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Study of the effect of microbial inoculation on onion (*Allium cepa* l.) cultivation

Abstract

Onion (*Allium cepa* L.) is a horticultural species whose bulb and aerial parts are consumed, the latter as green onion. Onion cultivation is affected by diseases and is extremely sensitive to water stress, which significantly reduces its yield. The aim of this study was to determine the effect of applying a microbial consortium consisting of biofertilizers, biostimulants, and biocontrol agents on onion cultivation in the Province of Catamarca (Argentina). A bio-input composed of native strains of the biocontrol fungus *Trichoderma spp.* and bacterial strains of *Azospirillum brasilense*, *Bacillus thuringiensis*, *Rhizobium leguminosarum*, and *Bradyrhizobium* sp. was used. The study was conducted in a plot located in Colonia del Valle, Capayán Department, Catamarca. Two treatments were implemented: one with inoculation of the microbial consortium and the other with water application as a control. Two foliar applications were carried out. The evaluation of onion crop performance considered total yield, average bulb weight, bulb size, harvest index, biomass production, and plant count. The results indicate that the application of the microbial consortium increased yields, growth, and development of onion plants. It was determined that the application of selected native microorganisms has a growth-promoting effect on plants, enhancing the growth and productivity of onion crops.

Keywords: *Allium cepa, Trichoderma spp., Azospirillum brasilense, Bacillus thurigiensis, Rhizobium leguminosarum, Bradyrhizobium sp*hylene biguanide, chlorhexidine digluconate, propamidine isethionate, trypan blu

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Introduction

The agricultural sector is in crisis due to the high costs of fertilizers and agrochemicals and the damage these products cause to soil fertility and public health. The indiscriminate and excessive use of these inputs in agricultural production has led to severe imbalances in agroecosystems, prompting significant global pressure to reduce or completely eliminate certain agrochemicals. Coupled with the continuous increase in the global population, the reduction of cultivable land, soil erosion, and contamination are aspects that make the application of strategies and biotechnologies essential to improve crop productivity. This problem has driven the search for production methods based on biological soil renewal processes and the interactions within the soil-plant-environment system.[1]

These strategies are founded on the use of new cultivars of plant species, more productive varieties better adapted to their environment, with greater resistance to pathogens and pests, and the use of soil microorganisms that promote plant growth. Soil microorganisms play a vital functional role in agriculture as they are responsible for processes related to nutrient cycling, plant nutrition, and plant health. Plant nutrition generally depends on the composition of the soil microflora, creating a two-way relationship between root and soil mediated by environmental conditions and the plant system.[2]

There is a wide range of interactions among soil microorganisms, such as synergistic, antagonistic, physical, and biochemical competition, influenced by complex biotic and abiotic factors. Among soil microorganisms are nitrogen-fixing bacteria, phosphate solubilizers, plant growth promoters, biocontrol agents, and pathogenic species competing for space and nutrients.[3–6]

Plant Growth-Promoting Microorganisms (PGPMs) enhance plant growth through different mechanisms, either directly by providing nitrogen (N), phosphorus (P), and essential minerals or through the biosynthesis and regulation of hormone levels, or indirectly by reducing the inhibitory effects of phytopathogens and acting as biological control agents.[3,4,7–9] The use of PGPMs has been investigated for many years, with *Azospirillum* being one of the most prominent bacteria due to its ability to produce a wide range of active metabolites, such as indole-3-acetic acid, cytokinins, gibberellins, and siderophores,[10,11] which positively influence healthy plant growth and development.

Onion (*Allium cepa* L.), a member of the Amaryllidaceae family, is a horticultural species consumed for its bulb and green tops as scallions. It has significant social importance, as a considerable percentage of producers (60%) are small- and medium-scale farmers.[12] Therefore, its production represents an important source of employment. Onion cultivation is affected by diseases and is extremely sensitive to water stress, both of which reduce its yield. The incidence and severity of these diseases depend on the causative organism, the plant's susceptibility, and the environment. The causal agents include fungi, bacteria, viruses, and nematodes, all of which can cause significant yield losses and reduce the commercial quality of onions.

Diseases affecting onion crops must be managed to minimize their harmful effects on plants while avoiding environmental contamination from chemical fungicides and reducing control costs to maintain crop productivity. Therefore, the working hypothesis was that the growth, development, and yield of onion crops are enhanced by the application of free atmospheric nitrogen-fixing microorganisms and biocontrol agents.

The objective of this study was to determine the effect of applying a microbial consortium consisting of biofertilizers, biostimulants, and biocontrol agents on onion cultivation in the Province of Catamarca (Argentina).

Materials and methods

In the town of La Colonia, Santa Rosa Department, Catamarca Province, Argentina, a direct sowing of onion (*Allium cepa* L.) was carried out. Each experimental plot was half a hectare in size, with two crop rows per bed 50 cm wide, and a 25 cm furrow width between beds for furrow irrigation. A completely randomized experimental design with two treatments was implemented. The treatments included a control (without inoculation) and a second treatment with foliar inoculation along the crop rows using a microbial consortium.

Foliar inoculations were performed using a bio-input called Bio MAsT, composed of selected native strains of the biocontrol fungus *Trichoderma spp.* and bacterial strains of *Azospirillum brasilense*, *Bacillus thuringiensis*, *Rhizobium leguminosarum*, and *Bradyrhizobium* sp. Two applications of the microbial consortium were performed on the onion crops. The first inoculation was applied with a mechanical sprayer, and the second with a manual sprayer along the crop rows.

The first foliar application was conducted when the plants had 6 to 8 leaves, with a microbial titre of 1.1×10^9 PGPM mL^{-1}. The second application took place 30 days after the first spraying, using a bio-input with a titre of 1.5×10^9 PGPM mL^{-1}, quantified in a Neubauer chamber.[13] At the end of the cultivation cycle, sampling was conducted in each experimental plot. The sampling area was 0.5 m^2 in the central zone of each plot to avoid edge effects. Three samples were taken and analyzed for each treatment.

For the evaluation of onion crop performance, agronomic and physiological parameters were considered. The agronomic parameters evaluated included:

- Total yield: Production per unit area (tons per hectare).
- Average bulb weight: Indicator of the average size of onions.
- Bulb size: Classification of bulbs by weight (small, medium, large).

The physiological parameters evaluated included:

- Harvest index: Ratio of bulb weight to total plant weight.
- Biomass production: Total plant weight (bulbs, leaves, and roots).

The results were statistically analyzed using analysis of variance (ANOVA), and the means were compared using Fisher's Least Significant Difference (LSD) test at a significance level of 0.05, employing the statistical program Infostat (Figures 1&2).[14]

Figure 1 Onion crop (*Allium cepa L.*) during the first and second inoculation.

Figure 2 Onion plants (*Allium cepa L.*) from each treatment.

Results and discussion

The onion crop was cultivated during the winter and spring of 2024. Plant extraction and evaluation were conducted 7 months after planting.

Statistically significant differences were observed between treatments. Onion plants inoculated with the microbial consortium showed higher bulb production throughout the crop cycle (Table 1). Although no statistically significant differences were recorded for the other evaluated variables, increases were observed with the application of microbial consortia (Table 1& Figure 3).

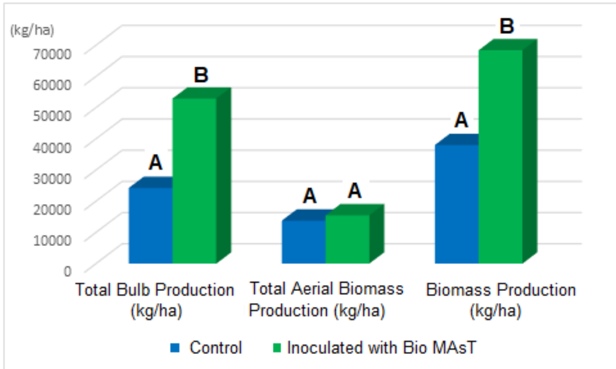

Figure 3 Onion (*Allium cepa*) crop yield expressed as total production in kilograms per hectare.

Table 1 Yield parameters for onion (*Allium cepa*) cultivation

Parameters	Treatments	
	Control	**Inoculated**
Total bulb production (kg/ha)	24239,11 **a**	52883,11 **b**
Total aerial biomass production (kg/ha)	13764,4 **a**	15489,3 **a**
Average bulb weight (g)	204,14 **a**	150,60 **a**
Harvest index	0,66 **a**	0,77 **a**
Biomass production (kg/ha)	38003,55 **a**	68372,44 **b**

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

The evaluation conducted at harvest time for the variables "number of plants" and "number of bulbs," both directly related to onion crop yield, showed the best results in the treatment inoculated with the microbial consortium, with statistically significant differences compared to the control treatment (Table 3).

Table 2 Classification by weight of onion bulbs (*Allium cepa*)

Size category	Approximate weight (g)
Small	Less than 150 g
Medium	150 - 300 g
Large	More than 300 g

Table 3 Yield parameters for onion (*Allium cepa*) cultivation

Parameters	Treatments	
	Control	**Inoculated**
Average number of plants per sample (0.5 m^2)	10,33 **a**	25 **b**
Average number of plants per hectare	206.600 **a**	500.000 **b**
Average number of small bulbs	4 **a**	15,66 **b**
Average number of medium bulbs	3,66 **a**	7,33 **b**
Average number of large bulbs	2,66 **a**	2 **a**

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

The higher number of plants observed in the treatment inoculated with the microbial consortium is presumed to result from the biostimulant action of the microorganisms, which enhance the plant's ability to overcome stress conditions (Table 3). Therefore, the use of bio-inputs (biofertilizers, biostimulants, and biocontrol agents) represents an increasingly prominent alternative in crop management schemes, offering economically attractive and environmentally acceptable options (Mamani de Marchese & Filippone, 2018).

Onion bulbs were classified by weight into different categories: Small, Medium, and Large (Table 2).

The destination of the onion crop production depends on the size of the bulbs, and consequently, it is determined whether it will be for the domestic or foreign market, for fresh consumption, or for industrialization.

The results showed a significant increase in the various plant production variables evaluated in the onion crop due to the inoculation with selected native microorganisms capable of promoting plant growth.

The foliar application of the microbial consortium composed of beneficial native bacterial and fungal strains to the onion crop yielded the best results, attributed to increased water and nutrient uptake—particularly nitrogen, which can be incorporated into the soil through biological nitrogen fixation. This is due to the ability of *A. brasilense* to fix nitrogen biologically, synthesize auxins, and produce other phytohormones.[15]

A management strategy to improve soil fertility and agricultural production is the integration of fertilization with bio-inputs, which serve multiple functions: as biofertilizers, biocontrol agents, and biostimulants. This strategy maximizes crop productivity while minimizing environmental impact by reducing the application of synthetic chemical products.[16]

This study highlights the potential of selected microorganisms in the bio-input used as an alternative to improve onion crop nutrition and productivity in the Central Valley of Catamarca Province.[17]

Conclusion

A. Foliar inoculations of onion (*Allium cepa L.*) crops with selected native microorganisms generated a positive effect on all evaluated variables, improving development and productivity due to enhanced nutrition.

B. Significant differences were observed in the evaluated variables as a result of the applied treatment, with yield-related variables being the most consistent.

C. The application of the microbial consortium enhanced the crop's potential, achieving the best results through the dual inoculation process, which significantly increased yields compared to the controls.

D. The microbial inoculants used in this experiment were native species, which, due to their origin, demonstrated better adaptation mechanisms to environmental conditions. This is believed to be one of the reasons for the promising results observed in the onion crop growth.

E. The applied bio-input, composed of Plant Growth-Promoting Microorganisms (PGPM), benefited onion plant growth through various mechanisms, primarily biological nitrogen fixation and the biocontrol of phytopathogens.

F. Th7is study is pioneering in the studied region and is considered highly promising for achieving increased onion production.

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None.

Conflict of interest

Authors declare that there is no conflict of interest.

References

1. Siqueira JO, Moreira FMS, Lopes AS, et al. Interrelation between fertility, soil biology, and plant mineral nutrition: Basis for a new paradigm in 21st century agro–technology. Interrelation fertility, soil biology, and plant nutrition. Brazilian Society of Soil Science. Federal University of Lavras. Department of Soil Science. LAVRAS – MG: 1999. p. 1–24.
2. Sánchez de Prager M. Mycorrhizas: a shared strategy for soil colonization. Chapter 4. Endomycorrhizas: Bioedaphic expression of importance in the tropics. Univ Nac de Colombia. Fac de Cs Agropecuarias. 2007. p. 115–175.
3. Díaz–Zorita M, Fernández–Caniggia MV. Field performance of a liquid formulation of *Azospirillum brasilense* on dryland wheat productivity. *Eur J Soil Biol.* 2009;45:3–11.
4. Hungria M. Inoculation with *Azospirillum brasilense*: innovation in low–cost yield. *Embrapa Soybean*. 2011. 36 p.
5. Pernasetti S, Di Barbaro G. Plant growth–promoting rhizobacteria as biofertilizers. *ReBeA*. 2012;2(2):119–128.
6. Pereira NCM, Galindo FS, Gazola RPD, et al. Corn yield and phosphorus use efficiency response to phosphorus rates associated with plant growth promoting bacteria. Front Environ Sci. 2020.
7. Perrig D, Boiero L, Masciarelli O, et al. Plant growth–promoting compounds produced by two agronomically important strains of *Azospirillum brasilense*, and their implications for inoculant formulation. *Appl Microbiol Biotechnol*. 2007;75:1143–1150.
8. Piccinin Gleberson G, Braccini AL, Dan LGM, et al. Efficiency of seed inoculation with *Azospirillum brasilense* on agronomic characteristics and yield of wheat. *Ind Crops & Prod*. 2013;43:393–397.
9. Ahemad M, Kibret M. Mechanisms and aplications of plant growt promoting rhizobacteria: Current perspective. *J King Saud Univ Sci*. 2014;26(1):1–20.
10. Caballero–Mellado J. The genus Azospirillum. In "Microbes Online". In: E Martinez–Romero, J Martínez–Romero, editors. Univ Nac Autónoma de México; 2002. p. 177–198.
11. Bashan L, Holguín G, Glick B, et al. Plant growth–promoting bacteria for agricultural and environmental purposes. In: Agricultural Microbiology: Fungi, bacteria, micro and macrofauna, biological control, plants–microorganisms. In: Ronald Ferrera–Cerrato, A Alarcon, CA Champer, editors Publisher by Editorial Trillas. Mexico; Chapter 8: 2007. p. 170–224.
12. Blanco C. Onion production manual. Ch. 7 Onion harvest. Instituto de Desarrollo Agropecuario – Instituto de Investigaciones Agropecuarias. INIA Bulletin No. Santiago de Chile; 2025. p. 83–88.
13. Manacorda AM, Cuadros DP, Álvarez AS. Practical manual of microbiology – Volume I: Environmental microbiology I. Ch. 8: Microorganism Counting. 2007. 8 p.
14. Di Rienzo JA, Casanoves F, Balzarini MG, et al. InfoStat version 2018. InfoStat transfer center, FCA, Univ. Nac. de Córdoba, Argentina. 2018.
15. Larraburu EE, Yarte ME, Llorente BE. *Azospirillum brasilense* inoculation, auxin induction, and culture medium composition modify the profile of antioxidant enzymes during in vitro rhizogenesis of pink lapacho. *Plant cell tiss organ cult. 2016.*
16. Di Barbaro G, Andrada H, Del Valle E, et al. Biological activity of soils cultivated with Jerusalem artichoke inoculated with *Azospirillum brasilense* and mycorrhizal fungi. FAVE, *Ciencias Agrarias*. 2020;19(1):33–41.
17. Mamani de Marchese A, Filippone MP. Bioinputs: key components of sustainable agriculture. *Rev Agron Noroeste Argent.* 2018;38(1):9–21.

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