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Effect of the application of organic amendment and microorganisms that promote plant growth on tomato production (*Solanum lycopersicum* L.)

Abstract

It is important to conserve and improve water use efficiency and crop productivity in arid and semi-arid zones. For which, the use of beneficial microorganisms and water retainers can help in the tolerance of plants to drought conditions. Therefore, the objective of this work was to determine the effect of inoculation with MPCV- plant growth promoting microorganisms (*Azospirillum brasilense* and mycorrhizal fungi) and the application of organic amendment of potassium acrylate on the production of tomato plants (*Solanum lycopersicum* L.). A greenhouse trial was carried out with a completely randomized experimental design with 4 treatments (T1: Control without application of amendment or MPCV; T2: application of K acrylate amendment; T3: with MPCV inoculation; T4: with joint application of K acrylate amendment and MPCV), with 15 replicates. The highest production and size of tomato fruits was achieved with the inoculation of MPCV (T3) and with the application of K acrylate (T2) individually. The inoculation with *Azospirillum brasilense* and mycorrhizal fungi, and the application of the organic amendment of potassium acrylate at the time of transplanting tomato (*Solanum lycopersicum* L.) improves growth and increases its production.

Keywords: potassium acrylate, *Azospirillum brasilense*, mycorrhizal fungi, mycorrhizae

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Introduction

In arid and semi-arid regions, agricultural production faces a serious problem: "water scarcity". Therefore, it is important to seek alternatives and forms of use of the region's water resources for rational and sustainable water management.[1]

On the other hand, the knowledge of the contribution of soil microorganisms in the promotion of plant growth is considered of interest to resort to the use of these in crops of economic importance in the region. Among these microorganisms are the PGPM, Plant Growth Promoting Microorganisms, which facilitate plant growth either directly by providing nitrogen, phosphorus, and essential minerals or by biosynthesis and regulation of hormone levels, or indirectly by decreasing the inhibitory effects of various phytopathogens and the development in forms of biological control agents. All this due to the ability of the rhizobacteria *Azospirillum brasilense* to biologically fix atmospheric nitrogen, the increase in nitrate reductase activity when they grow endophytically in plants, the production of hormones, such as auxins, cytokinins, gibberellins, ethylene and a variety of of other molecules, phosphate solubility, and by favoring mycorrhizal associations that are beneficial for plants and can act indirectly on growth by protecting plants from phytopathogenic microorganisms in the soil.[2–7] Mycorrhizal fungi depend on the plant for the supply of energy, carbohydrates, and vitamins, which the fungus itself is unable to synthesize while the plant can do so thanks to photosynthesis and other internal reactions. At the same time, mycorrhizal fungi deliver mineral nutrients to the plant, especially those that are not very mobile, such as phosphorus and water.[8–11]

Water has always been considered the factor that most affects food production in the world. This is clearly understood if it is assumed that more than 500 liters of water are needed to produce a kilogram of corn grain, and more than 800 liters of water are needed for a kilogram of soybean or wheat grain, with which to obtain a harvest satisfactory, about 500 mm are required, that is, 5 million liters of water per hectare.[12] Water stress is often the most important environmental factor affecting the survival, growth, and development of plant species. The evaluation of the vegetable plantations established during 1983-1986 by the National Institute of Agricultural Technology in the Catamarca Valley, reports that 24.7% of the failures were attributed to moisture deficiencies.[13]

The amendments are intended to correct problems that affect physical and/or chemical conditions of soil fertility. They favor root development and exploration, improving the efficiency of nutrient and water absorption by the roots. The amendments can be classified into organic and inorganic.[14] Among the organic amendments of artificial or synthetic origin, some superabsorbent polymers are considered, such as: polyacrylate, acrylamide and potassium acrylate, and the latter is the object of study in this work.

Hydrogels or water retainers are used in agricultural activity as soil conditioners, mainly because they increase the capacity to store water in the soil.[15,16] However, little is known about the compatibility of its use with other agricultural products. Therefore, the objective of this work was to determine the effect of inoculation with plant growth promoting microorganisms (*Azospirillum brasilense* and mycorrhizal fungi) and the application of organic amendment of potassium acrylate on the production of tomato plants (*Solanum lycopersicum* L.).

Materials and methods

In the greenhouse of the Faculty of Agrarian Sciences of the National University of Catamarca in April 2021, a trial with a completely randomized experimental design with 4 (four) treatments [T1: Control (without application of amendment or PGPM); T2: with K acrylate amendment; T3: with PGPM inoculation; T4: with application of K acrylate amendment and PGPM], with 15 (fifteen) repetitions. In containers with 5 liters of substrate formed by compost and soil from the agricultural area of the Central Valley of the Province of Catamarca, tomato seedlings (*Solanum lycopersicum* L.) variety

Platense were transplanted. At the time of transplantation, treatments were defined according to the following procedures:

- *K acrylate application*: 0.075 g of K acrylate per container. The substrate was mixed with the superabsorbent polymer and water (T2) or with the inoculant (T4) and the root of the seedling was submerged in the mixture. This kept the roots always hydrated, because potassium acrylate can hold large amounts of water, also allowing the roots to breathe.

- *Inoculation with PGPM*: the roots of the seedlings were submerged in the inoculant of *Azospirillum brasilense* and mycorrhizal fungi prior to transplantation. While the seedlings of the uninoculated control treatment (T1) were placed in sterile running water.

The composition and load of the PGPM inoculum of the inoculated treatments (T3 and T4) consisted of the bacterium *Azospirillum brasilense* strain Pi 8 (24h culture in MPSS medium) plus mycorrhizal fungi that form vesicular-arbuscular mycorrhizae (VAM) in *Melilotus officinalis* roots, *Cenchrus ciliaris* and *Avena sativa*.[17]

The total production and the average production of tomatoes per plant were evaluated, performing the fresh weight of fruits with an analytical balance. The results were statistically analyzed by analysis of variance (ANAVA) and the means were compared by Fisher's LSD (least significant difference) test at a significance level of 0.05 using the Infostat statistical program.[18]

Results and discussion

The highest production of tomatoes expressed in fresh weight of tomato fruits per plant was achieved with the inoculation of PGPM (T3) and with the application of K acrylate (T2) individually, without registering statistically significant differences between these treatments. However, the lowest production was obtained with the simultaneous application of the microbial consortium and K acrylate (Table 1, Figure 1). The combination of the MPCV inoculation and the potassium acrylate amendment caused an antagonistic effect on tomato production with respect to the application of these products individually (T3 and T2), probably this response is due to a negative effect on the mycorrhizal fungi of the amendment since there are methoxy-acrylate fungicides.[19] Mycorrhization is affected by various factors, for which mycorrhizae show diverse and contradictory responses.[20]

Table 1 Total Fresh Weight and Average Fresh Weight of tomatoes (*Solanum lycopersicum* L.) variety platense per plant grown in the greenhouse of the FCA of the UNCa

Variable	Treatments			
	T1: Control	**T2: K acrylate**	**T3: PGPM**	**T4: acrylate + PGPM**
Total FW (g)	718,76+306,72 **ab**	867,90+332,14 **b**	956,15+344,04 **b**	546,19+288,35 **a**
Average FW (g)	39,70+9,20 **b**	39,82+6,22 **bc**	46,35+8,30 **c**	28,49+8,28 **a**

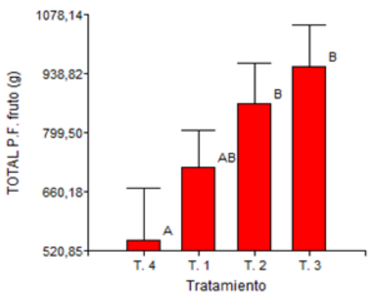

Figure 1 Production of tomatoes (*Solanum lycopersicum* L.) variety platense expressed as Total Fresh Weight of fruits per plant grown in the greenhouse of the FCA of the UNCa.

In addition, with the inoculation of the microbial consortium of *Azospirillum brasilense* and mycorrhizal fungi (T3), larger fruits were achieved than with the other treatments. Results that are expressed in Table 1 and Figure 2, as average fresh weight of tomato fruits.

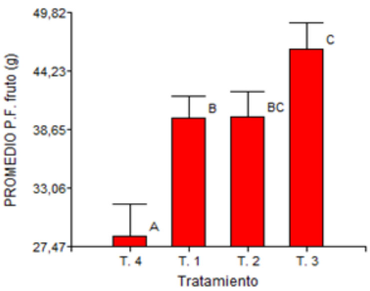

Figure 2 Size of tomatoes (*Solanum lycopersicum* L.) variety platense expressed as Average Fresh Weight of fruits per plant grown in the greenhouse of the FCA of the UNCa.

The higher production of tomato fruits with the application of K acrylate is consistent with those obtained in experiments with another vegetable, lettuce (*Latuca sativa*).[1] While the lowest results were obtained with the joint application of the PGPM consortium and the potassium acrylate amendment (T4), statistically significant differences were observed with the individual application treatments of the amendment (T2) and the inoculant (T3). This could be since the edaphic humidity conditions were not limiting for the water-retaining action of the K acrylate, for which the ability of the mycorrhizae to deliver a greater amount of water to the plants when this is not manifested. Resource is in deficit. Results that do not coincide with a study carried out on a forest floor where the response of microorganisms to organic amendments was evaluated, comparing the incorporation of wheat straw and a mixture of sawdust with chicken manure. In said study, the beneficial effect of the incorporation of sawdust and manure on the population and microbial diversity in the soil is verified, as well as the availability of nutrients for use by plants.[21]

In general, it is estimated that the use of water retainers in vegetables increases the water retention capacity of the soil, favoring the development of plants. The application of K acrylate as an amendment increases the moisture content of the soil, which is associated with higher yields in the agroecosystems of semi-arid and arid regions.[1] By mixing this polymer with the soil, it is possible to take better advantage of rainwater or irrigation water, since less water is lost through filtration, and its evaporation is also reduce.[22] By implementing this technology in different crops, it will allow them not to suffer from water stress, which is the main obstacle in their development. By having this element installed in the plant, they have a constant supply of water, allowing their maximum development, as well as great savings in water and fertilizers.[13] Which results in a significant increase in production (Images 1–4).

Images 1 – 4 Tomato cultivation test (*Solanum lycopersicum* L.) variety platense in greenhouse of the FCA, of the UNCa.

Conclusion

The highest production of tomatoes was obtained with the independent activity of the two products under study. Inoculation with the microbial consortium of *Azospirillum brasilense* and native mycorrhizal fungi, and the application of the potassium acrylate amendment independently at the time of transplanting tomato (*Solanum lycopersicum* L.) improves growth and increases production. The use of potassium acrylate as an amendment can improve water retention in the soil, so developing this technology is feasible to help solve water problems in the agroecosystems of arid and semi-arid regions fundamentally.

The inoculation with PGPM and the application of organic amendments of potassium acrylate can be considered as valid alternatives for the conservation of water and soil resources, since water consumption is reduced, the soils improve their release and retention properties, and it is achieved greater production and resistance of the species in hostile conditions. All of this also represents a positive impact on the environment and benefits for the producer and the community.

Therefore, it is expected that this knowledge will facilitate the implementation of this technology in the field and on a larger scale, to face the challenges posed by the scarcity of water for agricultural production, because it is necessary to conserve and improve the efficiency of water use. and productivity, especially in arid and semi-arid zones. The use of these biotechnologies has a positive impact not only on the health of the soil, but also on production systems in general, since they allow the conservation of soil resources and biodiversity, in addition to avoiding desertification, limiting the degradation of the soil, improve water and nutrient retention.

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None.

Conflicts of interest

Author declares there is no conflict of interest.

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