Investigation note

Effect of salicylic acid on tomato germination and root growth

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Abstract

Tomato (*Solanum lycopersicum* L.) is a vegetable belonging to the family of Solanaceae. This crop is important in several countries, mainly for its high economic value reflected in its high demand, with markets for fresh or industrialized consumption. Due to its commercial importance, research is carried out on its cultivation to obtain good quality seedlings. Salicylic acid has been proposed as a plant growth regulator, due to the induced effects on some physiological processes of plants. The objective of this study was to evaluate the effect of different concentrations of salicylic acid on the germination and quality of tomato seedlings. The seed imbibition tests, and salicylic acid preparation were carried out in the laboratory of plant physiology and biotechnology of the Technological Institute of Conkal, Yucatán, during 2016-2017. Tomato seeds of the Rio Grande variety with a determinate growth habit were used. The seeds underwent an imbibition process for 24 h under controlled laboratory conditions. The treatments evaluated were 0, 1, 0.01 and 0.0001 µM of salicylic acid (AS) and as a control one without imbibition. With the results, an analysis of variance was performed, as well as the test of comparison of means by the Tukey method ($p \leq 0.05$), using the SAS version 9.3 statistical package. The results showed that the time of seed imbibition in concentrations of salicylic acid does not inhibit germination and stimulates the differentiation of secondary roots at concentrations of 1 and 0.01 µM of AS.

Keywords: *Solanum lycopersicum* L., germination, salicylic acid.

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Tomato (*Solanum lycopersicum* L.) is one of the most important vegetable crops worldwide due to its consumption both fresh and processed products. For a good yield of this vegetable, it is important to obtain good quality seedlings that have a better root growth, which favors a better production of tomato (Calero *et al*., 2019).

Germination is one of the most important stages in the process of growth and development of the plant, which begins with the intake of water by the seed in a process called imbibition. The use of plant growth regulators (PGRs), such as salicylic acid (AS) found in all plant tissues (Martín *et al*., 2015), are considered an alternative to increase the production of foods of horticultural importance and cereals either under greenhouse conditions or in open field (Martín *et al*., 2013).

In *Capsicum chinense*, AS increases the size of the roots, favoring the absorption and accumulation of macro and micronutrients (Tuchuch-Haas *et al*., 2019) as well as other studies propose salicylic acid as a viable alternative to increase production and nutraceutical quality in tomatoes (Vázquez-Diaz *et al*., 2016).

Martín *et al*. (2013) report the beneficial effects of salicylic acid on the production of varieties of tomato, cucumber, habanero chili, pepper and other species. The foliar evaluation of AS in tomato and pepper seedlings favors certain growth variables and mineral content (Valdez-Sepúlveda *et al*., 2015). Tomato plants from seeds treated in concentrations of salicylic acid showed a positive effect on leaf area, root length, fruit size, as well as yield per plant (Rodríguez-Larramendi *et al*., 2008).

In other species such as *Phaseolus vulgaris* L, the time of seed imbibition determines the effect of AS (Rodríguez-Larramendi *et al*., 2017). However, there are reports (Benavides-Mendoza *et al*., 2004; Rodríguez-Larramendi *et al*., 2017) that this plant regulator has an inhibitory effect on germination in some vegetables at certain concentrations and periods of imbibition. The objective of this research was to evaluate, in tomato, the effect of salicylic acid imbibition on seed germination and to measure whether this growth regulator affects the growth of seedling roots.

The study was conducted at the Technological Institute of Conkal, Yucatán. Seed imbibition tests and salicylic acid preparation were carried out in the laboratory of plant physiology and biotechnology during 2016-2017. Tomato seeds of the commercial variety Rio Grande with a determinate growth habit were used. To evaluate germination, batches of seeds were placed in cheesecloth bags, they were imbibed in each solution corresponding to each treatment for 24 h in a growth room under controlled conditions (temperature 21 ±1 °C, relative humidity 30%).

The treatments evaluated were 0 μM, 1 μM, 0.01 μM and 0.0001 μM of AS and one control without imbibition. To prepare the three concentrations of AS, the methodology described by Gutiérrez-Coronado *et al*. (1998) was used. The bioassays to evaluate the germination and growth of the radicles were carried out following the technique described by Larqué-Saavedra *et al*. (1975). The test consisted of sowing the tomato seeds on cloth meshes in glass jars, with 250 ml of distilled water or the AS solution corresponding to each treatment.

The jars were kept in a germination room under controlled conditions. A completely randomized experimental design was established with five treatments (0, 1, 0.01, 0.0001 μM of AS and a control without imbibition). Twenty seeds per repetition were used, five repetitions per treatment. Seven days after starting the experiment, the germination percentage and root length were evaluated (through the ImageJ program), for this variable 10 seedlings were measured for each treatment.

An analysis of variance was performed with the results, as well as the test of comparison of means by the Tukey method ($p\leq 0.05$), using the statistical package SAS version 9.3. No effect of inhibition by AS on the germination of tomato seeds could be seen in the two trials. In bioassay one the percentage of germination oscillates from 87% to 94%. The percentage of germination in bioassay two presented from 89% to 97%, compared with the treatment of seeds without imbibition or imbibed with distilled water. The analysis reports that there are no statistically different differences between treatments (Tukey, $p\leq 0.05$).

These results presented responses similar to that reported by García-Osuna *et al*. (2015) that in green tomato, (*Physalis ixocarpa*) salicylic acid does not inhibit germination and stimulates this physiological process from the first day of sowing in concentrations 10^{-2} M, 10^{-4} M and 10^{-6} M. It is important to note that concentrations 10^{-2} and 10^{-3} M of AS, reported by Benavides *et al*. (2004), inhibit the germination of seeds of Tampiqueño chili (*Capsicum annuum*) variety 74. Using low concentrations of 10^{-5} M, germination data are reported with a similar behavior to the control.

This behavior suggests that the effect of AS concentrations depends on the time of exposure to this plant growth regulator, which probably increases endogenous levels of abscisic acid and thus inhibits germination (Rodríguez-Larramendi *et al*., 2017). The results obtained confirm that germination pretreatments are a tool that increases germination percentage.

The root length of the seedlings grown in distilled water from tomato seeds imbibed for 24 h in one of the different concentrations of AS was evaluated at seven days. The statistical analysis of the bioassay indicates significant differences between treatments. The treatment of seeds imbibed in distilled water and seeds directly sown have the lowest values and concentrations 0.01 and 0.0001 μM of AS showed the greatest stimulating effect (Figure 1).

The root length of seedlings without pretreatment of AS that were cultivated in solutions of different concentrations of AS or distilled water for seven days is shown in Figure 2. The statistical analysis of the bioassay indicates significant differences between treatments. The results of the trial show that when the roots are grown in the solution with 0.01 μM of AS, they have greater root length compared to other treatments.

According to what was reported by Larqué-Saavedra *et al*. (2010), seedlings treated with AS at concentrations 0.01 and 1 μM favor the development of the root of *Lycopersicon esculentum* Mill. The applications of low concentrations of salicylic acid to the shoots of seedlings of horticultural plants, such as the genus *Capsicum*, reflect its positive effect on the growth, development of the plant, as well as root growth that correlates a greater absorption of macronutrients and micronutrients that are assigned in plant tissues (Tucuch-Haas *et al*., 2017).

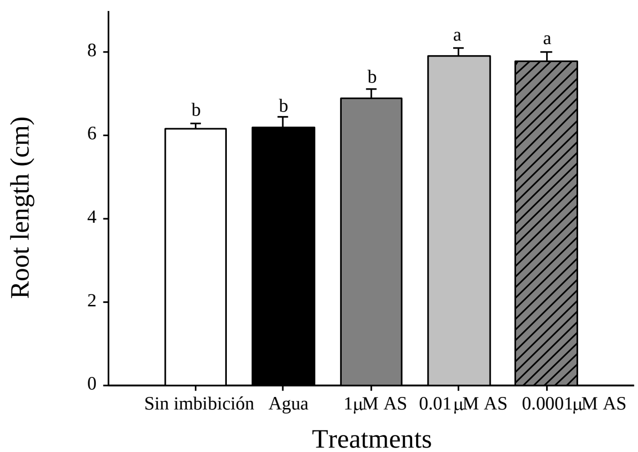

Figure 1. Root length of tomato seedlings grown for seven days in distilled water. These seedlings came from seeds imbibed for 24 h in one of the different concentrations of salicylic acid indicated in the graph of seeds imbibed in distilled water or seeds sown directly. Different literals indicate statistically significant difference (Tukey, $p\leq 0.05$). The data are means ± standard error (n= 10).

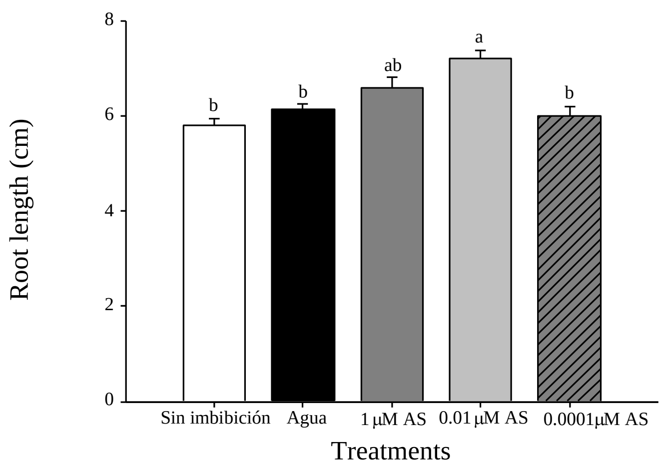

Figure 2. Root length of tomato seedlings of Río Grande variety grown for seven days in one of the different concentrations of salicylic acid indicated in the graph or in distilled water. Different literals indicate statistically significant difference (Tukey, $p\leq 0.05$). The data are means ± standard error (n= 10).

It should be noted that it was observed that the roots cultivated in the solutions of different concentrations of AS presented secondary root formation, an effect that was not manifested in the roots cultivated only in water or those of the direct sowing seeds (Figure 3).

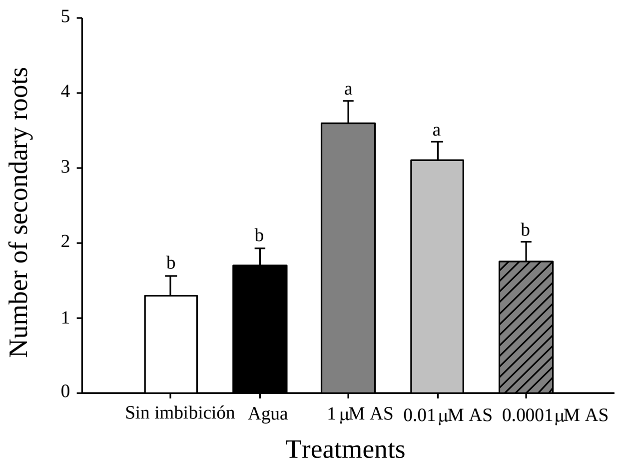

Figure 3. Number of secondary roots of tomato seedlings of Río Grande variety grown for seven days in one of the different concentrations of salicylic acid indicated in the graph or in distilled water. Different literals indicate statistically significant difference (Tukey, $p \leq 0.05$). The data are means ± standard error (n= 10).

The application of AS to plants of C*apsicum annuum* L. *cv* Chichimeca in contact with AS in concentrations of 0.1 and 0.2 mM shows an increase in the production of foliar biomass, root and fruits (Sánchez-Chávez *et al*., 2011).

The results of this study coincide with what was published by authors such as Vázquez-Diaz *et al*. (2016), who reported significant effect on tomato yield at doses 0.025 and 0.1 mM of AS when being diluted in a nutrient solution.

Guzmán-Antonio *et al*. (2012) mention that AS in concentration of 10^{-8} M, in synergy with fertilization of N, P and K (190 mg L^{-1} of N-P_2O_5-K_2O), increased the height, number of leaves and specific root length of the seedlings in habanero chili. The effect of the exogenous application of AS on plant growth depends on the species, the stage of development and the concentration applied (Rivas and Plascencia, 2011). Based on the results, the AS represents an alternative in tomato germination and production.

Conclusions

The imbibition of tomato seeds in salicylic acid (1, 0.01 and 0.0001 µM) for 24 h does not inhibit their germination. Salicylic acid at concentrations 1 and 0.01 µM significantly favors the root length of seedlings and the formation of secondary roots compared to controls.

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