horticultura brasileira

Research

TEIXEIRA, AG; PARAJARA, MC; OLIVEIRA, FL; ZUCOLOTO, M; DALVI, LP. 2022. Ornamental cauliflower production using growth regulator. *Horticultura Brasileira* 40: 076-081. DOI: http://dx.doi.org/10.1590/s0102-0536-20220110

Ornamental cauliflower production using growth regulator

Ariany G Teixeira [1]; Magno do C Parajara [1]; Fábio Luiz Oliveira [1]; Moises Zucoloto [1]; Leandro P Dalvi [1]

[1]Universidade Federal do Espírito Santo (UFES), Alegre-ES, Brasil; arianyteixeira@yahoo.com.br; magnocp1@hotmail.com; fabio.oliveira.2@ufes.br; moiseszucoloto@gmail.com; leandropin@yahoo.com.br

ABSTRACT

Some vegetables have been used as an innovation in the ornamental plant market, such as cauliflower, which has well-defined morphological traits. This study aimed to evaluate the effect of paclobutrazol, applied via soil, in order to produce cauliflower for ornamental purposes. The design used was completely randomized with five treatments and seven replicates. The treatments consisted of doses of the growth regulator paclobutrazol (PBZ) (0.5; 1.0; 1.5; 2.0 mg dm^{-3}) and the control (without application). For vegetative growth, we evaluated number of leaves, stem diameter, plant height, leaf area, total chlorophyll, flavonoid index, and nitrogen balance. For production, we evaluated fresh mass of shoot and root, fresh and dry weight, diameter and length of the inflorescences. The application of PBZ promoted significant changes in the development of the cauliflower, resulting in more compact plants, with shorter stems, smaller leaves and a more intense green color (visual observation), and also early inflorescence emission. The authors verified higher fresh and dry weight, diameter and longer inflorescence with application of 0.5 mg dm^{-3} of PBZ, demonstrating the potential of PBZ to obtain mini cauliflower to serve the potted plant market.

Keywords: *Brassica oleracea* var. *botrytis*, ornamental plants, paclobutrazol, floriculture.

RESUMO

Produção de couve-flor ornamental com uso de regulador de crescimento

Algumas hortaliças vêm sendo utilizadas como uma inovação no mercado de plantas ornamentais, dentre elas a couve-flor, com características morfológicas bem definidas. Neste estudo objetivou-se avaliar o efeito do paclobutrazol, aplicado via solo, na produção da couve-flor para fim ornamental. O delineamento utilizado foi inteiramente casualizado com cinco tratamentos e sete repetições. Os tratamentos foram constituídos pelas doses do regulador de crescimento paclobutrazol (PBZ) (0,5; 1,0; 1,5; 2,0 mg dm^{-3}) e a testemunha sem aplicação. No crescimento vegetativo foram avaliadas número de folhas, diâmetro do caule, altura da planta, a área foliar, clorofila total, índice de flavonoides, e balanço de nitrogênio, enquanto que para variáveis de produção avaliou-se massa fresca da parte aérea e das raízes, peso fresco e seco, diâmetro e comprimento das inflorescências. A aplicação do PBZ promoveu mudanças significativas no desenvolvimento da couve-flor originando plantas mais compactas, com caules mais curtos, folhas menores e com tonalidade de cor verde mais intensa (observação visual), além de ter promovido a emissão da inflorescência precocemente O maior peso fresco, seco, diâmetro e comprimento da inflorescência ocorreu com aplicação de 0,5 mg dm^{-3} de PBZ, demonstrando potencial do PBZ para obtenção de mini couve-flor para atender o mercado de flor envasada.

Palavras-chave: *Brassica oleracea*, var. *botrytis*, plantas ornamentais, paclobutrazol, floricultura.

Received on August 12, 2021; accepted on January 5, 2022

Floriculture has gained considered importance in the last decade in all Brazilian regions, mainly due to the fact that this is a significant profitable activity, generating employment in both rural and urban areas (Brainer, 2019).

This exploration involves multiple forms from the production of cut flowers and foliage, potted plants and seedlings, aimed at landscaping and gardening, as well as for indoor environments (Brainer, 2019). However, the ornamental market needs innovations and new products which can improve the competitiveness of the sector, increasing profit of the final product (Costa *et al*., 2019).

In terms of innovations in the ornamental plant market, vegetables have been highlighted as an option. The use of pepper and tomato plants cultivated for ornamental purposes is popular in Europe and the United States (Bosland & Votava, 1999). However, other species with high potential for exploitation are also available in the market. Among these vegetables is the cauliflower, which has ornamental potential, as it has a diverse coloration and compact architecture, which is ideal for potted cultivation (Torres et al., 2017).

Nevertheless, the exploration of a vegetable for ornamental purposes requires well-defined morphological traits which are in accordance with the market it will meet (Fischer, 2015). For this purpose, the use of good strategies for its production in order to guarantee the desired morphological patterns in the ornamental vegetable is essential.

Among these patterns, obtaining the desired size is one of the most common, which can be obtained through the use of growth regulators (França *et al*., 2018).

Paclobutrazol (PBZ) is a popular growth regulator, mainly because it is an inhibitor of gibberellin biosynthesis and, therefore, promotes restrictions on vegetative development in several species (Rademacher, 2000). In brassicas, this technique changes the physiology and growth rate of these plants, modifying them to meet the ornamental potential (Wanderley *et al*., 2014; Teto *et al*., 2016; Jie Kuai *et al*., 2017; Chen *et al*., 2019; Mog *et al*., 2019).

However, the effectiveness of PBZ varies according to the plant species, which is mainly dependent on the product dose, time and mode of application, stage of development and physiology, and environmental conditions of the cultivations (Mabvongwe *et al*., 2016; Shankaraswamy & Neelavathi, 2016).

Applying PBZ in cauliflower can help in growth inhibition, growing plants with reduced size for ornamental purposes, mainly because cauliflower is a plant which develops in a very short period of time, about 90 days. Therefore, despite recent studies on the efficiency of PBZ in controlling the growth of some species, little is known about the effects of this regulator on cauliflower. Given the above, this study aimed to evaluate the effect of PBZ, applied via soil, in order to produce cauliflower for ornamental purposes.

MATERIAL AND METHODS

The experiment was carried out in an agricultural property located in the municipality of Alegre-ES (20°47’3”S, 40°36’55”W, 667 m altitude), from March 24 to June 24, 2019, in a nursery covered with 50% shading screen.

According to Köppen’s classification, the local climate is Cwa, hot, humid tropical, cold and dry winter and annual rainfall around 1.200 mm (Alvares *et al*., 2013). Cultivation was carried out during winter. Temperatures ranged between 19º (minimum) and 28º (maximum), around 80% relative humidity.

The soil used as substrate was classified as Red-Yellow Latosol, medium texture (Santos *et al*., 2018), collected at 0-20 cm depth. The soil sample was submitted to the laboratory analysis, showing the following chemical characteristics: pH= 5.05; 1.7 mg dm^{-3} $P_{(Mehlich)}$; 36.0 mg dm^{-3} K; 0.87 cmolc dm^{-3} Ca; 0.36 cmolc dm^{-3} Mg; 0.15 cmolc dm^{-3} Al; 1.39 cmol dm^{-3} sum of bases; 1.54 cmolc dm^{-3} effective CTC; 43.3% base saturation; 44% sand, 38% silt and 17% clay. Afterwards, the sample was air-dried and then sieved through a 5 mm mesh. The pH was corrected by raising the basis saturation at 70%, using limestone PRNT 90.

At 15 days before planting, organic fertilization was performed. Sixty grams of cattle manure were applied per pot (60 t ha^{-1}). The dried manure was submitted to analysis, showing the following characteristics: 12.88 g kg^{-1} total N, 2.71 g kg^{-1} P, 20.90 g kg^{-1} K, 16.75 g kg^{-1} Ca, 5.62 g kg^{-1} Mg, 2.38 g kg^{-1} S, 5.03 mg kg^{-1} B, 93.35 mg kg^{-1} Zn, 535.3 mg kg^{-1} Mn, 8730.9 mg kg^{-1} Fe, 16.13 mg kg^{-1} Cu.

The experiment was carried out in a completely randomized design (DIC) with five treatments and seven replicates. The treatments consisted of doses of paclobutrazol (PBZ), a plant growth regulator (0.5; 1.0; 1.5; 2.0 mg dm^{-3}) and the control without the application. The doses were defined according to Zanão *et al*. (2018).

The cauliflower seedlings, hybrid Barcelona, were produced in disposable polyethylene trays with 162 cells filled with commercial substrate Plantmax ®. Transplanting was carried out when the seedlings showed two pairs of definitive leaves, approximately 10 to 12 (cm) length. The seedlings were transplanted to 3 liter plastic pots: 15.6 cm height, 19.8 cm top diameter and 13.8 cm bottom diameter. The pots were completed up to 90% capacity and placed on benches, approximately 80 cm above the ground, laid out under 50% shading screen cover.

The commercial product Cultar ® (active ingredient of paclobutrazol, 25% PBZ) was applied via soil on the seedlings 10 days after transplanting with a syringe within a 2 cm radius of the seedlings. Then, the seedlings were irrigated in order to homogenize the active ingredient into the substrate. The pots were irrigated daily in order to keep soil moisture at homogeneous levels (similar to the field capacity), standardizing by the moisture loss from the pots (in weight).

At 104 days after transplanting, the number of leaves, stem diameter, plant height and leaf area were evaluated, with the aid of LICOR photoeletric area meter (model 3100). Total chlorophyll content was evaluated using Clorofilog Falker, flavonoid content and nitrogen balance (N) in the leaves were evaluated using the Dualex Scientific +TM, FORCE-A.

Right after being harvested, the plants were fractionated and weighed in order to obtain the fresh mass of shoot and root, fresh and dry mass, diameter and length of the inflorescences. The roots were previously washed under running water. Then, the chopped plants were oven-dried, at 65ºC for 72 hours until reaching constant mass.

For data evaluation, linear regression models were tested in order to assess the equation adjustments which would relate the studied variables with PBZ doses. The models were chosen based on evaluations of the behavior of the graph of variables, the sum of squares of the complete models, the coefficient of determination (R^2) and significance of the regression coefficients ($p<0.05$) using Student’s t test. All statistical analyses were performed using Sisvar 5.0 (Ferreira, 2014).

RESULTS AND DISCUSSION

The authors observed that paclobutrazol (PBZ) application promoted significant changes in cauliflower growth, originating more compact plants, with shorter stems, smaller leaves, showing more intense green color (visual observation), besides having promoted early emission of inflorescences (Figure 1).

We noticed a drastic decrease in cauliflower growth at a dose of 1.5 mg dm^{-3}. This lower vegetative development was observed at a dose of 0.5 mg dm^{-3}, when the plants reached 9.0 cm high, 7.0 mm stem diameter and 745.7 cm^2 leaf area (Figure 2). We noticed a more interesting plant size for ornamental purpose, due to a more symmetrical conformation, showing a more attractive visual presentation (Figure 1).

In general, PBZ application decreased by 42.82% the height, 34.8% the stem diameter, 80% the leaf area and increased 33% the number of leaves, when applying greater doses of the

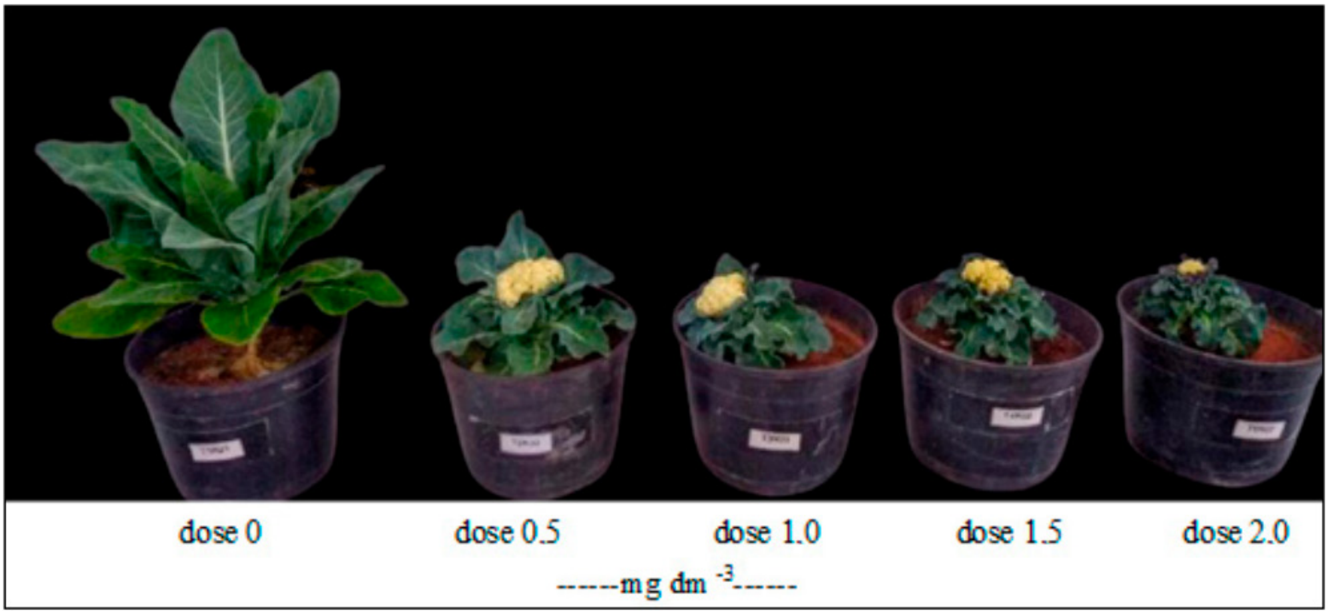

Figure 1. Cauliflower plants treated with paclobutrazol (PBZ) at doses 0.0; 0.5; 1.0; 1.5; 2.0 mg dm^{-3}, 104 days after transplanting. Alegre, UFES, 2019.

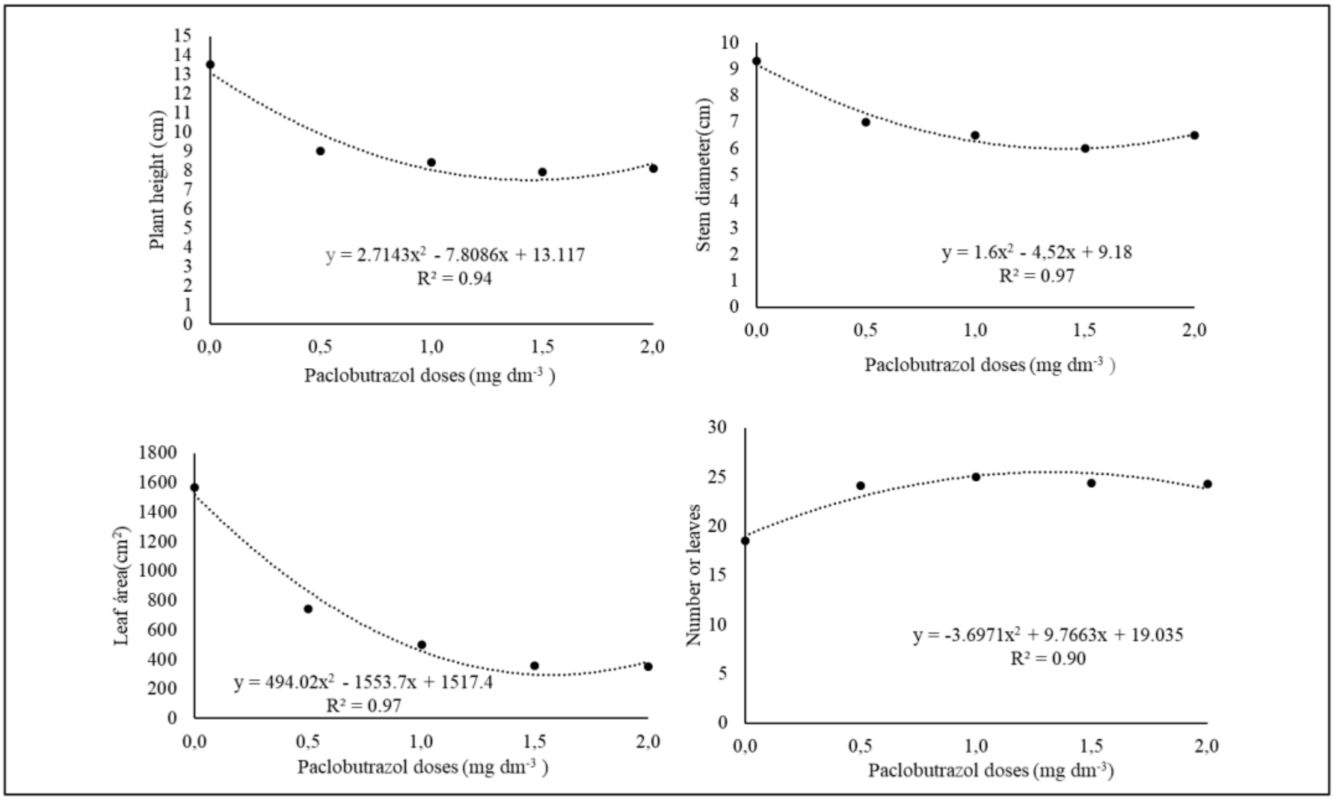

Figure 2. Plant height, stem diameter, leaf area and number of leaves in cauliflower plants, applying paclobutrazol (PBZ), 104 days after transplanting. Alegre, UFES, 2019.

product (Figure 2), in relation to the plants which did not receive PBZ.

The lower values for height, diameter and leaf area can be explained by PBZ action on plants, as it affects the multiplication of the meristem, by reducing the levels of endogenous gibberellins, which are responsible for cell elongation (Mog *et al*., 2019). The increase of the number of leaves can represent a compensatory reaction of the plant to the decrease in leaf area, seeking to recover the photoassimilates production capacity, an effect already observed with PBZ application in jatropha (*Jatropha curcas*) (Ghosh *et al*., 2010).

PBZ application promotes an increase in chlorophyll content in cauliflower leaves. The authors noticed that the dose of 1.5 mg dm^{-3} promoted greater increases in chlorophyll content, in relation to plants which did not receive PBZ application. However, at a dose of 0.5 mg dm^{-3}, the authors also observed effects on chlorophyll content with an increase of 34.7% (Figure 3). The more intense and velvety green color also contributed in visual presentation of the plants, which can make the plant more attractive for the observers (Figure 1).

The effect of PBZ application is related to degradation of active gibberellins. Thus, several intermediates in the biosynthetic pathway are activated, increasing the synthesis of phytol, which plays an important role in the regulation of chlorophyll synthesis (Chaney, 2003). The increase in phytol synthesis contributed to higher chlorophyll contents observed in leaves (Sebastian *et al*., 2002). The darker color improves the visual aspect of the plant and consequently attracts the consumer's attention for ornamental vegetables.

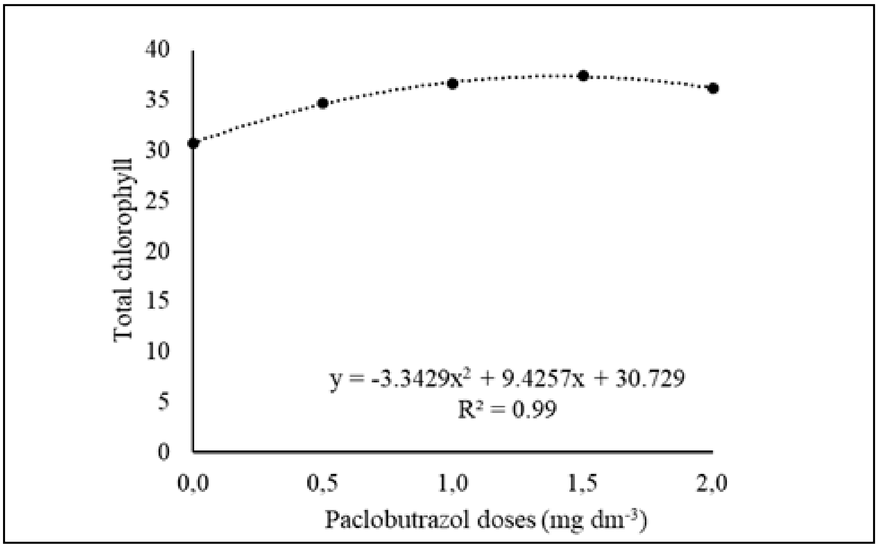

Figure 3. Total chlorophyll contents in cauliflower leaves, after paclobutrazol (PBZ) application, at 104 days after transplanting. Alegre, UFES, 2019.

The authors noticed a decrease in flavonoid contents when PBZ was applied (up to the dose of 1.5 mg dm^{-3}) and a tendency to increase these contents with the increase of the dose (Figure 4). This result shows that up to the dose of 1.5 mg dm^{-3}, the plant tolerates the stress caused by the application of the growth regulator, perhaps even by the effect of PBZ, which belongs to the chemical group of triazoles, which regulate some constituents of antioxidant activity in plants (Lin *et al*., 2006). It may also indicate the activation of plant defense mechanisms, due to the increase of stress caused by the application of the product, though.

The authors observed an increase in nitrogen (N) balance up to the dose of 1.0 mg dm^{-3} of PBZ (Figure 4). This behavior was observed as a consequence of an increase in chlorophyll content (Figure 3), which provided greater N uptake by the leaves. Once again, applying a dose of 0.5 mg dm^{-3} of PBZ, it is possible to observe an increase in N balance, with quantities 60% higher when compared to plants with no PBZ at

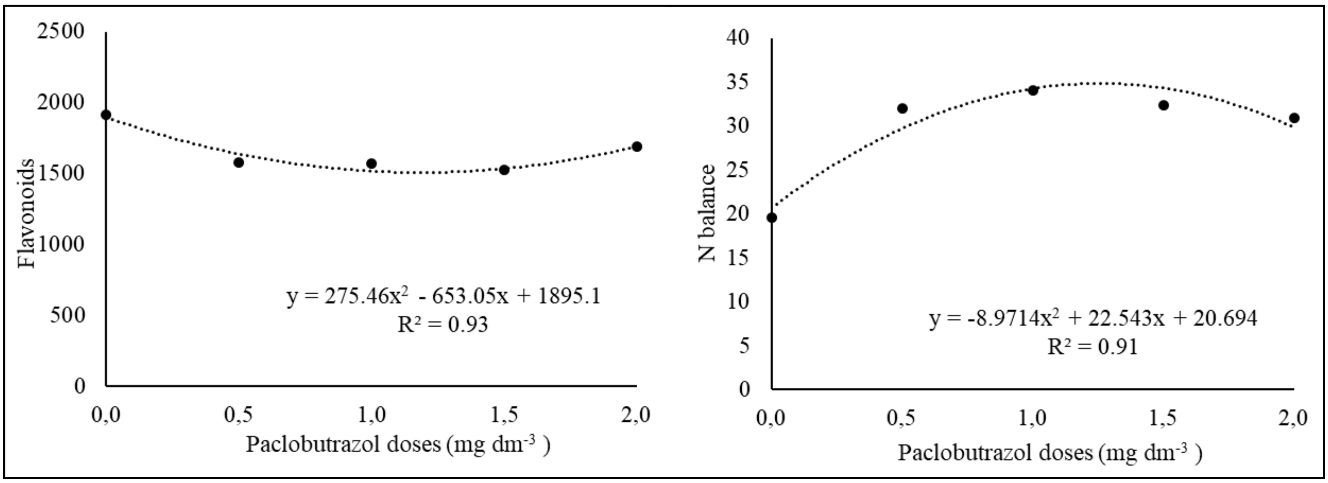

Figure 4. Flavonoids and nitrogen balance of the cauliflower plants, applying paclobutrazol (PBZ), 104 days after transplanting. Alegre, UFES, 2019.

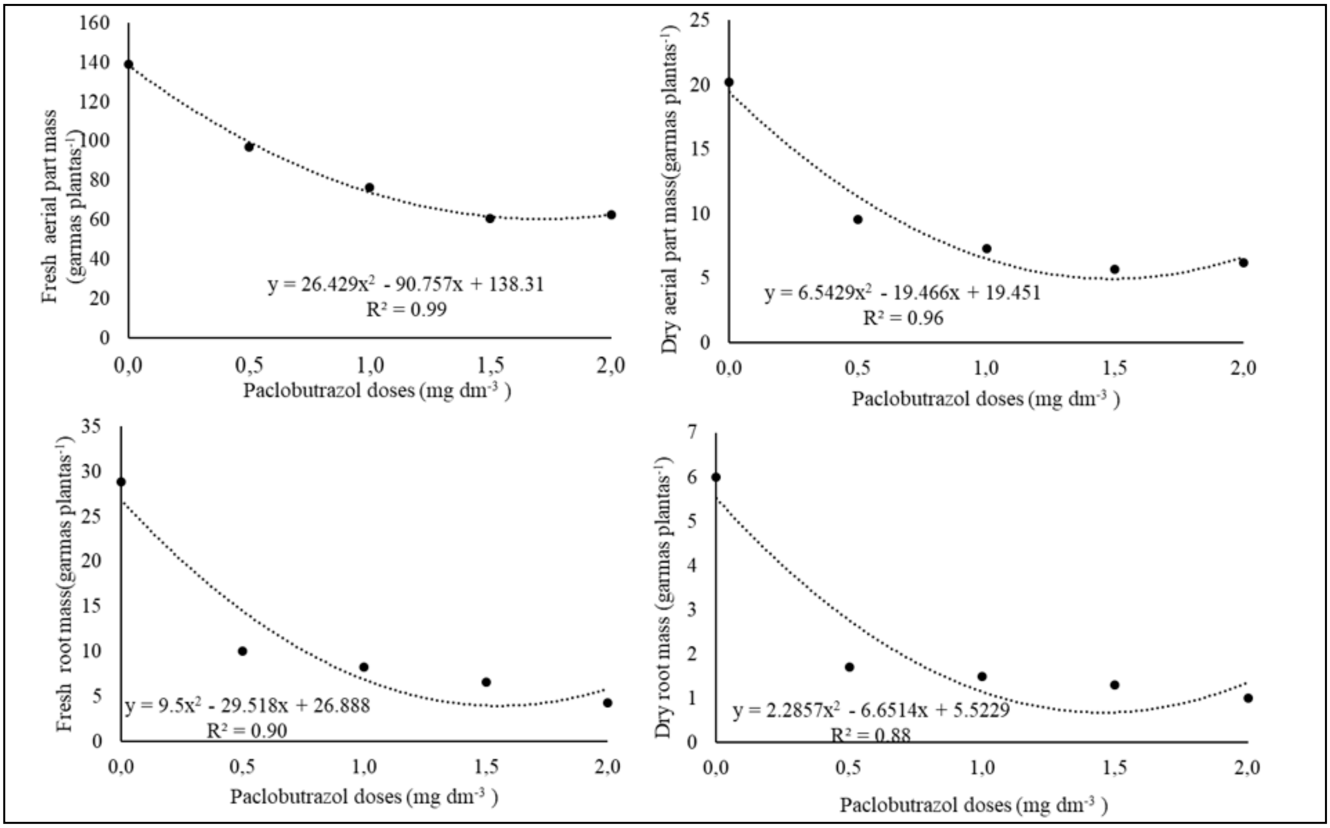

Figure 5. Fresh and dry mass of shoot area, and fresh and dry mass of cauliflower root, applying paclobutrazol (PBZ), 104 days after transplanting. Alegre, UFES, 2019.

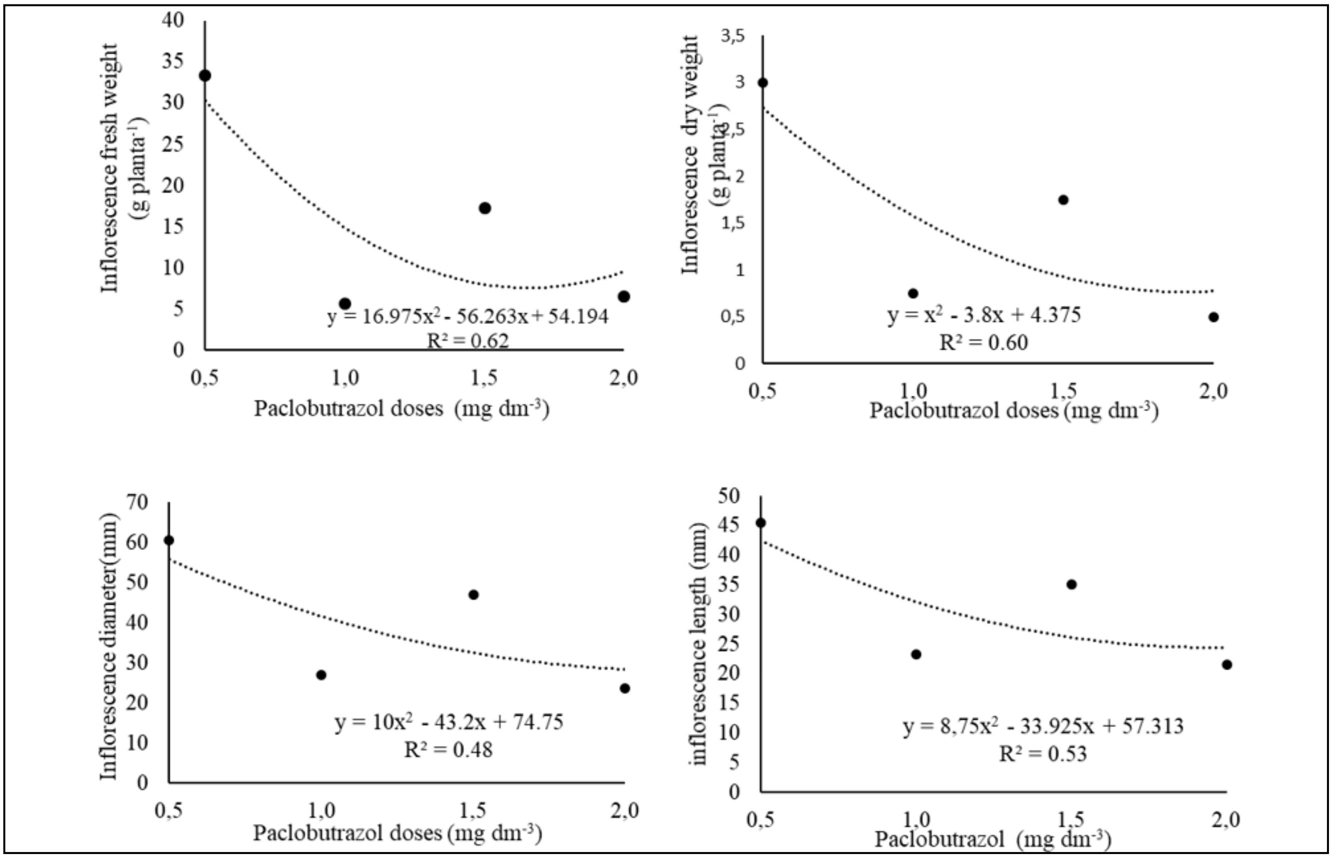

Figure 6. Fresh mass, dry mass, diameter and length of the cauliflower inflorescence, using paclobutrazol (PBZ), at 104 days after transplanting. Alegre, UFES, 2019.

all, which means an interesting stimulus to the cauliflower plant. Considering that this plant accumulates high quantities of N during its vegetative development, as guarantees for the reproductive phase and N supply for inflorescence (Kano *et al*., 2010).

PBZ promoted a decrease in the cauliflower plant development: lower dry and fresh mass accumulations, both in shoot and root parts of the plants (Figure 5). However, we highlight that a drastic decrease caused by higher doses of PBZ (1.0 to 2.0 mg dm^{-3}) shall result in loss of visual quality of plant presentation. Thus, the accumulations of shoot fresh mass (97.1 g $plant^{-1}$) or shoot dry mass (9.6 g $plant^{-1}$), as well as the accumulation of root fresh mass (10.0 g plant-1) and of root dry mass (1.7 g $plant^{-1}$), obtained using a dose of 0.5 mg dm^{-3}, showed that PBZ is able to decrease the cauliflower plant development, promoting smaller plants, keeping the visual aspect attractive to the observer.

The doses of PBZ provided early cauliflower inflorescence, considering that the plants, which did not receive any PBZ, were the only ones which did not flower up to 104 days after transplanting (Figure 1). Besides, the authors observed that in Figure 6 the highest fresh and dry masses, diameters and the longest inflorescence lengths were obtained with the use of 0.5 mg dm^{-3} (Figure 6).

Based on the results obtained in this study, the authors concluded that PBZ application promoted significant changes in the development of cauliflower originating more compact plants, with shorter stems, smaller leaves, and more intense green color (visual observation) and also presence of inflorescence.

Applying 0.5 mg dm^{-3} of PBZ, the authors observed a better balance between vegetative development and flowering, obtaining the best visual observation of the plant. This may indicate the potential of this dose to obtain minicauliflower to serve the potted flower market.

ACKNOWLEDGEMENTS

The authors thank to Foudantion for Research Support of Espírito Santo (FAPES) and to The National Council for Scientific and Technological Development (CNPq) for granting research scholarships.

REFERENCES

ALVARES, CA; STAPE, JL; SENTELHAS, PC; GONÇALVES, JLM; SPAROVEK, G. 2013. Köppen's climate classification map for Brazil. *Meteorology Zeitschrift* 22: 711-728.

BOSLAND, PW; VOTAVA, EJ. 1999. Peppers: vegetable and spice capsicums. Wallingford: CABI Publishing. 204p.

BRAINER, MSCP. 2019. Flores e plantas ornamentais. Escritório Técnico de Estudos Econômicos do Nordeste - ETENE. 95.

CHANEY, WR. 2003 Tree growth retardants: arborists discovering new uses for an old tool tree care industry. *Magazine* 54: 2-6.

CHEN, W; ZHANG, Y; REN, J; MA, Y; LIU, Z; HUI, F. 2019. Effects of methylene blue on microspore embryogenesis and plant regeneration in ornamental kale (*Brassica oleracea* var. *acephala*). *Scientia Horticulturae* 248: 1-7.

COSTA, GN; SILVA, BMP; LOPES, ÂCA, CARVALHO, LCB; GOMES, RLF. 2019. Seleção de acessos de pimenta com potencial ornamental. *Caatinga* 32: 566-574.

FERREIRA, DF. 2014. Sisvar: a computer statistical analysis system. *Ciência e Agrotecnologia* 6: 1039-1042.

FISCHER, SZ; BARBIERI, RL 2015. Abóboras ornamentais: atributos valorizados por consumidor final e decoradores florais. *Horticultura Brasileira* 33: 480-487.

FRANÇA, CDFM; RIBEIRO, WS; SANTOS, MNS; PETRUCCI, KPDOS; RÊGO, ERD; FINGER, FL. 2018. Growth and quality of potted ornamental peppers treated with paclobutrazol. *Pesquisa Agropecuária Brasileira* 53: 316-322.

GHOSH, A; CHIKARA, J; CHAUDHARY, DR; PRAKASH, A; BORICHA, G. ZALA, A. 2010. Paclobutrazol interrompe crescimento vegetativo e revela potencial de rendimento não expresso de *Jatropha curcas* Journal of *Plant Growth Regulation* 29: 307-315.

JIE, KUAI; LI, XY; YANG, Y; ZHOU, GS. 2017. Effects of paclobutrazol on biomass production in relation to resistance to lodging and pod shattering in *Brassica napus* L. *Journal of Integrative Agriculture* 16: 2470-2481.

KANO, C; SALATA, AC; CARDOSO, AII; EVANGELISTA, RM.; HIGUTI, ARO; GODOY, AR. 2010. Produção e qualidade de couve-flor cultivar Teresópolis Gigante em função de doses de nitrogênio. *Horticultura Brasileira*. 28: 453-457.

LIN, KHR; TSOU, CC; HWANG, SY; CHEN, LFO; LO, HF. 2006. Paclobutrazol pre-treatment enhanced flooding tolerance of sweet potato. *Journal of Plant Physiology* 163: 750-760.

MABVONGWE, O; MANENJI, BT; GWAZANE, M; CHANDIPOSHA, M. 2016. O efeito do tempo e variedade de aplicação de paclobutrazol no crescimento, rendimento e qualidade da batata (*Solanum tuberosum* L.). *Avanços na Agricultura* 1-5.

MOG, B; JANANI, P; NAYAK, MG; ADIGA, JD; MEENA, R. 2019. Manipulation of vegetative growth and improvement of yield potential of cashew (*Anacardium occidentale* L.) by Paclobutrazol. *Scientia Horticulturae* 257: 108748.

RADEMACHER, W. 2000. Growth retardants: effects on giberellin biosynthesis and other metabolic pathways. *Annual Review of Plant Physiology and Molecular Biology* 51: 501-531.

SANTOS, HG; JACOMINE, PKT; ANJOS, LHC; OLIVEIRA, VA; LUMBRERAS, JF; COELHO, MR; CUNHA, TJF. 2018. Sistema brasileiro de classificação de solos. Brasília, DF: *Embrapa,* 20p.

SEBASTIAN, B; ALBERTO, G; EMILIO, AC.; JOSE, AF; JUAN, AF. 2002. Growth, development and color response of potted *Dianthus caryophyllus* cv. Mondriaan to paclobutrazol treatment. *Scientia Horticulturae* 1767: 1-7.

SHANKARASWAMY, J; NEELAVATHI, R. 2016. Effect of growth regulators, nutrients, seaweed extract and pruning on induction of early flowering in mango (*Mangifera indica*) cv. Kesar. *Indian Journal of Agricultural Sciences* 86: 1175-1178.

TETO, AA; LAUBSCHER, C; NDAKIDEMI, PA; MATIMATI, I. 2016. Paclobutrazol retards vegetative growth in hydroponically-cultured *Leonotis leonurus* L. R. Br. Lamiaceae for a multipurpose flowering potted plant. *South African Journal of Botany* 106: 67-70.

TORRES, JLR; CIABOTTI, ED; GOMES, FRC; LEAL, ALBJ; VIEIRA, DMS; COSTA, LL. 2017. Physico-chemical attributes of no-till Brassica crops cultivated after various cover crops. *Horticultura Brasileira* 35: 252-257.

WANDERLEY, CS; FARIA, RT; REZENDE, R. 2014. Crescimento de girassol como flor em vaso em função de doses de paclobutrazol. *Revista Ceres* 61: 35-41.

ZANÃO, CMP; ZANÃO JÚNIOR, LA; GROSSI, JAS; PEREIRA, N. 2018. Produção de roseiras em vaso com aplicação de paclobutrazol no substrato. *Ciência Rural* 48: 1-7.