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Research Article
Effects of Season and GA_3 Concentrations on *Hylocereus undatus* Flowering and Production

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Abstract
Background: The exotic fruit market in Brazil has gained prestige and cultivation of pitaya is promising. But the cycle is limited throughout the year and its flowering by photoperiod. **Methodology:** The plant growth regulator use especially gibberellin can replace the need for long days in this sense, it was studied different application periods and various GA concentrations in non-inductive period in order to anticipate flowering. **Results:** The experimental design was randomized blocks in factorial scheme 3×5, being 3 times of application and five concentrations of the plant growth regulator. The application periods began in May, June and July and it was applied 3 times, one every 30 days. The concentrations studied were (0, 100, 200, 300 and 400 mg L^{-1} of GA_3). Application season did not influence any of the traits, on the other hand, the concentration factor, despite of not having anticipated the flowering but increased fruit set, fruit number, average fruit mass and productivity. **Conclusion:** Based on the results, it was concluded that the GA_3 application was beneficial to the pitaya's agronomic characteristics.

Key words: Gibberellin, plant growth regulator, fruit set, pitaya

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Exotic fruit market in Brazil has gained prestige, especially pitaya which is promising by its rusticity. Low water and mineral nutrition are interesting aspects of this plant and for Brazilian tropical conditions it has presented good growth and production[1].

The pitaya's production period in Brazil occurs only 6 months per year, starting in December and finishing in May[2], this creates a market problem, because there are months with large quantities of fruits and there are months without fruits. Environmental cues seem to be involved in floral induction in many species, such as photoperiod and temperature, which are the most important conditions[3]. In *Hylocereus undatus* floral induction is mediated by photoperiod[4] and the long day is the responsible for the floral induction[5].

In long day plants, the most important plant hormone appears to be gibberellin, that its levels are related to floral induction in many species and high levels are required in long day plants. There are some techniques that can substitute the necessity for long day, such as the use of plant growth regulator but to use this resource it is necessary more study[6].

According to Khaimov and Mizrahi[7], GA_3 can delay cropping, so, its is possible to extend the production of pitaya. The gibberellin also has other effects, it is involved with cell elongation, which will generate largest and heavier fruits, another effect is the increase of fruit set, so, together all these effects will provide more yield and more quality of fruits. In this sense, this study reports the effect of gibberellin (GA_3) concentrations and spray application season this plant growth regulator on flowering and production aspects of *Hylocereus undatus*.

MATERIALS AND METHODS

The study was conducted in commercial orchard in Presidente Prudente city, in West São Paulo State, Brazil, 22°03' (S) and 51°02' (W), at 426 m of altitude. The climate data can be observed in Fig. 1. During the experimental period 3 year old plants were used, conducted in trellis system and were planted using a spacing of 10×2.5 m.

The experimental design was organized in randomized blocks in a 3×5 factorial scheme, with three seasons with 3 applications (May-June-July, June-July-August and July-August-September) and five GA_3 concentrations (0, 100, 200, 300 and 400 mg L^{-1}). Pro-Gibb® was the commercial product used, soluble powder containing 10% of GA_3 and 90% of inert ingredients. To improve the efficiency nonionic spreader-sticker Haiten® to 0.5%, applying 200 mL of solution per plant was used.

Hylocereus undatus flowering started in November, 2010 and finished in April, 2011, in this sense the harvest started in December, 2010 and finished in May, 2011. In this period the flower waves, total number of flowers, total number of fruits, fruit set, length of fruits, diameter of fruits, average weigh and yield were evaluated.

The data were submitted to variance analysis and when season factor was significant, average test (Tukey test 5% probability) was made and when concentration factor was significant, regression analysis was made.

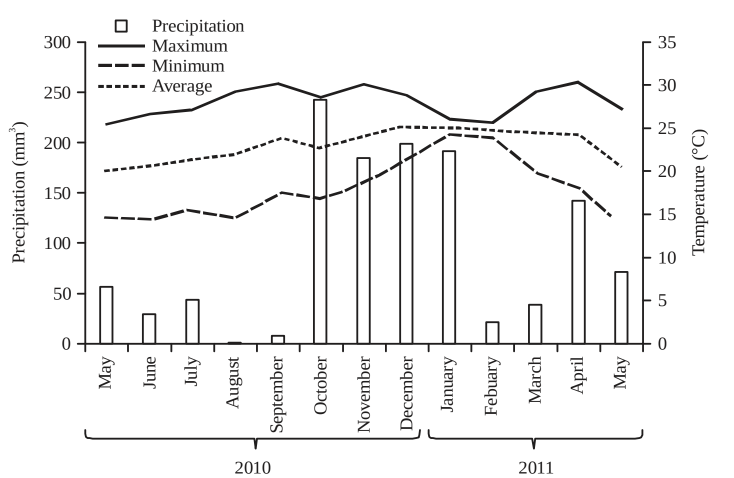

Fig. 1: Climate data in the vine cactus of *Hylocereus undatus*. Presidente Prudente/SP, Brazil, 2010/2011

RESULTS AND DISCUSSION

The flower waves did not present significant difference ($p>0.05$), in all treatments the plants issued flowers started in November and finished in April. The number of waves presented the same characteristics too. According to Khaimov-Armoza *et al*.[8] the optimal temperatures ranging between 20-30°C and lower or higher will drecrease or even inhibit induction of flower bud production. In this study, until October and after April the minimal temperatures was lower than 20°C (Fig. 1), than it can be a possible cause of the no flower induction as it was reported[7].

Total number of flowers did not present significant difference ($p>0.05$). The flower number variation was between 30 and 56 issued flowers per plant. The control seemed to have a greater number of flowers issued than treated plants and more elevated concentrations seems to decrease the flowers issue (Fig. 2a). Working with passion fruit, Ataide *et al*.[9] also found no significant difference in the number of flowers among treatments, attributing the results to the concentration of growth regulator used. Although, exogenous application can substitute the environmental requirements such as photoperiod and vernalization to promote flowering in non-ideal conditions, these results were contrary to those

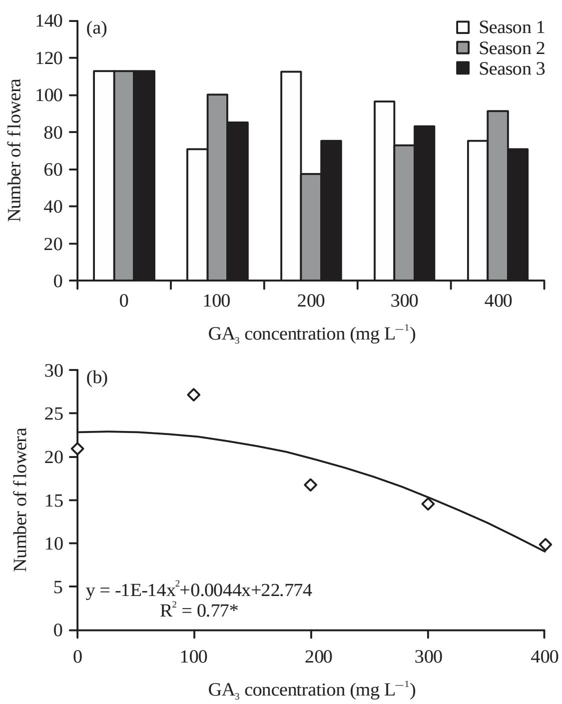

Fig. 2(a-b): (a) No. of flower of *Hylocereus undatus* with different season and concentrations of GA_3 application and (b) No. of fruits of *Hylocereus undatus* with different concentrations of GA_3

reported by Pereira-Netto[10]. Etiene *et al*.[11] report that absorption efficiency of the plant growth regulator, as well as the transport and metabolism thereof is different between the plants. In this study, it has been to pay attention on the environment conditions.

Even the number of flowers does not present difference, there was difference in the number of fruits ($p<0.05$) considering GA_3 concentrations. It could be observed in equation from quadratic regression analysis that the best concentration to achieve the highest number of fruit is 22 mg L^{-1} (Fig. 2b). Increase in number of fruits can be explained by fruit set data, that had increase of 42-63% ($p<0.05$), where the best concentration by equation of the quadratic regression analysis is 129 mg L^{-1} of GA_3 (Fig. 3). Tomato flowers before pollination have small amounts of GA[12], however after pollination there is an increase in GA ovary[13]. Serrani *et al*.[14] applying GA biosynthesis inhibitor found decrease in the amount of fruits, even with the pollination, suggesting that GA can be largely responsible for the fruit set.

Observing the length of fruit it was expected an increase, however, there was linear decrease (Fig. 4a). The fruits diameter did not change as the concentrations and application of GA_3 ($p>0.05$). Their results can be observed in Fig. 4b that has constancy in their data for all treatments, less to treatments that received 400 mg L^{-1} of GA_3 where they seem to have looks decreased. When a plant has a smaller number of fruits its photo assimilates need to be less partitioned than a plant that has a greater number of fruits, in this sense it was expected that fruits from plants that received treatments with higher GA_3 concentrations, would have an increase in the biometric characteristics of the fruit.

Another aspect is that plant hormones and plant growth regulators like gibberellins are responsible for cell elongation and hence to increase the size of the plant organ[15]. However, as there was an increase of GA_3 concentration, there was a

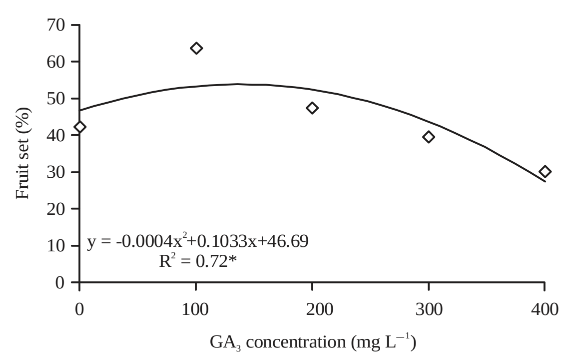

Fig. 3: Fruit set of *Hylocereus undatus* with different concentrations of GA_3

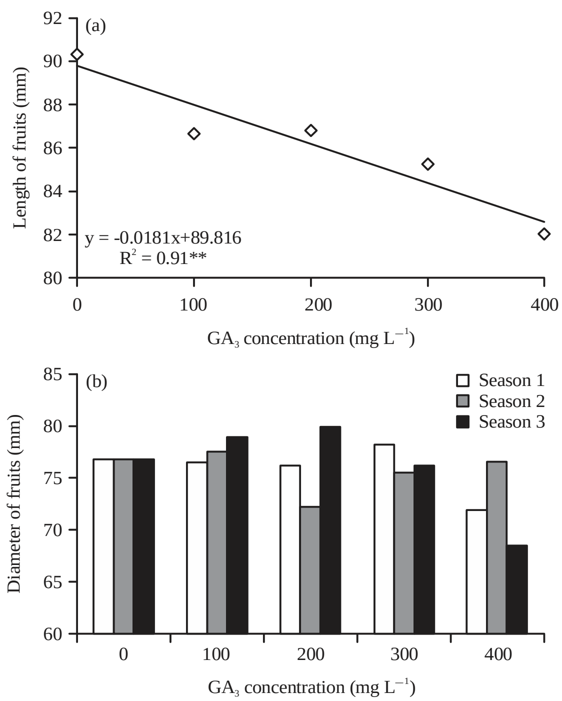

Fig. 4(a-b): (a) Fruit's length of *Hylocereus undatus* with different concentrations of GA_3 and (b) Diameter of fruits of *Hylocereus undatus* with different season and concentrations of GA_3 application

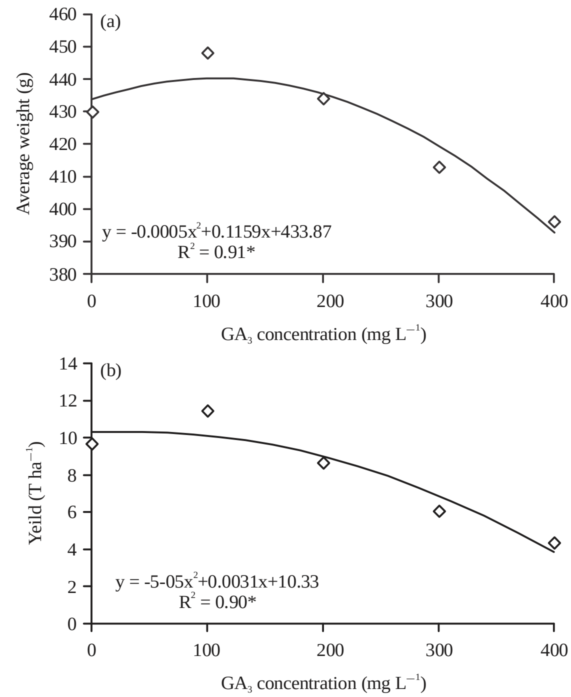

Fig. 5(a-b): (a) Fruit's average weight of *Hylocereus undatus* with different concentrations of GA_3 and (b) Productivity of *Hylocereus undatus* with different concentrations of GA_3

reduction in fruits length. Similar results were found in several species[16], which can be related to hormonal imbalance caused by supplementation of exogenous gibberellin. Martins and Castro[17] found no difference in the measurements of the tomato with the GA application in the plant, before there were flowering. On the other hand, when the GA application was carried out in full bloom, there was an increase in both diameter and fruits length[18]. The difference in results regarding the application time of GA can explain the fact of not having pitaya's fruit increase in their measurements.

Cell elongation caused by gibberellin needs auxin, that is responsible to provide decrease of the cell wall's pH, than enzymes synthetized by gibberellin effect, become active and cell elongation can happen, so an application of both plant growth regulators would provide the increase of fruit's size[19]. Water is one of the most important factor to provide cell elongation[20]. The measurements was collected during all the period of the study and there were months with low precipitation (Fig. 1), so, probably the size of the fruits were influenced by low hydric available.

Due to the fact that the fruit's length and diameter have not shown increase, it was expected that the average weight presents the same characteristics, however, it had increase in their characteristics studying the influence of GA_3 concentrations like quadratic regression analysis, obtaining a maximum value for these characteristic using 115.9 mg L^{-1} by regression equation plotted on Fig. 5a. Gibberellin can modify the source-sink relation, providing an increase of photosynthesis and enzyme invertase activity[21], so even the fruits did not grow, its become heavier because of the accumulation of photoassimilates.

The yield increased according to quadratic model ($p<0.05$) and according to regression analysis the best concentration is 31 mg L^{-1} of GA_3 (Fig. 5b). This increase can be explained by other variables studied such as the number of fruits and the average weight that had the same behavior. Degenhardt *et al.*[22] found positive correlation between length, diameter and weight but in our case this did not happen. It is important to highlight that environmental factors like hydric availability can affect those characteristics, especially in fleshy fruits[23].

CONCLUSION

Under conditions of the experiment it can be concluded that the GA_3 application did not promote flower and increase the production of pitaya's flowers, however, it was possible to increase the percentage of fruit set and consequently increase the number of fruits and pitaya's yield. The season of GA application did not presented effect on all characteristics studied.

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REFERENCES

1. Junqueira, K.P., N.T.V. Junqueira, J.D. Ramos and A.V. Pereira, 2002. Informacoes preliminares sobre uma especie de Pitaya do Cerrado. Documentos No. 62, Embrapa Cerrados, Planaltina-DF., pp: 18.
2. Marques, V.B., R.A. Moreira, J.D. Ramos, N.A. de Araujo and F.O.D.R. Silva, 2011. Reproductive phenology of red pitaya in Lavras, MG, Brazil. Ciencia Rural, 41: 984-987.
3. Davenport, T.L., 2000. Processes influencing floral initiation and bloom: The role of phytohormones in a conceptual flowering model. HortTechnology, 10: 733-739.
4. Luders, L. and G. McMahon, 2006. The pitaya or dragon fruit (*Hylocereus undatus*). Agdex No. 238/10. Department of Primary Industry, Fisheries and Mines. Northern Territory Government. http://www.nt.gov.au/d/Con tent/File/p/Fruit/778.pdf
5. Raveh, E., A. Nerd and Y. Mizrahi, 1998. Responses of two hemiepiphytic fruit crop cacti to different degrees of shade. Sci. Hortic., 73: 151-164.
6. De Andrade, R.A., A.B.G. Martins and M.T.H. Silva, 2007. [Influence of the material source and the cicatrize time in vegetative propagation of red dragon fruit (*Hylocereus undatus* Haw)]. Revista Brasileira de Fruticultura, 29: 183-186.
7. Khaimov, A. and Y. Mizrahi, 2006. Effects of day-length, radiation, flower thinning and growth regulators on flowering of the vine cacti *Hylocereus undatus* and *Selenicereus megalanthus*. J. Hortic. Sci. Biotechnol., 81: 465-470.
8. Khaimov-Armoza, A., O. Novak, M. Strnad and Y. Mizrahi, 2012. The role of endogenous cytokinins and environmental factors in flowering in the vine cactus *Hylocereus undatus*. Israel J. Plant Sci., 60: 371-383.
9. Ataide, E.M., C. Ruggiero, J.D. Rodrigues, J.C. de Oliveira, T.J.D. Rodrigues and J.R. de Silva, 2006. [Plant regulator and biostimulant in yellow passion-fruit floral induction under non inductive condition]. Revista Brasileira de Fruticultura, 28: 347-350.
10. Pereira-Netto, A.B., 2002. Crescimento e Desenvolvimento. In: Fisiologia Vegetal: Producao Pos-Colheita, Wachowicz, C.M. and R.I.N. Carvalho (Eds.). Champagnat Publishing, France, ISBN: 9788572920728, pp: 17-41.
11. Etiene, H., B. Sotta, P. Montoro, E. Miginiac and M.P. Carron, 1993. Relations between exogenous growth regulators and endogenous indole-3 acetic acid and abscisic acid in the expression of somatic embriogenesis in *Hevea brasiliensis* (Muell. Arg.). Plant Sci., 88: 91-96.
12. Fos, M., F. Nuez and J.L. Garcia-Martinez, 2000. The gene pat-2, which induces natural parthenocarpy, alters the gibberellin content in unpollinated tomato ovaries. Plant Physiol., 122: 471-479.
13. Koshioka, M., T. Nishijima, H. Yamazaki, Y. Liu, M. Nonaka and L.N. Mander, 1994. Analysis of gibberellins in growing fruits of *Lycopersicon esculentum* after pollination or treatment with 4-chlorophenoxyacetic acid. J. Hortic. Sci., 69: 171-179.
14. Serrani, J.C., R. Sanjuan, O. Ruiz-Riviero, M. Fos and J.L. Garcia-Martinez, 2007. Gibberellin regulation of fruit set and growth in tomato. Plant Physiol., 145: 246-257.
15. Tofanelli, M.B.D., J.E. Amaya-Robles, J.D. Rodrigues and E.O. Ono, 2003. [Gibberellic acid on pepper parthenocarpic fruits production]. Hortic. Brasil., 21: 116-118.
16. Ayub, R.A. and B.L.A. Rezende, 2010. [Gibberellic acid contribution to tomato fruit size]. Biotemas, 23: 25-28.
17. Martins, M.B.G. and P.R.C.E. Castro, 1997. [Bioregulators on the morphology and productivity of tomato fruits, CV. Angela gigante]. Bragantia, 56: 237-248.
18. Tabarelli, M., A. Vicente and D.C.A. Barbosa, 2003. Variation of seed dispersal spectrum of woody plants across a rainfall gradient in north-eastern Brazil. J. Arid Environ., 53: 197-210.
19. Cleland, R.E., 2010. Auxin and Cell Elongation. In: Plant Hormones, Davies, P.J. (Ed.). Springer, Netherlands, ISBN: 978-1-4020-2684-3, pp: 204-220.
20. Taiz, L. and E. Zeiger, 2012. Plant Physiology. 5th Edn., Sinauer Associates, Sunderland, UK.
21. Iqbal, N., R. Nazar, M.I.R. Khan, A. Masood and N.A. Khan, 2011. Role of gibberellins in regulation of source-sinkrelations under optimal and limiting environmental conditions. Cur. Sci., 100: 998-1007.
22. Degenhardt, J., J.P. Ducroquet, M.P. Guerra and R.O. Nodari, 2003. [Plant phenotypic variation of two half sib families of feijoa (*Acca sellowiana* Berg.) From an orchard in Sao Joaquim, SC]. Revista Brasileira de Fruticultura, 25: 475-479.
23. Hedden, P. and Y. Kamiya, 1997. Gibberellin biosynthesis: Enzymes, genes and their regulation. Annu. Rev. Plant Physiol. Plant Mol. Biol., 48: 431-460.