Scientific Article

# Physiological effect products in the cut rose production – application and growth[1]

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## ABSTRACT

The introduction of the cut rose culture in high temperature environment requires the use of technologies that allows its acclimation to the unusual environment. Products based on strobilurins, carboxamides and anilides as well as plant regulators that promote changes in the plant growth, can be a viable tool for the introduction of cut roses in the semiarid Northeast of Brazil. Thus, the objective of this study was to evaluate the effect of products with physiological effects on the growth of cut rose 'Ambiance' in the Submedium of the São Francisco Valley. The experimental design was a randomized block with four replicates and six treatments: control (water application); Boscalid; Pyraclostrobin; mixture of Boscalid + Pyraclostrobin; Fluxapyroxad + Pyraclostrobin; Kinetin + $GA_3$ + IBA; and consisted of foliar applications every 15 days for 280 days. The growth evaluations were performed through physiological indexes assessment, chlorophyll content and production of flower buds per stem. The results obtained showed that, especially Boscalid, both isolated and combined with Pyraclostrobin, the Fluxapyroxad + Pyraclostrobin and the plant regulators provided better physiological responses on the growth of the rose 'Ambiance', considering the relative growth rate, net assimilation rate, leaf area ratio and specific leaf area. Although the average increase on production of flower buds per stem of all treatments applied in relation to the control was in the order of 135%, none of the treatments applied produced stem for cut roses with the required commercial standards, indicating that further studies are needed for an adequate introduction of the crop in Submedium of the São Francisco Valley.

**Keywords:** 'Ambiance', carboxamides; strobilurins, plant regulators, protected environment.


## RESUMO

**Produtos de efeito fisiológico na produção de rosa de corte - aplicação e crescimento**

A introdução da cultura de rosa de corte em ambiente de temperaturas elevadas requer uso de tecnologias que possibilitem sua aclimatação às condições impostas. Produtos à base de estrobilurinas, carboxamidas e anilidas, bem como reguladores vegetais que promovem alterações no crescimento do vegetal pode ser uma ferramenta viável para a introdução do cultivo de rosas de corte no semiárido nordestino. Assim, objetivou-se avaliar a influência de produtos de efeitos fisiológicos no crescimento de rosa de corte 'Ambiance' no Vale do Submédio São Francisco. O experimento foi instalado em blocos casualizados, com quatro repetições e seis tratamentos: testemunha (aplicação de água); Boscalida; Piraclostrobina; mistura de Boscalida + Piraclostrobina; Fluxapiroxade + Piraclostrobina e Cinetina+$GA_3$+IBA; aplicados via foliar a cada 15 dias por 280 dias. As avaliações de crescimento foram realizadas através de avaliação de índices fisiológicos e teor de clorofila. Os resultados obtidos demonstraram que, especialmente Boscalida, tanto isolada quanto combinada à Piraclostrobina, o Fluxapiroxade + Piraclostrobina e os reguladores vegetais proporcionaram melhores respostas fisiológicas no crescimento da rosa 'Ambiance' considerando a taxa de crescimento relativo, taxa de assimilação líquida, razão de área foliar e área foliar específica. Embora o incremento médio na produção de botões florais por haste de todos os tratamentos aplicados em relação ao controle foi na ordem de 135%, nenhum dos tratamentos aplicados produziu hastes de rosas com os padrões comerciais exigidos, indicando que mais estudos são necessários para introdução adequada da cultura no Submédio do Vale do São Francisco.

**Palavras-chave**: 'Ambiance', carboxamidas, estrobilurinas, reguladores vegetais.

## 1. INTRODUCTION

The floriculture business is an important segment within the intensive horticulture, becoming an important sector and it has been explored more intensively in the southern regions of Brazil (JUNQUEIRA and PEETZ, 2008). The São Francisco Valley in the Northeastern region of Brazil is a consolidated national fruit producing area which has potential to be an agricultural frontier for the production of flowers, such as the cut rose, which has been the most commercialized flower in the world. However, considering the growth requirements of the rose bush for its ideal

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development (BARBOSA et al., 2005), i.e. temperatures between 17 to 18 ºC at night and 23 to 25 ºC during the day, it indicates that further use of technologies enabling the introduction of culture in adverse climate environments is necessary.

In terms of high light intensity and high temperatures, the rose bush may have increased photosynthetic efficiency, causing the differentiation of several vegetative buds per stem, requiring the removal of lateral buds, as well as reduction in stem length and number of petals, compromising the quality of the final product (BARBOSA et al., 2005).

In order to produce cut roses in the semi-arid region, the foliar application of products of the chemical group of strobilurins, carboxamides and anilides, as well as plant regulators, emerges as a technology that can alter the plant physiology, favoring the establishment in an adverse climate environment. Molecules such as Pyraclostrobin, Fluxapyroxad and Boscalid, besides the fungicide action, have a positive effect on the yield of the crops in which they are applied, causing possible changes in metabolism and growth, providing higher productivity, greener leaves, greater chlorophyll accumulation and better development. These effects result from the increase of liquid photosynthesis, as these products temporarily reduce the photorespiration of plants, causing less carbon consumption, leaving a favorable net energy for the plant (MUELLER and BRADLEY, 2008; RAMOS et al., 2015; MACEDO et al., 2017). On the other hand, plant regulators act by modifying plant growth and development, influencing various physiological processes (PAROUSSI et al., 2002).

Studies such as Kozlowski et al. (2009), Ramos et al. (2015), Macedo et al. (2017) and Amaro et al. (2018) demonstrated that such products can cause physiological changes, and creating a new tool to be used to increase the physiological and agronomic characteristics of several crops, modifying positively their metabolism, which may be an alternative for the viability of new crops in environments with little or no tradition in its cultivation.

Based on the context above, the objective of this work was to evaluate the physiological effects of Boscalid, Pyraclostrobin, Fluxapyroxad and plant regulators on the growth of cut rose ‘Ambiance’ cultivated in the Submedium of the São Francisco Valley.

## 2. MATERIAL AND METHODS

The study was carried out from April 2016 to January 2017, in a covered environment with a 50% shading screen. According to Köppen’s climate classification (ALVARES et al., 2014), the region is classified as BSh (dry, semi-arid and with low latitude and altitude; a dry period of nine months and rainfall concentrated from February to April, where the annual rainfall is less than 500 mm). The soil was classified as Psamment (EMBRAPA, 2013). Throughout the cultivation, temperature and relative humidity data were obtained from HOBO U12-012 Data Logger installed under the screen, while precipitation data was obtained from the meteorological station installed 500 m from the experimental area. The mean temperature recorded during the experiment under the screen was 27.8 °C, with a minimum of 15.1 °C and a maximum of 43.6 °C. The mean relative air humidity was 54%, with a minimum of 15.9% and a maximum of 97.9%, while mean precipitation was 7.0 mm, with a minimum of 0 and a maximum of 35 mm.

Seedlings of ‘Ambiance’ propagated by cutting were transplanted in single rows spaced 1.0 m between rows and 0.25 m between plants. The irrigation system consisted of drip irrigation with one emitter per plant and flow set to 3.3 L $h^{-1}$. For the fertilization regime, calcium nitrate 153 g $L^{-1}$was used weekly via fertigation and leaf fertilization 2 mL $L^{-1}$ every 15 days, according to Villas Bôas et al. (2008) and the results obtained in the soil chemical analysis, carried out 60 days before the implantation of the crop.

The experiment was arranged in randomized blocks with six treatments and four replications and 12 plants per replication, i.e. 10 useful plants and two used as border. The treatments used were: control (water application); Boscalid (0.15 g $L^{-1}$ p.c.); Pyraclostrobin (0.8 ml $L^{-1}$ p.c.); Mixture of Boscalid + Pyraclostrobin; Fluxapyroxad + Pyraclostrobin(2.5 ml $L^{-1}$); and plant growth regulator with Kinetin+$GA_3$+IBA(1 ml $L^{-1}$), compound of kinetin (0.009%), gibberellic acid (0.005%) and 4-indol-3-ylbutyric acid (0.005%).

The first treatment application occurred as 32 days after transplant (DAT) and subsequent applications occurred every 15 days for 280 days, where 0.5% of vegetable oil was added to the mix to protect against evaporation, drift or washing losses and it was used a plastic curtain to avoid drift between treatments.

During the experimental periodit was performed three prunings at 116, 172 and 228 DAT; and consisted of stripping and removal of flower buds; control of weeds through manual weeding, monitoring and control of pests and diseases.

Ten destructive evaluations were performed at 28-day intervals after transplanting. Firstly we analyzed thefoliar area ($cm^2$), obtained with the bench leaf area meter (Li-Cor ©, model LI-3100); the dry mass of the leaves and total dry mass (sum of the shoot parts), which were dried in an oven with forced air circulation at 70 ºC until reaching constant weight and later weighed in 0.01 g precision scale (Sartorious©). With these data, the following physiological indexes were determined: relative growth rate (RGR), net assimilation rate (NAR); leaf area ratio (LAR) and specific leaf area (SLA) determined according to mathematical equations proposed by Benincasa (2003). The results obtained with the mathematical equations were presented in the form of graphs, evaluating the behavior of the curves, since these do not meet the basic statistical assumptions of the analysis of variance.

The total chlorophyll index of leaves was measuredevery 28 days using an electronic chlorophyll meter (ClorofiLOG-Falker®), which uses the Falker chlorophyll index (FCI) as a unit of measurement. Three distinct leaves per repetition for the statistical evaluation were used. From the eighth growth evaluation (224 DAT until 280 DAT), it was evaluated the production of flower buds per stem in each treatment. The assessment was conducted until the end of the evaluations and the result is expressed as a sum of the evaluations.

Chlorophyll data and production of flower buds per stem were submitted to analysis of variance, with a $p < 0.05$ F test and the means were compared by the Scott-Knott test, using the statistical software SISVAR version 5.6 (FERREIRA, 2014). To make the graphs related to the physiological indexes, Sigma Plot software version 10.0.1 was used.

## 3. RESULTS AND DISCUSSION

Evaluating the relative growth rate (RGR) of rose bushes, it can be verified that in the first growth analyzes there was a rapid accumulation of dry matter, followed by a decrease in practically all treatments. This effect can be explained by the increase in respiratory activity and by the self-shading of the crop, which increases with plant age (BENINCASA, 2003) (Figure 1).

The influence of pruning on rose bush is also demonstrated in this index, since it stimulates the assimilative system for dry matter production, as can be observed when prunings occurred after 112, 168 and 224 DAT, with a decrease in RGR followed by rapid growth between pruning intervals. All treatments had similar results, except for plants treated only with Pyraclostrobin, which presented an inverse tendency to the other treatments at the end of the cycle (Figure 1).

It was also verified that plants treated with Fluxapyroxad + Pyraclostrobin, as well as those that received application of plant regulators, reached the maximum value for the RGR at 84 DAT, different behavior from the other treatments that reached at 56 DAT (Figure 1). It can be suggested that the application of these two treatments led to a delay in the development of rosebushes, which reached the same maximum RGR as the other treatments but required a greater interval of time, which may indicate that these products have a later performance in the development of the plants.

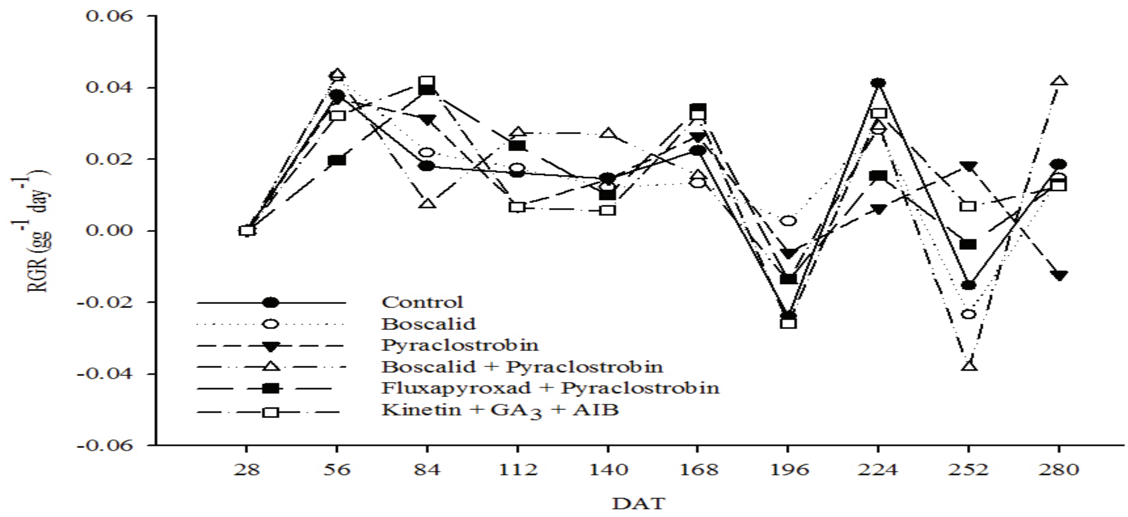


**Figure 1.** Relative growth rate (RGR) of rose bushes as a function of days after transplant (DAT) and application of physiological effects products.

The results presented in the curves of the net assimilation rate (NAR) in the rose bushes show that none of the treatments provided a relevant accumulation of dry matter per unit area and per unit of time in comparison with the control until 56 DAT (Figure 2). At 84 DAT, plants treated with Boscalid + Pyraclostrobin had a higher NAR in relation to the other treatments. At 112 DAT plant growth regulators and Pyraclostrobin showed NAR increase and, after the first pruning Fluxapyroxad + Pyraclostrobin and plant growth regulators showed positive net accumulation. Similar results were observed at 252 DAT, after the third pruning, when the treatment with Fluxapyroxad + Pyraclostrobin again showed a higher NAR than the other treatments. In general, it may be noted that the curves of the Fluxapyroxad + Pyraclostrobin are more regular for the NAR during the cycle evaluated. At 280 DAT, a similar tendencyto the RGR was observed (Figure 1), where the treatment with boscalid + pyraclostrobin obtained the highest rate, whereas only pyraclostrobin showed the greatest decrease, even in relation to the control.This effect may have been due to the dose of Pyraclostrobin applied, which may have generated additional stress for the plant and consequent lower NAR, negatively influencing the growth of the roses, since the same result was observed for RGR.

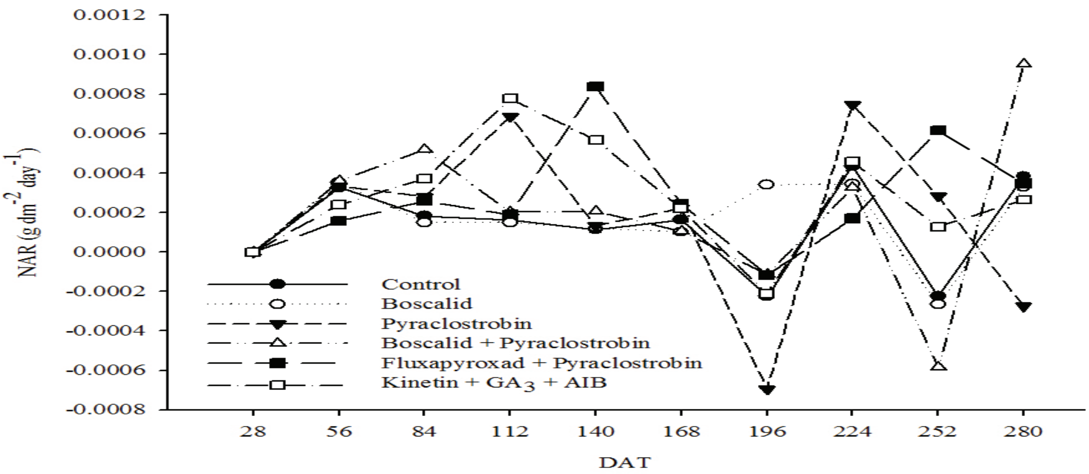


**Figure 2.** Net assimilation rate (NAR) of rose bushes as a function of the days after transplant (DAT) and the application of products with physiological effects. 2016 - 2017.

As the greater decrease in the leaf area ratio (LAR) indicates faster growth, i.e. when the curve decreases, indicates that the treatment provided faster growth to the plant and when the curve rises indicates slower growth, it can be seen for this index (Figure 3) that the control presented a high growth rate up to 56 DAT, but between 56 and 112 DAT, this treatment remained stable, indicating slower growth over that period of time. On the other hand, treatments with plant regulators presented a more pronounced growth after 56 DAT, while the treatments with boscalid alone, Boscalid + Pyraclostrobin and Fluxapyroxad + Pyraclostrobin presented a more pronounced growth only after 84 DAT, indicating that these molecules have later physiological action, when compared to other products. Similar results were reported by Campos et al. (2008) in which soybean plants treated with Kinetin+$GA_3$+IBA showed delay in initial development when compared to plants treated with other regulators.

It was also verified that at 112 DAT, when the pruning started, similar results occurred between the treatments for LAR. However, it is notorious that the roses treated with boscalid have a higher growth response after pruning, since this active principle caused greater reductions in the leaf area ratio after the second and third pruning. In the same way, it was observed that the plants that received application of the plant regulators maintained a high and continuous growth between 168 and 252 DAT, opposed to the other treatments (Figure 3).

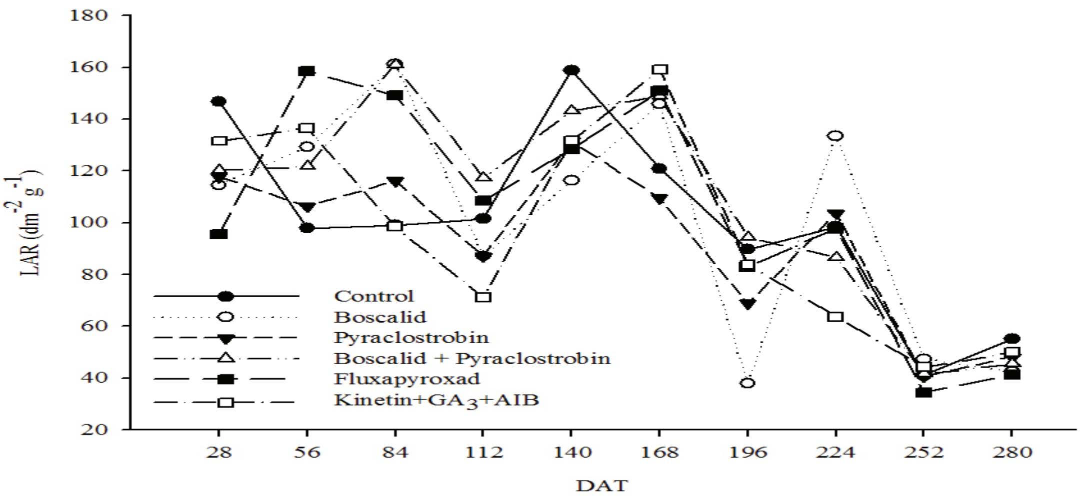


**Figure 3.** Leaf area ratio (LAR) of roses as a function of days after transplant (DAT) and the application product physiological effects. 2016 - 2017.

Regarding to specific leaf area (SLA), this represents the differences in leaf thickness, that is, it allows verifying if the plants are accumulating photoassimilates in their leaves or are translocating to other organs. In this study it was found that in the first four evaluations, all treatments acted similarly. At 140 DAT, plants that received applications of Boscalid, Fluxapyroxad + Pyraclostrobin and plant regulators were the ones with the highest leaf thickness and, the lowest thickness were observed by the control because it presented the highest SLA index. At 168 DAT, plants treated with plant regulators had a lower leaf thickness and, at 224 DAT, the plant with Boscalid application presented the lowest leaf thickness, while the plants treated with the plant regulators had the highest thickness. At the end of the experiment, all treatments presented similar results (Figure 4).

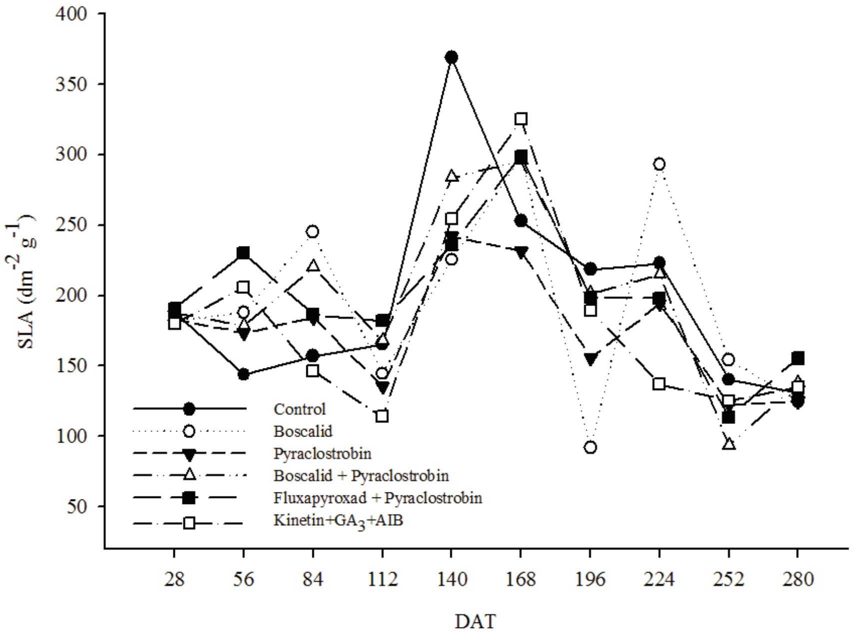


**Figure 4.** Specific leaf area (SLA) of roses a function of days after transplant (DAT) and the application product physiological effects. 2016 - 2017.

Studying the action of fungicides with physiological effects in melon plants cultivated in protected environment, Macedo (2017) observed that, for the physiological indexes of RGR, NAR, LAR and SLA, in general, the plants treated only with Boscalid or combined with Pyraclostrobin were the ones that had the best initial development, whereas the Fluxapyroxad alone as well as combined with Pyraclostrobin, were the treatments that presented more constant results, when observed the whole cycle of the culture. These resultsare corroborating with the results found in this experiment, in which the treatments with Boscalid, Fluxapyroxad, as well as the plant growth regulators were the ones that presented more benefits of rose bushes.

Positive results promoted with boscalid, Boscalid + Pyraclostrobin, Fluxapyroxad + Pyraclostrobin and plant regulators observed on rose plants growth probably may have been provided by the increase in hormone levels promoted by such substances. According to Köehle et al. (1994), auxin levels are altered by strobilurin-based substances, with an increase in the production of indolylacetic acid, which will stimulate cell elongation and division, as well as promote delay of leaf senescence and consequently increase longevity. As observed in other studies, Boscalid and Fluxapyroxad have demonstrated similar action to strobilurins in the plants to which they are applied (RAMOS et al., 2015; MACEDO et al., 2017). With the use of such substances, combined with the use of plant regulators, there may be an increase in the synthesis of hormones, which may be reflected in enhanced plant growth and development (MACEDO, 2017).

Evaluating the Falker chlorophyll index (FCI) in rose plants (Table 1), it was observed that the products tested did not interfere in this variable, when analyzed every 28 days. However, there was a variation in FCI over time, in which it was observed that from 196 to 252 DAT the plants had a higher accumulation of chlorophyll, but with no difference between the products tested and the control. This result can be related to the observed high temperatures i.e. maximum 42.3, 43.6 and 40.2 °C occurring during this period. According to Bormrmann et al. (2009) and Kerbaury (2012) the plants with C3 metabolism, such as roses, present higher photosynthetic responses at temperatures between 20 and 30 °C. When subjected to temperatures above 30 °C such plants tend to decrease the assimilation of $CO_2$, which may lead to the degradation of the chlorophyll molecule. Thus, the use of products that increase or even maintain stable chlorophyll contents in high temperatures can bring benefits to the maintenance of the photosynthetic activity of plants.

**Table 1.** Falker chlorophyll index (FCI) of cut rose 'Ambiance' cultivated with the application of physiological products via foliar spray every 15 days for 280 days.

| | Falker chlorophyll Index (FCI) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Treatments** | **28** | **56** | **84** | **112** | **140** | **168** | **196** | **224** | **252** | **280** |
| Control (water) | 44.40 aB | 40.10 aC | 48.65 aB | 50.67 aB | 48.05 aB | 48.90 aB | 58.07 aA | 59.75 aA | 58.15 aA | 37.60 aC |
| Boscalid | 37.68 aB | 41.85 aB | 45.95 aB | 49.25 aA | 45.67 aB | 42.72 aB | 52.92 aA | 58.75 aA | 58.82 aA | 36.35 aB |
| Pyraclostrobin | 38.77 aB | 42.50 aB | 51.58 aA | 48.15 aB | 43.77 aB | 41.17 aB | 53.30 aA | 62.02 aA | 58.47 aA | 39.90 aB |
| Mixture of Boscalid + Pyraclostrobin | 36.00 aC | 41.20 aC | 47.10 aB | 48.05 aB | 46.85 aB | 42.60 aC | 54.87 aA | 56.12 aA | 57.27 aA | 36.35 aC |
| Fluxapyroxad + Pyraclostrobin | 45.16 aB | 44.00 aB | 46.97 aB | 44.85 aB | 45.52 aB | 41.35 aB | 57.10 aA | 58.97 aA | 55.65 aA | 33.77 aC |
| Kinetin + $GA_3$ + IBA | 36.31 aB | 42.40 aB | 45.55 aB | 48.62 aB | 47.90 aB | 44.35 aB | 57.00 aA | 57.82 aA | 59.22 aA | 40.62 aB |
| CV (%) | 17.11 | 9.48 | 12.57 | 13.84 | 7.59 | 16.2 | 8.16 | 14.35 | 12.13 | 19.79 |

Averages followed by the same lowercase letters in the column and capital letters in the same line do not differ by the Scott-Knott test at 5% probability.

Differently from the results found here, Ramos et al. (2015), observed that at 45 DAT, tomato plants treated with Boscalid + Pyraclostrobin showed an increase in chlorophyll content and consequently greener leaves, maintaining this effect up to 96 DAT, demonstrating that these fungicides can delay the yellowing of the leaves, delaying its senescence and prolonging the photosynthetic activity. However, these results were obtained in a study developed in Southeastern Brazil, with humid subtropical mesothermal climate, while the present work with rose plants was developed in the semi-arid region, with semi-arid climate, which may result in differences in action of the products on the analyzed variables.

Campos et al. (2008) report that plants treated with plant regulators containing kinetin may have their total chlorophyll content increased or maintained. Thus, although no statistical difference was observed in the increase in chlorophyll content among treatments tested in rose plants, the applied products may have maintained the chlorophyll content needed to keep the leaves photosynthetically active longer.

From the eighth evaluation (224 DAT) the rosebushes entered the generative phase, but the flower stems did not meet the quality standard required by the national market, in which the stems and buttons did not reached the minimum size required (data not shown). However, it was observed that 'Ambiance', under the conditions of the experiment, presented a high production of flower buds per stem for all tested treatments, except for the control (6.1) (Figure 5). The average increase in production of flower buds per stem of all treatments applied in relation to the control was in the order of 135%.

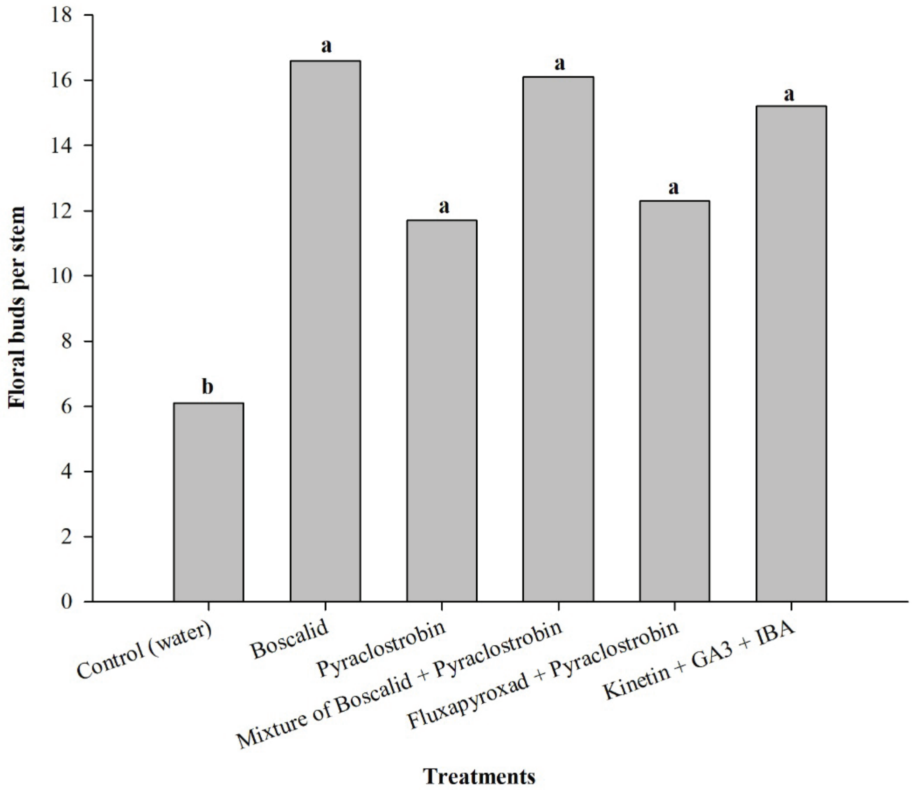


**Figure 5.** Averages of floral buds per stem in cut rose 'Ambiance' from 224 to 280 days after transplanting in each treatment. Means followed by the same letters do not differ by Scott-Knott's test at 5% probability.

For Barguil et al. (2010), the average length of the stem of the cut rose 'Ambiance' is around 56 cm, under optimal conditions for the development of the culture. Our plants did not reach this length in any of the applied treatments (data not shown). The results obtained in the experiment can be a consequence of the high temperatures recorded under the screen during the cultivation. Between November and January, when the plants were in production, diurnal temperatures ranging from 27.1 to 43.6 ºC were recorded, when the ideal for the adequate development of the crop and consequent production should be between 23 and 25 ºC (BARBOSA et al., 2005).

According to Greyvenstein et al. (2014) plants subjected to excessively high temperatures can suffer irreversible damage, compromising the growth and final quality of roses. However, despite not reaching the commercial quality of the floral stem, 'Ambiance' produced a high number of floral buds per stem, opening up to another potential for cultivating in the region, i.e. use for spray roses or mini roses, consisting of a stem with several smaller flower buds that can be used in bouquets and ornamental arrangements (KIM et al., 2009; LIVEPZ, 2009; PAIVA and ALMEIDA, 2014).

## 4. CONCLUSIONS

Based on the results obtained, it was concluded that the fungicides Boscalid, the mixture of Boscalid + Pyraclostrobin, the Fluxapyroxad + Pyraclostrobin and the plant regulators Kinetin+$GA_3$+IBA were ameliorated physiological responses on the growth of the roses 'Ambiance' compared to the control treatment in the area of study. However, none of the treatments yielded cut roses according to the present commercial standards, indicating that further studies must be carried out to properly introduce the of the culture in the region.

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