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AGRICULTURAL SIGNIFICANCE OF RHIZOBIUM SPECIES FROM DIFFERENT SOURCES

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ABSTRACT
Strong demand for food necessitates efforts by researchers to create methods for sufficient production. Agricultural challenges include soil fertility loss, climate change, and increased pest infestations. Environmentally friendly practices such as the use of bio pesticides, bio fertilizers, and the return of crop residues are used to produce sufficient quantities in a healthy and sustainable farming system. The wide range of beneficial impacts of soil microorganisms, notably plant growth stimulation, emphasizes the need for more research and application in modern agriculture. Legumes are an important part of many people traditional diets around the world because they provide a slew of benefits to a soil and other crops produced alongside or after them in a variety of cropping systems. Legumes ability to fix atmospheric nitrogen in conjunction with rhizobia allows them to thrive in severely deteriorated soils. Is it, nevertheless, necessary to inoculate legumes on a regular basis? Rhizobia are extremely valuable agriculturally and economically since they are the primary supplier of nitrogen in agricultural soils. Aside from nitrogen fixation, several rhizobia strains have plant-growth-promoting features such phytohormone synthesis, siderophores, and 1-aminocyclopropane-1-carboxylic acid deaminase, as well as inorganic phosphate solubilization. Rhizobia have become important for both legumes and non-legumes as a result of these factors. Plant growth has been improved by screening and using effective rhizobial strains as inoculants. Plant growth has been improved by screening and using effective rhizobial strains as inoculant. The use of rhizobia as a bio fertilizer ensures crop yield while also reducing the demand for expensive and environmentally harmful artificial fertilizers. Rhizobia and other plant-growth-promoting rhizobacteria inoculated together resulted in increase in plant-growth promotion. Bioremediation properties of certain rhizobial strains have also been found.
Keywords: Rhizobia, Plant-growth-promoting rhizobacteria, Nitrogen fixation

INTRODUCTION

Increased food demand, with growing population, has been a major concern throughout the globe hence food production needs to increase by 70%, mostly through yield increases, to feed the world in 2050. The world's population in 2015 was about 7.3 billion and is still increasingwith Africa 738 million (10%), Europe 9% (634 million), and North America 358 million (5%). The world population is expected to reach 8 billion people in 2023 and 11.2 billion in 2050 as per the united nation (in 2026 according to the U.S. Census Bureau). As population increases, stable food supplies will be a problem due to severe weather and soil fertility. Food protection therefore is an important aspect of ensuring the preservation of the world's population FAO estimates show that 12,5% of the world's population is undernourished in terms of food consumption. Twenty-six percent of children in the world are stunted. 2 million people suffer from micro-nutrient deficiencies (Chiara et al., 2019). Food insecurity is linked to factors such as, disease, drought, climatic changes and low soil fertility (Sub-Saharan Africa, 2014). To address the problem of decreasing food production and livelihoods addressing soil fertility issues is necessary.

Low fertility and inadequate soil management have been significant issues for producers' productivity, but they are sadly confronted with obstacles that have held back their progress. Soil fertility and productivity is characterized as "the physical, biological and chemical characteristics of a soil, such as its microbial activity, acidity, texture, depth, and water-retention ability, all of which influence fertility." (Kehali, *et al.*, 2017)/ The main cause of low fertility through continous cropping,excessive use of fertilizer, nutrients stratification, and intensification, specialization of crop and livestock production without consideration of the natural site-specific soil and climate conditions has caused pronounced degradation and partly irreversible damage to the soil (Kehali *et al.,*2017).

Furthermore, human activity, especially in highly developed countries, has resulted in serious problems with forest ecological sustainability. Since the mid-1970s, for example, new types of forest decline have been occurring. This harm is caused by soil pollution as well as other sources (Awudu et al, 2011). Despite significant debate, there is no doubt that air pollution pressures such as "acid rain" and increased nitrogen deposition have an impact on forest soils, such as accelerating soil acidification. The loss of cationic nutrients like Mg, Ca, and K from the ecosystem rises as a result of this process. As a result, it is not unexpected that Mg and K deficits play a role in diverse sorts of this new injury.

Methods of enhancing plant productivity

Soil fertility and sustainable agriculture need to be rebuilt. Grazing, soil conservation, green manuaring, soil test, mineralisation, fertiliser prorities, fossil humates and soil assesment play a role in estabishing self-regenerative, sufficient, soil fertlity. There have been various studies conducted to address the matter of soil fertility, but the majority of them focus on the application of various forms of chemical fertilizers as well as pesticides. According to Vanlauwe et al. (2014), inorganic fertilizers have been widely used as a major nutrient management tool, but they are unsustainable, resulting in soil depletion and pollution. When chemical fertilizers are used in excess, the soil may become chemically 'overloaded,' gradually poisoning the soil and preventing plants from establishing. Chemical fertilizers dissolve quickly and release nutrients before plants can use them (Weiwei, *et al.,* 2019).

Microorganism and soil fertility

Since the mid-1970s, for example, new types of forest decline have been occurring. This harm is caused by soil pollution as well as other sources (Awudu et al, 2011). Despite significant debate, there is no doubt that air pollution pressures such as "acid rain" and increased nitrogen deposition have an impact on forest soils, such as accelerating soil acidification. The loss of cationic nutrients like Mg, Ca, and K from the ecosystem rises as a result of this process. As a result, it's not unexpected that Mg and K deficits play a role in diverse sorts of this new injury. Microorganisms in the soil bear a peculiar relation to soil fertility. The function of soil microorganisms is to render potential fertility available (Kiriya & Sukanya, 2019). Microorganisms in the soil work by biodegrading organic matters, and use nutrients and carbon in the organic matter to fuel their own growth. Excess nutrients are released iin the soil, where plants can absorb them. Microorganisms are mainly responsible for the degradation of agricultural pesticides in soil. Some soil microorganisms contain enzymes that can degrade agricultural pesticides and other harmful substances that have been added to the soil. The ease with which these compounds are degraded by microbial enzymes determines how long they stay in the soil (Stefan, 2013). Higher plants and microbes thrive in close proximity to one other and are mutually dependent in a variety of ways. Plant and animal remnants provide food for a significant number of bacteria as well as molds in the soil, which constantly turn them into humus and plant nutrition. They are also responsible for the progressive release of available food from insoluble minerals in the soil and inaccessible fertilizer ingredients through the creation of CO_2 and other acids like as nitric and sulfuric. Some species convert elemental sulfur and sulfides into soluble form sulfate, whereas others use protein material to produce ammonia and nitrates. Other species use atmospheric nitrogen to produce compounds that are eventually absorbed into humus, increasing the availability of nitrogen, which is frequently a limiting element in soil fertility.

There is a special kind of soil bacteria called rhizobia that has a favorable influence on the growth of legumes. Rhizobia bacteria are unique in that they can exist in both the soil and the root nodules of their hosts legumes (Ouma et al., 2016). Rhizobia are a type of bacteria that can dwell in soil or even in nodules formed on legume roots. They create a symbiotic relationship with the legume in root nodules, absorbing nutrients from the plant while also creating nitrogen in a process known as biological nitrogen fixation. Only rhizobia that are compatible with a given legume species can promote the production of root nodules, a process known as nodulation. This approach offers a significant economic benefit for the production of legumes. Hence, rhizobial inoculants are commercially manufactured in a number of nations. Rhizobia obtained from plant nodule and cultivated (cultured) artificially inside the laboratory are included in inoculants (Donald E *et al.,* 2010). The projected effects of nitrogen-fixing bacteria could be either positive or negative depending on the rhizobium species and its connection with the environment. (Xu *et al.,* 2012) Rhizobia are well-known for their capacity to shape legume root nodules and stimulate plant development by fixing nitrogen. Growth of plants and nitrogen fixation capacity can be improved under stress situations by isolating and selecting rhizobia stress-tolerant strains (Bhattacharyya & Jha 2011). Legumes contain flavonoids, which attract nodulating bacteria. Choosing the correct Rhizobium strains is the most crucial component of obtaining the most from this technology (Oruru & Njeru2016). Regardless of their involvement in direct plant growth promotion, Rhizobia can defend the host plant from pests and pathogens. Plant defense via rhizobium inoculation could include nutritional competition, abiotic stress, and induce resistance in the host plant. Rhizobia have the capacity to both directly and indirectly enhance plant development. Plant growth stimulation by rhizobia is mediated by a number of processes, which are mentioned below.

Direct plant growth promotions

Biological nitrogen fixation

Nitrogen is an essential element for plant development and growth; nitrogen is needed for synthesis of organic molecules such as amino acids, chlorophyll, nucleic acids and proteins. Despite the fact that nitrogen makes up 78 percent of the atmosphere, plants cannot directly absorb it because it is in a gaseous state. In agriculture, nitrogen fertilizers are utilized to increase food production yields. Biological nitrogen fixation (BNF) is the primary source of converting atmospheric nitrogen to a usable organic form by the pants. Approximately 60% of the nitrogen used in agriculture comes from biological nitrogen fixation (BNF). Chemical fertilizer synthesis and consumption expanded at an exponential rate in the previous century, until crop productivity has become a mystery. Both industrialized and developing countries have seen significant increases in fertilizer-N usage. The need for fertilizer-N is expected to rise much more in the future. (Hungria & Kaschuk, 2014). Previously, extensive use of factory-produced fertilizers posed less of a threat to the environment. A high carbon footprint and nitrogen contamination of water bodies, such as eutrophication, have given ample reason to pause and doubt the long-term sustainability of N fertilizer use. Large doses of fertilizer, on the other hand, have a harmful and volatile effect on the climate, contaminating water, soil, and natural resources. These effects are regarded as a danger to human and animal health, and they have an impact on people's quality of life. The importance of BNF in agriculture production systems has regained attention due to environmental concerns about the synthetic alternative and the additional cost of cultivation. Furthermore, developing countries must employ less expensive and environmentally sustainable alternatives. (Khattab *et al.*,2013). Legumes are capable of biological nitrogen fixation and can satisfy their own nutritional requirements. The use of legume crops decreases the amount of nitrogen that must be obtained from outside sources. BNF has captivated scientists interested in plant mineral nutrition for more than a century, and it has been widely used in agricultural practice. Its effectiveness, however, varies and is dependent on the genotype of the host, rhizobia quality, soil conditions, and climatic factors. Using microbes that can fix atmospheric nitrogen is currently very important since it avoids constraints of chemical fertilization that has culminated in unsustainable aspects of water contamination (Ahemadm & Khan, 2010).

Different sources on biological nitrogen fixation

Sources	Plant used	Isolates	Positive isolates	Results	Reference
Pegion pea	Pegion pea	10 isolates	10 isolates	Each of the ten isolates in terms of morphological characterization, all of the isolates had been found to be rod-shaped and gram negative for gram staining reaction. All of the isolates were found to be positive for citrate utilization, urease, gas production, and oxidase tests, but negative for indole production, nitrate reduction, and Voges proskauer's tests.	(Harshitha et al., 2020)
Beans		41 rhizobia isolates	41	When incubated in dark on YEMA-CR medium, all isolates were Gram negative rods that did not absorb Congo red dye	
Soybeans	Soybeans	70 isolates	0	All the positive isolates failed to form failed to form root nodules in either soybean cultivar	(Safiullah *et al.*, 2017)
Bambara	18 isolates				
Lentils		98 isolates	30	The positive isolates were able to form nodules with Lathyrus sativusandPisum sativum under the same growth conditions.	(Harun *et al.*, 2014)

Groundnuts	groundnuts	8 isolates	3 isolates	All the positive isolates were able to nodulate their host plant, exhibiting their potential to be used as native groundnut rhizobial inoculum.	(Rabia *et al.*, 2020)

Nitrogenase, an oxygen-sensitive metal-loenzyme, is solely responsible for biological nitrogen fixation. Despite the fact that a wide range of microbes can fix nitrogen, they all generate nitrogenases, which have similar catalytic mechanisms and assembly of the metal-containing cofactors required for their functions (Dos *et al*., 2012). Two catalytic partners are found in all nitrogenases mentioned so far. One of those partners, dinitrogenase reductase, acts as a nucleotide-dependent electron delivery agent to the other, dinitrogenase. Dinitrogenase binds as well as reduces N2 to form ammonia after accumulating an adequate number of electrons from the reductase. As each N2 is reduced, eight electrons and 16 ATP are absorbed, the metabolic the cost of nitrogen fixing can be understood. In addition to the catalytic components of the enzyme, proteins are necessary for the construction and insertion of the metal clusters required to activate the nitrogenase catalytic unit (Yang *et al.*, 2014).

Rhizobium or Bradyrhizobium infect the host plant's root system, causing nodules to form to house the bacterium. After that, the bacteria begin to fix the nitrogen that is needed by the plant. Because it has access to fixed nitrogen, the plant may produce nitrogen-fortified leaflets that can be recycled. As a result, the plant's photosynthetic potential is increased, and nitrogen-rich seed is produced. The implications of not nodulating legumes can be severe, especially when the plants are cultivated in nitrogen-deficient soil. Plants that result are chlorotic, nitrogen-deficient, and generate very little seed. It increases plant development through methods which are not dependent on biological nitrogen fixation by rhizobia.

Harshitha et al, (2020), assesed nodulation of pegion pea under laboratory conditions, they obtained rhizobium like isoates from root nodules and nodulated the host using small plastic cups filled with sterilized soil.they also fuctional characterised the rhizobial isolates,they used 10 isolates and all the isolates had a positive impact. The isolates' morphological properties were investigated.. The results were that all the isolates showed a positive results for nodulation and the formation of root nodules varied from around 12 -14 per plant. All the 10 isolates were discovered to be rod shaped and when tested for gram staining reaction, the results were gram negative, according to morphological characterization. All of the isolates tested positive for urease, citrate acid and citrate utilization, and oxidase tests, but negative for indole formation, nitrate reduction, and Voges proskauer's tests. (Harshitha et al, 2020). Another study by Yarmilla, et al., (2020), on effect of nitrogen appication on nitrogen fixation on common bean production.they noted the assosiation between the rhizobia bacetria and host pant.

A study conducted by Ali *et al.*, *(*2017) ,they isoated rhizobia species from lentlies and studied its pysiological,morphoogical and biochemical characteristics.they identified that the bacterium were gram negative,aerobic,non-spore forming. Citrate utilization, starch hydroysis, congored test, nitrification test, and oxidase test were all positive in the rhizobial isoates. Starch, methly red, indole, and hydrogen suphide synthesis were all negative in the isolates. The 16S rDNA gene was used to identify the rhizobia isolates in the study. The isolated strain was found to be homologous to the bacterial strain Rhizobium species based on 16S rDNA sequencing. According to Ali et al. (2017), rhizobia, a unique group of the soil bacteria, have a beneficial effect on the growth of legumes such as Lentil

Phosphate solubilization

After nitrogen, phosphorus (P) is the most limiting factor for plant development. Organic forms include bound and inorganic forms such as set, or labile, with concentrations varying depending on the source. Carbonate rocks have a concentration of 140 parts per million, while volcanic materials have a concentration of over 1000 parts per million(Gray and smith, 2005) The most common of Phosphurus provided as fertilizer reaches the stationary pools via precipitation interactions with reactive Al3+ and Fe3+ in acidic soils, and with Ca2+ in calcareous soils (Bhattacharyya & Jha, 2012). The amount of phosphorus available to plants is determined by several parameters, including aeration, soil pH, temperature, texture, the size of plant root systems, and root exudates and microbial secretions. Microorganisms in the soil play a significant role in the phosphorus dynamics in the soil and the phosphorus availability to plants as a result (Jörg, 2015). Although chemical fertilizers meet the phosphorus requirements of plants, excessive usage of phosphorus fertilizers is both expensive and damaging to the environment. Plants have a phosphorus content of 0.2 to 0.8 percent by dry mass, but only 0.1% of that phosphorus is present to them (Sharma *et al.*, 2013). The principal source of P for the plant is still the sediment. Agricultural soil solution have a low P concentration, making them unsuitable for the host plant's demands. The ability of the microbial system to solubilize phosphate enables it to replace the amount of P required for the host plant's growth. Rhizobia organisms that can solubilize phosphorus include R. leguminosarum, Bradyrhizobium sp., and B. japonicum (Mouazen & Kuang, 2016). Because these bacteria produce low molecular weight organic acids which work on inorganic phosphorus, phosphorus is soluble. A considerable proportion of Rhizobium strains were able to solubilize phosphorous in liquid culture (Vaccari, 2009). The ability of some rhizobia to solubilize phosphorus has been shown to play a role in plant growth in chickpeas and barley. According to Harshitha et al, (2020),p-solubilisation of pegion pea isolates varied from 4-10.and the results were that out of 10 isolates only six were able to exhibit p-solubiisation.the rhizobium species differ in ability to produce the organic acids such as propionic,formic, lactic, succinic and fumaric acids.

Sources	**Plant used**	**Isolates**	**Positive isolates**	**Results**	**Reference**
Runner beans	Runner beans	25	25	all the isolates have the potential to solubilize the inorganic form of P as indicated by a gradual increase in the amount of soluble P in the medium	(Gabriela, et al., 2016)
Beans	beans	31	16	Only the positive isolates were able to produce large zone of clearing on calcium-phosphate and promotion of growth beans-amended agar media.	(Khaled, Amr, & Krishnapillai, 2008)
Pegion pea	Pegion pea	10 isolates	6 isolates	All the positive isolates exhibited solubilization of p, Zn and one isolate showed magnesium trisilicate solubilization	(Harshitha et al, 2020)
Groundnuts	Groundnuts		41 isolates	All positive isolates exhibited clear zones on the agar plates were selected as phosphate solubilizing bacteria	(Nwanyanwu *et al.*, 2015)

Siderophore

Iron (Fe) is a micronutrient that is required by all living creatures, including bacteria, plants, and humans. It is essential for plant growth, and the amount of iron in crops is a crucial driver of human wellbeing (Briat *et al*., 2015). Total Fe in soils frequently surpasses plant requirements, but bioavailability is low in circumneutral settings, where many crop plants are grown, due to its reliance on pH and redox conditions (Lemanceau *et al.*, 2009). Iron bioavailability drops dramatically as pH rises, making iron a constraining factor for plant growth in calcareous soils (which account for up to 30% of the world's soils). As a result, plants and microbes have developed active iron absorbing techniques.

Iron is a crucial micronutrient to plants, and it can be found in a variety of quantities in the soil. Divalent (ferrous or Fe2+) and trivalent (ferric or Fe3+) iron occur in two states. The pH and Eh (redox potential) of both the soil, as well as the availability of numerous other minerals, determine the status of iron in soil. Leguminous plants absorb the majority of ferrous ions. In aerobic conditions, iron exists as insoluble hydroxides and oxyhydroxides, which are unavailable to plants and microbes. Bacteria can produce siderophores, which are low-molecular-weight molecules that can bind to Fe3+ and sequester it. Plants can obtain iron through these siderophores because they have a high affinity for Fe3+. Both external and internal habitats contain water-soluble siderophores. Rhizobacteria, both Gram-positive and -negative, reduce Fe3+ ions to Fe2+ and release them into cells. As a result of the reduction, siderophores are either killed or recycled. Siderophores can form stable complexes with heavy metals including Aluminum, copper, as well as radionuclides like U and NP. As a result, inoculating plants with siderophore-producing bacteria shields them against heavy metal stress while also boosting iron uptake. Several rhizobia species produce siderophores, which influence the growth of certain legumes.

Plant Growth Promotion and disease control for Green Gram by Siderophore Producing Pseudomonas sp. was investigated by G.K. Sahu and S.S. Sindhu (2011). Pseudomonas isolates were isolated by plating serial dilutions on King's B (KB) medium plates from the soil samples of chickpea and green gram. Pseudomonas colonies were chosen based on morphology and pigment production properties that are typical of the genus. On MM9 medium, 37 of the 80 Pseudomonas strains evaluated for siderophore production were developed to create siderophore. Inoculation with siderophore-producing Pseudomonas sp. could thus be used to reduce disease and promote plant development in legumes. Sarwar et al. 2020 published a study called Screening of Siderophore-Producing PGPRs Isolated from Groundnut. A total of 120 distinct bacterial isolates (MGS-1 to MGS-120) were collected and screened for siderophore synthesis. MGS-14 produced the most siderophores (73 percent), followed by MGS-11 (69%), and MGS-91 (91 percent) in quantitative siderophore estimation (68 percent). On the 32nd day of incubation, the three SPB isolates (MGS-11, MGS-14, and MGS-91) that produced the most siderophore units (>60 percent SU) showed an increase in iron release of 82 percent, 71 percent, and 69 percent, respectively, over the control.

Source	**Plant used**	**Isolates**	**Positive isolates**	**Results**	**Reference**
Bean	**Bean**	**4 isolates**	**3**	Fe-CAS complex have blue color but sequestering of iron from this complex by bacterial siderophores turn its color to the orange that appears as halo surrounding bacterial colony.	(Mahtab *et al.*, 2010)
chickpea and green gram	chickpea and green gram	**80 isolates**	**37 isolates**	Siderophore production was also determined on iron deficient succinate medium. Only two *Pseudomonas* strains MPS52 and CP20 showed large halo zone formation	(Sahu & Sindhu, 2011)
Groundnut	**Groundnuts**	**120 isolates**	**3 isolates**	Results revealed that the three SPB isolates (MGS-11, MGS-14, and MGS-91) which produced maximum siderophore units (>60% SU) showed an increase in iron release and 82%, 71%, and 69% over control on 32nd day of incubation, respectively.	(Sarwar, et al., 2020)

Phytohormone production

Phytohormones are compounds that, at low quantities, encourage plant growth. Indole-3-acetic acid (auxin), cytokinins, gibberellins, and abscisic acid are some of these compounds. A kind of indole-3-acetic acid is indole-3-acetic acid (IAA). IAA is a key member of the auxin family; it is a cutting-edge phytohormone that stimulates root growth and development, which leads to faster plant growth and development. IAA plays a role in cell division, differentiation, and vascular beam development, and also nodule formation (Kaiser, *et al*., 2015).

IAA production has indeed been discovered in a number of isolated rhizosphere bacteria, albeit it varies amongst isolates (Mandal *et al.,* 2009). Rhizobia create IAA through the indole-3-pyruvic acid or indole-3-aldehyde acetic routes. Vetch roots inoculated with *R. legumin* Sarum by. viciae produced a 60-fold increase in IAA in nodules (Dakora, 2015). Inoculating B. japonicum-SB1 with B. thuringiensis-KR1 produced one of the highest amounts of IAA, according to (Mishra *et al.,* 2009). The creation of AIA as a result of *Pseudomonas* co-inoculation for *R. galegae* via orientalism has resulted in enhanced nodule numbers, root and root growth, and nitrogen content. Environmental and genetic stresses have an impact on AIA biosynthesis.

Cytokinins

In some circumstances, cytokinin encourages plant cell proliferation, root growth, and the creation of absorbent hairs (Mandal *et al.*, 2009). The majority of rhizosphere microbes make cytokinin. Rhizobium strains can produce cytokinin as well.

Abscisic acid

Abscisic acid is created by a combination of circumstances, including low temperatures and a lack of water. Carotenoids are processed in a way that indirectly influences biosynthesis. Abscisic acid, unlike auxin, has no polarity in plants and can be carried by the vascular tissues. Abscisic acid has been demonstrated to drive stomatal closure, restrict shoot growth without hurting or even boosting root growth, induce seeds to store proteins and fall dormant, and hence provide a buffer against infections and gibberellins. *Rhizobium* sp. and *B. japonicum* produced abscisic acid (Kanchan *et al*., 2017).

Indirect plant growth promotions

Biological control of plant disease

Furthermore, *Rhizobium* spp. have been increasingly connected to disease adverse effects in recent research (Chandrima, et al., 2020), pest and pathogen antagonistic mechanisms, as well as activation of plant host defenses, increase plant health, effect of rhizobia to pathogens and pest. *Rhizobium* spp. attack a wide range of pest and pathogen species, including fungi, bacteria, and parasitic plants. A strain of *Bradyrhizobium japonicum* has been shown to diminish *Phytophthora megasperma* sporulation by up to 75%, *Pythium ultimum* sporulation by up to 65%, *Fusarium oxysporum* sporulation by up to 47%, and *Ascochyta imperfecta* sporulation by up to 35%. These findings suggest that a single bacterial strain can control a population of numerous harmful strains, possibly giving bioprotection to the host plant (Gabriele, *et al.*, 2006). These findings show that rhizobia have a lot of promise for battling plant diseases and, as a result, should be given more attention in cropping system research in the future.

Several studies have been conducted on the mechanism of action of Rhizobium species have found that the production of poisonous chemicals ensures plant pathogen growth suppression. Antimicrobial activity connected to extracellular *Rhizobium* spp. compounds, such as trifolitoxin (Mabrouk, et al., 2007) have been identified, implying that antibiosis may be a component of their established biocontrol efficacy. Mabrouk et al. (2007) recently discovered that specific *Rhizobium* isolates promote pea growth and N-fixation output. Pea inoculation with rhizobia protects pea from parasitic plant infection (*O. crenata*) as well as nodulation. Inoculated peas showed evidence of induced resistance such as reduced broomrape seed germination, radicle development, parasite attachment to pea roots, and tuber growth blocking on host roots. Following rhizobia strain inoculation, lignification and toxic substance accumulation in pea roots resulted in these observations

Rhizobia induces plant defense against pests and diseases.

Plants can benefit from Rhizobium populations because they stimulate their hosts. When a pathogen is present, Rhizobium spp. will indirectly drive the plant to activate its defense mechanisms by causing the production of plant defense chemicals. Induced resistance to Orobanche in peas inoculated with some rhizobial strains was associated to considerable alterations in defense enzymes including polyphenol oxidase,peroxidase, oxidative lipoxygenase, as well as the buildup of toxins such phenolic acids, pisatin, and pea phytoalexin.These modifications were caused by the inoculation of pea plankton, which activated defense genes (Abd et al., 2011).

Several Rhizobium spp. isolates were found by Arfaoui et al. (2006). It stimulated chickpea defense against *Fusarium oxysporum* f. sp. and reduced the severity of the host plant's disease. They discovered that inoculating chickpea plants with Rhizobium strains a few days before they are struck by *Fusarium oxysporum* f.sp. ciceris reduces the incidence of wilting caused by a substantial increase in the activities of many protective scheme enzymes such as peroxidases and polyphenoloxidases, resulting in phenolic compound accumulation and gelatinase expression. Many plant species have developed rhizosphere bacteria-induced resistance to pathogens such as viruses, bacteria, and fungus. The induction methods and compounds involved in the induction of plant protection vary greatly depending on the bacterial strain and pathosystem. Bacterial salicylic acid has been demonstrated to promote resistance in a range of plant species in various investigations. Rhizobia lipopolysaccharides have been implicated in the beginning of mediated systemic resistance in several investigations. According to certain writers, LPS from R. etli has been demonstrated to elicit/trigger ISR in potato against the Globodera pallida cyst nematode.

CONCLUSION

Plant growth and productivity are influenced by a variety of factors, including mineral nutrition, insect pest resistance, and disease resistance. Fortunately, symbiotic rhizobia can activate biological pathways that result in results that promote and safeguard plant growth in both direct and indirect ways Studying the interlinkages of consequences from the legume-rhizobia symbioses suggests the possibility to identify microsymbionts for usage as inoculants due to the variety of activities that microsymbionts elicit. Rhizobia can produce more symbiotic N for host plant growth and productivity, elicit the formulation of host-plant biomolecules for defense and increased plant growth, produce environmental cues that regulate stomatal function, and generate vitamins as growth factors for plant resistance and increased growth/productivity. While some of rhizobia's effects may be tied to their symbiotic relationships with legumes, the effects of some of the signal molecules they create commonly extend to non-legumes, suggesting a wider dispersion of these characteristics among bacterial species.

RECOMMENDATIONS

More study should be done to identify rhizobial species that can operate in stressed soil environments so that inoculation legume productivity does not suffer in degraded soils. In order to achieve sustainable food systems, agroecological management strategies that promote biological nitrogen fixation as component of the nitrogen cycle, as well as photosynthesis as part of the carbon cycle, are required. In the Next Green Revolution, rhizobium-legume symbioses must be a key component of agroecosystem management techniques.

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