Investigation note

Effect of root biostimulants on growth in avocado plants

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Abstract

For a proper and successful establishment of avocado crop, plants with a developed and healthy root system are needed. However, in commercial avocado nurseries, management oriented to root improvement is not carried out. The objective of this study was to evaluate the effect of root biostimulants based on microorganisms and organic acids on growth, chlorophyll content and mycorrhization in avocado plants. There were seven treatments, including one control. The experimental design was completely random, with eight repetitions. The variables evaluated were number of leaves, plant height, main root length, SPAD units, root dry weight and percentage of mycorrhization. In each of the variables, the best treatment was the combination Nutrisorb® L + Biofit® RTU, which confirms that the use of microorganisms and organic acids favors vegetative and root growth, as well as promotes greater mycorrhization.

Keywords: avocado, microorganisms, organic acids.

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Avocado is one of the crops of greater economic importance in the country, as of January 2020, the avocado production obtained in Mexico was 206 466 t, where the state of Michoacán contributed 94.6% (195 366 t) to the national total, which makes it the main producer (SIAP, 2020).

In Mexico the production of avocado plants is mainly based on the use of rootstocks originated by seed; however, there is no certified avocado plant, since the respective technical rule indicating the procedures for producing plant in a nursery is not yet available, therefore, the procedure for propagation is variable (Campos-Rojas *et al*., 2012).

As for their management in the nursery, they are mainly fertilized with diammonium phosphate (DAP-18-46-00) as well as applications from some other sources of chemical fertilizers (Ortíz-Estrella and Vázquez-Collado, 2008). On the other hand, there are biostimulants derived from various substances and microorganisms that help improve plant growth (Calvo *et al*., 2014; du Jardin, 2015). Likewise, plant roots influence the physical, chemical and biological characteristics of the rhizosphere of the soil (Koo *et al*., 2005) and act directly on microorganisms by the secretion of different compounds (Bais *et al*., 2006).

The use of microbial inoculants such as rhizobacteria, endophytic fungi and mycorrhizas has increased in recent years for different purposes (Hayat *et al*., 2010). So, the proposed objective was to evaluate the effect of different biostimulants on the development of avocado seedlings. The present study was carried out in the facilities of the Faculty of Agrobiology 'Presidente Juárez' dependent on the Michoacán University of San Nicolás de Hidalgo, located in the city of Uruapan, Michoacán at coordinates 19° 23' 41. 375'' north latitude, 102° 3' 30. 192''west longitude and an altitude of 1 589 m.

Plants from a commercial nursery in the locality of Tingambato, Michoacán were used. These had been grafted for 15 days with the Hass variety onto creole rootstock of the region and had a homogeneous visual size, later they were transferred to the experimental area (greenhouse) within the facilities of the Faculty of Agrobiology.

A completely randomized design was used, with seven treatments and eight repetitions. The experimental unit consisted of an avocado plant. The products evaluated were a control and the commercial biostimulants: Nutrisorb® L (carboxylic acids, 11%), Mycoroot® (*Pisolithus tinctrius*,1 x 10^6 UFC g^{-1}, *Glomus intraradices*, 1 x 10^3 UFC g^{-1}; *Azospirillum brasilense*, 1 x 10^6 UFC g^{-1}, carboxylic acids, 19.7%), Biofit® RTU (*Trichoderma harzianum*,1.35 x 10^5 UFC g^{-1}, *Penicillium bilaiae* + *Penicillium* spp. + *Paecilomyces lilacinus*, 1.25 x 10^7 UFC g^{-1}, *Bacillus subtilis*, 1.25 x 10^8 UFC g^{-1}, *Azospirillum brasilense*, 1.25 x 10^5 UFC g^{-1}, carboxylic acids, 34%) and Glumix® (*Glomus* spp. 1 x 10^3 UFC g^{-1}) (Table 1).

Table 1. Treatments evaluated to determine their biostimulant effect on avocado seedlings under greenhouse conditions in Uruapan, Michoacán.

Treatment	Dose*
A) Nutrisorb® L	3 ml
B) Mycoroot®	5 g
C) Biofit® RTU	5 g

Treatment	Dose*
D) Nutrisorb® L + Mycoroot®	3 ml + 5 g
E) Nutrisorb® L + Biofit® RTU	3 ml + 5 g
F) Glumix®	5 g
G) Control	Water

*= dose in one liter of water per seedling per application.

Applications were made in drench every 21 days. In total nine applications starting in October 2019 and ending in April 2020, where the following response variables were evaluated: number of leaves, plant height, main root length, SPAD units and root dry weight, the percentage of mycorrhization was also determined. With the data obtained, an analysis of variance and a Tukey mean separation test α= 0.05 were performed, with the statistical program Statistical Analysis System version 9.0 (SAS, 2002). All the agronomic variables evaluated presented highly significant differences ($p\leq 0.01$) for treatments in the analysis of variance (Table 2).

Table 2. Response of avocado seedlings to different biostimulant treatments in Uruapan, Michoacán.

Treatments	No. of leaves	Chlorophyll content (SPAD units)	Plant height (cm)	Root length (cm)	Root dry weight (g)
A) Nutrisorb® L	40.12 b	66.86 b	51.7 bc	43.47 bc	8.62 d
B) Mycoroot®	40 bc	72.37 ab	49.42 c	49.38 b	12.75 bc
C) Biofit® RTU	38.75 bc	70.47 ab	51.77 bc	45.12 bc	11.96 c
D) Nutrisorb® L + Mycoroot®	40.25 b	68.56 ab	53.37 b	49.38 b	13.65 b
E) Nutrisorb® L + Biofit® RTU	53.87 a	75.48 a	58.58 a	63.23 a	24.5 a
F) Glumix®	41.75 b	65.25 b	54.87 b	47.5 b	13.75 b
G) Witness	32.62 c	55.65 c	41.91 d	34.25 c	4.91 e

The means grouped with the same literal do not differ statistically from each other, according to Tukey's test ($p\leq 0.05$).

In the Tukey mean comparison tests for the variables, it was observed that the mixture of Nutrisorb® L + Biofit® RTU had a higher number of leaves with an average of 57.87 leaves per plant. This coincides with González and Fuentes (2017), who evaluated different microorganisms, which produced beneficial effects on the number of leaves for sunflower plants (*Helianthus annuus* L). Sakthiselvan *et al*. (2014) have suggested that microorganisms may favor plant growth, since they generate a positive effect on some chemical properties of the soil increasing the solubilization of nutrients and their absorption capacity.

It is common for chlorophyll content to be used in nutritional management programs (Blasco *et al*., 2010) and is a useful tool to monitor nutrition and thereby improve crop yields (López-Bellido *et al*., 2004). The Nutrisorb® L + Biofit® RTU treatment presented the highest chlorophyll content with 75.48 SPAD units. The results obtained differ from those found by Arellano (2017), who, in the case of chlorophyll content in avocado leaves, obtained that the highest average value was recorded by the mycorrhizae treatment (40.2 SPAD units), while Leal-Almanza *et al*. (2018), when evaluating *Bacillus cereus*, *B. subtilis*, *Pseudomonas fluorescens* and *Trichoderma harzianum* as plant growth promoters in the cultivation of potato *Solanum tuberosum* L., also found no significant differences.

This can be explained because the application of organic acids together with microorganisms favors its activity in the rhizosphere, also increases the root architecture and this is reflected in a greater assimilation of nutrients in plants, and therefore a higher content of chlorophyll (Badri and Vivanco, 2009; Zare-Maivan *et al*., 2017).

As for the height of the plant, on average, the Nutrisorb® L + Biofit® RTU presented on average 58.58 cm in length. These results coincide with Canseco-Martínez *et al*. (2020), who found that applications of organic matter directly influence the size of plants compared to the control without application, they report that they obtained coffee plants (*Coffea arabica* L.) of bigger size, because as there is a greater amount of organic matter, there is also a greater microbial activity and therefore greater possibility of release of nutrients that when applied to the soil continue with the process of decomposition. Likewise, Silveira *et al*. (2003) report a greater development of foliage when performing inoculations of mycorrhizae in avocado.

In the root length variable, the best treatment was Nutrisorb® L + Biofit® RTU, which presented an average of 63.23 cm while the control was the shortest. In avocado plants, the effects of mycorrhizae on better root development have been demonstrated (Carreón-Abud *et al*., 2014), which coincides with the results obtained. González and Fuentes (2017) mention that microorganisms favor the production of auxins, which increases the length of the roots.

As for the root dry weight, the mixture Nutrisorb® L + Biofit® RTU presented the highest dry weight with 24.5 g, followed by the treatments of Glumix® and Nutrisob® L + Mycoroot®. Barroetaveña and Rajchenberg (2003) and González and Fuentes (2017) report similar results when using mycorrhizae, bacteria and *Trichoderma*, finding a higher number of roots due to the production of phytohormones such as cytokinins, which impacted on the dry weight in pine plants (*Pinus ponderosa* Douglas ex C. Lawson), rice (*Oryza sativa* L.) and lettuce (*Lactuca sativa* L.).

The percentage of mycorrhization was influenced by the application of organic acids of the Nutrisorb® L + Biofit® RTU mixture, resulting in the treatment with the highest percentage (73%), followed by Mycoroot® and Glumix® with 58 and 57% respectively (Figure 1).

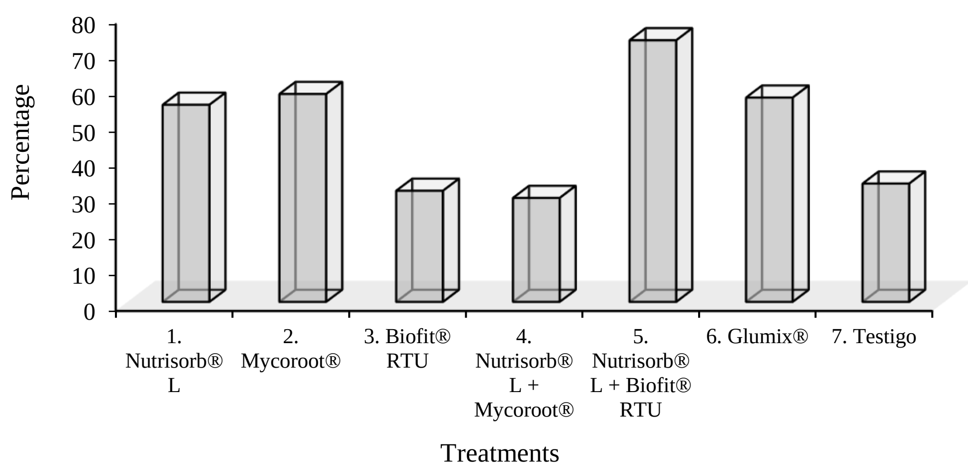

Figure 1. Effect of biostimulants on the percentage of mycorrhization of avocado seedlings.

This coincides with Quiñones-Aguilar *et al*. (2014), who when incorporating sources of organic matter with mycorrhizae obtained higher percentages of mycorrhization in papaya roots (*Carica papaya* L.) compared to the control where they were not applied. In nursery, the greatest effects in the implementation of the symbiosis of arbuscular mycorrhiza have been obtained, as a way to improve the health and nutritional status of plants, in the propagation of some fruit trees (Monticelli *et al*., 2000; Úsuga *et al*., 2008). Huang *et al*. (2014); Dey and Sengupta (2020) mention that the presence of organic substances is vital to increase microbial activity in the rhizosphere, so that the plant is favored during its development. The above supports these results so it is feasible to use microorganisms and organic substances in seedling management programs in avocado nurseries.

Conclusions

The application of the Nutrisorb® L + Biofit® RTU mixture has the greatest effect on the growth characteristics and chlorophyll content in the avocado seedlings grafted with the Hass variety in creole rootstock of the region, so it is advisable to use it for the commercial production of plants grafted in nursery.

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