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Role of Microbial Constoria on Plant Growth Promotion

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Abstract
Plant-related microorganisms assume a significant part in farming creation. Albeit different examinations have shown that solitary microorganisms can apply useful impacts on plants, it is progressively apparent that when a microbial consortium—at least two communicating microorganisms—is included, added substance or synergistic outcomes can be anticipated. This happens, to a limited extent, because of the way that different species can play out an assortment of errands in an environment like the rhizosphere. Thus, the helpful components of plant growth incitement (i.e., upgraded supplement accessibility, phytohormone tweak, biocontrol, biotic and abiotic stress resistance) applied by various microbial players inside the rhizosphere, for example, plant-growth-promoting microscopic organisms (PGPB) and parasites (like Trichoderma and Mycorrhizae), are checked on. Also, their communication and advantageous movement are featured when they go about as a component of a consortium, chiefly as combinations of various types of PGPB, PGPB–Mycorrhizae, and PGPB–Trichoderma, under ordinary and different pressure conditions. At long last, we propose the development of the utilization of various microbial consortia, just as an expansion in research on various combinations of microorganisms that work with the best and most reliable outcomes in the field.
This review describes the main characteristics, ecosystem functions, crop benefits, and biotechnological applications of microbial consortia composed of arbuscular mycorrhizal fungi (AMF), plant growth-promoting rhizobacteria (PGPR), and Actinobacteria,to promote the restoration of agricultural soils and, consequently, the quality and health of agricultural crops. The aim is to provide knowledge that will contribute to the development of sustainable and sufficiently productive agriculture, which will adapt in a good way to the pace of the growing human population and to climate change. Keywords: microbial consortia; arbuscular mycorrhizas; plant growth-promoting rhizobacteri
Keywords*: Microbialconsortium, rhizoshere, Phytohormone*

I. Introduction

Today, there is a need to create sufficient nourishment for the in excess of 7 billion individuals in the world, and it is normal that constantly 2050, the worldwide populace will reach ~9.5 billion Moreover, in 2020, it was assessed that ~900 million individuals were malnourished. For quite a long time, the unpredictable utilization of agrochemicals (mostly substance manures and pesticides) in horticulture to build creation or potentially decline the consistent danger of contaminations brought about by plant microbes has prompted a deficiency of plant well- being. Tragically, the manner by which the creation of the different agrarian frameworks has expanded in by far most of nations isn't sustainable. Agricultural soils, straightforwardly or by implication, are constantly losing their quality and actual properties (soil surface, penetrability, porosity, and waste), just as their compound (lopsidedness of nutritive components) and natural (useful creatures) well-being For the situation of the dirt microbiota, a few creators have shown that pesticides can diminish their bounty and variety, prompting a debilitation of their working in agro-frameworks. Pesticides likewise adversely sway other advantageous creatures in farming, like pollinating creepy crawlies, which are significant in working on the creation of a few yields.

In specific areas of the world, endeavors have been made to lessen or wipe out the utilization of conceivably malicious agrochemicals, chiefly because of their danger to human wellbeing, however in many agricultural nations, they keep on being utilized with no kind of guideline There is a squeezing need for approaches that work with food creation without the inordinate utilization of agrochemicals and for the utilization of hereditarily further developed harvests, including determination of plant assortments that are impervious to bugs and different antagonistic natural conditions Much of this might be accomplished by the hereditary alteration of plants/or the use of plant-growth-promoting microorganisms at times, utilizing a combination of at least two viable microorganisms of various species (or strains) can work with gainful added substance or synergistic outcomes, since the absence of exercises in one added organism can be found through the activity of the other Here, characterize these two ideas with regards to this work. An added substance impact is the amount of exercises, while collaboration alludes with an impact that goes past the amount of individual activities, since there is an incitement of one activity (or microorganism) by another. These new "plant micro biome designing" approaches, comprising of adding powerful bioinoculants, incite new organized natural organizations in different soil types. This advances the recuperation of useful, useful microbial gatherings that are emphatically connected to soil fruitfulness and renews the normal micro biome, which has been diminished by crop training rehearses. The expansion of microbial consortia, hence, can rebuild and invigorate plant-growth-promoting instruments in both ideal conditions and under various sorts of biotic and abiotic stress Here, the procedure of planning microbial consortia between microscopic organisms, *Trichoderma,* or potentially carbuncular mycorrhizae parasites to animate plant growth is audited; this is a system that is relied upon to altogether increment horticultural usefulness.

Plant-Growth-Promoting Microorganisms

Plant-growth-promoting microorganism (PGPM) is a term that applies to all microorganisms (e.g., microscopic organisms, actinomycetes, parasites, and green growth) that beneficially affect plant growth through the activity of either immediate or backhanded systems (e.g., mineral sustenance, ethylene decrease, infection concealment) PGPMs play a huge part in manageable farming. They increment the creation of different harvests, further develop soil ripeness, advance variety and communication with other helpful microorganisms, restrain the growth and infective activity of possible microbes, and by and large keep up with the supportability of the frameworks Most investigations of PGPMs depend on cooperation's of single microorganisms with plants, assessing various boundaries of growth and plant well -being, like length or weight of the plant or its singular tissues, chlorophyll content, or the dietary substance of its tissues or organic products This has prompted a superior comprehension of plant–organism associations, however leaves to the side the "genuine" factor of these collaborations in the climate, where an assortment of microbial animal categories can exist.

For instance, one gram of soil normally contains a wide scope of organic entities, including microorganisms (~9 × 107 cells for every g), actinomycetes (~4 × 106 cells for each g), growths (~2 × 105 cells for every g), green growth (3 × 104 cells for each g), protozoa (~5 × 103 creatures for every g), and nematodes (~3 × 101 creatures for each g) From this variety of organic entities, a few animal types can involve various specialties and numerous associations can happen. The plant impacts the cooperations in the rhizosphere, since, through the exudation of mixtures (e.g., sugars, amino acids, and natural acids), new fights for supplement procurement, colonization of spaces, and endurance are created. It has been proposed that, because of the plenty of communications that can happen when single species are immunized in the field, positive and reliable outcomes as far as working with plant growth are not generally accomplished.

In any case, more predictable positive outcomes might be acquired by vaccinating plants with microbial consortia containing at least two useful microorganisms [25,26]. Following seed germination, plants constantly interface with microorganisms that live both beneath and over-the-ground. These communications are dynamic and change contingent upon the microbial construction that is framed during the various phases of plant growth and advancement [27,28]. To a limited extent, this dynamic is because of the unstable mixtures discharged by the aeronautical pieces of the plant just as root exudates that are emitted into the dirt, drawing in and organizing a specific rhizospheric micro biome Other abiotic variables can likewise impact the cooperations that happen between the dirt microbiome and plants, including temperature, water accessibility, pH, and the accessibility of supplements Under normal conditions, where the climate is consistently changing, plants speak with different microbial species, and thusly, these microorganisms speak with one another to bring about networks that can have helpful (or unsafe) repercussions for plant growth, hence forming a plant microbiome Various examinations have recommended that microbial consortia can by and large perform assignments better than individual strains.

This incorporates utilizing complex mixtures, doing responses with at least two stages, corrupting plant polymers like cellulose, and staying stable in a fluctuating climate. A portion of these exercises are not occupant in a solitary microorganism; thusly, the utilization of microbial consortia is important The initially marketed bioinoculants included single natural specialists, for example, rhizobial microscopic organisms, which can frame knobs on the foundations of vegetable plants and in that fix barometrical nitrogen, working with plant growth and improvement. Sadly, the viability of this sort of bioinoculant is restricted in that it can just help vegetables. In certain occurrences, vegetables, for example, *Phaseolus vulgaris* (bean), are co-developed with non-vegetables, for example, *Cucurbita pepo* (zucchini) or Zea mays (maize). In these examples, the utilization of a bacterial consortium, like *Rhizobium* in addition to Pseudomonas or Bacillus, or a bacterial-contagious consortium, like *Rhizobium* in addition to *Trichoderma* or a mycorrhizae strain, could help the three previously mentioned vegetable yields. This expansion in plant growth may happen through arrangement of a superior stock of assimilable supplements, (for example, P, Fe, and N) Bioinoculants dependent on microbial consortia might incorporate microorganisms of various species, while others might incorporate both helpful microscopic organisms and parasites. The use of various PGPM species with different components of activity ought to give a wide range of advantages for the plant, including direct incitement of its growth and well -being, just as expansions underway. Moreover, a diminishing in sicknesses brought about by microbes would be normal.

Bacterial Consortia

At present, engineered composts are applied to crops for a huge scope to meet the developing worldwide food interest, prompting high wellbeing, monetary, and natural expenses A very much read and reasonable option for further developing plant growth and soil richness is the utilization of plant-growth-promoting microbes (PGPB), which have practical characteristics that manage the growth, advancement, and usefulness of yields. These growth-promoting impacts are because of the improvement of the accessibility and biosynthesis of a few restricting full scale and micronutrients, just as yield security against upsetting natural conditions Lately, the effect of various PGPB strains on plants has been all around investigated, prompting the commercialization of an enormous number of microbial inoculants To upgrade the useful capacities showed by these microorganisms, the plan of bacterial consortia has acquired revenue as a reasonable procedure for supportable food creation. A bacterial consortium for the most part establishes at least two viable microscopic organisms of various species in a synergistic or added substance communication.

At times, a combination of various strains of similar species can show upgraded exercises and furthermore be viewed as a consortium. Bacterial consortia have been accounted for to work on advantageous attributes in plants in contrast with individual strains because of the inclusion of a different arrangement of plant growth advancement and natural control systems The utilization of these consortia is an achievable technique for enhancing dry spell saltiness supplement take-up bothers, and phytopathogenic contaminations of farming harvests. Likewise, some bacterial consortia can fix nitrogen, change some inaccessible supplements into an assimilable structure, produce phytohormones, and chelate iron, which is significant in keeping up with soil quality and wellbeing; these can likewise diminish the adverse consequences of some customary non-supportable rural practices.

There are two sorts of bacterial consortia known—straightforward and complex. The distinctions are the aging procedure or convention (creation of an enormous populace of microscopic organisms to be subsequently formed into an inoculant), where strains are developed separately or in mix with different species/strains in a reasonable vehicle for all PGPB species. This is a significant stage, since a higher number of animal groups for the most part bring about a higher number of associations among the strains, thusly producing contrasts in metabolite discharges. Then again, the achievement of bacterial consortia under field conditions is reliant upon the kind and capacity of strains utilized, where a few viewpoints require uncommon consideration, including variation to antagonistic climatic conditions, endurance, and diligence in the dirt after vaccination. The choice of these strains is reliant upon the wellspring of the strain segregation, since consortium individuals need to multiply in the ecological conditions (soil type, environment, and host) where they will be applied. Likewise, note that, when at least two strains are important for a bacterial consortium, each strain not just contends practically with the others for plant growth advancement, yet in addition supplements the others for soil and additionally plant foundation Figure 1 sums up the various kinds of microbial consortia talked about in this original copy.

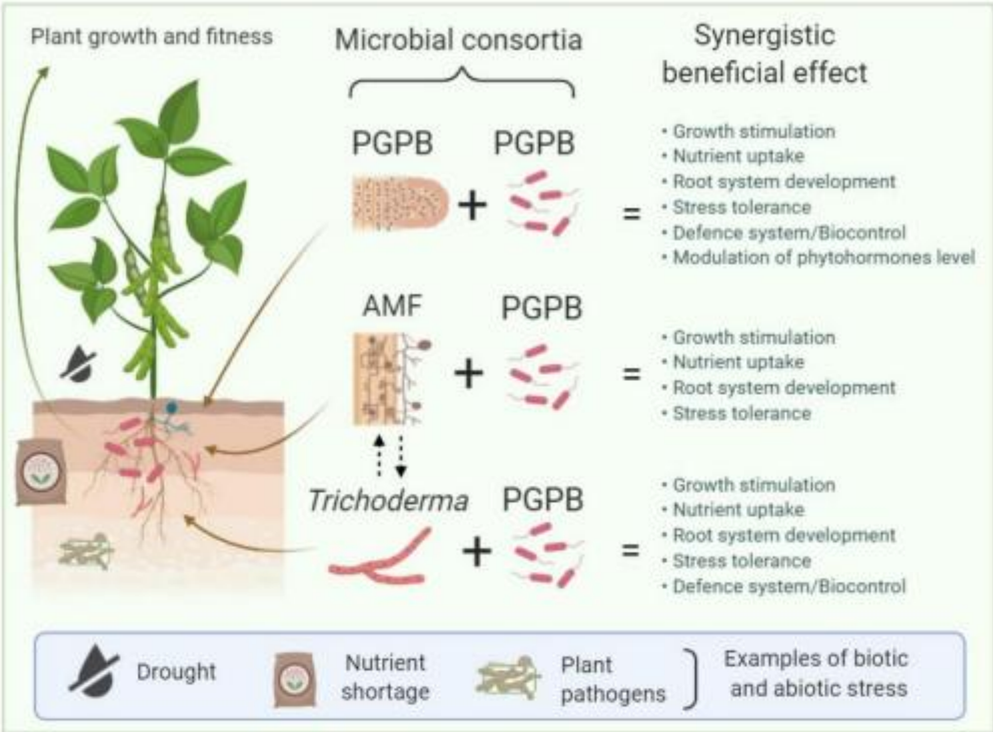

Figure 1. Microbial consortia. Rhizosphere microorganisms like plant-growth-promoting microscopic organisms (PGPB), arbuscular mycorrhizal parasites (AMF), and parasites from the class *Trichoderma* spp. can build up valuable associations with plants, promoting plant growth and improvement, expanding the plant protection framework against microorganisms, promoting supplement take-up, and upgrading resilience to various ecological anxieties. Rhizosphere microorganisms can impact each other, and the subsequent consortia of PGPB + PGPB (e.g., a nitrogen-fixing bacterium, for example, *Rhizobium* spp. what's more, *Pseudomonas* fluorescent), AMF + PGPB, and *Trichoderma* + PGPB might effectsly affect plant growth and wellness, furnishing the plant with upgraded advantages to defeat biotic and abiotic stress. Run bolts show gainful cooperations among AMF and *Trichoderma.*

Bacteria–Bacteria Interactions

Bacteria–Bacteria Interactions There is a great diversity of bacteria that are part of the plant microbiota and that have traits that promote the growth and development of plants in both optimal and stress environments A key factor influencing the beneficial effects of bacterial consortia is the interaction between their members to guarantee a stable long-term co-existence Bacterial interactions within a consortium can be classified into three types based on the effects they have on each other: (i) stimulatory or positive, (ii) inhibitory or negative, or (iii) neutral Positive interactions generally create a network to support individual members through cross-feeding, where one bacterium utilizes the metabolic products produced by another consortium member. Mutualism, protocooperation, and commensalism are examples of positive associations. In mutualism, each of the members need the others to survive since they mutually exchange required substances or mutually remove toxins In protocooperation, the interaction between species is beneficial to the growth rate of both populations, but is not required for either to persist.

Commensalism is a positive single direction communication, where one part benefits while the other is unaffected Negative associations lead to the concealment of bacterial individuals in a consortium, annihilating the local area construction and its working [60]; they incorporate amensalism, predation, parasitism, and rivalry. Amensalism is a sort of unidirectional association where the growth of one of the individuals is influenced by the creation of harmful mixtures by its accomplice Predation and parasitism portray collaborations where the growth of one animal types relies upon devouring another species with the goal that the populace elements regularly show constant motions. Rivalry happens when individuals from a consortium need a similar asset, be it supplements, water, or even space; hence, the more quickly developing species overwhelms after some time [59,60]. In nonpartisan associations, individuals from the consortium don't impact or influence each other. Neutralism happens when two species burn-through various substances (wholesome disparity) and neither one of the produces compounds inhibitory to different individuals from the consortium.

In farming, consortia individuals ought to emphatically collaborate, where mutualistic growth is attractive for stable execution over delayed development to get the normal constructive outcome when applied to a yield. In such manner, bacterial correspondence is just cursorily perceived right now. This correspondence depends on the creation, identification, and reaction to extracellular flagging particles that direct and shape the bacterial populace in the consortium, where just viable organisms are associated with modifying the plant safeguard reaction influencing in general plant wellbeing and growth Consortium correspondence is profoundly reliant upon sub-atomic signs; among them, majority detecting assumes a huge part in bacterial similarity in consortium details Among a few sign atoms, the acyl homoserine lactone (AHL) signal particles are the most notable in microorganisms.

Unadulterated AHLs have shown acceptance of intracellular Ca2+ levels and essential root growth [61,64], while AHLs created by PGPB, for example, Serratia liquefaciens and S. phymuthica, have animated root advancement and all out plant biomass; different microorganisms, as Sinorhizobium fredii and Pantoea ananatis, invigorated the arrangement of biofilm in the foundations of *Oryza sativa* (rice) and Phaseolus vulgaris (bean) plants. Different types of nitrogen-fixing microorganisms, like Sinorhizobium meliloti, makers of AHLs, advanced nodulation in Medicago truncatula (Figure 2). Majority detecting permits microscopic organisms to switch between two unmistakable quality articulation programs: (I) one at low cell thickness for individual and asocial conduct, and (ii) one more at high cell thickness for social and gathering practices, which are special for consortia.

Williams et al. showed that the reaction to changes in cell number in quorum sensing frameworks happens as follows. Low-sub-atomic weight particles called auto-inducers are blended intracellular; then, at that point, these atoms are inactively delivered or effectively emitted outside of cells. As the quantity of cells in a populace builds the extracellular grouping of auto-inducers increments At long last, the auto-inducers are amassed over the base limit level needed for location, and the related receptors tie the auto-inducers and trigger sign transduction falls that outcome in populace wide changes in quality articulation. Consequently, majority detecting empowers cells in a populace to work as one and, in this manner, they complete conduct as a group, not changing the ideal impacts of viable PGPB in consortia.

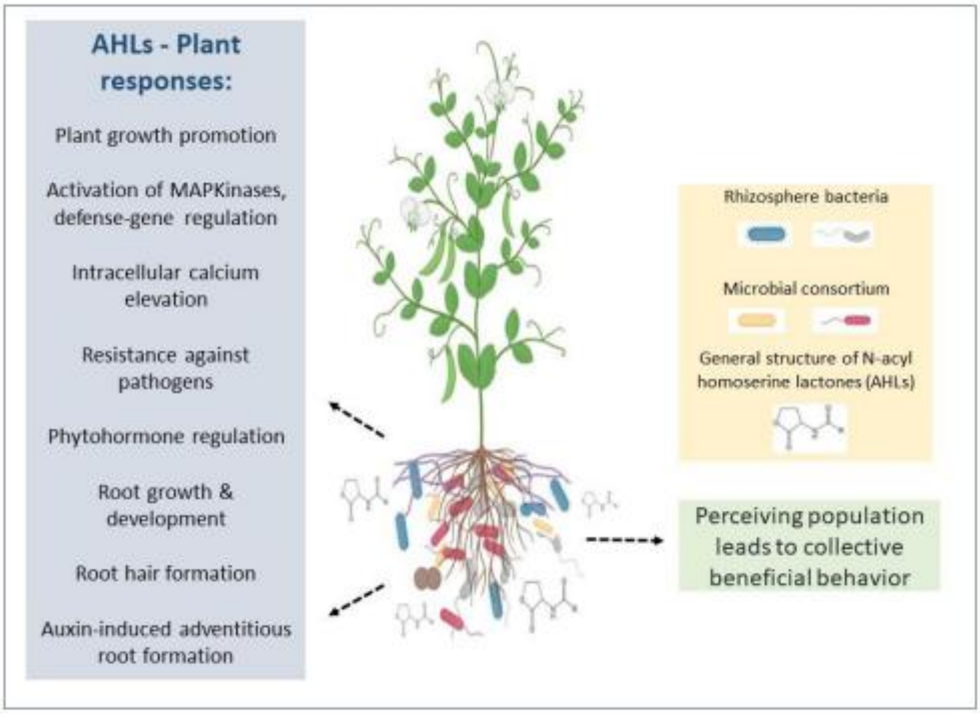

Figure 2 Plant reactions to N-acyl homoserine lactones (AHLs) delivered by plant-growth-promoting microbes in the rhizosphere. Single individuals from a bacterial consortium could interface/convey to see certain populace densities and react as a group to instigate a few plant-advantageous exercises, like incitement of root hair arrangement, root growth and improvement, and general plant growth and self-protection instruments.

Other significant flagging mixtures revealed in bacterial consortia are unstable natural mixtures (VOCs), which are embroiled in the two microbes microorganisms and plant-microscopic organisms correspondence. These mixtures incorporate terpenoids, alkanes, alkenes, ketones, sulfur-containing mixtures, and alcohols that go about as low-sub-atomic weight (<300Da), low-limit, high-fume pressure, and lipophilic sign particles These properties work with dissipation and dissemination through gas-and water-filled pores in soil and rhizosphere conditions VOCs delivered by microscopic organisms can effectsly affect the growth of other close by or far off microbes, altering their conduct and balancing bacterial protection from anti-microbials. Bacterial VOCs can likewise have direct hostile impacts against different microorganisms; hence, numerous types of *Pseudomonas* and *Bacillus* that produce VOCs with antibacterial action are utilized as biocontrol specialists against plant microorganisms Furthermore, VOCs impact quality articulation associated with hormonal flagging, cautious pathways, and microbial pressure resilience, harmfulness, and biofilm development.

Plant Growth Stimulation by PGPB Consortia under Non-Stress Conditions

There are a few investigations wherein the capability of bacterial consortia to further develop plant growth has been shown in nursery or potentially field conditions. For instance, Jha and Saraf tracked down that the vaccination of a multispecies consortium comprised of Micrococcus sp., *Acinetobactercalcoaceticus, Brevibacillus brevis*, and *Bacillus licheniformis* with the capacity to create indole-3-acidic corrosive (IAA), 1-aminocyclopropane-1-carboxylate (ACC) deaminase, and siderophores and to solubilize inorganic phosphorus worked on the yield of the plant *Jatropha curcas*. Likewise, a bacterial consortium including *Azospirillum, Pseudomonas striata*, *Pseudomonas* sp. B15, and *Leuconostoc mesenteroides* further developed the plant tallness and biomass of seedlings of tomato, brinjal, and stew [79]. In another investigation, Molina-Romero et al. showed that a consortium comprising of drying up open minded microorganisms (*Pseudomonas putida* KT2440, *Acinetobacter* sp. EMM02, *Sphingomonas* sp. OF178, and *Azospirillum brasilense* Sp7) had the option to stick to seeds and colonize the rhizosphere of maize plants. This last test showed that these microbes can coincide in relationship with plants without opposing impacts, and that immunization with this consortium expanded maize plant tallness, breadth, and shoot–root dry weight (contrasted with the un-vaccinated control). seen that the immunization of *Solanum tuberosum* and *Lupinus luteus* plants with a consortium made out of *P. putida, P. agglomerans, Bradyrhizobium* sp., and *Pseudomonas* sp. showed higher plant growth advancement in root dry weight, aeronautical dry weight, nitrogen content, and last yield.

Rojas Padilla et al. utilizing a local Bacillus consortium with *Triticum turgidum* L. subsp. Durum (wheat) under non-stress conditions, detailed an expansion in plant length and weight, just as the biovolume list, contrasted with vaccinations of a solitary bacterial endure a period. Likewise, Robles Montoya et al. [84] detailed that the utilization of a *Bacillus consortium* made out of *B. paralicheniformis, B. subtilis, B. megaterium,* and *B. cabrialesii* with wheat showed a huge increment (contrasted with un-immunized seedlings) in the length of the aeronautical piece of the plant, root length, all out length, stem breadth, boundary, dry load of the flying piece of the plant, and the biovolume file. Rhizobia have been generally read for their capacity to shape knobs and fix climatic nitrogen; they are an assorted gathering of microorganisms that structure a cooperative relationship with leguminous plants. This gathering is made out of microbes having a place with Proteobacteria classes, basically Alphaproteobacteria (e.g., *Rhizobium, Sinorhizobium, Ensifer, Bradyrhizobium, Mesorhizobium*) and Betaproteobacteria (e.g., *Paraburkholderia*, *Cupriavidus*, *Trinickia*) [85]. Rhizobia incite the leguminous plant's cooperative reaction and the improvement of knobs where the nitrogen obsession measure happens. Then again, leguminous plants make a specialty and increment chances of endurance for advantageous microscopic organisms by giving carbon sources to the rhizobia inside the knobs.

The cooperative cycle begins with the impression of plant-emitted flavonoids (present in root exudates) by rhizobia, which, thusly, produce lipochitooligosaccharides, named nodulation (Nod) factors (NFs), which are detected by the plant and lead to the enactment of the knob organogenesis programs.Therefore, the rhizobia present in the rhizosphere enter the plant root hairs by means of root breaks and afterward move and colonize the knob structure through contamination strings At the point when present inside the knob, rhizobia separate into a bacteroid express, a particular cooperative organelle-like structure that potentiates the nitrogen obsession measure As bacteroids, rhizobia fix climatic N2 through the activity of the nitrogenase compound, giving NH4 to the plant have in return for photosynthetically fixed carbon (Figure 3). It is assessed that vegetable rhizobial organic nitrogen obsession (BNF) worldwide records for ~200 million tons of fixed nitrogen each year [90], assuming an essential part in soil N cycles and generally farming usefulness. *Rhizobia* are normal soil and rhizosphere occupants and, as an outcome, have developed in direct contest and additionally synergism with other soil and rhizospheric microorganisms, including rhizobial and non-rhizobial microscopic organisms (NRB; free-living rhizospheric and endophytic microbes). Truth be told, under normal conditions, leguminous plant roots and root knobs contain a wide scope of rhizospheric and endophytic microorganisms, just as rhizobia Critically, a portion of these microbes might potentiate rhizobial knob development and advance plant growth in both ideal and upsetting conditions Henceforth, acquiring and investigating the synergistic impacts among rhizobia and NRB consortia might be the key for the improvement of inoculants with expanded execution and plant-growth-promoting properties (Figure 3).

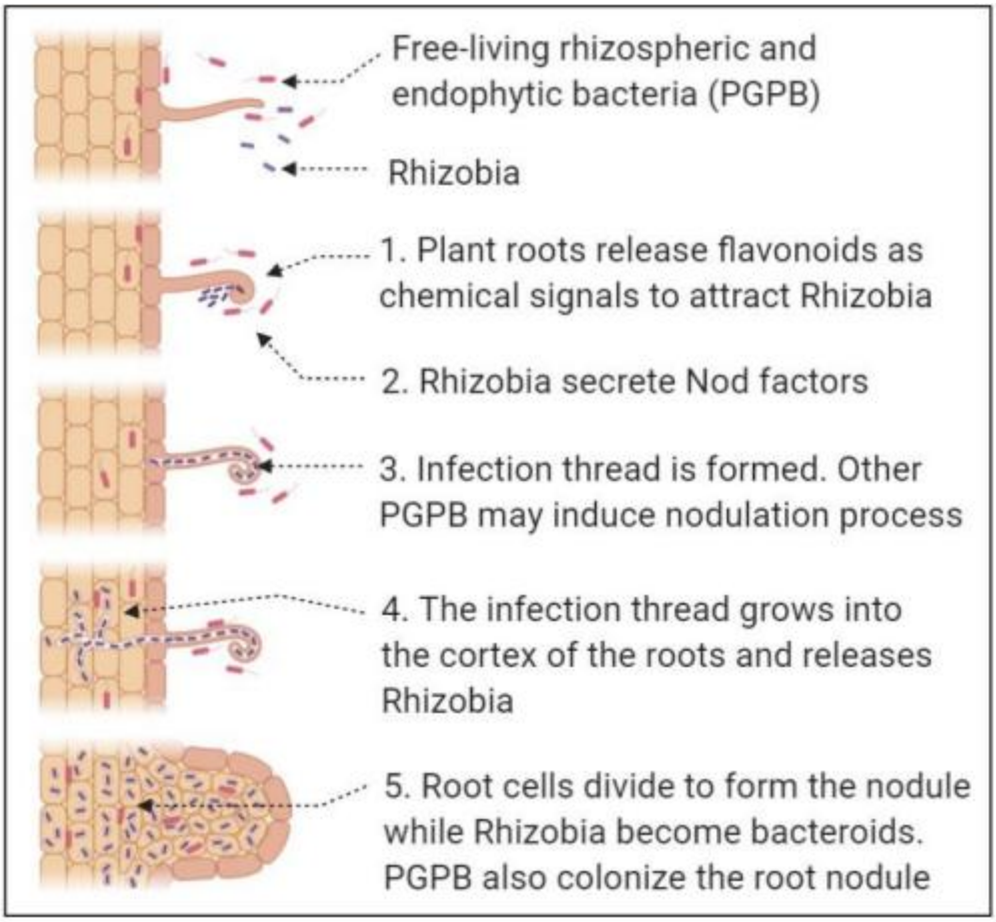

Figure 3. The development of N-fixing knobs instigated by rhizobia Free-living plant-growth-promoting rhizobacteria and bacterial endophytes may initiate the nodulation interaction and increment the nitrogen obsession, general plant growth, and nutrimental state.

A few examinations have exhibited that a different scope of free-living rhizospheric and endophytic microscopic organisms can potentiate the nodulation and nitrogen obsession cycles of a few rhizobial strains, prompting expanded leguminous plant growth (Table 1). The NRB accomplices incorporate microorganisms having a place with the Firmicutes (e.g., *Bacillus, Paenibacillus*), Proteobacteria (e.g., *Pseudomonas, Azospirillum, Pantoea*) Actinobacteria (e.g., *Streptomyces, Nocardia*), Flavobacteria, and some cyanobacteria. Additionally, the gainful impacts of co-vaccinations have been seen in different frameworks (e.g., shaping determinate or vague knobs) between a few leguminous plants (e.g., *Phaseolus vulgaris, Glycine max, Cicer arietinum*) and their particular viable alpha and beta-rhizobial symbionts (e.g., *Rhizobium, Neorhizobium, Bradyrhizobium, Ensifer/Sinorhizobium,Mesorhizobium, Cupriavidus*). This demonstrates that the co-immunization interaction can be a by and large gainful practice that benefits most vegetable rhizobia symbioses.

II. Conclusions

In any regular or rural environment, plants are found to connect with soil microorganisms By far most of these communications, regardless of whether pathogenic, impartial, or gainful, happen through a complicated organization of signs, which incorporate metabolites, unpredictable and non-unstable mixtures actual connections, and collaborations that control quality articulation, either by expanding or stifling it. It is fundamental for exploit this complex organization of regular communications to design counterfeit microbial consortia that considerably and reliably advantage plant growth and wellbeing, increment crop creation, and lessening the utilization of compound manures. As of late, Berg et al. proposed returning to and rethinking the idea of the plant (and human) microbiome, considering the related microbiota and the "theater of action" that includes the creation of proteins, lipopolysaccharides, metabolites, and mixtures as ecological components. This is in concurrence with our proposition of utilizing a microbial consortium as a component of the plant microbiome that communicates synergistically to advance plant growth and wellbeing through the creation of metabolites with anti-infection action and by solubilizing supplements and making them accessible to the plant, shaping knobs to fix nitrogen, and delivering plant-growth-invigorating phytohormones or proteins that corrupt ethylene forerunners, for example, ACC deaminase The coordinated utilization of microbial consortia will work with the creation of plants in a more reasonable manner that, in the end, won't rely upon agrochemicals.

References

[1]. Green, R.E.; Cornell, S.J.; Scharlemann, J.P.W.; Balmford, A. Farming and the fate of wild nature. Science 2005, 307, 550–555.

[2]. Gomiero, T.; Pimentel, D.; Paoletti, M.G. Is There a Need for a More Sustainable Agriculture? CRC Crit. Rev. Plant Sci. 2011, 30, 6–23.

[3]. Tilman, D.; Cassman, K.G.; Matson, P.A.; Naylor, R.; Polasky, S. Agricultural sustainability and intensive production practices. Nature 2002, 418, 671–677.

[4]. Singh, U.; Walvekar, V.A.; Sharma, S. Microbiome as Sensitive Markers for Risk Assessment of Pesticides. In Pesticides in Crop Production; Wiley: Hoboken, NJ, USA, 2020; pp. 89–108.

[5]. Uhl, P.; Brühl, C.A. The Impact of Pesticides on Flower-Visiting Insects: A Review with Regard to European Risk Assessment. Environ. Toxicol. Chem. 2019, 38, 2355–2370.

[6]. Rodríguez, A.M.D.; Cota, F.I.P.; Santoyo, G.; de los Santos Villalobos, S. Chlorothalonil tolerance of indole producing bacteria associated to wheat (Triticum turgidum L.) rhizosphere in the Yaqui Valley, Mexico. Ecotoxicology 2019, 28, 569–577.

[7]. Stamati, P.N.; Maipas, S.; Kotampasi, C.; Stamatis, P.; Hens, L. Chemical Pesticides and Human Health: The Urgent Need for a New Concept in Agriculture. Front. Public Health 2016, 4, 148.

[8]. Mitchell, C.; Brennan, R.M.; Graham, J.; Karley, A.J. Plant Defense against Herbivorous Pests: Exploiting Resistance and Tolerance Traits for Sustainable Crop Protection. Front. Plant Sci. 2016, 7, 1132.

[9]. Gong, Z.; Xiong, L.; Shi, H.; Yang, S.; Estrella, L.R.H.; Xu, G.; Chao, D.Y.; Li, J.; Wang, P.Y.; Qin, F.; et al. Plant abiotic stress response and nutrient use efficiency. Sci. China Life Sci. 2020, 63, 635–674.

[10]. Zhang, J.; Khan, S.A.; Heckel, D.G.; Bock, R. Next-Generation Insect-Resistant Plants: RNAi-Mediated Crop Protection. Trends Biotechnol. 2017, 35, 871–882.

[11]. Chen, M.; Arato, M.; Borghi, L.; Nouri, E.; Reinhardt, D. Beneficial services of arbuscular mycorrhizal fungi—From ecology to application. Front. Plant Sci. 2018, 9, 1270.

[12]. Glick, B.R.; Glick, B.R. Introduction to Plant Growth-Promoting Bacteria. In Beneficial Plant-Bacterial Interactions; Springer International Publishing: Cham, Switzerland, 2015; pp. 1–28.

[13]. Kashyap, P.L.; Solanki, M.K.; Kushwaha, P.; Kumar, S.; Srivastava, A.K. Biocontrol Potential of Salt-Tolerant Trichoderma and Hypocrea Isolates for the Management of Tomato Root Rot Under Saline Environment. J. Soil Sci. Plant Nutr. 2020, 20, 160–176.

[14]. Khatoon, Z.; Huang, S.; Rafique, M.; Fakhar, A.; Kamran, M.A.; Santoyo, G. Unlocking the potential of plant growth-promoting rhizobacteria on soil health and the sustainability of agricultural systems. J. Environ. Manag. 2020, 273, 111118.