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RESEARCH ARTICLE

Efficacy of *Acinetobacter rudis* as Phosphate Solubilizing Bacteria (PSB) on potato growth and nutrient availability

Joshi Chinmay[1]*, **Soni Manish**[2]

1 Department of Microbiology and Biotechnology, C. U. Shah University, Wadhwan City, Surendranagar, Gujarat, India
2 School of Engineering and Technology, Department of Biotechnology, Jaipur National University, Jaipur, Rajasthan, India

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* **Corresponding author**.

chinmayjoshi1511@gmail.com

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Abstract

Objective: To determine the effect of *Acinetobacter rudis*-S23 as a Phosphorus-Solubilizing Bacterium (PSB) on potato growth. **Methods:** A field experiment was conducted in two growing seasons, 2019/2020 and 2020/2021, using a Randomized Complete Block Design (RCBD) with three replications. The treatment group applied *A. rudis*-S23 as a Phosphate-Solubilizing Bacterium (PSB) to the soil, whereas the control group was untreated. **Findings:** The application of *A. rudis*-S23 resulted in a significant improvement in various plant growth metrics compared to untreated plants. Specifically, PSB-treated plants exhibited an 18% increase in plant height, a 38% increase in branch number, and a 29% increase in shoot dry weight. The availability of phosphorus in the soil was significantly enhanced by the application of PSB, showing an increase of up to 57% compared to the untreated. Potato tuber absorption of nutrients also saw a substantial improvement, with a 74% increase in tuber nutrient uptake noted in the PSB-treated plants. **Novelty:** This report signifies the pioneering field study of potato plants employing the mangrove endophytic bacterium *A. rudis*-S23 as a phosphate solubilizer. This bacterium was originally isolated from an unexplored region within the Kutch, Gujarat, India, marking a significant contribution to the scientific understanding of this unique microbial resource.

Keywords: Acinetobacter rudis; Biofertilizer; Phosphorus Solubilizing Bacteria; Potato

1 Introduction

Phosphorous (P) is the important component for plant development and mineral nutrition of soil[(1)]. Involved in almost all of the key metabolic and essential biochemical processes in plants, phosphorous is the second most critical macronutrient for plant development and productivity[(2)]. Many agricultural soils are rich in organic and inorganic forms of phosphorus (P), but the quantity of P given to the soil is much more

compared to the quantity of P taken by plants [3]. Thus, plants are negatively affected by a high P content, which might lead to micronutrient scarcity like zinc and iron and nutrient over-enrichment in agricultural watersheds [4]. Therefore, ensuring future food supply and effectively regulating the environment necessitates better P management.

Potato (*Solanum tuberosum L.*) stands as a vital global staple crop, renowned for its rich nutritional composition [5]. However, potato is commonly recognized as a secondary non-cereal crop, owing to the fact that it has never achieved its true potential in terms of food security. Furthermore, inadequate soil fertility and crop nutrient imbalances are two main impediments to Indian farmers accomplishing high crop yields [6].

Massive amounts of synthetic P fertilizers are often applied in agricultural soils to regulate plant P availability. It can be costly and harmful to the environment and soil microbial community. In comparison to chemical fertilizers, bio fertilizers are an economical and sustainable substitute for commercial P fertilizers [7]. Due of worldwide concerns about climate change and its effects on agricultural systems, study on the agronomic effects of bio fertilizers is increasing.

Endophytic bacteria are the bacteria residing in living tissues of the host plant without causing apparent harm to the host [8]. They serve a variety of beneficial role for the plant like improved nutrient absorption, disease resistance and drough resistance [9]. *Acinetobacter rudis* S23, employed in this current study is a mangrove endophytic bacteria derived from an unexplored location of Kutch, Gujarat, India [10]. Not much work has been done to learn how the inoculation potential of this endophyte as PSB influences the absorption of phosphorus in potatoes grown in the field condition. In light of the organism's significance, we evaluated the impact of P solubilization on potato production under field conditions.

2 Methodology

2.1 Cultivation of Phosphate Solubilizing bacteria

In the previous investigation, *Acinetobacter rudis*-S23 was isolated from the Kutch mangrove rhizopshere and its phosphate solubilizing activity was analyzed [11]. Phosphorus-Solubilizing Bacteria (PSB) were cultured in a nutrient medium at 35°C with agitation for 24 hours. They were then mixed with sterile zeolite and incubated at the same temperature for a week. The PSB population reached approximately 10^8 CFU/g. For inoculation, 1 gram of dried PSB was suspended in a 0.85% NaCl solution, adjusting the bacterial density to 10^8 CFU/ml.

2.2 Field Experiment

This study was conducted at the Ami Agro Agency's experimental farm in Ahmedabad, India located at 22.9160884°N, 72.5425996°E during the 2019/2020 and 2020/2021 growing seasons. Lady rosetta potato tubers were cultivated, and *A. rudis*-23 was introduced to the plants post-emergence, followed by a second application a week later. The experiment comprised a control group and a test group, organized using a randomized full block design with three replicates, covering a 10-square-meter experimental plot. During land preparation, K-feldspar with 12% potassium (K_2O) was added at 200 kg K_2O per hectare, and nitrogen fertilizer (urea, 40% N) was applied at 250 kg N per hectare, divided into three equal doses every 30 days until the 90^{th} day after planting. Additionally, potassium in the form of P_2O_5 with 18% phosphorus (P) was added at 250 kg P_2O_5 per hectare during field preparation. Growth parameters were measured and recorded from the gathered plant samples. The samples underwent cleaning, air-drying, and oven drying at 70°C until a constant weight was reached before chemical analysis. Soil physiochemical properties are mentioned in Table 1.

Table 1. Physico-chemical properties of soil

Properties	Values
Sand	31.0
Silt	38.6%
Clay	30.04%
pH	7.4 ± 0.02
EC	1.3
Organic matter	1.15%
Total N	0.03%
Total P	0.02%
Total K	0.03%

2.3 Soil Characteristics

A suspension of soil and water (1:2.5) was used to measure the soil's pH and electrical conductivity (EC). The organic matter in the soil was quantified with K_2CrO_7. Whereas, total nitrogen were determined using the Kjeldahl method. Available phosphorous was assessed by $NaHCO_3$ extraction.

2.4 Statistical analysis Top of Form

Data analysis employed one-way analysis of variance (ANOVA) at a significance level of 5%. To identify specific significant differences between treatments, the least significant difference (LSD) test was applied with a significance threshold of $P < 0.05$. Graphpad Prism (Version 10) was used for statistical investigation.

3 Results and Discussion

3.1 Impact of PSB on Potato growth

The effect of *A. rudis*-S23 on various growth parameters of potato plants during both growing seasons, revealed statistically significant enhancements ($P<0.05$). A significant 18% increase in plant height was seen in the first season after biofertilization was applied, and a further 19% increase was observed in the second season compared to the control group as displayed in Figure 1. Additionally, the number of branches increased substantially, by 27% the first season and 38% the second (Figure 2). The shoot dry weight of potato plants ranged from 29 to 49 g/plant, indicating a 44% and 17% increase in shoot biomass output, respectively, in the first and second seasons, as compared to the control group (Figure 3).

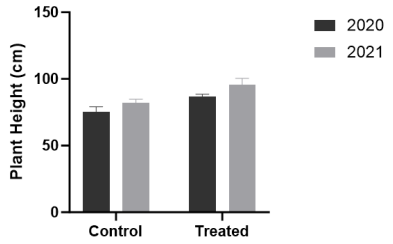

Fig 1. Influence of *Acinetobacter rudis*-S23 on potato plant shoot Height

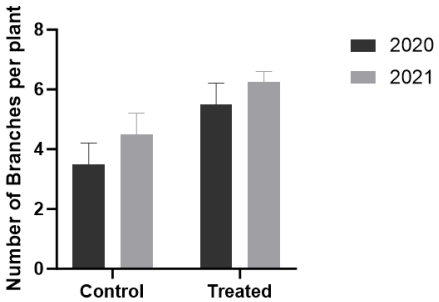

Fig 2. Influence of *Acinetobacter rudis*-S23 on number of branches of potato plant

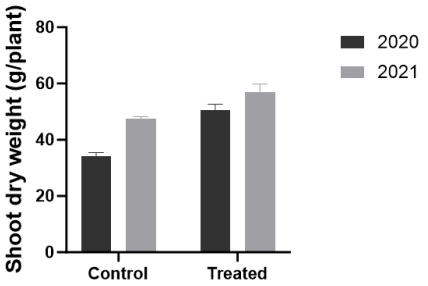

Fig 3. Influence of *Acinetobacter rudis*-S23 on potato shoot dry weight

These results are consistent with prior study which focused on PSB biofertilization for the growth and development of potato [12,13]. A field study focused on PSB application as a biofertilizer on Stress tolerant potato yielded efficient increase in plant height, number of shoots, roots and root length [14].

3.2 Potato tubers yield

The use of *A. rudis* as a bio-fertilizer resulted in a notable enhancement in potato crop yields, exhibiting a statistically significant increase of 21% in comparison to plants that were not subjected to this treatment as displayed in Table 2. These results align with previous studies conducted in the field [15]. The increase in yield may be attributed to the greater absorption of nutrients and improved development of plants, which is aided by the capacity of *A. rudis* to create plant hormones after inoculation.

Table 2. Influence of *Acinetobacter rudis*-S23 on the overall potato tuber yield

Treatments	Total tuber yield ton/ha	
	2020	**2021**
Control	34	37
PSB	46	47

4 Conclusion

The study emphasizes the use of *Acinetobacter rudis* -S23, a phosphate-solubilizing bacterium obtained as an endophyte from mangroves of unexplored habitat of Kutch, Gujarat, for its remarkable skills as a Plant Growth-Promoting Rhizobacteria (PGPR). This research demonstrates its exceptional potential for significantly enhancing potato growth and output. The results of the trials show that phosphate-solubilizing bacteria play an important role in promoting plant development by increasing plant height, dry biomass, nutrient availability, and nutrient absorption. This emphasizes the necessity of selecting bacteria with numerous favorable features throughout the screening and selection procedures, and encourages further exploration of similar microorganisms in this particular ecological niche.

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