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TRINEXAPAC-ETHYL ACTION IN THE GERMINATION PROCESS OF VARIETIES OF ENDIVE

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ABSTRACT

The use of plant regulators in agriculture is a reality. This work aimed at studying the action of trinexapac-ethyl in the germination process of endive varieties. The experimental design was completely randomized in a 3x4 factorial scheme using three cultivars of Endive: Endive cv. Radiche (ER); Cv. Sugar Loaf (ESL) and cv. Catalan (EC); with four doses of trinexapac-ethyl: Zero ml L^{-1} (control); 0.033 ml L^{-1}; 0.066 ml L^{-1}, and 0.133 m L^{-1}, and four replicates. After 15 days were evaluated: Germination Speed Index (GSI); Speed of Germination (SG); Percentage of Normal Plants (%NP); Percentage of Abnormal Plants (%AP); Number of Leaves (NL); Total Leaf Area (TLA); Average Root Length (ARL); Average Length of Aerial Part (ALAP); Dry Root Mass (DRM); Dry Shoot Mass (DSM). The use of trinexapac-ethyl did not benefit the germination process of the endive cultivars. Trinexapac-ethyl caused a lower initial development in endive cultivars from the 0.033 ml L^{-1} dose.

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INTRODUCTION

Endive (*Cichorium intybus* L.) is found between the most consumed and cultivated leafy vegetables in Brazil, mainly in Southeast area, which has the biggest population density in the country. This vegetable has high nutritional values of calcium, phosphorous, iron, and others (Almeida *et al*., 2013). Seed dormancy in Endive, as other vegetables, is a continuity tool of the specie, since, even if it has good germination conditions, it remains inert and do not germinate (Goudel *et al*., 2013). According to Bernardes et al. (2008), gibberellins has the stimulation role in germination process in seeds with or without physiological dormancy, in which gibberellic acid (GA_3) is commonly used as a promoter in this process. Vegetables Regulators or Phytorregulators are synthetic compounds applied in plants in order to promote results regarding to effects of enhance, delay or inhibition in vegetative growing, without negative effects in their productions (Rademacher, 2000).

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Etil-trinexapac acts on plants by reducing cell elongation at the vegetative stage, since it interferes in the final step of the metabolic route of gibberellic acid biosynthesis (Heckman *et al*., 2002). In Brazil, trinexapac-ethyl is only registered for use in the sugarcane, barley and wheat crops (*Alvarez*, *et al*. 2007). In endive culture, there is a lack of studies using this regulator. This show how important is to study its effects in endive culture. This work has as its aim study the action of trinexapac-ethyl in germination process of different endives varieties.

MATERIALS AND METHODS

On April, 2016, an experiment was carried out in Laboratory of Vegetal Morphophysiology and Forages at College of Agricultural and Technological Sciences – São Paulo State University, in Dracena, São Paulo State, Brazil. The experimental design was completely randomized in a 3x4 factorial scheme using three cultivars of Endive: Endive cv. Radiche (ER); Cv. Sugar Loaf (ESL) and cv. Catalan (EC); with four doses of trinexapac-ethyl: Zero ml L^{-1} (control); 0.033 ml L^{-1}; 0.066 ml L^{-1} and 0.133 m L^{-1} and four repetitions, 48 parts in total. The parts were compounded by 25

seeds each specie, performing 100 seeds per treatment. Selected seeds were soaked in the product solution during 30 minutes, using their specific doses. After the soaking term, the selected seeds were removed and sowed in a humid paper type germitest, as the method described by Sá *et al*. (2011), and kept in a transparent color germitest type box. The boxes were transported to the germination chamber, under a ±30°C constant temperature, with a 12-hour day/night alternated photoperiod, during 15 days. During the 15-day term, it was caried out the count process of germinated seedlings in order to ascertain the Germination Speed Index (GSI) and the Speed of Germination (SG), according to the methods described by Popinigis (1977).

Fifteen days after, at harvesting moment, it was detected the following parameters: Percentage of Normal Plants (%NP): being considered normal plants that showed development in aerial and root zone; Percentage of Abnormal Plants (%AP): being considered abnormal plants with aerial or root zone absence, as described by Sá et al. (2011); Number of Leaves (NL): set by direct counting; Total Leaves Area (TLA), Average Root Length (ARL) and Average Length of Aerial Part (ALAP): set from a milimetric ruler. To determinate Dry Root Mass (DRM) and Dry Shoot Mass (DSM), all produced material was dried in a laboratory oven with air circulation and renovation, under a 65°C temperature until the material reach a stable weight. All dried material was weighed in analytic balance and their results were shown in grams. Statistical data analysis consisted of analysis of variance through F ($p>0,05$) test. Since it was detected a significant result, it was done the polynomial regression in average of doses, in which the choice of the model for each variable was based on significance of the parameters, it was based on R^2´s values as well. R statistical software ran statistical data (R Development Core Team, 2009).

RESULTS AND DISCUSSION

Figure 1 shows GSI (Germination Speed Index) regression analysis, SG (Speed of Germination), %NP (Percentage of Normal Plants) and %AP (Percentage of Abnormal Plants) in cultivars of Endive cv. Radiche (ER), cv. Sugar loaf (ESL) and cv. Catalan (EC). Figure 1A reveals that endive cultivar had a negative response to trinexapac-ethyl doses. Lower values of Germination Speed Index (GSI) were present on 0.133 ml L^{-1} doses, with an 18% reduction. In the other hand, on Figure 1B, there was a positive response to trinexapac-ethyl use, since, the biggest obtained values were in 0.133 ml L^{-1} doses among the tested ones, and its peak reached approximately 0.153 ml L^{-1} among the studied varieties.

These results can be explained due to trinexapac-ethyl action on plants by reducing cell elongation on vegetative stage, so it interferes on metabolic route final stage in biosynthesis of gibberellin, leading to gibberellic acid absence due to enzyme 3-b-hidroxilase inhibition (Heckman *et al*., 2002). According to Taiz and Zeiger (2009), a plurality of species need gibberellin in germination process to active the embryo growth. Marcos Filho (2005) claims that lower speed in germination, potential reduction of conservation during storage, reduction in breath and biosynthetic activities, loss of germination power, and cell membranes degradation are indicatives of deterioration process in seeds. Thus, it shall be presumed that trinexapac-ethyl inhibited gibberellins synthesis in these seeds, leading to a negative influence on GSI parameter, as well as %NP and %AP ones, in which it was shown unviability of endive seeds in tested doses of trinexapac-ethyl. Kaspary *et al*. (2015) got to similar results, by observing a negative response to GSI in white oat seeds, leading to 50% reduction with the biggest trinexapac-ethyl dose.

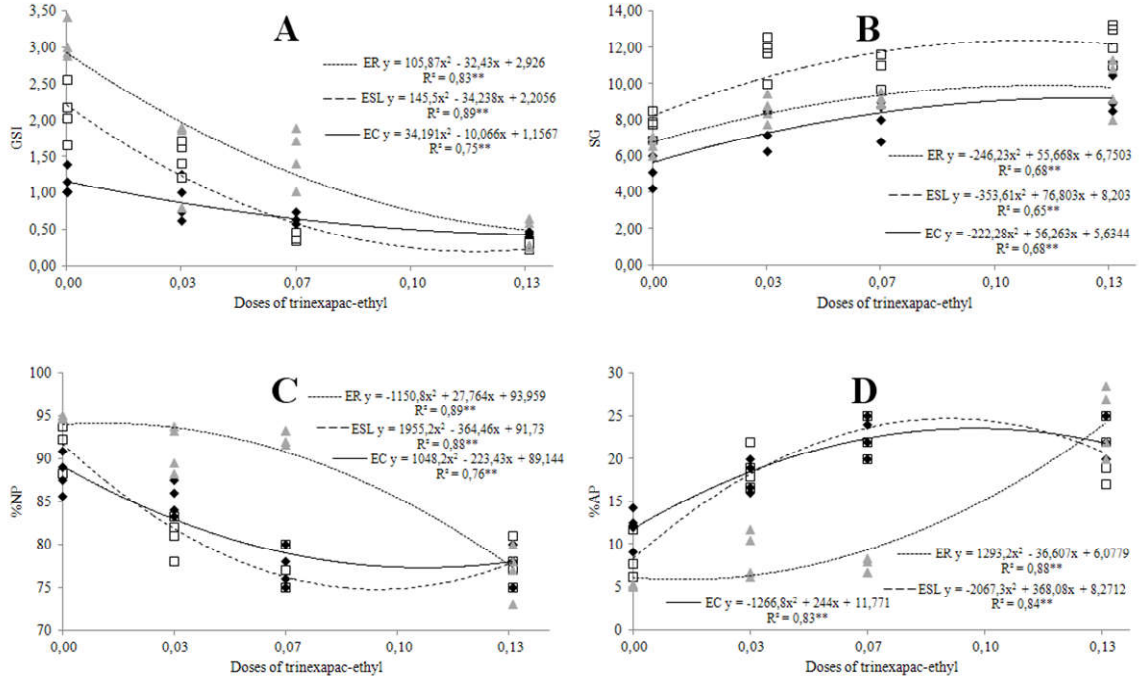

Figure 1. Regression analysis in Endive cv. Radiche (ER), cv. Sugar Loaf (ESL) and cv. Catalan (EC) GSI (Germination Speed Index), SG (Speed of Germination), %NP (Percentage of Normal Plants) and %AP (Percentage of Abnormal Plants)

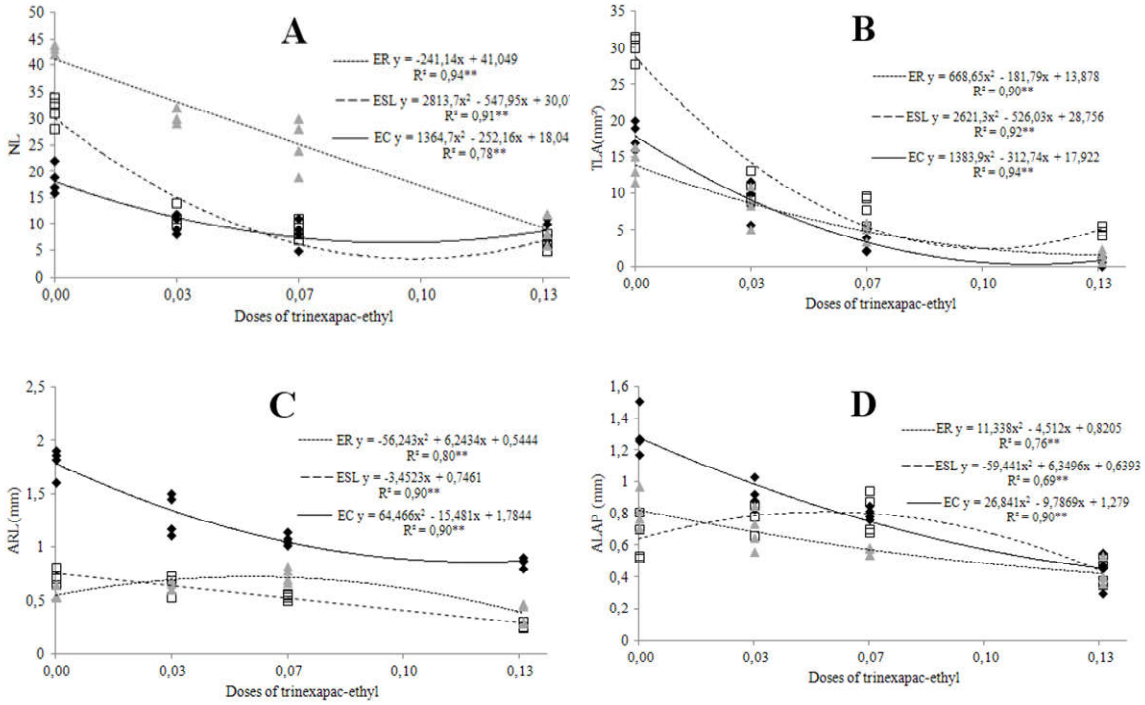

Figure 2. Regression analysis in Endive cv. Radiche (ER), cv. Sugar Loaf (ESL) and cv. Catalan (EC) in NL (Number of leafs); TLA (Total Leaf Area); ARL (Average Root Length) and ALAP (Average Length of Aerial Part) parameters

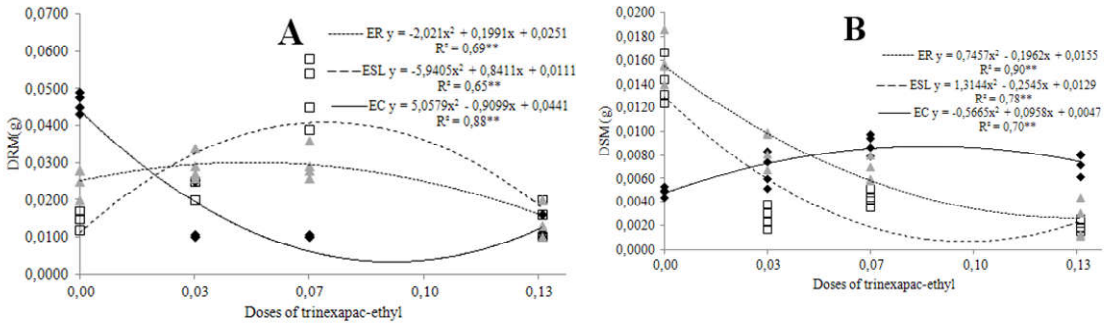

Figure 3. Regression Analysis of Dry Root Mass (DRM) and Dry Shoot Mass (DSM) on aerial part of Endive cv. Radiche (ER), Endive cv. Sugar Loaf (ESL) and cv. Catalan (EC)

Figure 2 shows regression analysis of Number of Leafs (NL), Total Leaf Area (TLA), Average Root Length (ARL), Average Length of Aerial Part (ALAP) in Endive cv. Radiche (ER); Cv. Sugar Loaf (ESL), and cv. Catalan (EC) cultivars. Figure 2A and 2B shows that endive cultivars had a negative response to trinexapac-ethyl doses. The lowest values obtained to the Number of Leafs parameter were found in 0.066 ml L^{-1} among the tested doses, and Cultivar Radiche (AR) presented the biggest reduction, besides, cultivar Sugar Loaf had the biggest reduction on Total Leaf Area parameter. According to Taiz and Zeiger (2009), equilibrium between endogen levels and phytorregulators is fundamental to cell elongation, thus they act together in order to increase cell wall extensibility, they also work together in activation of enzymes that act on cell wall rebuilding. That way, the endogenous unbalance caused by gibberellins inhibition through vegetal regulator trinexapac-ethyl affects negatively the leaf development as well as the average root length and average length of aerial part parameters, with the lowest values on 0.133 ml L^{-1} doses. However, there were positive responses in Endive cv. Radiche (ER), to Average Root Length (ARL) parameter, and Endive cv. Sugar Loaf (ESL) reveals a positive response in Average Length of Aerial Part (ALAP) parameter, reach their peaks of 0.055 ml L^{-1} and 0.053 ml L^{-1}. This result can be explained due to nature of the cultivars studied, since it is a dicotyledons, and this fact could not cause a stressful effect in this vegetal, as it occurs in monocotyledons vegetables. This behavior also was observed in evaluation that involves other poaceous species, as wheat (Berti *et al*., 2007; Espindula *et al*., 2010) and rice (Arf *et al*., 2012). According to the trinexapac-ethyl specifications, when the plant absorbs it, it selectively acts on gibberellins levels reductions and induces the plant to a temporary growth inhibition or a slower rhythm of growth, depending on the used doses and ambient conditions. Chavarria *et al*. (2015) observed that by applying trinexapac-ethyl on wheat cultivars in greenhouses, there was a reduction in number of leafs, on quartzo wheat cultivar there was a reduction in total leaf area, however, there was no significant difference in mirante wheat cultivar. Trevizsan *et al*. (2015) noted in his research a reduction in wheat plants height with trinexapac-ethyl application, being more significant on second visible knot. A similar result was noted by Kaspari *et al*. (2015), in which occurred a 60%-reduction in white oat height. These results show that some vegetables do not create this stressful effect, in the same way, it did not occur in this experiment. Other studies also showed trinexapac-ethyl effect on height reduction of plants. On wheat, with the increase of trinexapac-ethyl concentration, it was observed a linear reduction trend on height of plants, with lower performance in 100 a 150 g i.a. ha^{-1} intervals

(Berti *et al*., 2007; Zagonel and Fernandes, 2007). On rice cultivars, Arf *et al*. (2012) noted a height reduction in plants treated with 50, 100 and 150 g i.a. ha^{-1} doses on panicle primordial differentiation moment, it also leaded to the plants lodging. The linear reduction of the height of crotalaria plants was provided with the application of increasing doses of trinexapac-ethyl, in the range of 75 to 300 g i.a. ha^{-1} (Kappes *et al*., 2011). Figure 3 shows regression analysis of Dry Root Mass (DRM) and Dry Shoot Mass (DSM) on aerial part of Endive cv. Radiche (ER), cv. Sugar Loaf (ESL) and c.v Catalan (EC). Figure 3A reveals that Endive cv. Catalan (EC) had a negative response while trinexapac-ethyl doses were increased, leading to the lowest value on 0.133 ml L^{-1} dose. Endive cv. Radiche (ER), had a slightly positive response and reached its peak on 0.049 ml L^{-1}. Endive cv. Sugar Loaf had a positive response to trinexapac-ethyl doses and reached its biggest value on 0.007 ml L^{-1} doses. Results showed in Figure 3B were opposite of the Figure 3A ones. The reduction of the aerial part in order to a bigger carbon availability, which can be drained to the root system. Chavarria et al. (2015) reveals that Endive cv. Radiche and cv. Sugar Loaf had their highest levels by reaching 0.131 ml L^{-1} and 0.066 ml L^{-1}, respectively. In the other hand, Endive cv. Catalan (AC) had a positive response with trinexapac-ethyl use, reaching its peak with 0.084 ml L^{-1} dose. It shall be presumed that Catalan cultivar did not had carbon draining to root system, leading to a bigger development on aerial part. Espindula *et al*. (2011) found similar results, by using nitrogen in association with trinexapac-ethyl on pioneiro wheat, causing a dry mass reduction on aerial part. Nunes *et al*. (2016) also had a similar result, in which trinexapac-ethyl reduced dry mass in aerial part, without changes in wheat production performance.

Conclusion

Trinexapac-ethyl did not benefit the germination process of endives cultivars. Trinexapac-ethyl leaded to a lower early development on endives cultivars from 0.033 ml L^{-1} dose.

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