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Effect of a microbial consortium applied by foliar spraying on potato (*Solanum tuberosum* L.) cultivation, cv. SPUNTA

Abstract

Potato (*Solanum tuberosum* L.) cultivation is an agricultural system of great economic and social relevance for Argentina. The tuber is an important source of carbohydrates, containing approximately 80% water and 20% dry matter, of which 60 - 80% corresponds to starch. The objective of this study was to evaluate the effect of foliar application of a microbial consortium composed of biofertilizers, biostimulants, and biocontrol agents on potato cultivation of the Spunta variety. A completely randomized design was established, including two treatments: T0 (control) and T1 (foliar application of the microbial consortium). The foliar application was performed 45 days after planting, using a self-propelled sprayer over a 2-hectare area. The microbial consortium consisted of native strains of the biocontrol fungus *Trichoderma* spp. and bacterial strains of *Azospirillum brasilense*, *Bacillus thuringiensis*, *Rhizobium leguminosarum*, and *Bradyrhizobium* sp. Harvesting was carried out 120 days after planting. To determine crop productivity and quality, agronomic and production parameters were evaluated, including average tuber weight, size, and shape. Data were analyzed using analysis of variance (ANOVA), and means were compared using Fisher's Least Significant Difference (LSD) test at a significance level of 0.05, employing Infostat software. The results showed statistically significant differences on the main agronomic and productive parameters evaluated, with the highest value recorded in inoculated plants. In conclusion, foliar application of the microbial consortium increased the productive potential of the potato crop, resulting in substantial improvements on both yield and tuber quality.

Keywords: bio-inputs, biofertilizers, biostimulants, biocontrol agents

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Introduction

Potato (*Solanum tuberosum* L.) cultivation represents an agricultural system of high economic and social relevance in Argentina. The tuber is an important source of carbohydrates, containing approximately 80% water and 20% dry matter, of which 60 - 80% corresponds to starch. In addition, it provides high-quality proteins, vitamins, minerals, fiber, and antioxidant compounds with beneficial health effects.[1]

Potatoes are highly sensitive to water stress; therefore, supplemental irrigation is essential to ensure adequate growth and achieve optimal yields. The availability of water and nutrients in the soil's surface horizons is critical for sustaining crop productivity, which poses challenges related to both economic and environmental sustainability. Major agronomic constraints include soil degradation, high water and nutrient demand, and pressure from pests and diseases. Consequently, the incorporation of biotechnologies aimed at improving agronomic management efficiency represents a strategic and valuable approach.

Plant growth-promoting microorganisms (PGPM) have been extensively studied. Among them, the genus *Azospirillum* stands out for its ability to synthesize a variety of bioactive metabolites, such as indole-3-acetic acid, cytokinins, gibberellins, and siderophores, which stimulate growth and enhance the physiological development of plants.[2–5]

Rhizobia, on the other hand, are the most thoroughly characterized symbionts of legumes. They exhibit high efficiency in biological nitrogen fixation, potentially covering up to 90% of the nitrogen requirements of host plants.[6] These soil-dwelling alpha- and betaproteobacteria are capable of establishing specific symbioses with legumes, actively competing in the rhizosphere, and differentiating into functional bacteroids within nodules.[7] In addition to their central role in atmospheric nitrogen fixation, numerous studies have shown that various rhizobial species can solubilize and mineralize phosphorus, expanding their ecological functions and biotechnological potential.[8–11]

In recent years, multiple studies have investigated bipartite inoculations of *Azospirillum* and rhizobia on legumes, aimed at increasing the sustainability of agricultural systems. These studies have highlighted the biotechnological value of secondary metabolites produced by rhizobia and the synergistic effect of inoculants combining rhizobia with *A. brasilense*, improving growth and yield in both legumes and field crops such as maize.[12–15]

Fungi of the genus *Trichoderma* are recognized as effective biological control agents, with mechanisms of action that include competition for nutrients and space, antibiosis, and mycoparasitism.[16–19] Additionally, these fungi utilize nutrients from parasitized organisms and organic matter, contributing to decomposition and nutrient recycling.[20]

Bacillus thuringiensis (Bt) is known for producing spores and a crystalline parasporal body (δ-endotoxin) composed of proteins toxic to insects of the orders Coleoptera, Diptera, and Lepidoptera, as well as to certain phytopathogenic nematodes.[21] *Bt* is recognized not only for its entomopathogenic and insecticidal action but also for its role as a plant growth-promoting endophytic bacterium. Additional documented capabilities include degradation of chemical pollutants and, more recently, anticancer activities associated with parasporal crystals, greatly expanding its biotechnological potential.[22]

Within this framework, biofertilizers have emerged as key tools for promoting organic and sustainable agricultural systems due to their ability to reduce production costs, decrease agrochemical use, and improve soil fertility. The use of biofertilizers formulated from native strains of plant growth-promoting microorganisms represents an effective strategy for integrated disease management and optimization of agronomic performance.[4]

The objective of the present study was to evaluate the effect of foliar application of a microbial consortium composed of biofertilizers, biostimulants, and biocontrol agents on potato (*Solanum tuberosum* L.) cultivation, Spunta variety.[23]

Materials and methods

The experiment was conducted in a field located in Colonia del Valle, Capayán Department (Catamarca, Argentina). Potato (*Solanum tuberosum* L.), Spunta variety, was planted on March 15, 2025. A completely randomized design was employed, consisting of two treatments. Each treatment corresponded to a 2-hectare plot, with a planting density of 5 plants per linear meter and a row spacing of 0.8 m.

The treatments were defined as follows: T0 (control, without microbial inoculation) and T1 (foliar application of a microbial consortium). The foliar application of the consortium was performed 45 days after planting (April 30, 2025), using a self-propelled sprayer along the planting rows over a 2-hectare area.

The inoculant used consisted of a microbial consortium called Bio MAsT, with a microbial concentration of 8.1×10^9 microorganisms mL^{-1}, quantified using a Neubauer chamber.[23] The consortium included selected native strains of the fungus *Trichoderma* spp. and bacterial strains of *Azospirillum brasilense*, *Bacillus thuringiensis*, *Rhizobium leguminosarum* and *Bradyrhizobium* sp.

Harvesting was carried out 120 days after planting (July 15, 2025) using a mechanical harvester. To determine crop productivity and quality, the following agronomic and production parameters were evaluated:

Average tuber weight (g): obtained by dividing the total tuber weight by the total number of tubers harvested; this parameter reflects the individual development of each tuber.

Tuber size and shape: categorized as small, medium, or large, and as round, oval, or elongated; characteristics relevant for market acceptance. For this purpose, tuber diameters and length were measured.

Data were analyzed using analysis of variance (ANOVA), and means were compared using Fisher's Least Significant Difference (LSD) test at a significance level of 0.05, employing the statistical software InfoStat (Figures 1–6).[24]

Figure 1 Potato (*Solanum tuberosum* L.) cultivation trial, Spunta variety (Colonia del Valle, Capayán Department, Catamarca, Argentina) (1); Manual sampling and harvesting (2)".

Figure 2 Potato (*Solanum tuberosum* L.) plants Spunta variety, from the control treatment (T0) (3 and 4); Potato plants from the foliar application treatment of a microbial consortium (T1).(5).

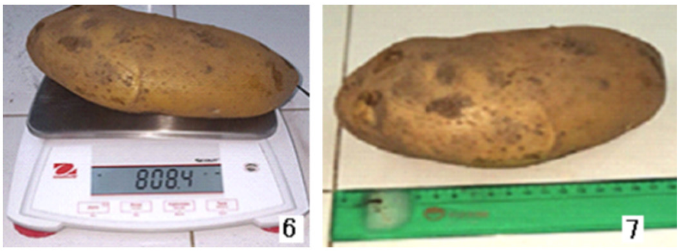

Figure 3 Fresh weight of potato (*Solanum tuberosum* L.) tuber, Spunta variety (6); Length of potato tuber (7).

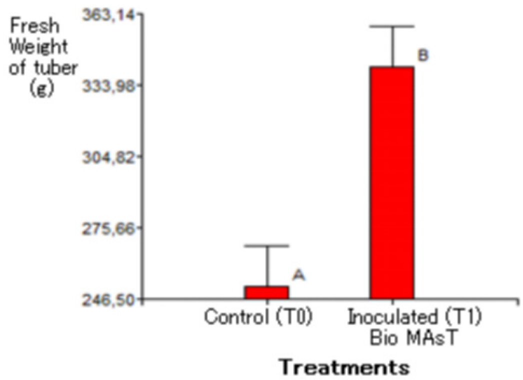

Figure 4 Fresh weight of potato tuber (*S. tuberosum*), Spunta variety.

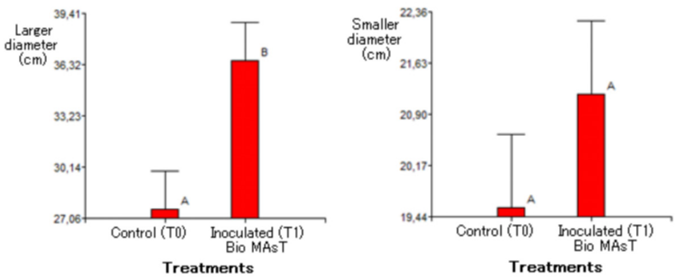

Figure 5 Maximum and minimum tuber diameter of potato (*S. tuberosum*), Spunta variety.

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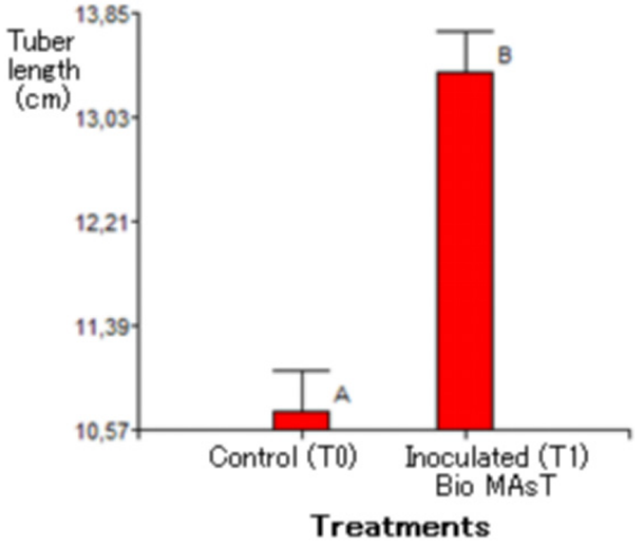

Figure 6 Tuber length of potato (*S. tuberosum*), Spunta variety.

Table 1 Physiological parameters of potato (*S. tuberosum*) cultivation, Spunta variety

Parameters	Treatments	
	Control (T0)	**Inoculated (T1)**
Average fresh weight of tuber (g)	251,80 **A**	341,34 **B**
Average maximum tuber diameter (cm)	27,62 **A**	36,54 **B**
Average minimum tuber diameter (cm)	19,58 **A**	21,20 **A**
Tuber length (cm)	10,72 **A**	13,38 **B**

Different letters within the same variable indicate significant differences according to the LSD test (Least Significant Difference) at P<0.05.

Results and discussion

A total of 100 tubers per treatment were evaluated, all selected according to commercial quality criteria: appropriate size, regular shape and absence of damage, disease, or deformities.

Average tuber weight (g): Tubers from plants inoculated with the microbial consortium showed a higher average weight, with statistically significant differences compared to the control treatment (T0) (Table 1).

Tuber size and shape: The maximum diameter, minimum diameter, and length of the tubers (cm) were measured. The largest tubers were recorded in the treatment with foliar application of the microbial consortium (T1) (Table 1). Statistically significant differences were observed between the inoculated treatment (T1) and the control (T0) for maximum diameter and tuber length (Table 1, Figure 2).

These results demonstrate the compatibility of the different plant growth-promoting microorganisms included in the formulation applied to the potato crop. Based on the inoculation and evaluation of these soil microorganisms, it is confirmed that the application of the microbial consortium improved plant growth and yield by contributing both to nutrition and defense against phytopathogens. Its use offers the advantage of being an environmentally friendly practice while remaining compatible with the ecological conditions of the soil.

Conclusion

Statistically significant differences were observed in the growth parameters of potato (*S. tuberosum*), Spunta variety, following foliar application of the Bio MAsT microbial consortium, with the best results recorded in inoculated plants.

Additionally, the compatibility of the various plant growth-promoting microorganisms included in the inoculant formulation applied to the crop was confirmed.

The development and use of biofertilizers, biostimulants, and biocontrol agents represent a valuable alternative for the partial or total replacement of mineral fertilizers. Their large-scale application in diverse agricultural production systems could generate substantial benefits without causing negative environmental impacts.

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