Acta Scientific Microbiology (ISSN: 2581-3226)

Volume 9 Issue 7 July 2026

Research Article

Role of Phosphate-Solubilizing Biodecomposer Legend Super 9 in Improving Growth, Yield, and Nutrient Uptake in Potato

Jigar Mistry, Aditi Bijalwan and Yagnesh Thakkar*

Agrilogy Biosciences Pvt Ltd, Valsad, Gujarat, India

***Corresponding Author:** Yagnesh Thakkar, Agrilogy Biosciences Pvt Ltd, Valsad, Gujarat, India.

DOI: 10.31080/ASMI.2026.09.1611

Received: May 25, 2026

Published: July 01, 2026

Abstract

The study aimed to evaluate the effectiveness of a phosphate-solubilizing fungal Biodecomposer (Legend Super 9), along with its associated beneficial microbial consortium, on potato (*Solanum tuberosum* L.) growth and soil microbial activity under 60 days pot conditions.The experiment was laid out in a completely randomized design with six treatments and three replications. The results showed that the combined application of Biodecomposer formulation with microbial consortium substantially improved soil microbial population, plant growth, and yield attributes compared to other treatments and the control. The highest soil microbial population was recorded in T_6 (Legend Super 9 combined with a microbial consortium) with 8.9×10^6 CF/g soil, while the lowest was observed in the control. Among growth parameters, maximum plant height of 52.9 cm, number of leaves 31.5 per plant, root length 26.8 cm, fresh biomass 132.4 g per plant, and dry biomass 31.9 g per plant were recorded in T_6. Similarly, yield attributes were enhanced, with the highest tuber yield of 342.8 g per plant, number of tubers 9.6 per plant, and average tuber size 5.8 cm under the same treatment. Tuber size distribution also improved, with a higher proportion of large-sized tubers at 32.2 percent and a reduced percentage of small-sized tubers at 18.6 percent. Soil available phosphorus increased to 51.3 kg/ha, while soil pH showed a slight decrease under microbial treatments. Hence, the study indicates that the combined application of Biodecomposer formulation and microbial consortium enhances soil health, plant growth, and yield performance of potato and can be considered an effective approach for sustainable crop production.

Keywords: Biodecomposer; Microbial Consortium; Phosphate-Solubilizing Fungi; *Solanum tuberosum* L. Sustainable Agriculture

Introduction

Soil microorganisms play a fundamental role in ecosystem functioning and agricultural productivity by regulating nutrient cycling, organic matter decomposition, and plant–microbe interactions that support plant health and soil fertility [1]. Microbial communities in soil influence nutrient availability, soil structure, and plant immunity, making them essential components of sustainable agricultural systems [2].

Biodecomposer microorganisms, including diverse bacterial and fungal communities, contribute to the breakdown of complex organic residues such as plant wastes, compost, and organic inputs in agricultural soils [3]. These organisms secrete extracellular enzymes, organic acids, and secondary metabolites that catalyze the breakdown of cellulose, hemicellulose, lignin, and other recalcitrant compounds into simpler forms that can be utilized by plants and other soil microbes [4]. As a result, biodecomposers

improve soil nutrient availability and enhance microbial diversity in the rhizosphere [5]**.** The application of microbial biodecomposers has been shown to stimulate beneficial soil microorganisms such as *Trichoderma viride*, *Metarhizium anisopliae*, *Paecilomyces lilacinus*, which are known for their plant growth–promoting and biocontrol activities [6]**.** These beneficial microbes produce phytohormones, siderophores, amino acids, and antimicrobial compounds that enhance nutrient uptake, root development, and plant vigor while suppressing soil-borne pathogens [7,8]. Such microbial interactions contribute to improved plant immunity and resilience against biotic and abiotic stresses [9,10].

Phosphatesolubilizing fungi (PSF) and other phosphatesolubilizing microbes play a crucial role in enhancing phosphorus bioavailability in agricultural soil [11]. Phosphorus is an essential macronutrient required for energy transfer, root development, and overall plant growth; however, a large proportion of soil phosphorus exists in insoluble forms that are unavailable to plants [12]. Phosphate-solubilizing fungi (PSF), including genera such as *Aspergillus*, *Penicillium*, *Trichoderma*, and *Paecilomyces*, play a crucial role in soil phosphorus cycling by transforming insoluble inorganic and organic phosphorus fractions into plant-available forms [13,14] This process is primarily mediated through the secretion of low-molecular-weight organic acids (e.g., citric, oxalic, gluconic, and malic acids), which lower rhizosphere pH and chelate cations such as Ca^{2+}, Fe^{3+}, and Al^{3+} bound to phosphate, thereby releasing soluble orthophosphate for plant uptake [15]. In addition, PSF produce extracellular enzymes, including acid and alkaline phosphatases and phytases, which mineralize organic phosphorus compounds in soil [16]. Although these biochemical mechanisms are broadly conserved among PSF, the efficiency of phosphorus solubilization varies among fungal species and strains due to differences in organic acid profiles, enzyme activity, and rhizosphere colonization ability [17]. Beyond phosphorus mobilization, PSF contribute to plant growth promotion by producing phytohormone-like substances, improving nutrient acquisition, and interacting synergistically with other beneficial soil microorganisms, ultimately enhancing soil fertility and plant productivity under sustainable agricultural systems [18].

Potato (*Solanum tuberosum L.)* is a high-value tuber crop with a substantial requirement for phosphorus, particularly during early vegetative growth and tuber initiation [19]. Inoculation with PSF such as *Aspergillus niger* and *Penicillium* spp. has been reported to significantly improve phosphorus uptake, root length, shoot biomass, chlorophyll content, and tuber yield in potato under pot and field conditions. These fungi also contribute to improved soil microbial balance and reduced dependence on chemical phosphorus fertilizers [20,21].

Furthermore, PSF enhance the rhizosphere environment by promoting beneficial microbial consortia and indirectly suppressing soil-borne pathogens such as *Fusarium* spp. and plant-parasitic nematodes [22]. Co-inoculation of PSF with other beneficial fungi, particularly *Trichoderma* spp., has been shown to produce synergistic effects by improving nutrient uptake, inducing systemic resistance, and enhancing crop tolerance to environmental stresses [23]. Despite increasing evidence on the role of phosphate-solubilizing fungi and biodecomposer microorganisms, limited information is available on their combined effects on soil microbial consortia, crop immunity, and plant growth under controlled pot conditions [24,25]. Therefore, the present study aims to evaluate the effect of a phosphate-solubilizing fungal biodecomposer on soil microbial dynamics, plant growth parameters, and crop immunity in potato under pot conditions, highlighting its potential as a sustainable and eco-friendly agricultural input [26,27].

Soil nutrients based on decomposing organisms are a useful treatment to promote soil health. These formulations encourage amino acid-driven microbial interactions after soil application, which increases the decomposition of organic materials and strengthen the microbial populations that are beneficial to the soil. This microbial enrichment supports sustainable crop productivity by promoting the mechanisms that protect plants and reducing resistance to soil-based pests and plant-parasitic nematodes.

Materials and Methods

Experimental site and duration

A pot experiment was conducted under controlled environmental conditions to evaluate the effect of a Legend Super 9 (a phosphate-solubilizing Biodecomposer formulation) produced by Agrilogy Biosciences Pvt Ltd. on soil microbial population and growth of potato (*Solanum tuberosum* L.). The experiment was carried out for a period of 60 days during the Rabi season (November 2024–January 2025). Controlled pot experiments are widely used to assess the influence of microbial inoculants on soil microbial dynamics and plant growth responses under uniform environmental conditions.

Plant material

The potato variety used in the experiment was *Lady Rosetta*, a widely cultivated processing cultivar suitable for experimental studies.

Experimental design and treatments

The experiment was laid out in a Completely Randomized Design (CRD) with six treatments and three replications per treatment. The treatments were as follows in Table 1.

Treatment Code	Description
T_1	Control (Soil + Potato, no microbial inoculant)
T_2	Trichoderma viride (Tv)
T_3	Metarhizium anisopliae (Ma)
T_4	Paecilomyces lilacinus (Pl)
T_5	Biodecomposer formulation alone
T_6	Biodecomposer formulation + microbial consortium (Tv + Ma + Pl + Pseudomonas sp.)

Table 1: Different Treatments.

Pot preparation and treatment application

Earthen pots were filled with 10 kg of sterilized soil to eliminate native microbial interference. One certified tuber of potato cv. Lady Rosetta was planted per pot.

The phosphate-solubilizing Biodecomposer formulation (commercially known as *Legend Super 9*) was applied based on the recommended field dose of 5 kg/ha. The dose was converted to pot conditions considering a standard soil mass of 2×10^6 kg/ha (0–15 cm depth), resulting in 0.0025 g/kg soil (0.025 g per pot). However, to ensure ease of application and effective microbial establishment, the dose was adjusted to 0.25 g per pot. The Biodecomposer formulation was applied as a soil drench at the time of planting to ensure uniform distribution in the rhizosphere. Such adjustment of field-equivalent doses in pot experiments is a widely accepted practice for achieving effective microbial colonization [28]. Microbial inoculants including *Trichoderma viride*, *Metarhizium anisopliae*, *Paecilomyces lilacinus*, and *Pseudomonas* sp. were applied at a standardized concentration of 10^7 CFU/g soil at planting.

Crop management

All pots were maintained under uniform agronomic conditions throughout the experimental period. Irrigation was applied as required to maintain optimal soil moisture. No chemical fertilizers or pesticides were used, allowing the effects of microbial treatments to be evaluated without external interference.

Soil sampling and microbial analysis

Soil samples were collected from each pot at 60 days after planting (DAP) for microbial analysis. Microbial populations were quantified using the serial dilution and spread plate technique, with selective culture media employed for the enumeration of specific microbial groups. Results were expressed as colony-forming units per gram of soil (CFU/g). In parallel, potato growth parameters were recorded at 60 DAP for each treatment. The use of serial dilution coupled with selective media is a widely accepted and standard approach for assessing soil microbial populations in pot experiments.

Plant growth measurements

At 60 days after planting (DAP), the following growth parameters were measured for each treatment.

Plant height

Plant height was measured from the soil surface to the tip of the apical meristem using a measuring scale and expressed in centimeters (cm). Measurements were taken at 60 days after planting (DAP) for all plants in each treatment. Care was taken to maintain the plant in an upright position to ensure accuracy. The average plant height for each treatment was calculated for further analysis.

Number of leaves

The total number of fully expanded leaves per plant was counted manually at 60 days after planting (DAP). Senescent and newly emerging immature leaves were excluded from the count to ensure uniformity. Observations were recorded for all plants in each treatment under consistent conditions. The average number of leaves per plant was calculated and used for statistical analysis.

Root length

At 60 days after planting (DAP), plants were gently removed from the pots, and the root system was carefully cleaned with

water to remove soil particles. The maximum root length was then measured from the collar region to the tip of the primary root using a measuring scale and expressed in centimetres (cm). Measurements were taken for all plants under each treatment. The mean root length was calculated and used for further analysis.

Fresh biomass

Fresh biomass was recorded at 60 days after planting (DAP) by weighing the entire plant (shoot and root) immediately after removal from the pot using a digital balance. Care was taken to ensure that excess soil and moisture were removed before weighing. The recorded values were expressed in grams per plant (g/plant). The average fresh biomass for each treatment was calculated for statistical analysis.

Dry biomass

After recording fresh weight, plant samples were oven-dried at 65 ± 2 °C until a constant weight was obtained to ensure complete removal of moisture. The dried samples were then weighed using a digital balance, and the values were expressed as grams per plant (g/plant). This method is widely used for determining plant dry matter accumulation in controlled experiments [29,30].

Data analysis

All observations were expressed as mean ± standard deviation (SD). Analysis of variance (ANOVA) was performed at a 5% level of significance to determine treatment effects [31].

Results and Discussion

Soil microbial population at 60 DAP

Table 2 shows that soil microbial populations varied substantially among treatments after 60 days. The highest total microbial count was recorded in the combined treatment Legend Super 9 + microbial consortium (T6) (8.9 ± 0.7 $\times 10^6$ CFU/g soil), followed by Biodecomposer formulation alone (T5) (5.6 ± 0.5 $\times 10^6$ CFU/g soil). Individual microbial inoculations (T2–T4) resulted in moderate increases in microbial counts compared to the control. The lowest microbial population was observed in the untreated control (T1) (1.8 ± 0.2 $\times 10^6$ CFU/g soil), indicating enhanced microbial proliferation due to biodecomposer and consortium application.

Treatment	Total Microbial Count (CFU/g soil)
T1 – Control	1.8 ± 0.2
T2 – *Trichoderma viride*	4.5 ± 0.4
T3 – *Metarhizium anisopliae*	4.1 ± 0.3
T4 – *Paecilomyces lilacinus*	3.9 ± 0.3
T5 – Legend Super 9	5.6 ± 0.5
T6 – Legend Super 9 + Microbes	8.9 ± 0.7

Table 2: Final CFU count of beneficial microbes in soil after 60 days.

Influence of biodecomposer formulation on soil and plant growth parameters

Plant height

Plant height was considerably affected by different treatments at 60 days after planting. The highest plant height was recorded in treatment T_6 with 52.9 ± 3.1 cm, indicating superior growth under the combined application of Biodecomposer formulation and microbial consortium. This was followed by T_5, which recorded 45.3 ± 2.7 cm. Treatments T_2, T_3, and T_4 showed moderate and nearly similar plant height values (Table 3), suggesting comparable effects of individual microbial inoculations. The lowest plant height was observed in the control T_1 with 32.4 ± 2.1 cm. Previous studies have reported that the application of arbuscular mycorrhizal fungi resulted in a maximum plant height of 50.25 cm, indicating the beneficial effect of microbial inoculation on vegetative growth. The increase in plant height attributed to enhanced nutrient uptake, particularly phosphorus, along with improved root development [32]. Microbial activity in the rhizosphere improves soil fertility and nutrient availability, thereby supporting better plant growth. This observation indicates the positive role of microbial inoculation in improving plant vigor and overall growth performance.

Number of leaves

Table 3 demonstrated the number of leaves per plant varied substantially among treatments at 60 days after planting. The highest number of leaves was recorded in T_6, which received Biodecomposer formulation along with microbial consortium, with 31.5 ± 2.3 leaves per plant. The next highest value was observed in T_5 with 26.8 ± 2.0 leaves per plant. Other treatments showed moderate and comparable values. The lowest number of leaves was observed in the control T_1 with 18.2 ± 1.5 leaves per plant. The

increase in leaf number attributed to improved nutrient availability and enhanced microbial activity in the soil, which promoted better vegetative growth. Earlier pot-based study on *solanaceous* crop, including potato, have demonstrated that inoculation with *Trichoderma* spp. can increase the number of leaves to around 22–25 per plant, indicating its positive effect on vegetative growth. The improvement in leaf number is likely associated with the ability of *Trichoderma* to enhance nutrient availability, particularly nitrogen and phosphorus, and to stimulate plant growth through the production of growth-promoting substances [33]. In addition, *Trichoderma* is known to improve root development and overall plant health, which indirectly supports greater leaf formation. These outcomes are consistent with the present study, where increased leaf number was observed under microbial treatments, indicating the beneficial role of microbial inoculation in promoting plant growth and canopy development.

Root length

A noticeable improvement in root length was observed under microbial treatments at 60 days after planting. The maximum root length was recorded in T_6 with 26.8 ± 2.0 cm, while T_5 also showed higher root growth with 22.4 ± 1.8 cm. Other treatments exhibited moderate and comparable values. The minimum root length was recorded in the control T_1 with 14.8 ± 1.2 cm (Table 3). The enhanced root growth in treated plants attributed to improved soil microbial activity and increased nutrient availability. In another study, the application of *Trichoderma viride* in potato resulted in increased root length, with treated plants recording about 17.8 cm compared to lower values in the control. This improvement in root growth due to enhanced nutrient availability and increased microbial activity in the rhizosphere [34]. Similar improvement in root development was observed under the application of Biodecomposer formulation along with microbial inoculants in the present study.

Fresh biomass

Fresh biomass was markedly influenced by different treatments at 60 days after planting showing in table 3. The highest fresh biomass was recorded in T_6 with 132.4 ± 6.5 g/plant, indicating better overall plant growth under combined microbial application. T_5 also showed higher biomass production with 108.6 ± 5.8 g/plant. The remaining treatments exhibited moderate values, while the lowest fresh biomass was observed in the control T_1 with 72.5 ± 4.3 g/plant. In a previous controlled experiment, application of *Trichoderma*-based bioformulations in potato resulted in a substantial increase in plant fresh biomass (107%) and dry biomass (74%) compared to untreated plants [35]. The improvement in biomass attributed to enhanced nutrient uptake, better root development, and increased microbial activity in the rhizosphere, which supports overall plant growth.

Dry biomass

Variation in dry biomass was observed among the treatments at 60 days after planting. The highest dry biomass was recorded in T_6 with 31.9 ± 1.9 g/plant, indicating superior plant growth under combined microbial application. T_5 also showed increased dry biomass with 25.7 ± 1.6 g/plant. The remaining treatments exhibited moderate values, while the lowest dry biomass was recorded in the control T_1 with 16.8 ± 1.1 g/plant (Table 3). The higher dry biomass in treated plants due to improved nutrient uptake and better utilization of available resources supported by microbial activity. Application of *Trichoderma* in potato has been reported to considerably enhance dry matter accumulation, with treated plants recording 21.80 g per plant at 90 days after transplanting compared to 12.35 g per plant in the untreated control [36].

Treatments	Plant Height (cm)	Number of leaves	Root length (cm)	Fresh Biomass (g/plant)	Dry Biomass (g/plant)
T1- Control	32.4 ± 2.1^{d}	18.2 ± 1.5^{d}	14.8 ± 1.2^{d}	72.5 ± 4.3^{e}	16.8 ± 1.1^{e}
T2- (Tv)	41.6 ± 2.5^{c}	24.6 ± 1.9^{c}	20.5 ± 1.6^{c}	96.3 ± 5.2^{c}	22.9 ± 1.4^{c}
T3- (Ma)	39.8 ± 2.3^{c}	23.1 ± 1.7^{c}	19.6 ± 1.4^{c}	91.4 ± 4.9^{c}	21.6 ± 1.3^{c}
T4- (Pl)	38.7 ± 2.2^{c}	22.4 ± 1.6^{c}	19.1 ± 1.5^{c}	89.2 ± 4.6^{d}	21.1 ± 1.2^{d}
T5- LS9 (Biodecomposer formulation)	45.3 ± 2.7^{b}	26.8 ± 2.0^{b}	22.4 ± 1.8^{b}	108.6 ± 5.8^{b}	25.7 ± 1.6^{b}
T6- (LS9+consortium)	52.9 ± 3.1^{a}	31.5 ± 2.3^{a}	26.8 ± 2.0^{a}	132.4 ± 6.5^{a}	31.9 ± 1.9^{a}
F- value	48.62	36.85	29.74	65.12	58.43
P- value	0.001	0.001	0.001	0.001	0.001

Table 3: Effect of Biodecomposer Formulation and Microbial Treatments on Growth Parameters of Potato.

Effect of Biodecomposer formulation and microbial treatments on yield attributes of potato

Tuber yield

Tuber yield was considerably influenced by different treatments. The highest yield was recorded in T_6 with 342.8 ± 13.2 g/plant, T_5 with 285.7 ± 11.6 g/plant. Treatments T_2 and T_3 exhibited comparable yields, while T_4 recorded relatively lower values among the treated groups. The lowest tuber yield was observed in the control T_1 with 180.5 ± 8.2 g/plant (Table 4). In another study, application of microbial consortium increased tuber yield from 30,037 kg/ha to 49,136 kg/ha, showing an increase of about 63.6% [37]. The increase in yield was attributed to enhanced nutrient availability and improved microbial activity in the rhizosphere. In the present study, higher tuber yield was also recorded under combined application of Biodecomposer formulation and microbial consortium, indicating a similar positive effect on yield improvement.

Number of tubers per plant

The number of tubers per plant showed significant variation among treatments. T_6 recorded the highest number with 9.6 ± 0.7 tubers per plant, T_5 with 7.9 ± 0.6 tubers per plant. Treatments T_2 and T_3 showed similar values, whereas T_4 recorded comparatively lower values. The minimum number of tubers was observed in the control T_1 with 4.2 ± 0.5 tubers per plant (Table 4). In earlier study, microbial inoculation increased the number of tubers from 5.2 to 8.7 per plant [38]. Similarly, biofertilizer application improved tuber number by about 25–45% compared to the control [39]. This improvement reflects the beneficial role of beneficial microorganisms in enhancing nutrient availability and improving root and stolon development, which ultimately supports greater tuber initiation. Such microbial activity creates a more favorable rhizosphere environment, leading to better plant growth and productivity.

Average tuber size

Average tuber size was affected by the treatments. The largest tuber size was recorded in T_6 with 5.8 ± 0.4 cm, followed by T_5 (Biodecomposer formulation) with 4.6 ± 0.3 cm. Treatments T_2 and T_3 showed comparable values, while T_4 recorded slightly lower values among treated plants. The smallest tuber size was observed in the control T_1 with 2.2 ± 0.2 cm (Table 4). An increase in tuber size under microbial treatment has also been reported in earlier study, where application of *Trichoderma* resulted in higher tuber length of 7.75 cm compared to 7.09 cm in the control, along with improvement in tuber diameter [40]. The enhancement in tuber size showed better nutrient availability and increased microbial activity in the rhizosphere, which promote efficient assimilate translocation and improved tuber bulking.

Treatments	Tuber Yield (g/plant)	Number of Tubers per plant	Average Tuber Size (cm)
T1- Control	180.5 ± 8.2^{f}	4.2 ± 0.5^{f}	2.2 ± 0.2^{f}
T2- (Tv)	245.6 ± 10.5^{d}	6.8 ± 0.6^{d}	3.8 ± 0.3^{d}
T3- (MA)	232.4 ± 9.8^{d}	6.3 ± 0.5^{d}	3.5 ± 0.3^{d}
T4- (PL)	225.3 ± 9.2^{e}	6.0 ± 0.4^{e}	3.3 ± 0.2^{e}
T5- (LS9)	285.7 ± 11.6^{b}	7.9 ± 0.6^{b}	4.6 ± 0.3^{b}
T6- (LS9 + Consortium)	342.8 ± 13.2^{a}	9.6 ± 0.7^{a}	5.8 ± 0.4^{a}
F-value	72.45	38.62	55.83
P-value	0.001	0.001	0.001
CV (%)	6.2	7.1	6.5

Table 4: Influence of Biodecomposer Formulation and Microbial Treatments on Yield Parameters of Potato.

Tuber size distribution

The distribution of tuber sizes was significantly influenced by different treatments. The proportion of small tubers was highest in the control T_1 with 52.4 ± 2.1%, indicating poor tuber development, while all treatments reduced the percentage of small tubers, with the lowest recorded in T_6 at 18.6 ± 1.2%, T_5 at 28.4 ± 1.5%. In

contrast, the percentage of medium-sized tubers increased under microbial treatments, with the highest value observed in T_6 at 49.2 ± 2.3%, followed by T_5 at 46.7 ± 2.2%, whereas the lowest was in the control T_1 at 32.6 ± 1.8%. Similarly, the proportion of large tubers improved significantly with treatments, with T_6 recording the highest value of 32.2 ± 1.8%, followed by T_5 at 24.9 ± 1.6%, while treatments T_2, T_3, and T_4 showed moderate values, and the lowest percentage was observed in the control T_1 at 15.0 ± 1.2% (Figure 1). Application of organic inputs such as vermicompost, which act in a manner similar to biofertilizers by enhancing microbial activity and nutrient availability, has been reported to improve tuber size distribution in potato. In previous study, vermicompost applied at 5.0 t/ha increased the proportion of large-sized tubers to 61.48% compared to 59.10% in the control, while reducing the percentage of small-sized tubers from 13.18% to 11.22%. The proportion of medium-sized tubers showed only minor variation. This improvement in tuber size distribution due to better availability of essential nutrients, particularly nitrogen and phosphorus, along with improved soil structure and moisture retention [41]. Additionally, increased microbial activity in the rhizosphere enhances nutrient solubilization and uptake, which supports efficient translocation of assimilates towards tuber bulking. Similar mechanisms are observed with biofertilizer application, where beneficial microorganisms promote plant growth and improve yield quality by creating a more favorable soil environment for tuber development.

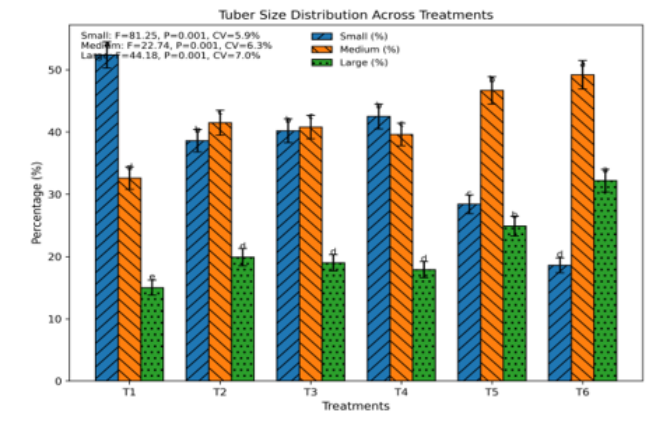

Figure 1: Effect of Biodecomposer formulation and microbial treatments on tuber size distribution (%) of potato.

Soil chemical properties

Soil available phosphorus

Soil available phosphorus increased under different treatments compared to the control. The highest value was recorded in T_6 with 51.3 ± 2.4 kg/ha, followed by T_5 with 42.6 ± 2.0 kg/ha. Treatments T_2 and T_3 showed similar phosphorus levels, while T_4 recorded slightly lower values. The lowest phosphorus availability was observed in T_1 with 28.4 ± 1.5 kg/ha (Table 5). Similar to the present study, a field experiment reported that inoculation with phosphatesolubilizing fungi increased soil available phosphorus by up to 44.73% compared with uninoculated controls, reflecting the ability of PSF to mobilize fixed phosphorus through organic acid secretion and thereby enhance plantavailable P in the rhizosphere [42]. In another study, application of T4 (recommended N, K, and P from phosphate-rich biofertilizer) considerably increased soil phosphorus content. Post-treatment, available phosphorus in the soil reached 16.56 mg/kg, compared to 12.64 mg/kg in the control [43].

Soil pH

Soil pH showed a slight decreasing trend across treatments in Table 5. The highest pH was recorded in T_1 with 7.6 ± 0.1, followed by T_2 and T_3 with 7.5 ± 0.1. Treatments T_4 and T_5 showed a gradual reduction, while the lowest pH was observed in T_6 with 7.2 ± 0.1. This indicates a mild acidifying effect of microbial treatments on soil.

Treatments	Soil Available P (kg/ha)	Soil pH
T1- Control	28.4 ± 1.5^{f}	7.6 ± 0.1^{a}
T2- (Tv)	36.2 ± 1.8^{d}	7.5 ± 0.1^{a}
T3- (MA)	34.8 ± 1.7^{d}	7.5 ± 0.1^{a}
T4- (PL)	33.5 ± 1.6^{e}	7.4 ± 0.1^{ab}
T5- (LS9)	42.6 ± 2.0^{b}	7.3 ± 0.1^{b}
T6- (LS9 + Consortium)	51.3 ± 2.4^{a}	7.2 ± 0.1^{c}
F-value	66.92	8.15
P-value	0.001	0.012
CV (%)	5.5	2.1

Table 5: Effect of Biodecomposer Formulation on Soil Properties of Potato.

Conclusion

This study concludes that Legend Super 9, particularly in combination with a microbial consortium, enhances soil microbial activity and plant growth, indicating its potential for sustainable potato production under controlled conditions. The combined treatment Legend Super 9 + microbial consortium consistently outperformed individual microbial inoculations and the untreated control in terms of agronomic measures such as plant height, leaf count, root length, and fresh and dry biomass accumulation. The results indicate a clear synergistic interaction among the applied microbial taxa.

Bibliography

1. Sandhu HS., *et al*. "Organic agriculture and ecosystem services". *Environmental Science and Policy* 13.1 (2010): 1-7.

2. Bashan Y and de-Bashan LE. "How the plant growth-promoting bacterium Azospirillum promotes plant growth—a critical assessment". *Advances in Agronomy* 108 (2010): 77-136.

3. Gautam SP., *et al*. "Biodegradation and recycling of urban solid waste". (2009).

4. Iqbal N., *et al*. "Role of decomposers in agricultural waste management". *Biotechnological Applications of Biomass* (2020).

5. Kamara A., *et al*. "Effect of rice straw biochar on soil quality and the early growth and biomass yield of two rice varieties". *Agricultural Sciences* 6.8 (2015): 798-805.

6. Manna MC., *et al*. "Enrichment of compost by bioinoculants and mineral amendments". *Journal of the Indian Society of Soil Science* 45 (1997): 831-832.

7. Nie H., *et al*. "Microbial inoculant-induced modifications of rhizospheric metabolites and microbial communities enhance plant growth". *Plant and Soil* 512.1 (2025): 619-637.

8. Asif Sanam., *et al*. "Reviewing the impact of seed-borne mycoflora on mycotoxin accumulation: A threat to lentil genetic resources". *Toxicon* 256 (2025): 108290.

9. dos Santos LBPR., *et al*. "Beneficial plants–Trichoderma interactions on host tolerance to abiotic stresses: a meta-analysis". *Frontiers in Plant Physiology* 3 (2025): 1569221.

10. Khan Masood., *et al*. "Acaricidal efficacy of Melia azedarach, Olea ferruginea, and Zanthoxylum armatum against Rhipicephalus microplus from District Buner, Mardan, and Nowshera, Khyber Pakhtunkhwa, Pakistan". *Asian Journal of Science, Engineering and Technology (AJSET)* 3.1 (2024): 99-114.

11. Bai K., *et al*. "Effects of phosphorus-solubilizing bacteria and biochar application on phosphorus availability and tomato growth under phosphorus stress". *BMC Biology* 22.1 (2024): 211.

12. Vessey JK. "Plant growth promoting rhizobacteria as biofertilizers". *Plant and Soil* 255.2 (2003): 571-586.

13. Vassileva M., *et al*. "Fungi, P-solubilization, and plant nutrition". *Microorganisms* 10.9 (2022): 1716.

14. Ullah S., *et al*. "Pathogenicity and survey of root rot disease of cotton in different villages of Dir Upper and Dir Lower, Khyber Pakhtunkhwa, Pakistan". *Journal of Agriculture & Forestry Research* 2.5 (2023): 74-81. "Pathogenicity and survey of root rot disease of cotton in different villages of Dir Upper and Dir Lower, Khyber Pakhtunkhwa, Pakistan" – Google Scholar.

15. Panchal P., *et al*. "Organic acids: versatile stress-response roles in plants". *Journal of Experimental Botany* 72.11 (2021): 4038-4052.

16. Tian J., *et al*. "Roles of phosphate-solubilizing microorganisms from managing soil phosphorus deficiency to mediating biogeochemical P cycle". *Biology* 10.2 (2021): 158.

17. Khan R., *et al*. "Mitigation of salinity stress in maize (Zea mays L.) using the endophytic fungus GR7". *Pakistan Journal of Weed Science Research* 31.2 (2025): 151-166. Mitigation of Salinity Stress in Maize (Zea mays L.) Using the Endophytic Fungus GR7.

18. Hossain MM., *et al*. "Biological management of soil-borne pathogens through tripartite rhizosphere interactions with plant growth-promoting fungi". *Applied Microbiology* 5.4 (2025): 123.

19. Khatun MT. "Growth, yield and quality of potato (Solanum tuberosum L.) as influenced by nitrogen and phosphorus levels". PhD diss., Department of Agronomy, Sher-e-Bangla Agricultural University (2018).

20. Fall AF., *et al*. "Roles of arbuscular mycorrhizal fungi on soil fertility: contribution in improvement of soil properties". *Frontiers in Fungal Biology* 3 (2022): 723892.

21. Saifullah M., *et al*. "Role of Rhizofungus (Aspergillus terreus) in Improving Biochemical and Physiological Parameters Affected by Lead Stress in Allium sativum L". *BioScientific Review* 7.3 (2025): 78-93.

22. Topalović O., *et al*. "Plants and associated soil microbiota cooperatively suppress plant-parasitic nematodes". *Frontiers in Microbiology* 11 (2020): 313.

23. Ullah S., *et al*. "Anagallis Arvensis As A Natural Allelopathic Agent: Effects On Growth Of Zea mays, Triticum aestivum, And Pennisetum glaucum." *International Journal on Food, Agriculture and Natural Resources* 6.4 (2025): 102-112.

24. Adedayo AA and Babalola OO. "Fungi that promote plant growth in the rhizosphere boost crop growth". *Journal of Fungi* 9.2 (2023): 239.

25. Sharma P., *et al*. "Trichoderma spp. in consortium and their rhizospheric interactions". *Trichoderma: Host Pathogen Interactions and Applications* (2020): 267-292.

26. Ughamba KT., *et al*. "Trends in the application of phosphate-solubilizing microbes as biofertilizers". *Soil Systems* 9.1 (2025).

27. Ullah Shakir. "The Effects of plant age on phytochemical and geographical distribution of Euphorbia helioscopia (sun spurge or madwoman's milk) Euphorbiaceae from Arrang District Bajaur". *Pakistan Journal of Weed Science Research* (2024).

28. Smith SE and Smith FA. "Roles of arbuscular mycorrhizas in plant nutrition and growth: new paradigms from cellular to ecosystem scales". *Annual Review of Plant Biology* 62.1 (2011): 227-250.

29. Hunt R. "Basic Growth Analysis: Plant Growth Analysis for Beginners". Unwin Hyman, London (1990).

30. Taiz L., *et al*. "Plant Physiology and Development". *Sinauer Associates* (2015).

31. Gomez KA and Gomez AA. "Statistical Procedures for Agricultural Research". John Wiley & Sons (1984).

32. Chauhan APS., *et al*. "Evaluation of potato growth attributes under natural farming system". *Journal of Experimental Agriculture International* 45.11 (2023): 271-277.

33. Purwantisari S., *et al*. "The resistance of potatoes by application of Trichoderma viride antagonist fungus". *E3S Web of Conferences* 73 (2018): 06014.

34. Pandey S., *et al*. "Biological management of late blight of potato using Trichoderma spp". *Plant Cell Biotechnology and Molecular Biology* 26.7-8 (2025): 340-348.

35. Napolitano A., *et al*. "Development and evaluation of a Trichoderma-based bioformulation for potato cultivation". *Horticulturae* 10.7 (2024): 664.

36. Pandey S., *et al*. "Biological management of late blight of potato using Trichoderma spp". *Plant Cell Biotechnology and Molecular Biology* 26.7-8 (2025): 340-348.

37. Wang Z., *et al*. "A microbial consortium-based product promotes potato yield". *Microbial Biotechnology* 14.5 (2021): 1961-1975.

38. Sharma A., *et al*. "Quality and yield of potato seed tubers influenced by plant growth promoting rhizobacteria". *Biocatalysis and Agricultural Biotechnology* 26 (2020): 103440.

39. Goswami SB and Thakur R. "Effect of biofertilizers on potato growth and physiological modulations". *Symbiosis* 85 (2021): 1-12.

40. Uddin MN., *et al*. "Effect of Trichoderma on growth and yield of potato". (2017).

41. Oli TS. "Effect of integrated NP and vermicompost fertilizer rate on potato yield". *Journal of Chemical, Environmental and Biological Engineering* 7.1 (2023): 31-37.

42. Hutagaol D., *et al*. "Application of phosphate solubilizing fungi increased P availability and crop growth". *Budapest International Research in Exact Sciences Journal* 3.3 (2021): 178-187.

43. Noor K., *et al*. "Formulation of phosphorus rich organic manure from rock phosphate and its dose optimization". *Journal of Plant Nutrition* 44.1 (2020): 96-119.