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Scientific Article

Paclobutrazol as growth regulator in Bahiagrass

Bruno Horschut de Lima[1], Patrick Luan Ferreira dos Santos[2]*, Jéssica Cristina Meira Bezerra[1], Maximiliano Kawahata Pagliarini[3], Regina Maria Monteiro de Castilho[1]

[1]Universidade Estadual Paulista (UNESP), Faculdade de Engenharia de Ilha Solteira, Departamento de Fitotecnia, Tecnologia de Alimentos e Sócio-Economia, Ilha Solteira-SP, Brazil
[2]Universidade Estadual Paulista (UNESP), Departamento de Ciência Florestal, Solos e Ambiente, Botucatu-SP, Brazil
[3]Universidade Federal da Grande Dourados (UFGD), Fazenda Experimental de Ciências Agrárias, Dourados-MS, Brazil

Abstract

Bahiagrass (*Paspalum notatum*) is a native species widely found on highways margins, however, cutting practices are necessary, which increase the maintenance cost, being an alternative, the use of growth regulators, such as Paclobutrazol. Thus, the objective of the present study was to evaluate the use of Paclobutrazol doses as growth regulator in Bahiagrass. The turf was implanted in black plastic containers (8.46 L), previously prepared with the mixture of soil + sand + organic compost (1:1:1). The experimental design was completely randomized, composed of 3 doses of Paclobutrazol [1.1 and 2.2 kg a.i. (active ingredient) ha^{-1} + control (0 kg a.i. ha^{-1})], in four applications of 2 L of syrup per container, thus forming a factorial 3x4 (doses x response time) with 3 repetitions. The fresh and dry mass, relative chlorophyll index, leaf N and the visual aspect of the green cover rate were evaluated on four different dates. It was observed that the product controlled the growth of the lawn, with less production of fresh and dry mass, and increase of the relative index of chlorophyll and concentration of leaf nitrogen; however, it decreased turfgrass density of green mass, which influenced the visual lawn aspect. Thus, Paclobutrazol controlled Bahiagrass growth at a dose of 2.2 Kg a.i. ha^{-1} in regular applications of 30 to 45 days, however it affected the density and consequently the aesthetics of the turfgrass.
Keywords: *Paspalum notatum*, visual aspect, growth reducer, triazol.

Resumo

Paclobutrazol como regulador de crescimento em grama batatais

A grama batatais (*Paspalum notatum*) é uma espécie nativa amplamente encontrada em margens de rodovias, entretanto, são necessárias práticas de corte, que acaba aumentando o custo de manutenção, sendo uma alternativa, o uso de reguladores de crescimento, como o Paclobutrazol. Assim, o objetivo do presente estudo foi avaliar o uso de doses de Paclobutrazol como regulador de crescimento em grama batatais. A grama foi implantada em contêineres de plástico preto (8,46 L), previamente preparados com a mistura de solo + areia + composto orgânico (1:1:1). O delineamento experimental foi inteiramente casualizado, composto por 3 doses de Paclobutrazol [1,1 e 2,2 kg a.i. (ingrediente ativo) ha^{-1} + controle (0 kg a.i. ha^{-1})], em quatro aplicações de 2 L de calda por contêiner, formando assim um fatorial 3x4 (doses x tempo de resposta) com 3 repetições. Foram avaliados em quatro diferentes datas, a massa fresca e seca, índice relativo de clorofila, N foliar e o aspecto visual da taxa de cobertura verde. Observou-se que o produto controlou o crescimento do gramado, com menor produção de massa fresca e seca, e aumento do índice relativo de clorofila e concentração de nitrogênio foliar, contudo, acabou diminuindo a densidade de massa verde da grama, o que influenciou o aspecto visual da grama. Com isso, conclui-se que o Paclobutrazol controlou o crescimento da grama batatais, na dose de 2,2 Kg i.a. ha^{-1} em aplicações regulares de 30 a 45 dias, contudo afetou a densidade e consequentemente a estética do gramado.
Palavras-chave: *Paspalum notatum*, aspecto visual, redutor de crescimento, triazol.

*Corresponding author: patricklfsantos@gmail.com

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Introduction

Bahiagrass (*Paspalum notatum*) is a grass species native of South America, including Brazil, which highlights for its aesthetics, functionality and rusticity (Amaral and Castilho, 2012; Steiner et al., 2017; Souza et al., 2020a). With leaves concentrated in the basal part of plant, it easily covers the ground, being used in green areas and embankments along road margins, which protects soil against erosion, as its surface rhizomes and roots intertwine, managing to retain the soil (Marchi et al., 2016; Antoniolli, 2019; Souza et al., 2020a). It is resistant to water deficit and well adapted to soils with low fertility. However it requires frequent maintenance in relation to pruning in periods of rain and intense heat, and therefore, there may be an increase in cost of constant management (Amaral and Castilho, 2012; Marchi et al., 2016; Santos and Castilho, 2018).

However, most lawns formed by this grass are the result of planting by "pieces" collected manually in degraded pasture areas because the commercial availability of this species is scarce (Souza et al., 2020a). Thus, there is a need to search for information about it for use on highways, urban avenues, or airport runways (Souza et al., 2020b). In recent years, research on Bahiagrass has gained prominence to be used for this purpose (Souza et al., 2016; Silva et al., 2018; Maximino et al., 2017; Souza et al., 2020b) and recently being launched commercial cultivars of *Paspalum notatum* registered by EMBRAPA (Brazilian Agricultural Research Corporation) (Souza et al., 2020a).

According to Souza et al. (2020b) it is essential that *Paspalum* species, when used as vegetation cover, have slower vertical growth, to reduce pruning need. Marchi et al. (2016) states that 5 to 7 mowing operations are necessary for Bahiagrass during its main growing season (summer), and Chaer (2015) mentions that in vegetation areas such as highways, it is estimated that the concessionaires performed up to 15 annual pruning. Thus, an alternative to reduce cutting operations would be the use of growth regulators, which has been shown to be an option for mechanical handling (March et al., 2013).

Plant regulators are gaining importance in lawn management programs, as they suppress vegetative growth without impairing their visual quality and without promoting phytointoxication, discoloration or leaves thinning (McElroy, 2012; March et al., 2013; Gazola et al., 2019). However, there are no registered products for lawns in Brazil for this purpose (Dias et al., 2019; Gazola et al., 2019). An alternative would be the use of Paclobutrazol, which is a regulator already studied and registered for other crops such as mango, tomato (Syngenta, 2019), and registered for turfgrass in the European Union (Semillas Fitó, 2010) and in the USA (McElroy, 2012).

Paclobutrazol acts on the synthesis route of gibberellins, and interferes in phase 2, that is, it blocks the action of the enzyme Kaurene Oxidase, which inhibits the conversion of kurene into kaurenol and, consequently, prevents the formation of any type of gibberellin as well as cellular elongation, creating compact leaf (McElroy, 2012; March et al., 2013; Glab et al., 2020). When applied directly to the soil or substrate, it has greater activity and efficiency compared to foliar application, as it is translocated almost exclusively by xylem and less by phloem, where it is absorbed by the roots and moved directly to the growth points (McCarty, 2008; Blank et al., 2009).

Studies on Brazilian conditions for growth control in Bahiagrass have been published in recent years (Marchi et al., 2016; Marchi et al., 2017; Barbosa et al., 2017; Dias et al., 2019), however none of them use Paclobutrazol as a growth regulator. In this context, the objective of the present study was to evaluate the use of Paclobutrazol doses as growth regulators in Bahiagrass.

Material and Methods

The experiment was conducted in the Northwest region of São Paulo state, in full sun, from September 2019 to February 2020 (average temperature of 28 ºC, average relative humidity of 72.8%). For planting the lawn, the Bahiagrass came from the experimental area of the University where the experiment was carried out, and it was harvested in the form of «plates». And was implanted in black plastic containers (47.5 x 17.5 cm top dimensions, 41.5 x 11.3 cm bottom dimensions, height of 15.5 cm, volume 8.46 L), previously prepared with a mixture of soil + sand + organic compost (1:1:1); height standardization cut was also performed, and the green mass obtained was discarded. After implantation, fertilization was performed with formulated 13-5-13, using 20 g diluted in 2 L of water per container. Weed control was performed whenever necessary manually, and irrigation was daily with 2 L of water per container, done in late afternoon, using a watering can.

Twenty-two days after planting, the installation of the experiment began, being applied 3 doses of Paclobutrazol (in 4 regular applications ranging from 22 to 28 days), and evaluated the product response time on 4 different dates, thus forming a factorial 3x4 (doses x response time) with 3 repetitions. For doses, Paclobutrazol was diluted in two concentrations being 1.1 and 2.2 kg a.i. (active ingredient) ha^{-1} + control (0 kg a.i. ha^{-1}), applied 2 L of syrup per container, directly on the substrate, as product is absorbed by roots (McCarty, 2008; Blank et al., 2009). The Paclobutrazol application dates were 0, 28, 55 and 78 days after the installation of the experiment (DAIE). All applications being performed in the morning presented data of relative humidity and temperature of 23.5 ºC, 61.7%; 31.0 ºC, 55.5%; 28.1 ºC, 70.7%; 28.0 ºC, 78.5%, respectively on each application date.

For the response time of Paclobutrazol on the lawn, evaluation was carried out 28, 55, 78 and 132 DAIE, being they: fresh and dry leaf mass; relative chlorophyll index (RCI); green coverage rate and leaf nitrogen content. For fresh and dry leaf mass, the material was collected manually, using scissors to remove all leaves from treatments. Thus, after mowing, turfgrass clippings were stored in a Kraft paper bag and weighed to obtain fresh mass. After that, they were allocated in a forced circulation oven, 60°C for 72 hours and again weighed to obtain the dry mass. The RCI was realized with the manual chlorophyll meter (atLEAF), being collected in 3 points per experimental plot, measured

in the middle third of leaves. For green coverage rate, the treatments were photographed, with a 12 Mp camera, at a distance of 1 m; these images were analysed using the Canapeo™ software to obtain green coverage rate of the turfgrass. It was also evaluated the leaf nitrogen content and was done by using methodology described by Malavolta et al. (1997).

The collected data were subjected to analysis of variance and, subsequently, the average were compared by the LSD test at 5% of significance using SISVAR program (Ferreira, 2019).

Results and discussion

Results demonstrate for fresh mass that there was statistically significant difference between Paclobutrazol applied doses, and it was observed that the highest concentration (2.2 kg a.i. ha^{-1}) managed to reduce growth at 28 and 55 DAIE, differing from control. At 78 and 132 DAIE, doses of the product differed from the treatment without application, inferring that there is greater effect of Paclobutrazol, when applied constantly at regular intervals.

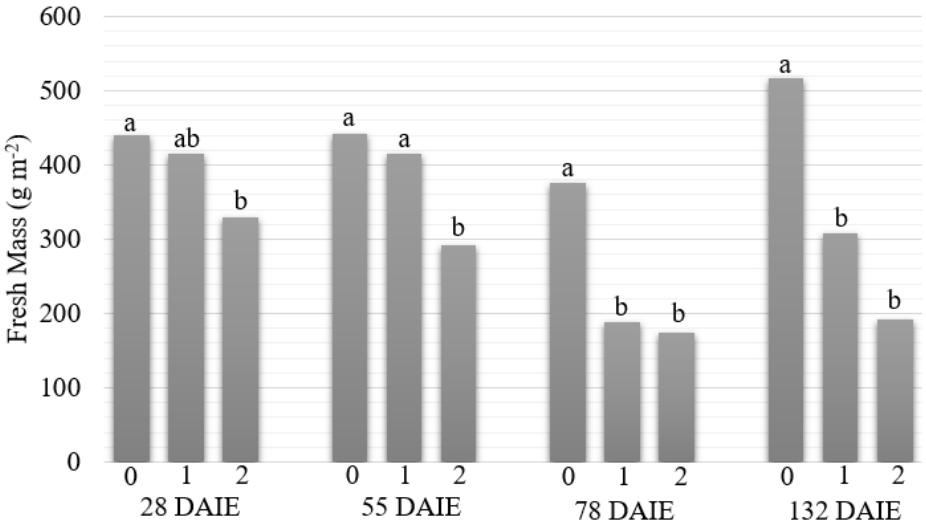

Figure 1. Fresh mass of Bahiagrass clippings after Paclobutrazol application at different evaluated times. Doses were: 0 – 0 kg a.i. ha^{-1} (control); 1 – 1.1 kg a.i. ha^{-1} and 2 – 2.2 kg a.i. ha^{-1}. DAIE: days after the installation of the experiment.

The fact of this reduction has occurred, is probably by execute mechanism of Paclobutrazol action, which acts in phase 2 of gibberellin synthesis root. Active ingredient blocks action performs of Kaurene Oxidase enzyme preventing formation of any gibberellin type (March et al., 2013; Glab et al., 2020), and thus, formation of the most compact leaf and, consequently, the lowest lawn growth (McElroy, 2012).

In absolute values, it is noted that for all evaluated dates (Figure 1), the greatest reduction was at treatment 2.2 kg a.i. ha^{-1}, where the decrease in growth was 25.35%; 33.90%; 53.67% and 62.79% at 28, 55, 78 and 132 DAIE, respectively. The drop in mass production increases over time, when the application of product is constant. Mass reduction was also reported up to 91% in 'Patriot' Bermuda grass (*Cynodon dactylon* x *C. transvaalensis*) after 4 weeks after Pacloburazol application (Volterrani et al., 2015), and 86% in 'TifEagle' (*C. dactylon* x *C. transvaalensis*) (McCullough et al., 2004) after two applications, values higher than those of the present study.

In the same way, as there was fresh mass reduction after Paclobutrazol application (Figure 1), there was also decreased in dry mass (Figure 2), where 2.2 kg a.i. ha^{-1} showed less growth, following the results of fresh mass. According to Santos and Castilho (2018), lower dry mass production decreases the need for mowing, which is recommended for species such as Bahiagrass. These results reported, therefore, the action of Paclobutrazol in the species as the product is indicated in the USA and the European Union for some turfgrass of warm climate such as Bermuda grass (*Cynodon* spp), Emerald grass (*Zoysia japonica*) and Saint Augustine grass (*Stenotaphrum secundatum*) (McCarty, 2008; Semillas Fitó, 2010).

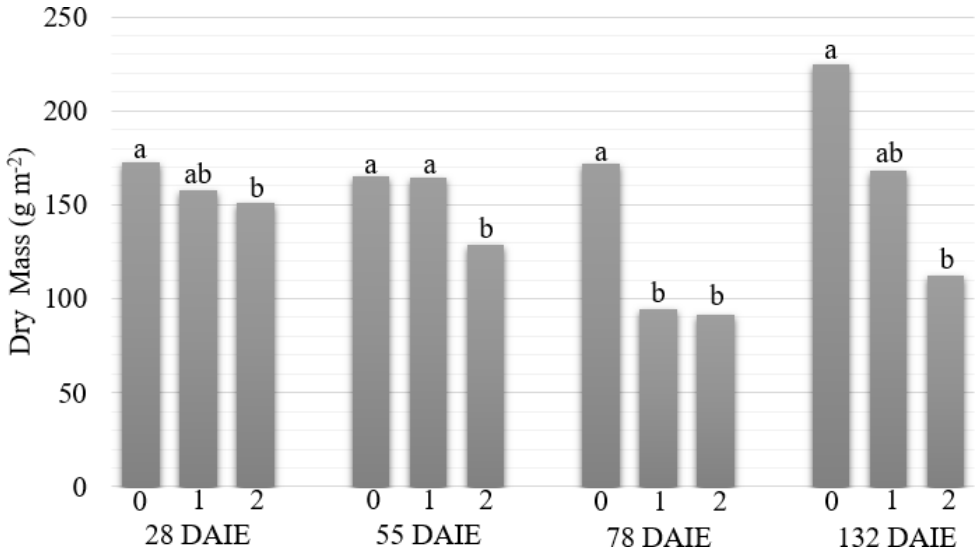

Figure 2. Dry mass of Bahiagrass clippings after Paclobutrazol application at different evaluated times. Doses were: 0 – 0 kg a.i. ha^{-1} (control); 1 – 1.1 kg a.i. ha^{-1} and 2 – 2.2 kg a.i. ha^{-1}. DAIE: days after the installation of the experiment.

On the other hand, other growth regulators such as Trinexapac-ethyl in different doses had no effect on reducing dry mass for studied species (Marchi et al., 2017), as well as Prohexadione-calcium in split applications (Marchi et al ., 2016). When a product is used as a growth regulator, it is essential that it does not decrease leaf chlorophyll concentration (Gazola et al., 2016), as this will affect the turfgrass physiological processes, as well as green colour characteristic (Santos et al., 2019), and the relative chlorophyll index (RCI) results demonstrate this fact (Figure 3).

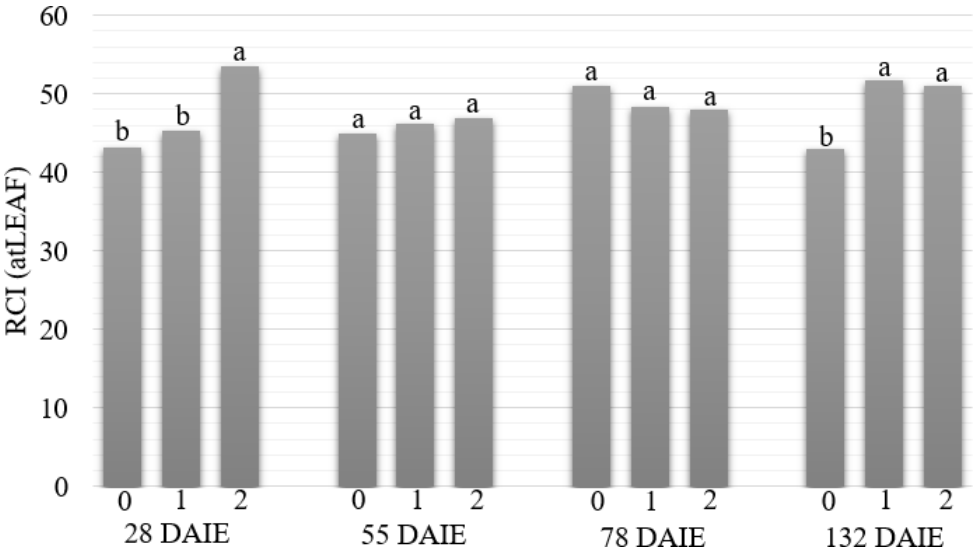

Figure 3. Relative chlorophyll index (RCI) of Bahiagrass after Paclobutrazol application at different evaluated times. Doses were: 0 – 0 kg a.i. ha^{-1} (control); 1 – 1.1 kg a.i. ha^{-1} and 2 – 2.2 kg a.i. ha^{-1}.
DAIE: days after the installation of the experiment.

It was observed that at 28 and 132 DAIE were the only dates where the RCI showed statistical difference between treatments, while at 55 and 78 DAIE doses did not differ between them. Thus, these results show that Paclobutrazol did not affect RCI and even in some cases, such as at 28 and 132 DAIE it provided chlorophyll increase. According to Brito et al. (2016), Paclobutrazol causes chlorophylls concentration in a smaller volume in cells, due to product preventing cell elongation, and consequent leaf development, which was observed visually, and is also inferred at fresh mass (Figure 1). In addition, it stimulates endogenous cytokines biosynthesis, maximizing

chloroplast differentiation, chlorophyll biosynthesis and delaying its degradation (D'Arêde et al., 2017). The results of the present study were close to those found by Amaral and Castilho (2012) in Bahiagrass from 39.67 to 49.60 atLEAF, when converting the values to the same unit.

The results of the present study still demonstrate that leaf N increased with the Paclobutrazol application (Figure 4), thus indicating a small relationship between RCI and leaf N, as also reported by Santos and Castilho (2015) and Oliveira et al. (2018) in Emerald grass and by Santos et al. (2019) in Bermuda grass. This is because chlorophylls are magnesian porphyrins composed of a central atom of Mg linked to another four atoms of N (Taiz et al., 2017). In addition, the leaf N values for the dose 2.2 kg a.i. ha^{-1} differed to all evaluated dates from control, indicating that the product did not interfere with plant nutritional status and increased N concentration. For both applied Paclobutrazol doses, the values were higher than those found by Amaral and Castilho (2012) in an experiment with fertilization of Bahiagrass (9.7 to 14.12 g kg^{-1}).

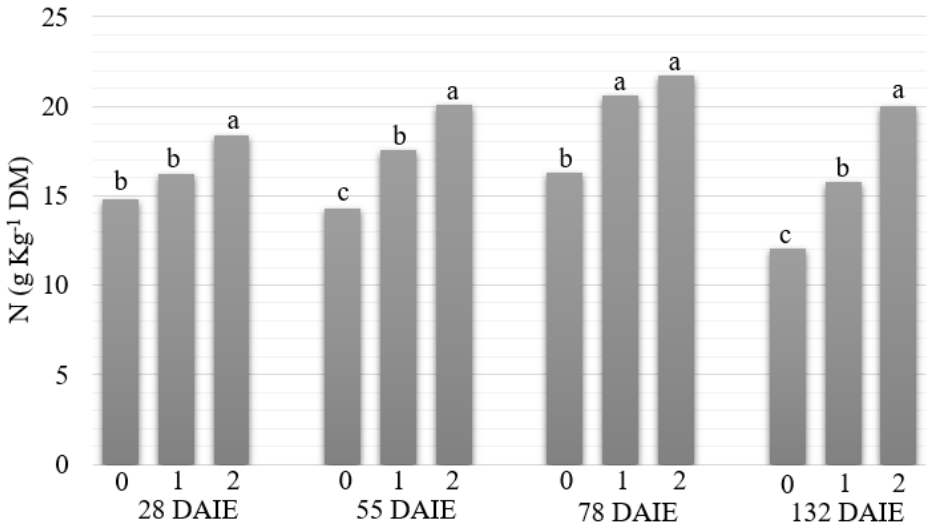

Figure 4. Nitrogen (N) content in leaves of Bahiagrass after Paclobutrazol application at different evaluated times. Doses were: 0 – 0 kg a.i. ha^{-1} (control); 1 – 1.1 kg a.i. ha^{-1} and 2 – 2.2 kg a.i. ha^{-1}. DAIE: days after the installation of the experiment.

For Bahiagrass green coverage rate after paclobutrazol application, it was observed that at 2.2 kg a.i. ha^{-1} showed lower density (Figure 5). This fact is because Bahiagrass has only rhizomatous growth, presenting superficial rhizomes (Souza et al., 2020a), and thus does not form an extremely dense lawn, where Paclobutrazol application exposed the rhizomes decreasing grass leaves density.

At 78 and 132 DAIE it was observed that the green coverage rates were low, being less than 50%, showing that after each cut, the surface rhizomes are increasingly exposed, and when using Paclobutrazol, this exposure is more visible, and the visual aspect highlights this fact (Figure 6).

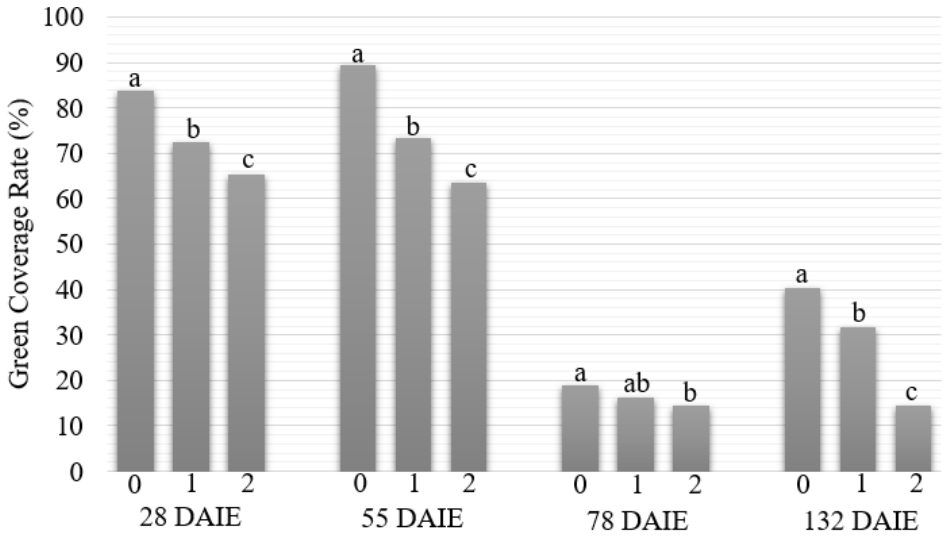

Figure 5. Green coverage rate of Bahiagrass after Paclobutrazol application at different evaluated times. Doses were: 0 – 0 kg a.i. ha^{-1} (control); 1 – 1.1 kg a.i. ha^{-1} and 2 – 2.2 kg a.i. ha^{-1}. DAIE: days after the installation of the experiment.

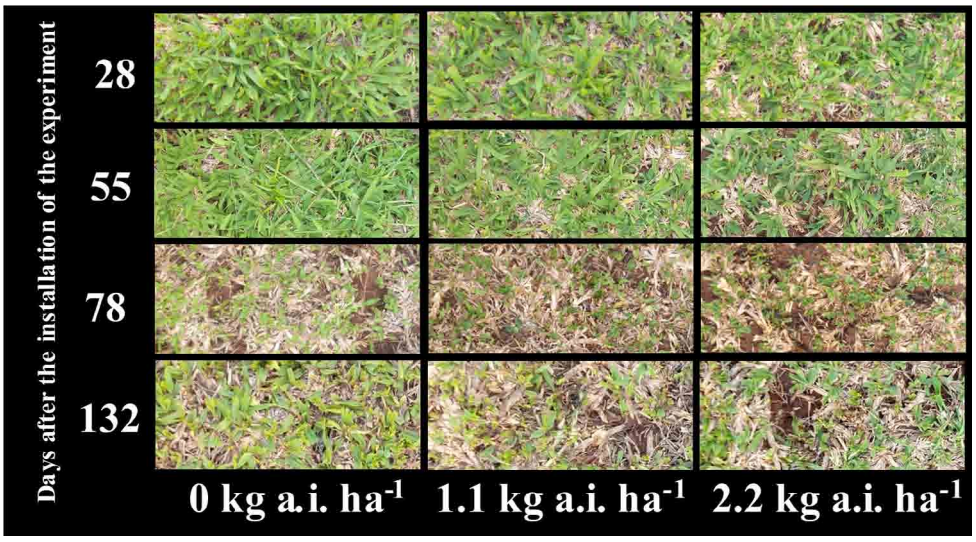

Figure 6. Visual aspect of Bahiagrass after Paclobutrazol application at different evaluated times. Doses were: 0 – 0 kg a.i. ha^{-1} (control); 1 – 1.1 kg a.i. ha^{-1} and 2 – 2.2 kg a.i. ha^{-1}.

The visual quality of species is essential for product acceptance as growth regulator (Gazola et al., 2019), especially on highways margins, where the importance of green lawns has been emphasized, as they are pleasant to drivers' eyes (Affonso and Freitas, 2003). However, in the present study, Paclobutrazol application interfered in coverage rate, regardless of dose used, being higher in the dose after 78 DAIE (Figure 5). As previously described, Bahiagrass only has rhizomatous growth, presenting superficial rhizomes, (Souza et al., 2020a), and thus does not form an extremely dense lawn such as Emerald grass and Bermuda grass, which has rhizomatous and stoloniferous growth (Santos et al., 2019; Gazola et al., 2019). Thus, by creating a more compact leaf, the application of Paclobutrazol ends up causing the turfgrass to leave its rhizomes exposed, which reduces the green density of the lawn. Dias et al. (2019) also observed reduction in green visual quality of Bahiagrass after application of glyphosate as growth regulator from the dose of 45 g a.e. (acid equivalent) ha^{-1}.

According to Gazola et al. (2016), when growth regulator is used on lawns, it is essential that it does not impair aesthetics, such as green colour characteristic and coverage rate (closed, flawless lawn). However, in the present study, from 78 DAIE, the great lack of green mass in all treatments is clear (Figure 6), as all leaves were cut for

analysis and the lawn did not have time for full recovery, inferring that turfgrass mowing height might be high to not damage the aesthetics.

Sampaio (2012) recommends not cutting more than 1/3 of the lawn during maintenance, and for Bahiagrass author suggests maintaining the leaf height of 3-6 cm, precisely to avoid this exposure of surface rhizomes.

Thus, Paclobutrazol can be a great option to be used as a regulator and growth in Bahiagrass, to reduce the need for mechanical mowing and consequently the cost of the operation. However, the use of the product must be associated with the correct management of the lawn, observing important issues, such as regular applications of the regulator and mowing at the ideal height so as not to interfere with the aesthetics of the turfgrass.

Conclusion

Paclobutrazol controlled Bahiagrass (*Paspalum notatum*) growth with dose of 2.2 kg a.i. ha^{-1} in regular applications of 30 to 45 days, however it affected the density and consequently the aesthetics of the turfgrass.

Author contribution

B.H.L.: Idea of the experiment, field analysis, data collection and analysis, interpretation of data. **P.L.F.S.**: Critical review, analysis and interpretation of data, approval of the final version. **J.C.M.B.**: Field analysis, data collection and analysis. **M.K.P.**: Critical review and translation. **R.M.M.C.**: Critical review, analysis and interpretation of data, approval of the final version, work advisor.

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