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Research Article

Efficacy of Commercial Phosphate Solubilizing Bacteria Ami PSB on the Growth of *Solanum tuberosum* L

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Abstract

This study aimed to evaluate the effect of commercial phosphorus solubilizing bacterium, Ami PSBTM, Bacillus sp., on the growth of potato. A Randomized Complete Block Design (RCBD) with three replications was employed in a field experiment conducted during two seasons (2021/2022 and 2022/2023). The treatment group was administered a commercial Ami PSB application to the soil, while the control group did not receive any treatment. Results revealed significant enhancement in various plant growth parameters with commercial PSB application. The treated plants demonstrated a 40% increase in plant height, a 62% increase in branch number, and a 40% increase in shoot dry weight compared to the untreated plants. Furthermore, phosphorus availability in the soil was substantially improved by the application of Ami PSB™, resulting in up to a 57% increase compared to untreated soil. Significantly, the absorption of nutrients by potato tubers exhibited a notable enhancement, with a recorded 44% rise in plants treated with Ami PSB™.

Keywords: Ami PSB™; Biofertilizer; Potato; Soil Health; Sustainable Agriculture

Abbreviations

RCBD: Randomized Complete Block Design; PSB: Phosphorus-Solubilizing Bacteria; CFU: Colony-Forming Units; EC: Electrical Conductivity; ANOVA: One-Way Analysis of Variance; LSD: Least Significant Difference

Introduction

Potato (*Solanum tuberosum L.*) holds a pivotal position as a global staple crop, renowned for its rich nutritional profile [1]. Notably, potatoes are characterized by their high starch content and significant presence of essential vitamins, particularly vitamin C and B. They typically contain 0.1% fat, 0.8-3% protein, 1.1% minerals, 11-23% carbohydrates, 17-29% dry matter, and 70-82% water [2]. In India, potatoes are cultivated across approximately 1.34 million hectares, yielding an impressive production of around 24.7 million tons.

Improving soil quality, particularly regarding essential plant nutrients, is imperative for enhancing plant growth and productivity [3]. In recent decades, bio-fertilizers have emerged as significant contributors to agricultural practices, owing to their ability to boost crop yields. These bio-fertilizers play multiple roles, including improving soil structure, facilitating the bioaccumulation or microbial leaching of inorganic chemicals, and promoting plant development through phytohormone synthesis [4].

Bio-fertilizers are advocated as a sustainable approach to enhancing plant nutrition. They play a multifaceted role by activating enzymes, maintaining cell turgor, facilitating the transit of sugars and starches, enhancing crop quality, boosting resilience to stresses such as diseases and insects, and reducing nitrite and nitrate levels

in potato tubers [5]. Moreover, the use of Phosphorus-Solubilizing Bacteria (PSB) can contribute to improvements in soil fertility, yield, and reduction in reliance on synthetic fertilizers [6].

Despite the presence of abundant phosphorus reserves in many soils, a considerable portion remains tightly bound to soil constituents, thus limiting its accessibility to plants. While soils deficient in phosphorus can be supplemented with fertilizers, retaining the added phosphorus poses a significant challenge. Unfortunately, a substantial majority, approximately 75–90%, of chemically applied phosphorus precipitates due to interactions with metal-cation complexes, leading to rapid immobilization within soils. This phenomenon has enduring ecological ramifications, including eutrophication, degradation of soil fertility, and an increased carbon footprint [7].

To tackle these challenges, bio-fertilizers have emerged as an environmentally friendly alternative to excessive chemical fertilizer usage [8-10]. They offer the dual benefits of mitigating health and environmental risks while preserving soil quality and enhancing crop productivity. Additionally, bio-fertilizers create conducive conditions for root growth, improve overall plant development, and enhance plant biological functions [11]. However, there is a notable lack of data regarding the utilization of bio-fertilizers such as PSB as a replacement for chemical fertilization in potato farming. Given that bio-fertilization represents a sustainable, chemical-free approach to potato production, this research endeavors to investigate its impact on productivity, growth, and phosphorus availability in the soil.

Materials and Methods

Experimental design

A bacterial inoculum Ami PSB containing *Bacillus sp.,* (NCBI accession no. OM702712) was incorporated as PSB. The research included Potato plant with one treated with Ami PSB serving as treated or test and the one without any inoculation serving as the control. The design was completely randomized and replicated three times.

Cultivation of phosphate solubilizing bacteria

Ami PSB™ was cultured in a nutrient medium at 35°C with agitation for 24 hours. Subsequently, they were mixed with sterile zeolite and incubated at the same temperature for a week. This cultivation process resulted in a PSB population reaching approximately 10^8 colony-forming units (CFU) per gram. For inoculation purposes, 1 gram of dried PSB was suspended in a 0.85% NaCl solution, with adjustments made to attain a bacterial density of 10^8 CFU/ml.

Field experiment

The study was conducted at an experimental farm in Ahmedabad, India, spanning the 2021/2022 and 2022/2023 growing seasons. *Lady Rosetta* potato tubers were cultivated, and Ami PSB™ was applied to the plants post-emergence, with a follow-up application a week later. The experiment consisted of a control group and a test group, arranged in a randomized full block design with three replicates, each covering a 10-square-meter experimental plot. During land preparation, K-feldspar containing 12% potassium (K_2O) was incorporated at a rate of 200 kg K_2O per hectare, while nitrogen fertilizer (urea, 40% N) was applied at 250 kg N per hectare, divided into three equal doses every 30 days until the 90th day after planting. Additionally, potassium in the form of P_2O_5, containing 18% phosphorus (P), was added at 250 kg P_2O_5 per hectare during field preparation. Various growth parameters were measured and recorded from the collected plant samples. Subsequently, the samples underwent cleaning, air-drying, and oven drying at 70°C until a constant weight was achieved before undergoing chemical analysis. Soil physiochemical properties are detailed in Table 1 for comprehensive characterization.

Soil characteristics

In the study, a suspension of soil and water in a ratio of 1:2.5 was utilized to measure the soil's pH and electrical conductivity (EC). The organic matter content in the soil was quantified using K_2CrO_7. Additionally, total nitrogen levels were determined employing the Kjeldahl method. The available phosphorous content was assessed through $NaHCO_3$ extraction.

Statistical analysisTop of Form

Data analysis in this study utilized 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 $P < 0.05$.

Table 1: Physico-chemical properties of soil.

Properties	Values
Sand	29.0
Silt	36.3%
Clay	32.01%
pH	7.2 ± 0.01
EC	1.4
Organic matter	1.21%
Total N	0.03%
Total P	0.02%
Total K	0.03%

Results and Discussion

Impact of PSB on Potato growth

The impact of Commercial PSB on various growth parameters of potato plants across both growing seasons revealed statistically significant enhancements ($P < 0.05$). In the first season following the application of biofertilization, a notable 40% increase in plant height was observed, with a further 44% increase noted in the second season compared to the control group, as depicted in Figure 1. Furthermore, there was a substantial increase in the number of branches, with a 57% rise in the first season and a 62% increase in the second season, as illustrated in Figure 2. The shoot dry weight of potato plants ranged from 62 to 76 g/plant for treated plant, indicating a remarkable 44% and 37% increase in shoot biomass output, respectively, in the first and second seasons compared to the control group, as demonstrated in Figure 3. These findings underscore the significant positive impact of Ami PSB™ on the growth and development of potato plants, highlighting its potential as a valuable biofertilizer in agricultural practices.

The findings obtained in this study are consistent with previous research that has investigated the efficacy of PSB biofertilization for the growth and development of potato plants [12,13]. A prior

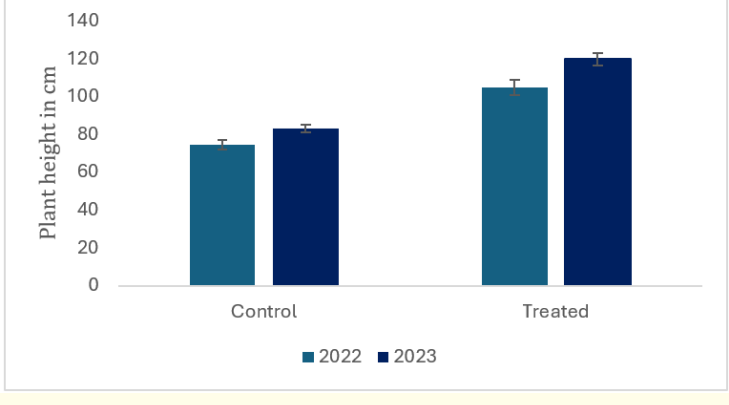

Figure 1: Efficacy of Ami PSB™ on height of S*olanum tuberosum L.*

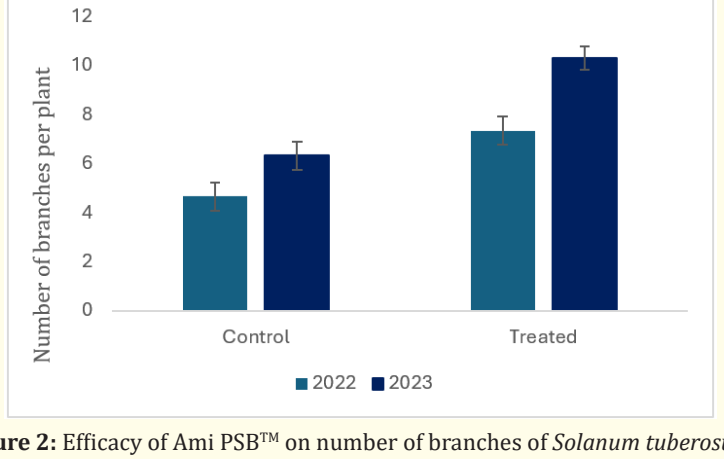

Figure 2: Efficacy of Ami PSB™ on number of branches of *Solanum tuberosum L.*

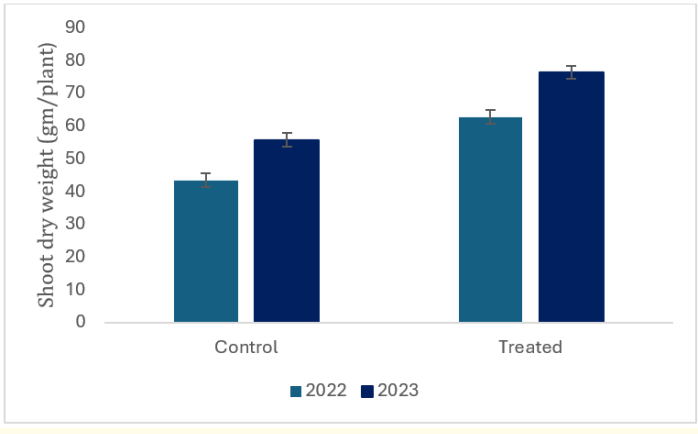

Figure 3: Efficacy of Ami PSB™ on shoot dry weight of *Solanum tuberosum L.*

field study specifically focusing on the application of PSB as a bio-fertilizer for stress-tolerant potato cultivation also reported efficient increases in plant height, the number of shoots, roots, and root length [14]. These consistent results across different studies further support the effectiveness and potential of PSB biofertilization in enhancing the growth and productivity of potato crops, emphasizing its relevance and applicability in agricultural practices aimed at sustainable and efficient crop production.

Potato tubers yield

The utilization of Ami PSB™ as a bio-fertilizer led to a significant enhancement in potato crop yields, demonstrating a statistically significant increase of 44% compared to plants not subjected to this treatment, as depicted in Table 2. These findings are consistent with previous field studies [15]. The observed increase in yield can be attributed to enhanced nutrient absorption and improved plant development facilitated by the ability of Ami PSB™ to stimulate the production of plant hormones upon inoculation. This highlights the potential of Ami PSB™ as an effective bio-fertilizer for promoting higher yields and improving overall crop productivity in potato cultivation.

Table 2: Influence of Ami PSB™ on the overall potato tuber yield.

Treatments	Total tuber yield ton/ha	
	2022	2023
Control	34 ± 5	39 ± 3
PSB	49 ± 7	56 ± 8

Conclusion

The imperative to utilize Ami PSB™ as a strategy to reduce dependency on mineral fertilizers and ensure the production of uncontaminated food has become increasingly crucial. This ongoing research, conducted over a span of two years, aimed to explore the effects of bio-fertilization with Ami PSB™ on the growth and development of *Solanum tuberosum* L. (potato) plants. The results underscored that the application of Phosphorus-Solubilizing Bacteria (PSB) had a significant positive impact on various growth parameters of potato plants compared to a control group receiving no treatment. The introduction of Ami PSB™ through inoculation resulted in notable improvements in several plant characteristics, including plant height, dry biomass, nutrient availability, and nutrient uptake. Furthermore, the utilization of bio-fertilizers led to a remarkable increase in both the overall potato crop yield and the quality of potato tubers, highlighting the promising potential of Ami PSB™ as a sustainable solution for enhancing potato cultivation practices.

Conflict of Interest

The authors declare no conflict of interest.

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