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Promotion of Plant Growth Promoting Rhizobacteria (PGPR) for Increases Production of Biomass

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Research Article

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ABSTRACT

Rhizobacteria that promote plant growth (PGPR) are naturally occurring soil bacteria that irritate plant roots while also assisting in the development of plant growth. The early introduction of plant extracts containing specific kinds of PGPR increases biomass production with immediate effects on root and shoot growth. Therefore, it's important to train specialists that can function successfully under field situations. It is intriguing to use PGPR's multi-strain inoculate with established functions because these structures can improve industry compliance. They offer the capacity to handle several processes, numerous diseases, and transient or local variations. PGPR offers a sustainable approach to boosting plant yield. Plant Growth Promoting Bacteria (PGPB) directly stimulate development by fixing nitrogen, solubilizing DNA, producing growth hormones, and producing an enzyme protease, chitinase and other helpful enzymes like cellulose, pectinase, which fights pathogenic fungi by producing siderophore, -1, 3-glucanase, antibiotics, fluorescent pigments, and cyanide, are examples of the enzymes that break down fungal cells. The rhizosphere of Glycine max contains an abundance of plants that encourage the growth of rhizobacteria (PGPR), but their capacity to penetrate roots and survive in soil is frequently constrained. Phosphate solubilizing bacteria was isolated from the soil in the current study, and its impact on Glycine max germination and plant growth was studied for bio-fertilizer purposes. Its multi-functional properties will draw more attention to the bio-fertilization and biological control of Pseudomonas, and its ability to extract phytohormones and antimicrobial metabolites can be used as bio-fertilizer and biocontrol agents in agricultural and environmental settings.

Keywords: Rhizobacteria; Phosphate solubilizing bacteria; Glycine max; Enzyme protease; Chitinase

INTRODUCTION

A special class of bacteria known as rhizobacteria promoting plant growth (PGPR) can be found in the rhizosphere, root zones, and root canals and can directly or indirectly enhance the quality of plant growth. Rhizosphere microorganisms can improve nutrient availability in the rhizosphere and influence root growth and development, which can have a substantial impact on crop production on agricultural soils and in land [1-3]. One of the most popular approaches to boost soil fertility and sustain high levels of phosphorus is to apply soluble forms of Phosphorus (P) fertilizers to the soil. These fertilizers are applied as simple reductions of immobile fertilizer forms that increase agricultural production of Phosphorus (P) and Nitrogen (N), the two most earth-limiting elements remain a major challenge in environmental science and global management green revolution has become one of the most successful human efforts in this century. These changes have led to global food security and played a key role in transforming developing countries, such as India [4-6]. The rising population, however, is reducing the increase in food production, and this has put the world's food security once more in jeopardy. Fertilizer was crucial in the transition to a green economy, but excessive use of it has decreased soil fertility and exacerbated environmental inequalities. Crop yield is significantly hampered by phosphorus deficit. Because the majority of the phosphorus is present in insoluble forms, only the inorganic phosphorus type is absorbed by plants, and the inert phosphorus level in the soil is very low. The over use of chemical fertilizers has resulted in high amounts of phosphorus in agricultural soils. Excessive use of chemicals and chemical fertilizers has caused soil pollution as well as devastating impacts on beneficial arthropods and other helpful creatures. Additionally, the majority of this organic matter is transformed into an unresolved state, rendering it unavailable to plants [7-9]. The PGPR plays a significant role in the biocontrol of plant diseases and is a native to the soil and trees of the rhizosphere. They have the ability to reduce a variety of bacterial, fungal, and nematode illnesses. Additionally, PGPR can offer defence against viral infections [10]. In numerous parts of the world, PGPR usage has become extremely widespread. Availability of soil P is largely governed by intermediary processes like important minerals and degradation levels. Given that P is created in non-available forms right away and accounts for low P performance through natural use and chemical rainfall that will soon erase the available phosphate, even if the total amount of P is considerable and if P fertiliser is used frequently. Phosphate solubilizes (PSB), which transform soluble phosphates into soluble forms, are rhizosphere-dwelling bacteria that have a favourable impact on plant growth and include a variety of species, including pseudomonas. Cheating, exchange reactions, and the creation of gluconic acid [11]. The use of chemical pesticides and inorganic fertilisers is currently being reduced, which is prompting the agricultural industry to explore for alternatives that enhance environmental quality. Inputs, plant wastes, green manure, and other environmental contaminants are needed for organic soil management. Protease, Chitinase, Indole-3-Acetic Acid (IAA), Amino-Cyclopropane-Carboxylate (ACC) deaminase production of fungal cell wall enzyme, and attempts are made in the normal production process of a group of plant growth that stimulates hormones and enzymes. Growth-promoting bacteria (PGPB) directly promote growth through nitrogen fixation. The ability to produce additional useful enzymes, such as cellulose, pectinase, test, and indirect defence against pathogenic fungi by producing

siderophores, chitinase, 1,3-glucanase, antibiotics, fluorescent colours, and cyanide is sometimes restricted. Drugs produced by various pseudomonas species have been extensively studied as biological agents and are an alternative to controlling phytopathogenic microorganism in agriculture because it binds to the iron form present in the rhizosphere, rendering it unavailable to phytopathogens to inhibit plant proliferation. Pseudomonas fluorescent has also been used as biocontrol agents based in part on understanding the mechanisms involved in antagonist interactions between bacteria; pathogen and bacteria. There are now some commercial Pseudomonas variants that work well as biocontrol agents on the market, but the introduction of pure siderophores, such as bacteriostatic or static fungi in combination with other antimicrobial compounds, will undoubtedly raise interest. In Pikovaskaya media, these microorganisms are recognised as fluorescent pseudomonas or phosphate bacteria. The morphological and biochemical characteristics of the 10 species, such as *P. aeuroginosa*, *P. putida*, *P.stutzeri*, and *P. fluorescence*, were used to group them. The bacteria *Pseudomonas sp*. are common in agricultural soil and have several qualities that make them suited for PGPR. Fluorescent *Pseudomonas spp*. have proven to be the most potent *Pseudomonas* species. Studies are being conducted all over the world to harness the power of a certain bacterium family called *fluorescent pseudomonads* (FLPs).

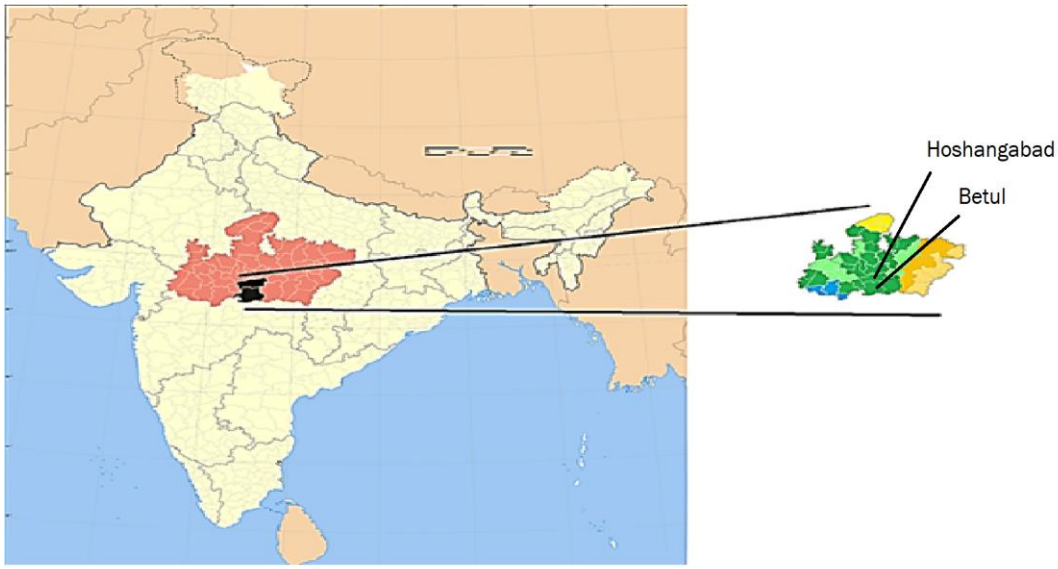
FLPs are extremely efficient and varied, and they help maintain soil health [12,13]. When used in conjunction with microbial fertilizer, the presence of *Pseudomonas fluorescence* inoculants significantly contributes to the regeneration of chickpea growth and symptoms. An enormous increase in fresh and dry masses results from separating FLPs from sugarcane soil, roots, and shoots [14]. The yield of legumes significantly increases in the pseudomonad (GRP3) field test. In order to promote growth and boost yields, some strains of the *P. fluorescence* putida family have lately been employed as seed pods in plant crops. These *pseudomonads*, known as PGPR, rapidly gather the roots of potato plants, beetroot plants, and seedlings, and in field trials they induce considerable mathematical yields to increase to 144%. Numerous environmental parameters, including soil type, nutrient density, pH level, and moisture content, as well as plant-related factors, have an impact on the existence and function of microorganisms in the soil (species, age). The *Pseudomonas* variety was discovered to have a high count during the operation of the two winter wheat types, therefore the size of the *Pseudomonas* bacterial population is dependent on the wheat crop's stage of growth [15]. Bio fertilizer is goods with well-chosen and practical organic chemicals that act as antibodies in the soil. Currently, bacteria that can dissolve phosphate are utilized as bio fertilizer. Since in vitro studies have shown that they bring rock melting phosphate and so reduce phosphate deficit in the soil, phosphate solubilizing bacteria in particular are gradually emerging as critical nutrients utilized to promote soil health. To construct a bio fertilizer to use these bacteria to improve soil quality, which would also increase productivity, phosphate was removed from the soil in the current study. The effect of this separation on Glycine max seed germination and seed growth was then evaluated.

MATERIALS AND METHODS

In Madhya Pradesh, India, samples were taken from the rhizosphere of Glycine max at Betul, Hoshangabad, Raisen, Rajgarh, Chhindwara, Shajapur, Shahdol, and Bhopal. These areas are situated in the centre of the Indian state of Madhya Pradesh. The depth of the soil samples is 0 to 30 cm. The soil samples were kept in a High-Density Polythene (HDPE) bag after the topsoil was rinsed away. To ensure that samples had the same particles, samples were run through a 2 mm sieve tube. As a result, soil samples were taken for further examination at the Department of Life Sciences and Biological Sciences, IES University Bhopal. Phosphate Solubilizing bacteria were

then isolated and identified from the soil sample using a serial dilution technique. Bacterial suspension at Pikovaskaya medium was increased from 10^{-1} to 10^{-6} solution (Hi-media) [16]. To keep the various colonies isolated from the *Pseudomonas* (Hi-media) culture, they were managed by the King's B centre as shown in Figure 1.

Figure 1. Study sites Hoshangabad and Betul.



Using a gram staining, individual bacteria are microscopic examined (Hi-media gramme kit kit). In Chrome Azurol S (CAS) agar medium (Hi-media), siderophores are properly measured [17]. Blue agar 60.5 mg CAS in 1 L was dissolved to make. A 10 ml solution of Fe III (1 mM $FeCl_3.6H_2O$, 10 ml HCl) (Ranbaxy) was combined with 50 ml of water. While stirring the mixture, 72.9 mg of hexadecyltrimethylammonium (HDTMA), dissolved in 40 ml of water, was slowly added. As a result, an automatic blue liquid effect was produced. Additionally, a purification combination consisting of 750 ml and 100 ml of MM9 salt water, 15 g of agar, 30.24 g of piperazine-1, 4-bis (2-ethanesulfonic acid), and gradually adding NaOH solution (6 M) to elevate the pH to 6.8 was added to it. The mixture was then placed into Petri plates (90 diameters, Borosil). The Pseudomonas isolated active culture was visible on dark blue plates, which were kept at 32 1°C for 48 hours in 24 incubators.

Plant growth that stimulates the release of hormones, enzymes, and fungus cell walls enzymes that reduce; One overnight colony of indole-3-acetic acid (IAA) was created in LB medium agar (Hi-media), which contained (litre): 10 grams of tryptone, 5 grams of yeast extract, 5 grams of sodium chloride, 15 grams of agar modified with 5 mM L-tryptophan, 0.06% sodium dodecyl sulphate, and 1% glycerol (Rankem). The virus was allowed to proliferate on plates covered with Whatman No. 1 filter paper (82 mm wide) for three days at 28°C. Following incubation, the paper was taken out and subjected to a Salkowski reagent treatment for 60 minutes at room temperature using a 2% composition of 0.5 M ferric chloride at 35% with each chloric acid. After adding the Salkowski reagent (Merck) to the filter papers in the Petri dish, the formation of IAA (Hi-media) was instantly recognised by the creation of a red

halo on paper around the colony; The activity of the enzyme aminocyclopropane-1-carboxylate (ACC) deaminase is assessed as previously described in Dworkin and Foster (DF) tiny salts, (Fermentos) containing (litre): Gluconic acid, citric acid, and trace element solution (1 mg $FeSO_4.7H_2O$, 10 Hg H_3BO_3, 11.19 Mng $MnSO_4.H_2O$, 124.6 g $ZnSO_4.7H_2O$, 78.222 g $CuSO_4.5H_2O$ and 10 Mog MoO_3) are added to 4 g KH_2PO_4, 6 g Na_2HPO_4, 0.2 g $MgSO_4.7H_2O$, 2 g glucose, and (Merck). Spread over agar plates, the fermented ACC filter (3 mM) was allowed to dry for 10 minutes before being cleaned.

Hydrogen cyanide (HCN) Production was examined on a 35 mm petal dish containing Kings B agar medium supplemented with 4.4 g glycine/l and filter paper imbedded in picric acid on the top cover and sealed with parafilm. See growth after two days of incubation at 28°C. Following inoculation, the plates were kept at 30 1°C for 24 to 144 hours, depending on the study's protocol. Pathogens that are suited for a plant's growth factor were measured based on local size and/or growth. The tests were run three times each; Skim milk agar medium (Hi-media), which contains (per litre): 5 g pancreatic digestion of casein, 2.5 g yeast extract, 1 g glucose, 7% skim milk solution, and 15 g of agar, was used to measure protease activity. Bacterial cells were injected, and after two days of 28°C incubation, a clear region around the cells indicated the presence of proteolytic activity; On chitin agar medium (Hi-media), which contains (litre): 1.62 g nutritional broth, 0.5 g NaCl, 6 g M9 salt, 8 g colloidal chitin, and 15 g agar, bacterial chitinase activity was examined. Chitinase activity was seen in a clear region surrounding the treated bacterial cells after 5 days of incubation at 30°C.

Pectinase production was assessed using an M9 medium that had been amended with 4.8 g of pectin per litre. Complete isolates were tested for in vitro antagonistic activity against *Sclerotium rolfsii*, *Macrophomina phaseolina*, *Fusarium solani*, and Fusarium oxysporum in potato dextrose agar (Hi-media) plates using a dual culture method. After two days of incubation at 28°C, the plates were filled with 2 mol -1 HCl, and concentrations surrounded by clear halos were considered positive for pe Cut from the 96-hour active fungal culture, the 5-mm-wide agar plug is then positioned in the center of the agar plate. The examined bacteria (adult 24 h) also had fibres 2 cm distant from the agar plug at the same time. Instead of the bacterial culture, plates containing only fungi were utilized as controls.

The differentiating effects of phosphate-soluble bacteria on seed growth were investigated by inoculating glycine max seeds and bacteria. Plates are placed at 30 1°C until the fungal mycelia covers the agar surface of the control plate [18]. 50 seeds were sterilized at 10^{-2} to 10^{-6} dilutions for 5 hours. As a control, distilled water-dipped seeds were used. For three days, seeds of both types were kept at 37°C in a wet environment. The length of the plumule of seeds that had begun to germinate was measured after three days of intensive incubation. The trial was conducted three times in all [19].

RESULTS AND DISCUSSION

There is evidence that several Rhizobacteria can promote plant development in a range of situations. The phosphate-soluble bacteria have always been isolated from the delicate compacted soil in the form of rod-shaped and chemically induced *pseudomonas fluorescens*, colourless colonies, pigment-less cells, and free of gram-positive cells. *Pseudomonas fluorescens*'s effective Solubilization (SE) impact was calculated to be 200.00. *Pseudomonas* typically predominates among plant bacteria found in the rhizosphere [20]. Small soil organisms transform non-soluble phosphorus species into soluble species, which helps phosphate plant roots to become

soluble. In Pikovskya's contact area, pressure from the tri-calcium phosphate processing could be felt [21]. By drawing in clear regions, each isolate solubilizes phosphate in Pikovskay's agar media. Phosphorus is regarded as a crucial macronutrient, and the majority of the phosphorus found in chemical fertilisers is soluble thanks to the soil's transformation of it into calcium or magnesium salts.

However, in stressful circumstances such high salinity, pH, and extremely high temperatures in degraded organisms represented by alkaline soils with a predisposition to fix phosphorus, the creation and functioning of PSM is most negatively impacted. Studies on mineral phosphates have shown that the nature of organic acids is more important than value and is greatly controlled by pH, melting is increased by pH there pH is decreased from 6.3 to 4.9. PSMs are known for solving Ca-P structures primarily by decreasing the pH of the media. The highest P-solubilization, 94.3 gml-1, was observed for up to 10 days of incubation, it was observed acidification and P-solubilization were linked, which diminished Fe-decongestant P's effects. The creation of organic acids, which are thought to be the cause of P-Solubilization, is indicated by a drop in pH [22]. For proper PGPR, the solubility potential of different soluble phosphates is always desired. Three unresolved phosphates have been shown to be very well dissolved by these separate organisms. The Ca_3 $(PO_4)^2$ solutions was discovered within the previously reported range. Chemical messengers called plant hormones influence a plant's capacity to react to its surroundings. Hormones are organic substances that function under extremely little stress; they are typically combined in one area of the plant before moving to another [23-26]. To produce physiological responses, such as fruit growth or maturation, they interact with specific target tissues. Two or more hormones normally cooperate to produce each response. Many botanists also refer to hormones as "plant growth regulators" since they can either stimulate or impede plant growth [27]. There are five main categories of hormones recognized by botanists: auxins, gibberellins, ethylene, cytokinins, and abscisic acid as shown as Figure 2 and Table 1.

Figure 2. Fluorescent pseudomonas to use organic acids as carbon sources.

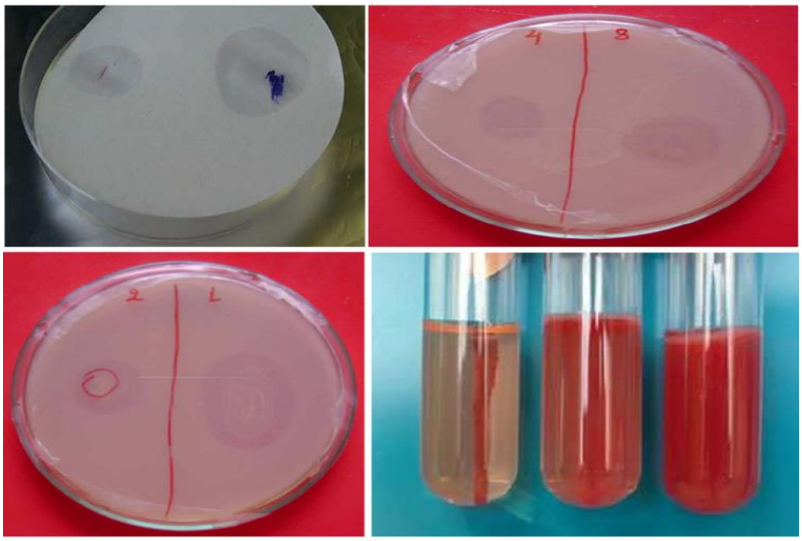


Table 1. Identification of isolated phosphate solubilizing bacteria.

S.No.	Characteristics	Bacterial Morphology
1	Colony Size	Pinpoint
2	Surface	Shiny
3	Margin	Smooth
4	Elevation	Raised
5	Optical features Pigment Production	Yellowish green
6	Growth in liquid medium	Turbid
7	Microscopic Examination	Rod
8	Gram staining	Negative
9	Motility	Polar flagella
10	Endospore Formation	Negative

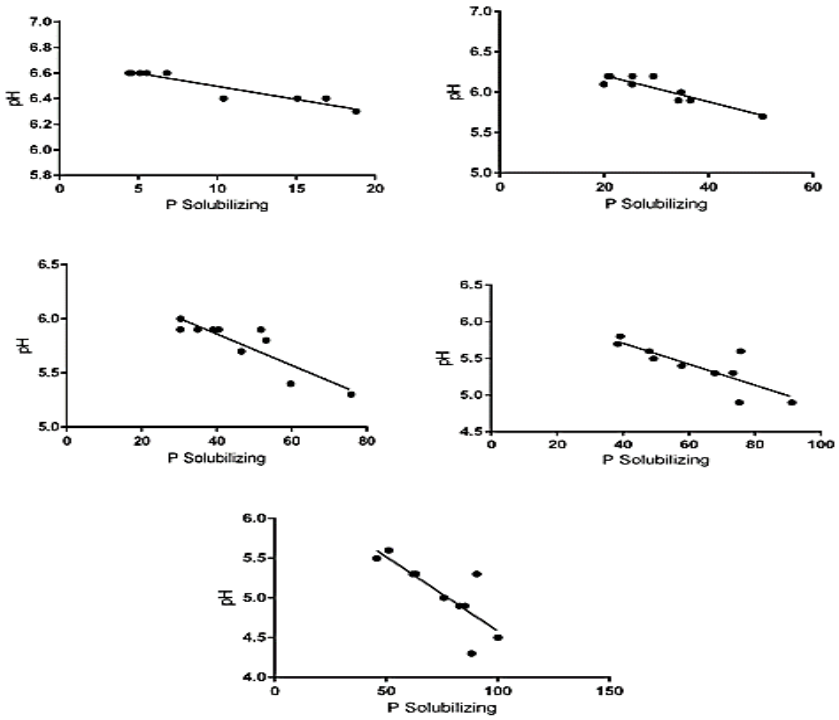
In response to changes in CAS medium color from blue to orange, all parameters were evaluated for siderophore generation. It is demonstrated that problems are justified by the plant growth byproduct that encourages IAA hormones. These findings also demonstrate the formation of IAA, a fungal cell wall that inhibits the activity of enzymes known to be implicated in antifungal and phytopathogenic activity, including cellulases, proteases, and chitinases. Challenges with their professional development and a constrained Foster medium that contains ACC. All of the investigated sources contained ACC deaminase producers, which are known to encourage root extension and plant growth by hydrolyzing ACC and reducing ethylene production in roots. JM1, JM2, JM4, JM5, JM6, JM7, JM8, and JM9 are additional factors that have demonstrated proteolytic action by drawing clear regions around the cells in the skim milk agar media as shown in Figure 3 and Table 2.

Table 2. Showed effect of pH on phosphate solubilization.

Strains	Days									
	2		4		6		8		10	
	P solubilized	pH	P solubilized	pH	P solubilized	pH	P solubilized	pH	P solubilized	pH
JM1	18.8	6.3	36.55	5.9	46.6	5.7	67.87	5.3	82.8	4.9
JM2	5.52	6.6	20.7	6.2	30.34	6	39.15	5.8	51.1	5.6
JM3	16.9	6.4	50.4	5.7	75.79	5.3	91.22	4.9	100	4.5
JM4	10.4	6.4	34.74	6	53.15	5.8	73.37	5.3	85.23	4.9

JM5	4.41	6.6	25.36	6.1	40.5	5.9	57.81	5.4	75.87	5
JM6	5.5	6.6	25.42	6.2	39.03	5.9	49.27	5.5	61.97	5.3
JM7	5.08	6.6	19.92	6.1	30.31	5.9	38.37	5.7	45.91	5.5
JM8	15.07	6.4	34.24	5.9	59.73	5.4	75.22	4.9	88.25	4.3
JM9	6.8	6.6	29.45	6.2	51.77	5.9	75.68	5.6	90.52	5.3
JM10	4.55	6.6	21.08	6.2	34.93	5.9	47.91	5.6	63.17	5.3

Figure 3. Incubation after 2nd, 4th, 6th, 8th and 10th day of inoculating phosphate solubilizing bacteria for relevant to days and PH. Phosphate solubilizing activity and low pH levels in the growth medium, which suggests that phosphate solubilization, is the result of organic acids released from bacterial metabolism.



A chitin agar medium attracted clear regions surrounding the cells in just 3 of the 10 cases where it was present. 90% of the P-solubilizers produced by Pseudomonas were composed of cellulose-resistant bacteria, 3 of which were chitinase producers out of a total of 10. Some fluorescent pseudomonad bacteria produce antibiotics, enzymes that break down the cell wall, HCN metabolites, and siderophores in order to protect plants against the harmful impacts of small phytopathogenic insects. It was thought that P. Fluorescens' synthesis of HCN acted as a biocontrol agent against pathogenic fungus [28]. The second important metabolite in plant protection—the characteristic of plant growth that encourages Rhizobacteria, prevents the spread of plant diseases, and so fortifies the immune system of the host is hydrogen cyanide. Making P available to all plants is a task that can be greatly aided by phosphate-soluble bacteria that have been isolated from the rhizosphere of Glycine max [29]. Producer testing of the JM1, JM2, JM3, JM4, JM6, JM7, JM8, JM9, and JM10 strains of HCN and pectinase has revealed good results. The study's source had over 6 species, which is a comparatively low number compared to other bacterial groups. Seven of the 10 isolates shown action against the study's *Sclerotium rolfsii*, *Macrophomina phaseolina*, *Fusarium solani*, and *Fusarium oxysporum* phytopathogenic and lethal fungus. The percentage of antibodies that

functioned against *S. Rolfsii* and *M. Phaseolina* was 17% in FWC, 28-34% in RSC, 38% in GVC, and 21% in macrofauna, whereas the percentage of antibodies that functioned against F. Solani and F oxysporum was 20% in FWC, 44% in RSC, 40% in GVC, and 25% in microorganisms. Research on rhizosphere microbial blooms is expanding right now, and the majority of these studies are geared at plants [30]. Despite the late start to the investigation, the rhizosphere bacteria are still a major area of interest.

The effects of treatment on independent species of *P. Fluorescens* on seed germination and seedling growth are provided. These findings indicate that, when compared to controls, treatment with phosphate-soluble bacteria is just as advantageous to seed germination, radicle length, and plum length growth. Concentration of several distinct inhibitors is necessary for development to progress. Treatment with a 10^{-4} dilution produced positive outcomes, and when compared to inoculating against separate viruses, combination inoculation was superior. When *P. Fluorescens* was installed, radicle length increased by 27.9%, 43.6%, and 58.6% from 10-2 to 10^{-4} dilution, respectively, whereas radical length dropped by 40.9%, 47.6%, and 63.1% from 10-2 to 10-5 and 10^{-6} dilution, respectively, when compared to controls. Similar to how the treatment with *P. fluorescens* increased plumule lengths by 19.0%, 22.7%, 29.1%, and 32.0%, it also decreased them by 54.5% and -70% in 10^{-5} and 10^{-6} dilutions when compared to controls as shown in Tables 3-6.

Table 3. Test for antagonists.

Bacteria	Strain	Fungi inhibited	Antifungal potential
P.aeuroginosa	JM1	R.s., M.p.,F.o.c., F.o.v,F. sp.	HCN, CHI
P. aeuroginosa	JM2	R.s., M.p., , F. sp.	HCN, PRN
P. fluorescence	JM3	R.s.,	HCN, DAPG, PRN
P. putida	JM4	R.s., M.p., , F. sp.	HCN, DAPG
P.stutzeri	JM5	F.o.c.,F.o.v.	HCN, CHI, DAPG
P.fluorescens	JM6	F.o.c.,F.o.v.	CHI
P.stutzeri	JM7	R.s.,	PCA
P. putida	JM8	R.s., M.p., , F. sp.	HCN, PCA
P.fluorescens	JM9	R.s., M.p., F. sp.	HCN, PCA, CHI
P. aeuroginosa	JM10	R.s., M.p.,F.o.c., F.o.v.	HCN, CHI, DAPG, PCA, PRN, PLT

Note: *Fusarium oxysporum f.sp. F.o.v*., *Fusarium oxysporum* f.sp. HCN, hydrogen cyanide; CHI, chitinase; DAPG, 2,4-diacetyl phloroglucinol; PRN, pyrrolnitrin; PLT, pyoluteorin; PCA, phenazine-1-carboxylic acid; ND, Not determined.

Table 4. Effects of PSB on germination of glycine max seeds.

Phosphate solubilizing bacteria used	Pseudomonas fluorescence
Control No. of seed germinated/Total No. of seeds used	7/10
10^{-2} No. of seed germinated/Total No. of seeds used	7/10
10^{-3} No. of seed germinated/Total No. of seeds used	9/10
10^{-4} No. of seed germinated/Total No. of seeds used	8/10
10^{-5} No. of seed germinated/Total No. of seeds used	8/10
10^{-16} No. of seed germinated/Total No. of seeds used	9/10

Table 5. Effect of PSB on radicle length of glycine max seeds.

Phosphate solubilizing bacteria used, percentage increase and decrease	*Pseudomonas florescence*
Control (cm)	3.1
10^{-2} (cm)	4.3
10^{-3} (cm)	5.5
10^{-4} (cm)	7.5
10^{-5} (cm)	2.6
10^{-16} (cm)	2.1

Table 6. Effect of PSB on plumule length of glycine max seeds.

Phosphate solubilizing bacteria Used, percentage increase and decrease	Pseudomonas florescence
Control (cm)	1.7
10^{-2} (cm)	1.8
10^{-3} (cm)	2.1
10^{-4} (cm)	2.5
10^{-5} (cm)	1.7
10^{-16} (cm)	1.2

The findings of this study imply that phosphate serves as a barrier separating various bacterial species from the soil. *Ps. fluorescens* will be more successful at boosting seed germination and seedling growth, among other challenges. As a result, it is advised to utilize bacterial-solubilizing phosphate as a biofertilizer [30]. Additional research on these strains' rhizome potential must include fermentation, chromatographic analysis, and taxonomic interactions of viruses based on 16SrDNA, as well as molecular pathways that can raise gene expression.

CONCLUSION

The majority of the phosphorus from chemically soluble compounds is converted into calcium or magnesium salts in the soil and is not found in small soil plants, even after the conversion of insoluble phosphorus species into soluble forms and consequently into soluble forms. Phosphorus is regarded as an important macronutrient. It is crucial that phosphate was later found in plant roots. Because they can adapt to the environment, phosphate-soluble microorganisms are used in agriculture and are regarded as being of great importance. It is thought that the release of organic acids and microbial metabolites occurs during microbially driven solubilization of dissolved phosphates in the soil. However, other techniques can also result in phosphate processing in addition to acid production. It has been noted that phosphate solubilization is influenced by the shape and size of the phosphate particles as well as the volume of organic acid generated by the bacteria. Among the bacteria associated with the rhizosphere, fluorescent pseudomonads are frequently the most significant. Potent phytohormones and potent

phytopathogen inhibitors are two different categories of plant growth that encourage Rhizobacteria. By enhancing the nutrient status of the soil, creating plant growth hormones and enzymes, and inhibiting the growth of phytopathogenic fungi, fluorescent pseudomonads promote plant growth. Plant growth is enhanced by one or more direct or indirect processes that support the rhizobacterial species of fluorescent pseudomonads. At various stages of plant growth, these mechanisms may operate in concert or in succession. The generation of vitamins, phytohormones, and antimicrobial metabolites as well as the dissolution of phosphate and iron are just a few of the numerous functional traits this group of bacteria exhibits. These traits will boost plant growth and seed germination and increase output. They can better withstand stress, salt, iron toxicity, and pesticides while also improving nutritional absorption.

COMPETING INTERESTS

The authors have no conflict of interest in this research

REFERENCES

1. Jitendra Malviya, et al. *In vitro* conservation and enhancement of secondary metabolite production in leptadenia reticulata. Nat Volatiles and Essent Oils. 2021;8:12274-12286.
2. Vikram A, et al. Effect of phosphate solubilizing bacteria nodulation and growth parameters of green gram (*Vigna radiate L.* Wilczek). Res J Microbiology. 2007:62-72.
3. Mohammad Saghir Khan, et al. Role of phosphate solubilizing microorganisms in sustainable agriculture-a review. Sustain. Agric. 2009;5:551-570.
4. Stephen Joseph, et al. Buffering reduces phosphate solubilizing ability of selected strains of bacteria. World J. Agric. Res. 2009;5:135-137.
5. Varsha Nenwani, et al. Isolation and characterization of a fungal isolate for phosphate solubilization and plant growth promoting activity. JYFR. 2004;1:009-014.
6. Lugtenberg B.J.J, et al. What makes *pseudomonas* bacteria rhizosphere competent? Environ. Microbiol. 1999;1:9-13.
7. Egamberdiyeva D. The effect of plant growth promoting bacteria on growth and nutrient uptake of maize in two different soils. Applied Soil Ecology. 2007;36:184-189.
8. Tilak KVBR, et al. Diversity of plant growth and soil health supporting bacteria. Curr. Sci. 2005;89:136-150.
9. Pal KK, et al. Growth promotion and yield enhancement of peanut (*Arachis hypogaea L.*) by application of plant growth-promoting rhizobacteria. Microbiol. Res. 2004;159:371-394.
10. Alikhani HA, et al. Phosphate solubilization activity of rhizobia native to Iranian soils. Plant and soil. 2006;287:35-41.
11. Chen YP, et al. Phosphate solubilizing bacteria from subtropical soil and their tri-calcium phosphate solubilizing abilities. App Soil Ecol. 2006;34:33-41.

12. Khalid A, et al. Screening plant growth-promoting rhizobacteria for improving growth and yield of wheat. Journal of Applied Microbiology. 2004;96:473-480.

13. Saharan BS, et al. Plant growth promoting rhizobacteria: a critical review. Life Sciences and Medicine Research. 2011.

14. Alikhani HA, et al. Phosphate solubilization activity of rhizobia native to Iranian soils. Plant and soil. 2006;287:35-41.

15. Pikovskaya, et al. Plant growth promoting rhizobacteria. In Encyclopedia of Genetics. 1948:1477-1480.

16. Schwyn B, et al. Universal chemical assay for the detection and determination of siderophores. Anal. Biochem. 1987;160:47-56.

17. Chaykovskaya LA, et al. Phosphorus mobilizing microorganisms and their influence on the productivity of plants. Plant Nutrition. Horst W.J. 2001:668-669.

18. Kannaiyan S, et al. Biofertilizers technology for rice based cropping system. Scientific pub (India), Jodhpur. 2004.

19. Miguel Sulbarán, et al. Characterization of the mineral phosphate-solubilizing activity of pantoea aglomerans MMB051 isolated from an iron-rich soil in southeastern venezuela (bolívar state). Cur. Microbiology. 2009;58:378-383.

20. Daimon H, et al. Tricalcium phosphate solubilizing by root nodule bacteria of *Sesbania cannabina* and *Crotalaria juncea*. Plant Prod Science. 2006;9:388-389.

21. Tran Thi Ngoc Son. Effect of bradyrhizobium and phosphate solubilizing bacteria application on soyabeen in totaional system in the mekong delta. omonrice. 2006:14.

22. Seshadri S, et al. Inorganic phosphate solubilization by two insect pathogenic *Bacillus sp*. Developments in Plant and Soil Sciences. 2007;102:351-355.

23. Gaind S, et al. Thermotolerant phosphate solubilizing microorganisms and their interaction with mungbean. Plant and Soil. 1991;133:141-149.

24. Abd-lla MH. Phosphatases and the utilization of organic P by Rhizobium *leguminosarum biovar viceae*. Lett. Appl. Microbiol. 1994;18:294-296.

25. Castango LN, et al. Biochemical and molecular characterization of phosphate solubilizing bacteria and evaluation of its efficiency promoting the growth of *Lotus tenuis*. Lotus Newsletter. 2008;38:53-56.

26. Lata, et al. Bio fertilizers to augment soil fertility and crop production. In Soil Fertility and Crop Production SciencePublishers, USA. 2002:279-312.

27. Ana Rincon. Water stress responses of two Mediterranean tree species influenced by native soil microorganisms and inoculation with a plant growth promoting rhizobacterium. Tree Physiology. 2008;28:1693-1701.

28. Khan AA, et al. Phosphate-solubilizing bacteria: occurrence, mechanisms and their role in crop production. J. Agric. Biol. Sci. 2009;1:48-58.

29. Adesemoye A, et al. Plant growth-promoting rhizobacteria allow reduced application rates of chemical fertilizers. Microbial Ecology. 2009;58:921-929.

30. Lal L. Phosphate mineralizing and solubilizing microorganisms. 2002:224.