', enxertada sobre citrumeleiro 'Swingle' *Rev Bras Frutic*;30:812-17

[34.] Rana, H., Sharma, K. and Negi, M. (2020). Effect of organic manure and biofertilizers on plant growth, yield and quality of sweet orange (Citrus sinensis L.). *International Journal of Current Microbiology and Applied Sciences*, 9: 2064-2070.

[35.] Ramezani, M., Riahi Madvar, A., Khaleghi, M. and Hemmati, R. (2015). Isolation and identification of new beneficial bacterial strains from rhizosphere of Citrus sinensis orchards. *Progress in Biological Sciences*, 5(1): 75-84.

[36.] Richardson AE, Barea J-M, Mcneill AM, Prigent-Combaret C (2009). Acquisition of phosphorus and nitrogen in the rhizosphere and plant growth promotion by microorganisms. Plant Soil; 321:305-39.

[37.] Saleemi, M., Kiani, M.Z., Sultan, T. Khalid, A. and Mahmood, S. (2017). Integrated effect of plant growth-promoting rhizobacteria and phosphate-solubilizing microorganisms on growth of wheat (Triticum aestivum L.) under rainfed condition. *Agric & Food Secur* 6, 46 PP.1-8

[38.] Shamseldin, A., El-Sheikh, M. H., Hassan, H. S. A. and Kabeil, S. S. (2010). Microbial biofertilization approaches to improve yield and quality of Washington Navel orange and reducing the survival of nematode in the soil. *J. Amer. Sci.* 6 (12): 264-271.

[39.] Shaimaa, M. A. and Massoud, O. N. (2017). Impact of Inoculation with Mycorrhiza and Azotobacter under different N and P rates on growth, nutrient status, yield and some Soil characteristics of Washington Navel Orange Trees, *Middle East J. Agric. Res*, 6 (3): 617- 638.

[40.] Sharma S, Kaur M (2017). Plant hormones synthesized by microorganisms and their role in biofertilizer- A review article. *Int J Adv Res.*;5(12):1753– 1762.

[41.] Spence C, Alff E, Shantharaj D, et al. (2012) Probiotics for Plants: Importance of Rhizobacteria on Aboveground Fitness in Plants, In: Bacteria in Agrobiology: Plant Probiotics, *Springer Berlin Heidelberg*, 1–14

[42.] Silveira APD da, Silva LR, Azevedo IC, Oliveira E, Meletti LMM (2003). Performance of arbuscular mycorrhizal fungi on seedling production of 25 yellow passion fruit, in different substrates. *Bragantia*; 62:89- 99.

[43.] Trivedi P, Pandey A, Palni LMS (2012) Bacterial inoculants for field applications under mountain ecosystem: present initiatives and future prospects, In: Bacteria in agrobiology: Plant probiotics, *Springer Berlin Heidelberg*, 15–44.

[44.] Ullah, M.I., Riaz, M., Arshad, M., Khan, A.H., Afzal, M., Khalid, S., Mehmood, N., Ali, S., Khan, A.M., Zahid, S.M.A. and Riaz, M. (2019). Application of Organic Fertilizers Affect the Citrus Leafminer, Phyllocnistis citrella (Lepidoptera: Gracillariidae) Infestation and Citrus Canker Disease in Nursery Plantations. *International Journal of Insect Science*, 11: 1–5.

[45.] Vandenberghe LPS, Garcia LMB, Rodrigues C, (2017). Potential applications of plant probiotic microorganisms in agriculture and forestry. *AIMS Microbiology*.;3(3):629–648.

[46.] Vives-Peris, V., Molina, L., Segura, A., Gomez-Cadenas, A. and Perez-Clemente, R. M. (2018a). Root exudates from citrus plants subjected to abiotic stress conditions have a positive effect on rhizobacteria. *Journal of plant physiology*, 228: 208-217.

[47.] Wang, M. and Xia, R. (2009). Effects of arbuscular mycorrhizal fungi on growth and iron uptake of Poncirus trifoliata under different pH. *Acta microbiologica Sinica*. 49: 1374-9.

[48.] Waleed Fouad Abobatta (2020) Citrus Research Department, Horticulture Research Institute, *Agriculture research center*, Egypt, Volume 6 Issue 3

[49.] Wong, H., J. Gao, X. Li, S. Zhang and H. Wang (2015). Nitrate accumulation and leaching in surface and groundwater based on simulated rainfall experiments. *PLOS ONE* 10(8): 1-18.

[50.] Xiao, J., Hu, C., Chen, Y., Yang, B. and Hua, J. (2014). Effects of low magnesium and an arbuscular mycorrhizal fungus on the growth, magnesium distribution and photosynthesis of two citrus cultivars. *Scientia Horticulturae*. 177: 14–20.

[51.] Yang CH, Crowley DE (2000) Rhizosphere microbial community structure in relation to root location and plant iron nutritional status. *App Environ Microb* 66: 345–351.

[52.] Young CC, Shen FT, Singh S (2012) Strategies for the Exploration and Development of Biofertilizer, In: Bacteria in Agrobiology: Plant Probiotics, *Springer Berlin Heidelberg*, 127– 139.

[53.] Zahgloul AE, El-Din MN, Ghaz AA (2015). Combination effects of biofertilization and biostimulants foliar application on yield, quality and marketability of Washington navel orange fruits. *J Agric Chem Biotechn Mansoura Univ*.;6 (12):627–655.