SILVA, J. M.; SILVA, J. H. B.; ARAÚJO, J. R. E. S.; GOMES, E. M.; CRUZ, J. M. F. L.; SILVA, A. V.; SILVA, F. G.; SANTOS, J. P. O.; PEREIRA, W. E. Growth and quality of 'Pérola' pineapple as a function of levels of gibberellic acid. **Revista de Agricultura Neotropical**, Cassilândia-MS, v. 9, n. 1, e6731, jan./mar. 2022. ISSN 2358-6303. DOI: https://doi.org/10.32404/rean.v9i1.6731.

Growth and quality of 'Pérola' pineapple as a function of levels of gibberellic acid

Juanderson Moura da Silva[1], João Henrique Barbosa da Silva[1], José Rayan Eraldo Souza Araújo[1], Eduardo Marinho Gomes[1], José Manoel Ferreira de Lima Cruz[2], Antônio Veimar da Silva[1], Francisco Gledson da Silva[1], João Paulo de Oliveira Santos[1], Walter Esfrain Pereira[1]

[1]Universidade Federal da Paraíba, Campus de Areia, Areia, Paraíba, Brasil. E-mail: juandersonufpb@outlook.com, henrique485560@gmail.com, rayanccaufpb@gmail.com, edujrsan18@gmail.com, veimar74185@gmail.com, fgsilva0711@gmail.com, jpos@agro.adm.br, walterufpb@yahoo.com.br

[2]Universidade Federal de Lavras, Lavras, Minas Gerais, Brasil. E-mail: cruz.jmfl@gmail.com

Received: 28/10/2021; Accepted: 22/02/2022.

ABSTRACT

Gibberellin is a plant hormone capable of enhancing the productivity of plant's productivity rants, due to its action in plant physiology, mainly in fruit formation. In this sense, this study aimed to evaluate gibberellic acid levels and application times on the growth and quality of 'Pérola' pineapple. The experiment was conducted under field conditions in the municipality of Pedras de Fogo, state of Paraíba, Brazil. The treatments consisted of five levels of gibberellic acid (0.0, 1.5, 3.0, 6.0, and 12.0 mg/plant), distributed in a randomized block experimental design, with four repetitions, in which three applications were made at 50, 80, and 110 days after flower induction. The soluble solids content, fruit height, fruit diameter, and weight were evaluated. The period of application and the levels of gibberellic acid altered the responses for the variables analyzed. The level of 7.5 mg/plant of gibberellic acid promoted an increase in the weight and diameter of the fruit. The application at 110 days after floral induction induced an increase in fruit weight and a greater concentration of sugar in the fruit. Further studies on the application of gibberellic acid and periods of application in different soil and climatic conditions should be carried out to determine more consistent results with this crop.

Keywords: *Ananas comosus* L., Gibberellin, Plant Hormones.

Crescimento e qualidade de abacaxi 'Pérola' em função de doses de ácido giberélico

RESUMO

A giberelina é um hormônio vegetal capaz de potencializar a produtividade das plantas, devido a sua atuação na fisiologia vegetal, principalmente na formação dos frutos. Nesse sentido, objetivou-se avaliar a atividade de doses de ácido giberélico e épocas de aplicação no crescimento e qualidade de abacaxi 'Pérola'. O experimento foi realizado em condição de campo no município de Pedras de Fogo, Paraíba. Os tratamentos consistiram em cinco doses de ácido giberélico (0,0; 1,5; 3,0; 6,0 e 12,0 mg/planta), distribuídos no delineamento experimental de blocos casualizados, com quatro repetições, na qual foram realizadas três aplicações aos 50, 80 e 110 dias após a indução floral. Foram avaliados o teor de sólidos solúveis, altura do fruto, diâmetro do fruto e peso do fruto. A época de aplicação e as doses de ácido giberélico alteraram as respostas para as variáveis analisadas. A dose de 7,5 mg/planta de ácido giberélico promove o aumento de peso e diâmetro dos frutos. A época de aplicação realizada aos 110 dias após a indução floral induz o aumento de peso dos frutos e maior concentração de açúcar nos frutos. Novas pesquisas com a aplicação de ácido giberélico e épocas de aplicação em situações edafoclimáticas distintas devem ser realizadas para determinar resultados mais consistentes nesta cultura.

Palavras-chave: *Ananas comosus* L., Giberelina, Hormônios vegetais.

1. Introduction

Brazil is the world's second-largest producer of pineapple (*Ananas comosus* L.) only behind Costa Rica, which is the largest producer and exporter of the crop (FAOSTAT, 2018). The regions that stand out in the cultivation of this species are the North and Northeast, in which the former is the record holder for the highest production in 2016, about 382.8 million fruits (IBGE, 2018). Pineapple is an herbaceous, perennial plant of the family Bromeliaceae, with the genus Ananas as the most important for including pineapple (Noronha et al., 2016).

World pineapple production in 2017 was 27.4 million tons, showing an increase of 12.52% between 2012 and 2017 (FAO, 2019). The national production between 2012 and 2018 reached 11.9 billion fruits (IBGE, 2019). In the Northeast region, the state of Paraíba stands out for the largest production of pineapple, accounting for 51.49% production in the region (CONAB, 2020).

Gibberellic acid (GA3) is a pentacyclic diterpenoid responsible for the promotion and acceleration of plant metabolism. Gibberellins are synthesized in different parts of the plant, which are conducted via xylem, related to the raw sap, throughout the plant (Taiz et al., 2017). Thus, gibberellins, such as GA3, have different functions in the plant, which is an important study for pineapple production in the state of Paraíba, which is considered one of the largest producers of the crop in the country (Nunes et al., 2017).

The use of plant regulators can increase seedling performance, favor the speed of emergence for several species and accelerate vegetative growth (Gonçalves et al., 2017). The use of bioactive compounds, such as GA3, can decrease the impacts and adverse factors on the quality and performance of seeds and fruits. The use of gibberellins in the fruit setting stage can promote an increase in fruit size, weight, diameter and sugar content. It also helps in flowering and in delaying the aging of plant tissues. Gibberellic acid can also regulate several metabolic processes in the plant, acting on growth and development, as well as on cell elongation (Taiz et al., 2017). GA3 is used in several fruit trees for the development and breaking dormancy of various seeds, promoting better germination (Dalanhol et al., 2013, Taiz et al., 2017). The use of GA3 in different application periods according to crop growth is essential, being a way to assist in increasing storage time (Dagar et al., 2012), reducing pre-harvest fruit drop (Yildiz et al., 2012), and improving fruit quality (Zeman et al., 2012).

This phytoregulator plays a major role in the inflorescence stage of pineapple and is present in fruit formation, and may contribute to their quality (Duarte Filho et al., 2004). Given this, the objective was to evaluate the effect of levels of gibberellic acid on the growth and quality of 'Pérola' pineapple, determining the best moment for application.

2. Material and Methods

The experiment was conducted under field conditions in the commercial area of 'Pérola' pineapple at Dois Riachos Farm, Pedras de Fogo, state of Paraíba, Brazil. The municipality is located in the Mata Sul area of Paraíba, with an AS climate, according to the Köppen climate classification, hot, humid with fall/winter rainfall occurring from the coast to a large portion of the Agreste. With an average annual rainfall of 1,600 mm/year, in which the rainy period begins in February and March and lasts until August. The dry period is five to six months, the average annual temperature is between 20° C and 30° C and the average relative humidity is 80% (Beltrão et. al., 2005).

This was a randomized block experimental design in a 5x3 factorial arrangement, consisting of five levels of gibberellic acid (0.0; 1.5; 3.0; 6.0 and 12.0 mg/plant) and three periods of application after flower induction (50, 80 and 110 days) in four repetitions. Each experimental unit was composed of 15 plants; the useful plot was represented by three fruits.

As a source of gibberellic acid, a commercial composition of this product was used. Applications were made by direct spraying in 50 mL dilution in the water around the fruit, without reaching the crown or the young shoots found along the upper part of the peduncle, just below the fruit. The first application was made 50 days after flower induction when the plants presented the fruitlets from their base changing from dark green to light green and from a pointed to flattened shape. The second application occurred at 80 days, in the reproductive or fruit formation stage. The third application occurred at 110 days in the propagation phase, which occurs in seedling formation (young plants and shoots).

Weight, height, diameter, and ºBrix were evaluated 460 days after planting, when the fruits were at harvest time, determined by apparent ripeness, based on skin color and the soluble solid content according to the Pineapple Classification Standards (CEAGESP, 2003).

Fruit length was measured with a measuring tape, disregarding the fruit crown; the results are expressed in cm. The average fruit diameter (cm) was measured using a digital caliper, measuring the two longitudinal axes of the fruit; the results are expressed in cm. Fruit weight was obtained using an analytical balance accurate to 0.001g. Data of ºBrix (%) were obtained with an analog refractometer, with readings taken by collecting about 10g fruit pulp.

Statistical analysis was run in the statistical software R (R Core Team, 2021) and the results were tested by

analysis of variance (ANOVA) and polynomial regression, testing the linear and quadratic models. The isolated effect for application period was compared by Tukey's test ($p \leq 0.05$). The criteria for selecting the model were the significance by F-test ($p \leq 0.05$) and coefficient of determination (R2) greater than 70%.

3. Results and Discussion

The results of the analysis of variance for fruit height (HF), fruit diameter (DF), fruit weight (FP), and soluble solids content (Brixº) of 'Pérola' pineapple in the different treatments are listed in Table 1. An isolated effect of GA3 levels at 5% probability was found for fruit diameter. The isolated effect was also observed for days of application, with a significant effect at 5% probability, on fruit height and diameter, and at 1%, on the soluble solids content. For fruit weight, a significant interaction of the sources of variation was observed at a 1% probability.

For the factor days after application of levels of gibberellic acid (Table 2), it was observed that, at 50 days, fruit height and diameter were larger than those applied at 80 days, but not statistically different from 110 days after planting. This can be justified by the application of gibberellic acid in the fruiting stage, at 50 days, resulting in a greater height and diameter of the fruit. The application of this product helps plant growth, flowering, cell elongation, and fruit formation (Lavagnini et al., 2014). According to these same authors, this product is mainly used during flowering in plants that have long days, like the pineapple, which justifies its use for floral induction.

A complementary justification for understanding the growth and diameter of the pineapple fruit at 50 days after application is that gibberellins are synergistic with other plant hormones, especially auxin. Possibly, gibberellins stimulated greater production of auxin, as reported by Björklund et al. (2007), who identified an increase in the production of indoleacetic acid in plants treated with gibberellin. The two hormones in harmony are protagonists of positive and reciprocal interaction at the same time, where they act in the division, cell expansion, and differentiation of tissues (Weiss and Ori, 2007), causing the growth of both the plant and the fruit.

For the parameter of soluble solids (Brixº), there was a significant difference between the periods of application, with the applications at 110 days standing out. This result can be explained by fruit development during a period of higher temperatures, in agreement with Bleinroth (2000), who states that the occurrence of higher temperatures during fruit development promotes the greater synthesis of sugars.

The soluble solids content is one of the most important parameters in pineapple crop because a high sugar content represents a fruit with excellent quality, justifying the results found by Silva et al. (2020), who, when working with 'Pérola' pineapple, verified that soluble solids are substances found dissolved in the juice and determine the degree of maturity of the fruit. In turn, gibberellic acid has a significant effect on fruit quality, promoting a lower loss of soluble solids, fresh mass, and titratable acidity (Aquino et al., 2016).

Table 1. Summary of the analysis of variance for fruit height (HF), fruit diameter (DF), fruit weight (WF), and soluble solid content (Brixº), Dois Riachos Farm, Pedras de Fogo-PB.

FV	GL	Mean squares			
		HF	DF	WF	Soluble Solids
Levels	4	0.19^{NS}	1.19^{*}	$20{,}269^{NS}$	0.29^{NS}
Days	2	4.00^{*}	1.31^{NS}	$32{,}528^{NS}$	5.05^{**}
Levels x Days	8	1.93^{NS}	0.55^{NS}	$31{,}919^{*}$	0.15^{NS}
Error	45	1.21	0.24	21,385	0.12
CV%		6.8	5.82	12.5	8.4

Source: Research data, 2019/2020. **, * significant at 1 and 5% probability by t-test. NS Non-significant. CV - Coefficient of Variation.

Table 2. Fruit height (HF), fruit diameter (DF), and soluble solids content of 'Pérola' pineapple according to the days after the application of levels of gibberellic acid.

Days	HF(cm)	DF (mm)	Soluble Solids (Brixº)
50	14.7 a	9.82 a	14.1 b
80	13.5 b	9.18 b	13.7 b
110	13.8 ab	9.37 ab	14.9 a

Source: Research data, 2019/2020. Means values followed by different letters in the same column are significantly different by Tukey's test at 5% probability.

In Figure 1, data on fruit diameter fitted to a quadratic model with a maximum response of 10.24 cm at a level of 7.46 mg gibberellic acid. Levels greater than 7.46 mg per plant caused a negative effect, obtaining smaller average fruit diameter.

Lacerda et al. (2017) tested higher levels of AG3 on pineapple fruit and observed a statistical difference for fruit diameter, where it grew linearly with increasing levels of gibberellic acid. On the other hand, Pereira et al. (2014) found no significant difference for the same variable. However, high levels of gibberellic acid in fruit trees are unfavorable for some fruit characteristics. The maintenance of this hormone in plants is essential when applied in regular levels (Aquino et al., 2016), corroborating the positive results of the levels applied in the study.

Moreover, another factor that justifies the positive results for fruit diameter with regular levels of AG3 has to do with the fact that gibberellins act strongly on plant growth by inducing cell expansion, chemically signaling, through the enzymes xyloglucan endotransglycosylase, the loosening of the cell wall and when water is available, microfibrils formed by celluloses are moved away so that others are deposited (Taiz et al., 2017). The weight of the fruits and the periods of application behaved differently. At 50 days, the increase in levels caused a negative effect, with a linear decrease in fruit weight as a consequence of the increase in levels of AG3 (Figure 2).

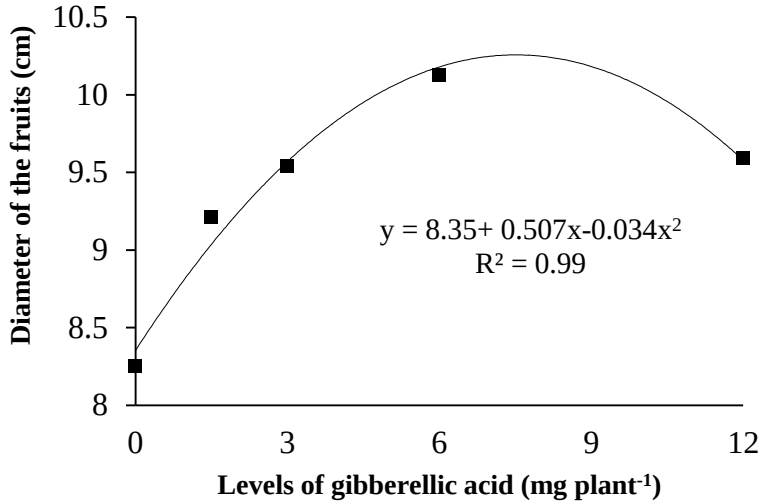

Figure 1. Diameter of 'Pérola' pineapple fruit as a function of levels of gibberellic acid (GA).

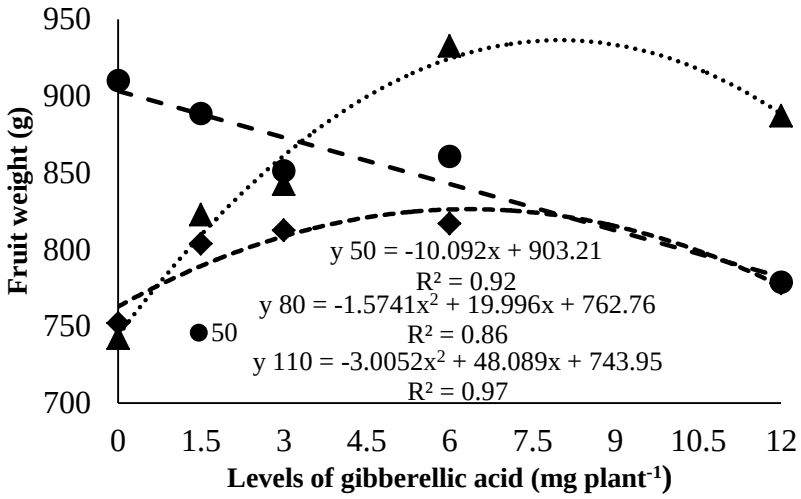

Figure 2. Weight of 'Pérola' pineapple fruit as a function of levels of gibberellic acid and days after flower induction.

At 80 days, quadratic effects can be observed for the application of the product, where 826.25 g was obtained when 6.3 g gibberellic acid was applied, totaling 8.32% increase when compared to the zero level. The results demonstrate that the application of gibberellic acid is not recommended before 110 days after floral induction when the aim is to obtain fruits of greater weight, confirming the results found by Lacerda et al. (2017), who observed positive results for fruit weight with the application of GA3 at 110 days after floral induction.

Importantly, gibberellin presents properties that stimulate an increase in cell length in various plant species, corroborating Moterle et al. (2011). It is a phytohormone with properties that will cause cell elongation and expansion, consequently, a greater accumulation of water in the cell, which will lead to a final increase in pineapple fruit weight (Li et al., 2011; Iqbal et al., 2011; Suwandi et al., 2016).

4. Conclusions

A level of gibberellic acid at 7.5 mg/plant is recommended to obtain an increase in fruit weight and diameter. The application at 110 days after flower induction promotes an increase in fruit weight and a greater concentration of sugar in the fruit.

Further studies on the application of gibberellic acid and periods of application in different soil and climatic conditions should be carried out to determine more consistent results with this crop.

Authors' Contribution

Juanderson Moura da Silva contributed to the execution of the experiment, data collection, analysis and interpretation of results, writing of the manuscript and final correction of the manuscript. João Henrique Barbosa da Silva contributed to the execution of the experiment, data collection, analysis and interpretation of results, writing of the manuscript and final correction of the manuscript. José Rayan Eraldo Souza Araújo contributed to the execution of the experiment, data collection, analysis and interpretation of results, writing of the manuscript and final correction of the manuscript.

Eduardo Marinho Gomes contributed to the execution of the experiment, data collection, analysis and interpretation of results, writing of the manuscript and final correction of the manuscript. José Manoel Ferreira de Lima Cruz contributed to analysis and interpretation of results, writing of the manuscript and final correction of the manuscript. Antônio Veimar da Silva contributed to analysis and interpretation of results, writing of the manuscript and final correction of the manuscript.

Francisco Gledson da Silva contributed to the execution of the experiment, data collection, analysis and interpretation of results, writing of the manuscript and final correction of the manuscript. João Paulo de Oliveira Santos contributed to analysis and interpretation of results, writing of the manuscript and final correction of the manuscript. Walter Esfrain Pereira contributed to analysis and interpretation of results, writing of the manuscript and final correction of the manuscript. All authors provided critical feedback and helped shape the research, analysis, and manuscript.

Bibliographic References

Aquino, C.F., Salomão, L.C.C., Azevedo, A.M., 2016. Qualidade pós-colheita de banana 'Maçã' tratada com ácido giberélico avaliada por redes neurais artificiais. Pesquisa Agropecuária Brasileira, 51 (7), 824-833. DOI: https://doi.org/10.1590/S0100-204X2016000700005

Beltrão, B.A., Morais, F., Mascarenhas, J.C., Miranda, J.L.F., Souza Junior, L.C., Mendes, V.A, 2005. Projeto cadastro de fontes de abastecimento por água subterrânea da Paraíba: Diagnóstico do município de Pedras de Fogo. CPRM/PRODEEM, 11 p. https://rigeo.cprm.gov.br/bitstream /doc/16247/1/Rel_Pedras_Fogo.pdf. (acessado 31 de julho de 2020).

Björklund, S., Antti, H., Uddestrand, I., Moritz, T., Sundberg, B., 2007. Cross-talk between gibberellin and auxin in development of Populus wood: gibberellin stimulates polar auxin transport and has a common transcriptome with auxin. The Plant Journal, 52 (3), 499-511. DOI: https://doi.org/10.1111/j.1365-313x.2007.03250.x

Bleinroth, E.W., 2000. Frutas Tropicais 2: Abacaxi. ITAL, Campinas.

CEAGESP. COMPANHIA DE ENTREPOSTOS E ARMAZÉNS GERAIS DE SÃO PAULO. 2003. Programa brasileiro para modernização da horticultura: normas de classificação do abacaxi, Central de Qualidade em Horticultura. http://minas1.ceasa.mg.gov.br/ceasainternet/_lib /file/docagroqcartilhas/ABACAXI.pdf. (acessado 21 de julho de 2020).

CONAB. COMPANHIA NACIONAL DE ABASTECIMENTO. 2020. Ministério da Agricultura, Pecuária e Abastecimento. A participação do abacaxi no desenvolvimento econômico nas regiões produtoras. Brasília, Ministério da Agricultura, Pecuária e Abastecimento, 14 p. https://www.conab.gov.br/institucional/publicacoes/compendio-de-estudos-da-conab/item/download/30706_fec8df8c31ba1fa1fd923e1c0b86baee. (acessado 21 de julho de 2020).

Dagar, A., Weksler, A., Friedman, H., Lurie, S., 2012. Gibberellic acid (GA3) application at the end of pit ripening: Effect on ripening and storage of two harvests of 'September Snow'peach. Scientia Horticulturae, 140(1), 125-130. DOI: https://doi.org/10.1016/j.scienta.2012.03.013

Dalanhol, S.J., Mombach, T.C., Toderke, M.L., Nogueira, A.V., Bortolini, M.F., 2013. Dormência em sementes de *Annona*

cacans warm.(annonaceae). Revista Acadêmica: Ciência Animal, 11 (1), 183-189. https://periodicos.pucpr.br/cienciaanimal/article/view/11462. (acessado 21 de julho de 2020).

Duarte Filho, J., Antunes, L.E.C., Pádua, J.G., 2004. GA3 e Paclobutrazol no florescimento e na produção de frutos em duas cultivares de morangueiro. Horticultura Brasileira, 22 (2), 202-205. DOI: https://doi.org/10.1590/S0102-05362004000200008

FAO. FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS. 2019. Tropical Fruits Article. http://www.fao.org/faostat. (acessado 21 de julho de 2020).

FAOSTAT. FOOD AND AGRICULTURE DATA. 2018. Major tropical fruits - Statistical compendium 2018. http://faostat.fao.org/. (acessado 24 de outubro de 2020).

Gonçalves, B.H.L., Ferraz, R.A., Souza, J.M.A., Tecchio, M.A., 2017. Biometria dos frutos e uso de ácido giberélico na germinação de sementes de abieiro (*Pouteria caimito*). Cultura Agronômica: Revista de Ciências Agronômicas, 26 (4), 530-539. DOI: https://doi.org/10.32929/2446-8355.2017v26n4p530-539

IBGE. INSTITUTO BRASILEIRO DE GEOGRAFIA E ESTATÍSTICA. 2018. Produção agrícola municipal – PAM 2018. https://sidra.ibge.gov.br/pesquisa/pam/tabelas. (acessado 24 de outubro de 2020).

IBGE. INSTITUTO BRASILEIRO DE GEOGRAFIA E ESTATÍSTICA. 2019. Produção Agrícola Municipal 2018. https://sidra.ibge.gov.br/tabela/1612. (acessado 31 de julho de 2020).

Iqbal, N., Nazar, R., Khan, M.I.R., Masood, A., Khan, N.A., 2011. Role of gibberellins in regulation of source–sink relations under optimal and limiting environmental conditions. Current Science, 100 (7), 998-1007. https://www.jstor.org/stable/24076517. (acessado 31 de julho de 2020).

Lacerda, J.T., Carvalho, R.A., Oliveira, E.F., 2017. Efeito do ácido giberélico na produtividade e qualidade do fruto do abacaxizeiro Pérola. Tecnologia & Ciência Agropecuária, 11 (6), 81-88. https://revistatca.pb.gov.br/. (acessado 21 de julho de 2020).

Lavagnini, C.G., Di Carne, C.A.V., Correa, F., Henrique, F., Tokumo, L.E., Silva, M.H., Santos, P.C.S., 2014. Fisiologia vegetal-hormônio giberelina. Revista Científica Eletrônica de Agronomia, 25 (1), 48-52. http://faef.revista.inf.br/imagens_arquivos/arquivos_destaque/bhVGBiNA87kYjIU_2014-7-1-21-4-1.pdf. (acessado 21 de julho de 2020).

Li, Y.H., Wu, Y.J., Wu, B., Zou, M.H., Zhang, Z., Sun, G.M., 2011. Exogenous gibberellic acid increases the fruit weight of 'Comte de Paris' pineapple by enlarging flesh cells without negative effects on fruit quality. Acta Physiologiae Plantarum, 33 (5),1715-1722. DOI: https://doi.org/10.1007/s11738-010-0708-2

Moterle, L.M., Santos, R.F.D., Scapim, C.A., Braccini, A.D.L., Bonato, C.M., Conrado, T., 2011. Efeito de biorregulador na germinação e no vigor de sementes de soja. Revista Ceres, 58 (5), 651-660. DOI: https://doi.org/10.1590/S0034-737X2011000500017

Noronha, A.D.S., Lemos, W.D.P., Fazolin, M., Sanches, N.F., Garcia, M.V.B, 2016. Pragas agrícolas e florestais na Amazônia. Embrapa, p. 22-43. https://livimagens.sct.embrapa.br/amostras/00084690.pdf. (acessado 21 de julho de 2020).

Nunes, J.S., Lins, A.D.F., Gomes, J.P., Silva, W.D., Silva, F.D., 2017. Influência da temperatura de secagem nas propriedades físico-química de resíduos abacaxi. Revista Agropecuária Técnica, 1 (1), 41-46. DOI: https://doi.org/10.25066/agrotec.v38i1.29991

Pereira, M.C.T., Santos, R.K.A., Nietsche, S., Mizobutsi, G.P., Santos, E. F. D., 2014. Levels de ácido giberélico na frutificação efetiva e qualidade de frutos de atemoieira'Gefner'. Revista Brasileira de Fruticultura, 36(1), 184-191. DOI: https://doi.org/10.1590/S0100-29452014000500022

R CORE TEAM. (2021) R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. https://www.R-project.org/. (acessado 01 de julho de 2020).

Silva, T.R.G., Silva, J.C., Lima, D.F., Santos, L.J.S., Barbosa Júnior, M.R., Santos, M.A.L., 2020. Produtividade e qualidade dos frutos do abacaxi 'Pérola' em função de lâminas de irrigação. Brazilian Journal of Development, 6 (6), 40140-40152. DOI: https://doi.org/10.34117/bjdv6n6-522

Suwandi, T., Dewi, K., Cahyono, P., 2016. Pineapple harvest index and fruit quality improvement by application of gibberellin and cytokinin. Fruits, 71 (4), 209-214. DOI: https://doi.org/10.1051/fruits/2016010

Taiz, L., Zeiger, E., Moller, IM, Murphy, A., 2017. Fisiologia e desenvolvimento vegetal, sexta ed. Artmed.

Weiss, D., Ori, N., 2007. Mechanisms of cross talk between gibberellin and other hormones. Plant Physiology, 144 (3), 1240-6. DOI: https://doi.org/10.1104/pp.107.100370

Yildiz, K., Ozturk, B., Ozkan, Y., 2012. Effects of aminoethoxyvinylglycine (AVG) on preharvest fruit drop, fruit maturity, and quality of 'Red Chief' apple. Scientia Horticulturae, 144, 121-124. DOI: https://doi.org/10.1016/j.scienta.2012.07.005

Zeman, S., Čmelik, Z., Jemrić, T., 2012. Size and Weight of Sweet Cherry (*Prunus avium* L. 'Regina') Fruit Treated with 3,5,6-TPA and GA3. Agriculturae Conspectus Scientificus, 77 (1), 45-47. https://acs.agr.hr/acs/index.php/acs/article/view/628. (acessado 15 de julho de 2020)