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# Acetylsalicylic acid (ASA) as inductor of growth and flowering in tomato

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**Abstract.** Tomato growth and fruiting are regulated by the interaction between environmental and endogenous factors. Thus, the use of organic compounds in the proper dosage can contribute to accelerate growth, development and productivity of tomatoes. In this sense, the objective of this work was to evaluate the growth and flowering of tomato plants submitted to different concentrations of acetyl salicylic acid (ASA). The experiment was carried out with the cultivar Santa Cruz Kada in a completely randomized design with five replications and six treatments with concentrations 0, 5, 10, 15, 20 and 25 mmol L-1 of acetylsalicylic acid. The different concentrations of AAS in this study did not change the stem diameter, however, other characteristics were influenced by the ASA. Concentrations over 15.6 mmol L-1 reduced the emission of tomato leaves, however, there was an increasing response to the emission of flower buds, SPAD (Soil Plant Analysis Development) index and plant height.
**Keywords:** Acetylsalicylic acid, tomato

## Introduction

The tomato, whose center of origin is in the Andean regions occupied by the Incas in Peru, Bolivia and Ecuador, is one of the most consumed vegetables in the world (TREICHEL, 2016), arriving on the market in a fresh or processed way. Total world production has increased by more than 35% over the past ten years (https://www.yarabrasil.com.br/conteudo-agronomico/blog/producao-mundial-de-tomate/ ). However, according to the Systematic Survey of Agricultural Production (IBGE, 2021), from 2019 to 2020 there was a loss of 7% in production and 6.5% in the planted area. This retraction was influenced by the impact of the pandemic, contributing to a lower demand, and consequently a reduction in the volume of purchases, and also affecting the price. Even in this context, with a peak in 2020, in 2021 there were small percentage changes of -0.70% and 1.2% for production and harvested area, respectively (https://sidra.ibge.gov.br/home / lspa / brasil), consolidating the tomato culture as being important in the economic scenario of vegetable production in Brazil.

Tomato production in Brazil is mainly concentrated in the states of São Paulo, Minas Gerais and Goiás (CAMARGO FILHO and CAMARGO, 2017). In addition to the economic issue, tomatoes stand out for their nutritional importance, as they are a source of vitamins A and C, minerals and antioxidant properties. (BERNARDINO et al., 2018). It is noteworthy that this specie is important in the world, national and state, and the state of Espirito Santo is the sixth producer in the national ranking (CONAB, 2019), the search for maximizing its income becomes important.

Thus, it is evident the need to seek less aggressive means to the environment and at the same time efficient to increase the production of the culture. Research reports the beneficial effects of Acetylsalicylic Acid (ASA) in some economically important crops, such as rice, sugar cane, custard apple among others (FARIAS, 2012; FIALHO et al., 2019).

The ASA is one of the essential compounds in stimulating plant defenses, due to its ability to move and stimulate the systemic protection of the crop. The activities of the antioxidant enzymes APX (ascorbate peroxidases), SOD (superoxide dismutase), POD (peroxidase) and CAT (catalase) increase significantly in response to the application of acetylsalicylic acid (Soliman et al., 2018). In a study by Kabiri et al., (2015), it was observed that acetylsalicylic acid reduced the negative effects of water stress by reducing the leakage of electrolytes and increasing the content of proline.

When applied externally, ASA has a preventive and not a curative effect. After its exogenous application, the plant takes 4-7 days to increase its defenses. The ASA viability within the plant is short prevent its immobilization on the cell walls, and the routine application is necessary in order to keep high levels of resistance (FARIAS, 2012).

Therefore, it is believed that acetylsalicylic acid has great potential to be used to improve Brazilian agricultural production, minimizing the effects of abiotic and biotic stresses on plants. However, most of the results obtained so far come from other countries and under conditions very different from those found in Brazil. This allows inferring that there is a vast field for our agricultural science to explore, with works that aim to improve the understanding of the role and importance of salicylic acid in tropical agriculture (FARIAS, 2012). Thus, the objective of this study was to evaluate the use of different doses of ASA in the growth, flowering and SPAD index of tomato plants.

## Materials and Methods

The experiment was carried out at the nursery of the Federal Institute of Education, Science and Technology of Espírito Santo - Campus Itapina, located in Colatina, in the northwest region of Espírito Santo, with geographical coordinates of 19º 29 '52, 7 ”south latitude, 40 ° 45 '36.9” north longitude, and average altitude of 71m. The region's climate according to the Köeppen climate classification is “Aw”, with an annual average temperature between 25°C (BUSATO et al., 2011) and a well-defined rainy season between October and January and an average climatological precipitation of 1029.9 mm (SALES et al., 2018).

The experimental arrangement used was a completely randomized design, with six treatments and five5 repetitions, with each treatment having 5 plants, totaling 30 plants in the total of the experiment (Table 1).

**Table 1**. Description of the evaluated treatments containing different concentrations of ASA

| Treatments | Concentrations |
|---|---|
| T1 | 0 mmol $L^{-1}$ of ASA |
| T2 | 5 mmol $L^{-1}$ of ASA |
| T3 | 10 mmol $L^{-1}$ of ASA |
| T4 | 15 mmol $L^{-1}$ of ASA |
| T5 | 20 mmol $L^{-1}$ of ASA |
| T6 | 25 mmol $L^{-1}$ of ASA |

Planting was carried out on March 16, 2017 with tomato seeds from São Paulo (Solanum lycopersicum), from the Feltrim® brand, with the characteristics of the seeds being 99.72% pure. Sowing was performed in trays with Bioplant® substrate, using two seeds per cell with subsequent thinning performed 20 days after sowing, leaving only one plant per cell. The transplant was carried out 30 days after sowing, for bags with a volume of 3 liters, receiving fertilizers for the crop, following the liming and fertilization manual for the state of Espírito Santo, 5th approach (PREZOTI et al., 2007). Fertilization were calculated according to the following soil analysis result (Table 2).

**Table 2.** Analysis of soil used for the experiment

| pH ($H_2O$) | SB | t | T | m | V | Saturation of CEC (T) | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | $Ca^{2+}$ | $Mg^{2+}$ | $K^{+1}$ |
| | cmol/dm³ | | | | | % | | |
| 4,72 | 2,4 | 2,7 | 4,5 | 8,0 | 54,0 | 32,0 | 20,0 | 2,0 |

Sum of Bases: SB; Ca: calcium; Mg: Magnesium; K: Potassium.
**Source**: Author himself

Irrigation was performed daily, according to the water requirements of the plants, as the bags were perforated and therefore drained naturally. All phytosanitary treatments were carried out according to the recommendations of Embrapa (MAROUELLI et al., 2012).

The treatments were fractionated in a weekly application, the first being at 30 days after transplanting, through sprays in the abaxial and adaxial part of the leaves with the amount of 10 ml of the solution per plant, with the aid of a manual compression sprayer. The solution was prepared in the laboratory of the Federal Institute of Espírito Santo, Itapina campus.

Growth parameters were analyzed, such as: plant height (AP) in cm; number of leaves (NF); number of flower buds (NB), stem diameter (DC) and the SPAD index using the second newer leaf fully expanded. The height of the plant was measured from the insertion of the stem to the apex of the plant, and the diameter of the main stem, determined at the height of root collar. All evaluations were performed at the end of the experiment, 65 days after transplantation (DAT).

The results were subjected to analysis of variance (Test F) and split of regressions to verify the effect of AAS doses. The entire statistical procedure was performed with the open source program R (R Core Team, 2019).

## Results and discussion

The results of the mean squares for all characteristics are shown in Table 3. The statistical analysis of the data revealed significant effects of ASA doses on all evaluated characteristics, except for the stem diameter (Table 3), indicating no response to the stimulus hormone for that characteristic.

**Table 3** - Average square of the evaluated characteristics of the tomato

| Source | DF | NL | NB | PH | SD | SPAD |
|---|---|---|---|---|---|---|
| Linear Regression | 1 | 994.57* | 102.92** | 730.15* | $0.0028^{ns}$ | 282,960** |
| Quadratic Regression | 1 | 1747.46** | $1.761^{ns}$ | $133.30^{ns}$ | $0.0080^{ns}$ | $26,040^{ns}$ |
| (Treatment) | 5 | 1737.90 | 37.44 | 410.51 | 0.0093 | 90.67 |
| Residual | 20 | 157.05 | 2.152 | 104.30 | 0.0050 | 15.81 |
| CV% | - | 13.75 | 18.05 | 16.29 | 12.94 | 10.62 |

Significant at 5%; ** significant at 1%; ns not significant; NL: number of leaves; NB: number of flower buds; PH: plant height; SD: stem diameter; SPAD: SPAD index. **Source**: Author himself.

Similar results were obtained by Brito Neto et al. (2012), in a study carried out with the application of 4 concentrations of ASA (0, 20, 40, 60 mg L-1) in castor bean plants by pulverizing, in which the authors verified that there was no significant influence of the studied factors, as well as their interactions on the stem diameter of plants. This can be explained by the fact that salicylic acid hinders the growth of vegetables through the regulation of lignin biosynthesis, which results in a stiffness in the secondary cell wall and, consequently, prevents cell elongation (GALLEGO-GIRALDO et al., 2011) . However, it is observed, in the context of a system irrigated with saline water, that the stem diameter (DC) may be greater in the absence of ASA, under CEa 1.5 dS m-1, decrease to CEa 2.5 dS m- 1. This response is in line with the deficiency in water absorption, due to the reduction of the osmotic potential of the soil-plant system and the absorption of toxic ions (TAIZ et al., 2017; SOUSA, et al., 2020).

The stem diameter, as well as the height, presents positive and significant correlations for most species, both parameters are frequently used to evaluate plant responses to the procedures, and can be used to evaluate the production potential of the plants (PORTO et al., 2014). Thus, with respect to the results of the growth parameters, only the number of leaves emitted presented a significant quadratic adjustment (Table 3), in which the dose that maximized the gain for this characteristic was 15.6 mmol $L^{-1}$, obtaining 102 , 9 sheets (Figure 1 A). For the characteristics number of flower buds, plant height and SPAD index, linear equations were adjusted (Figure 1B, 1C and 1D). This shows that there were increments as the concentration of ASA increased, reaching the maximum dose (25 mmol $L^{-1}$) of an estimated number of flower buds of 10.8 (Figure 1 B), maximum height 69, 4 cm (Figure 1 C) and 42 SPAD index (Figure 1 D).

Acetylsalicylic acid (ASA) is a vital signaling molecule involved in plant growth processes, flower growth and plant defense mechanisms (ASHRAF et al., 2010). ASA is an analogue close to salicylic acid and, when applied exogenously, is converted to salicylic acid (DROGOUDI et al., 2021). During biotic and abiotic stress, salicylic acid plays a crucial role in regulating physiological and biochemical processes throughout the life of the plant, as it affects a wide range of processes, such as seed germination, photosynthetic processes, growth, flowering, ripening of fruits and others (RIVAS-SAN VICENTE and PLASENCIA, 2011; KOO et al., 2020).

Regarding the beneficial action of ASA on plant growth, indicated by height (Figure 1 C), it is possible to report that this hormone increases the assimilation of carbon, synthesis of metabolites and maintenance of the water potential of tissues (KHAN et al., 2003; SZEPSI et al., 2005; KARLIDAG et al., 2009; FAROOQ et al., 2010), expanding the photosynthetic capacity of the plant, which results in tissue expansion. In addition, the role of ASA in improving photosynthetic pigments (HUSSAIN et al., 2020) may have contributed to an increase in the values of the SPAD index, with an increase in the concentration applied to tomato plants (Figure 1 D).

Favorable results with the application of salicylic acid on the levels of chlorophyll a were observed by Nivedithadevi et al. (2012), who found that the use of leaf sprays of salicylic acid increased the levels of chlorophyll in Thuthuvalai (Solanum trilobatum L), 110 days after the application of the treatments.

There are several reports in the literature that indicate that treatment with ASA can both increase and reduce the photosynthetic rate of plants (FARIDUDDIN et al. 2003; KHAN et al. 2003; KHODARY 2004; LIU et al. 2011; GHASEMZADEH and JAAFAR 2013; VINEETH et al. 2015). This indicates that the effect of ASA on photosynthesis does not depend only on the species, but also on the dosages applied, the mode of application (injection, leaf sprinkling, addition to the hydroponic solution, pre-soaking of seeds) or duration of treatment (HAYAT et al. 2012; JANDA et al. 2014).

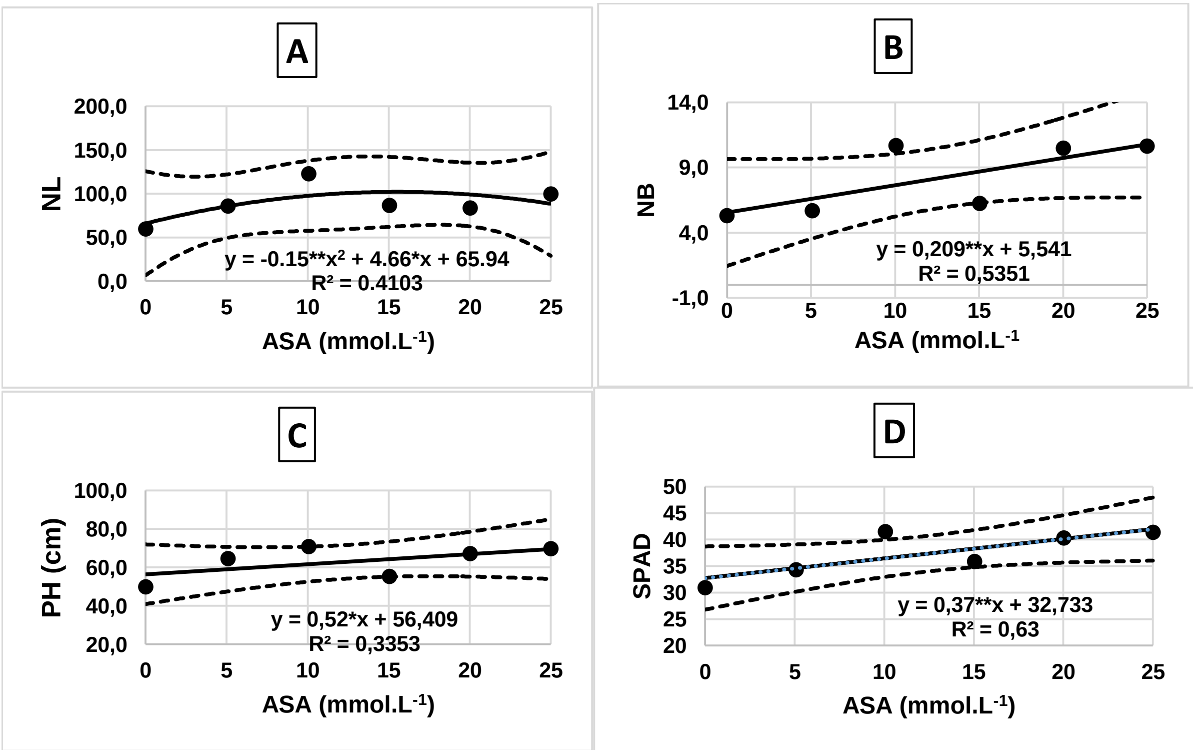


Figure 1. Effect of ASA concentrations on: A) NL: number of leaves; B) NB: number of flower buds; C) PH: plant height the height of the tomato plants and D) SPAD index. (Dashed line represents the 95% confidence interval around the regression line. Significant a * $p < 0.05$; ** $p < 0.01$.). **Source**: Author himself.

## Conclusion

The exogenous application of ASA provided the tomato plant's response to hormonal stimulation.

Applications greater than 15.6 mmol L-1 reduce the emission of tomato leaves, despite the linear response obtained for the emission of flower buds.

It is recommended to develop new research with a wider range of parameters evaluated for the crop in order to obtain more conclusive results on the influence of ASA on the productivity, quality and profitability of tomato fruits.

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