

EFFECT OF PLANT REGULATORS ON GROWTH AND FLOWERING OF 'MEYER' ZOYSIAGRASS¹

Efeito de Reguladores Vegetais sobre o Crescimento e o Florescimento de Grama-Esmeralda

MARCHI, S.R.², MARTINS, D.³, COSTA, N.V.⁴, and SILVA, J.R.V.⁵

ABSTRACT - This trial aimed to evaluate the effect of sequential applications of different plant regulators over growth and flower rachis emission of 'Meyer' zoysiagrass (*Zoysia japonica*). The study was conducted on 15-month old green turfgrass under a randomized complete block design with four replications. The following plant regulator and doses were tested: trinexapac-ethyl (113+113, 226+113, 226+226, 452+113, 452+226, 452+452, 678+339 e 904+452 g a.i./ha⁻¹), prohexadione-calcium (100+100 e 200+200 g a.i. ha⁻¹) and bispyribac-sodium (40+40 e 60+60 g a.i. ha⁻¹), as well as an untreated control. The turfgrass was mowed again at 3.0 cm aboveground and the second plant regulator was applied when 'Meyer' zoysiagrass was between 5.0 and 6.0 cm high. The effect of the treatments was visually rated for visual injury, plant height, height and number of flower rachis, and total dry mass production of clippings. Only bispyribac-sodium had visual symptoms of injury on 'Meyer' zoysiagrass, and no intoxication was observed at 28 days after the second application (DAAB). The sequential applications of trinexapac-ethyl, prohexadione-calcium and bispyribac-sodium reduced by more than 80% the total clipping dry mass produced by 'Meyer' zoysiagrass. All the plant regulators tested also showed promising results in reducing the height and emission of rachis, especially when trinexapac-ethyl was applied at the doses 452+452, 678+339 and 904+452 g a.i. ha⁻¹. 'Meyer' zoysiagrass turfgrass can be handled with the sequential application of a plant regulator, which reduces the need for mowing over a period up to 110 days after the application of the second plant regulator, and it also avoids deleterious visual effects over turfgrass.

Keywords: *Zoysia japonica*, trinexapac-ethyl, prohexadione-calcium, bispyribac-sodium, sequential application.

RESUMO - Este trabalho teve o propósito de avaliar o efeito da aplicação sequencial de diferentes reguladores vegetais sobre o crescimento e a emissão de hastes florais da grama-esmeralda (*Zoysia japonica*). O estudo foi instalado em um gramado com 15 meses, no delineamento de blocos casualizados com quatro repetições, e os reguladores de crescimento e doses testados foram: trinexapac-ethyl (113+113, 226+113, 226+226, 452+113, 452+226, 452+452, 678+339 e 904+452 g i.a. ha⁻¹), prohexadione-calcium (100+100 e 200+200 g i.a. ha⁻¹) e bispyribac-sodium (40+40 e 60+60 g i.a. ha⁻¹), além de uma testemunha sem aplicação de regulador de crescimento. Quando os tratamentos atingiram altura entre 5,0 e 6,0 cm, o gramado foi novamente aparado a 3,0 cm de altura, sendo em seguida realizada a aplicação da segunda dose dos reguladores. O efeito dos tratamentos foi avaliado quanto à fitointoxicação, por meio de avaliação visual, altura de plantas, altura e emissão de hastes florais e produção de massa seca de aparas. Apenas o bispyribac-sodium apresentou sintomas visuais de injúria, não se verificando mais intoxicação aos 28 dias após a segunda aplicação (DAAB). As aplicações sequenciais do trinexapac-ethyl, prohexadione-calcium e bispyribac-sodium apresentaram reduções acima de 80% na quantidade total de massa seca de aparas produzidas pela grama-esmeralda. Todos os reguladores de crescimento também demonstraram

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² Eng^a. Agr^a., Prof., Dr., Universidade Federal de Mato Grosso – UFMT, Avenida Governador Jaime Campos, 6390 – Barra do Garcas-MT, 78600-000, <sidneimarchi.ufmt@gmail.com>; ³ Eng^a. Agr^a., Prof., Dr., Faculdade de Ciências Agrônomicas – FCA/UNESP, Dep. de Produção Vegetal-Agricultura, Fazenda Experimental Lageado, s/n, Caixa Postal 237, 18610-307 Botucatu-SP; ⁴ Eng^a. Agr^a., Prof., Dr., Centro de Ciências Agrárias, Universidade Estadual do Oeste do Paraná, Caixa Postal 91, 85960-000 Marechal Cândido Rondon-PR; ⁵ Eng^a. Agr^a., Dr., Syngenta Proteção de Cultivos Ltda., Avenida das Nações Unidas, 18001 – 2^a andar, 04795-900 São Paulo-SP.



ser promissores em relação ao retardamento do crescimento e da emissão das inflorescências, com especial destaque para o trinexapac-ethyl aplicado nas doses de 452+452, 678+339 e 904+452 g i.a. ha⁻¹. Gramados formados com grama-esmeralda podem ser manejados com a aplicação sequencial de regulador vegetal, com a redução da necessidade de cortes por um período de até 110 dias após a aplicação, além de não causar efeito deletério no aspecto visual sobre o gramado.

Palavras-chave: *Zoysia japonica*, trinexapac-ethyl, prohexadione-calcium, bispyribac-sodium, aplicação sequencial.

INTRODUCTION

Good turfgrass maintenance provides a safe and comfortable place for leisure and sports activities, reduces air heating, releases oxygen and captures atmospheric CO₂, thus mitigating the greenhouse effect, and it also reduces the exposure of the soil to erosion. Turfgrass can be used for different purposes in different locations, such as residential areas, industrial and urban areas, slopes and hillsides and road beds. However, it is best used in sports activities, especially in soccer, golf and baseball fields.

There are dozens of species and varieties of grass for various purposes (Arruda & Henriques, 1995). The most used in Brazil are: Bahia Grass (*Paspalum notatum*), American carpet grass (*Axonopus compressus*) St. Augustine grass (*Stenotaphrum secundatum*), Korean Velvet grass (*Zoysia tenuifolia*), Bermudagrass (*Cynodon dactylon*) and, particularly, 'Meyer' zoysiagrass (*Zoysia japonica*). 'Meyer' zoysiagrass, originally from Japan, is also known as wild zoysia, zoysia grass or simply zoysia. It is a herbaceous rhizomatous creeping perennial grass. It ranges in height from 10 to 15 cm, and it has narrow and small leaves arranged in short and thick stems. It looks like a perfect lawn when mown frequently (Lorenzi & Souza, 2001).

One of the advantages of using 'Meyer' zoysiagrass is the formation of a beautiful lawn at intermingling of penetrating stolon which roots easily. It has great beauty, tender leaves and resistance to trampling; it is the most versatile type of grass (Alvarez & Henriques, 1995). However, regardless of the type of use or the choice of species, the major expenditure in the cost of turfgrass maintenance is the use of mowing to maintain proper height (Freitas et al., 2002). The successive mowing operations on the turfs are basically related

to plant growth and grass flowering, especially between October and March (Kissmann & Groth, 1992).

Turfgrass leaves are expected to grow up to a certain limit, beyond which the lower leaves are subject to self-shading and become chlorotic, acquiring yellowish spots after mowing. Another factor that changes the visual quality of turfgrass is the intense flower stem emission, which usually has shades of colors that differ from the color of leaves. Moreover, both the leaves as the flower stems can reach excessive heights, which affect the practice of sports and the comfort of users.

Thus, expenditures on successive mowing operations as well as aesthetic appeal call for alternatives to mechanical management, and one of them is to use plant growth regulators. The use of growth regulators is a common practice in the management of several species of grass in the United States, especially Type I regulators, i.e., inhibitors of cell division, such as mefluidide and maleic hydrazide, and Type II regulators, which are inhibitors of cell elongation, such as trinexapac-ethyl, paclobutrazol and prohexadione-calcium (McCullough et al. 2004; Ervin & Zhang, 2007). Particularly, Type II regulators are compounds able to modify the concentration of hormones in plants and to promote smooth expansions of leaf area and the development of side structures without incurring undesirable increases in the top growth of grass species (McCullough et al. 2004).

However, growth regulators can produce some undesirable effects if not used carefully. The occurrence of visual injury, thereby changing the visual quality of the turf, is often reported. Leaf injury varies according to environmental conditions: in temperate regions, dark green spots are observed (Ervin & Koski, 2001; Heckman et al., 2005; McCullough et al., 2006), while discoloration

characterized by yellowing leaves is seen in tropical regions (Heckman et al., 2001, McCullough et al., 2005, McCarty et al., 2011).

Besides reducing plant growth, Type I growth regulators are also effective in suppressing floral emissions. In contrast, Type II inhibitors are ineffective in suppressing the emission of flower stems (Johnson, 1990; Fry, 1991; Mittlesteadt et al. 2009).

Low-dose single applications usually result in low levels of injury associated with short periods of growth control in height and reduction of inflorescence. In contrast, high doses provide better results for longer periods, but with higher levels of injury. This imbalance between efficiency and injury can be solved with sequential applications involving well-adjusted doses (Fagerness & Yelverton, 2000; Lickfeldt, et al., 2001, McCarty et al., 2004; Waltz Jr. & Whitwell, 2005; Ervin & Zhang, 2007; McCullough et al., 2007).

Thus, this study aimed to verify the effect of the sequential application of different doses of growth regulators trinexapac-ethyl, prohexadione-calcium and bispyribac-sodium on growth and flowering of 'Meyer' zoysiagrass.

MATERIAL AND METHODS

The study was conducted in the experimental area of the Center for Advanced Research in Weed Science - NuPAM, Department of Plant Production, owned by the Faculty of Agricultural Sciences of Botucatu/UNESP, whose geographic coordinates are: 22°07'56" S latitude and 74°66'84" W longitude, and altitude of 760 meters. The turf, approximately 15 months old, was formed from 'Meyer' zoysiagrass in area which received overhead irrigation. The soil was classified as a red Alfisol, clayish texture, moderate degree, dystrophic (Embrapa, 2006). After application of 2.6 t ha⁻¹ lime, a chemical analysis revealed the characteristics shown in Table 1.

Table 1 - Attributes for chemical characterization of the soil in the experimental area in the layer of 0-200 mm

pH CaCl ₂ (0,01 mol L ⁻¹)	C org. (g kg ⁻¹)	P (mg kg ⁻¹)	Ca	Mg	K	Al	H+Al	CTC	V	Fe ₂ O ₃ (g kg ⁻¹)
5.9	15	12	27	13	9.6	0.3	32.9	82.9	60	176



During development, the turf was kept at an average height of 3.0 cm aboveground by successive mowing with an engine-powered mechanical mower, equipped with a rotary cutting blade and a special device to collect clippings.

The treatments, shown in Table 2, were arranged in a randomized complete block design with four replications. The total area of each plot was 1.5 m wide and 2.5 m long, totaling 3.75 m². Besides the control plot, a strip of 0.5 m² was maintained along the experimental blocks as lateral control, so that the injury caused by growth regulators could be better monitored.

Applications were made with a CO₂ pressurized backpack sprayer containing a bar with two flat spray tips VS TP 80.02, interspaced at 50 cm. The entire assembly was maintained at a constant pressure of 2.0 bar, so that the solution volume was equivalent to 200 L ha⁻¹.

Table 2 - Growth regulators and doses used in the first and second applications on 'Meyer' zoysiagrass

Treatment	Dose (g i.a.ha ⁻¹)		
	1 st Application	2 nd Application ^{1/}	Total
1. trinexapac-ethyl	113	113	226
2. trinexapac-ethyl	226	113	339
3. trinexapac-ethyl	226	226	452
4. trinexapac-ethyl	452	113	565
5. trinexapac-ethyl	452	226	678
6. trinexapac-ethyl	452	452	904
7. trinexapac-ethyl	678	339	1017
8. trinexapac-ethyl	904	452	1356
9. prohexadione-calcium	100	100	200
10. prohexadione-calcium	200	200	400
11. bispyribac-sodium	40	40	80
12. bispyribac-sodium	60	60	120
13. Control	-	-	-

^{1/} Second application when the average height of the treated area was between 5 and 6 cm in height.

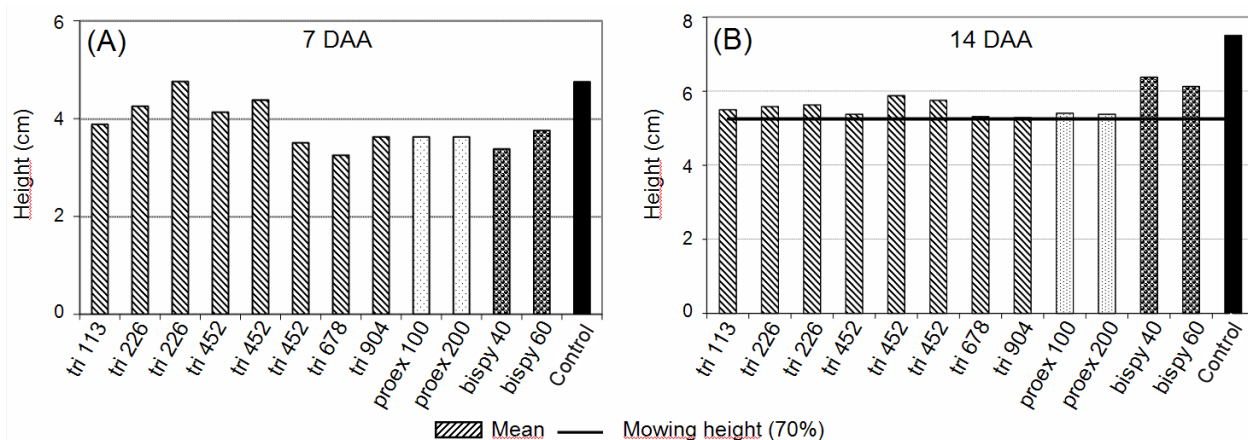


Figure 1 - Graph of the average height of 'Meyer' zoysiagrass obtained at 7 (A) and 14 (B) days after the first application (DAA) of growth regulators.

The first application was made at the end of November, with partly cloudy skies, air temperature of 26.3 °C, relative air humidity of 69% and wind gusting to 9.0 km h⁻¹, SE direction. During application, the plots were protected laterally with screens of plastic canvas, in order to avoid spraying the regulators onto adjacent parcels. Altogether, the experiment was conducted from November to early May – a period favorable to plant and reproductive growth of 'Meyer' zoysiagrass in the area where the study was undertaken.

When the treatments ranged between 5.0 and 6.0 cm in height, the turf was mowed to approximately 3.0 cm, and then the second dose of growth regulators was applied. The clippings were collected, placed in paper bags and maintained in a forced air circulation incubator at 65 °C to achieve constant dry mass for dry matter determination.

Ratings of injury and growth reduction were made weekly until mid-April, at which time both the control and the treated areas showed no change in height over time because of the decrease in temperature and length of daylight, phenomena which are typical of fall in the region where the study was conducted.

The injuries caused by the treatments were visually rated according to a scale of 0% - 100%, where 0 represents no injury and 100 represents plant death. The reduction in growth was assessed by direct measurement of plant height with a ruler graduated in

centimeters. Height and number of inflorescences were measured by sampling an area of 0.25 m² in the center of the plots, before the turf was mowed for reapplication, and also at the end of the trial period, in order to obtain the total dry mass of clippings (TDMC), which is represented by the sum of the dry mass of both clippings. The results were submitted to analysis of variance by the F-test; in case of significance, the means were compared by Tukey's test at 5% probability.

RESULTS AND DISCUSSION

Figure 1A shows the average heights of 'Meyer' zoysiagrass evaluated at seven days after application of the regulators (DAA), when it was observed that none of the treatments had reached a height of 5.0 cm, and at 14 DAA, when height ranged between 5.0 and 6.0 cm in all the treatments where regulators had been applied (Figure 1B), thus allowing for mowing and application of the second dose.

The resumption of growth in height is a common event for most tropical grasses. This is because non-structural carbohydrates like glucose, fructose, sucrose and starch can be stored and used as backup energy for stress tolerance, dormancy recovery and regrowth after shoot removal (Waltz Jr. & Whitwell, 2005). In this study, the rapid resumption of growth in height was due, especially, to the redistribution of nonstructural carbohydrates that were stored in the rhizomes and stolons

of 'Meyer' zoysiagrass immediately after the leaves were mowed for application of growth regulators (McCarty et al., 2004; Waltz Jr. & Whitwell, 2005; Ervin & Zhang, 2007; McCullough et al., 2007). It should be noted that single doses of Type II growth regulators promote not only the obvious reduction in the concentration of gibberellins, but also an increase in the total chlorophyll b in the leaves up to two weeks after application. Thus, the leaves are more efficient at capturing light energy, and, hence higher CO₂ fixation and higher production of non-structural carbohydrates occur (Ervin & Koski, 2001; Ervin & Zhang, 2007).

In Table 3, it can be seen that none of the treatments involving trinexapac-ethyl and prohexadione-calcium caused injuries on leaves of 'Meyer' zoysiagrass at 7, 21 and 28 days after the second application (DAAB).

The second application of bispyribac-sodium at 40 and 60 g a.i. ha⁻¹ resulted in injuries of 56 and 59%, respectively, at 7 DAAB. These injuries were characterized by yellowing of leaves - a characteristic symptom of ALS inhibiting herbicides. However, the levels of injury regressed considerably in the evaluation performed at 21 DAAB, with full recovery of turf coloring at 28 DAAB (Table 3).

The use of type II growth regulators generally provides visual symptoms of phytotoxicity when applied in grams (Heckman, et al. 2001; McCullough et al. 2005; McCarty et al. 2011), a similar effect caused by the use of ALS inhibiting herbicides (McDonald et al. 2006).

Some research has shown that the deleterious effects of injury caused by trinexapac-ethyl and bispyribac-sodium may be rapidly reversed with the use of an additional source of iron or nitrogen, which play an important role in the formation of chlorophyll, which gives back the grass leaves their green coloring (Johnson, 1997, Zhang et al. 2002; Ervin et al. 2004; McDonald et al. 2006). In this study, the rapid recovery of 'Meyer' zoysiagrass is probably associated with the high amount of iron available in the experimental area, given that the chemical analysis revealed a content of 176 g kg⁻¹ of iron oxide (Fe₂O₃).

Plant growth of 'Meyer' zoysiagrass was significantly modified by growth regulators, and the effects on plant height extended up to 110 days after the second application period. The assessments were discontinued at 110 days after second application because the plant development stays stabilized on control treatment as a result of weather and season conditions (temperature and luminosity decreased). It should be noted that the entire period between the first application of growth regulators and the final evaluation comprised 124 days.

Table 4 shows that trinexapac-ethyl was the main regulator of the development of 'Meyer' zoysiagrass, because all the doses applied were able to reduce plant height, regardless of when the rating was made. Height growth was reduced by more than 53%, compared to the growth observed in the control, even when the lowest sequential dose was used: 113 +113 g a.i. ha⁻¹.

The trinexapac-ethyl doses in sequential applications of 452+226, 452+452, 678+379 and 904+452 g i.a ha⁻¹ were the most effective

Table 3 - Means of the signs of injury observed in 'Meyer' zoysiagrass after the second application of growth regulators

Treatment	Injury (%) - DAAB ^{1/}		
	7	21 ^{2/}	28
trinexapac-ethyl 113+113	0 a	1.0 a (0)	0
trinexapac-ethyl 226+113	0 a	1.0 a (0)	0
trinexapac-ethyl 226+226	0 a	1.0 a (0)	0
trinexapac-ethyl 452+113	0 a	1.0 a (0)	0
trinexapac-ethyl 452+226	0 a	1.0 a (0)	0
trinexapac-ethyl 452+452	0 a	1.0 a (0)	0
trinexapac-ethyl 678+339	0 a	1.0 a (0)	0
trinexapac-ethyl 904+452	0 a	1.0 a (0)	0
prohexadione-calcium 100+100	0 a	1.0 a (0)	0
prohexadione-calcium 200+200	0 a	1.0 a (0)	0
bispyribac-sodium 40+40	56 b	1.3 a (1)	0
bispyribac-sodium 60+60	59 b	3.8 a (4)	0
Control	0 a	1.0 a (0)	0
F Treatment	803.07*	1.66 ^{NS}	-
F Block	0.55 ^{NS}	1.20 ^{NS}	-
DMS	3.82	1.50	-
CV (%)	17.23	47.93	-

^{1/} DAAB = days after the second application. ^{2/} Means transformed to $\sqrt{Y+1.0}$. Original means between brackets. NS - non-significant. * significant at 5% probability. Means followed by the same letter in the column do not differ by the Tukey's test at 5% probability.



Table 4 - Mean height values of 'Meyer' zoysiagrass obtained after the second application of the growth regulators

Treatment	Grass height (cm) – DAAB ^{1/}						Reduction (%) ^{2/}
	7	14	21	28	63	110	
trinexapac 113+113	3.0 A	3.0 a	3.3 a	3.4 A	4.0 ab	4.8 ab	64.7
trinexapac 226+113	5.6 A	5.9 ab	6.0 ab	6.0 Abc	6.4 abc	6.3 ab	53.6
trinexapac 226+226	3.0 A	3.1 a	3.2 a	3.3 A	3.8 ab	4.3 a	73.6
trinexapac 452+113	3.1 A	3.3 a	3.2 a	3.3 A	4.2 ab	4.3 a	68.4
trinexapac 452+226	3.0 A	3.0 a	3.2 a	3.3 A	3.3 a	3.6 a	73.5
trinexap 452+452	3.0 A	3.0 a	3.6 a	3.6 A	3.7 ab	3.6 a	73.5
trinexapac 678+339	5.0 A	5.1 ab	5.2 ab	5.3 Abc	5.5 abc	5.3 ab	61.0
trinexapac 904+452	4.2 Ab	4.5 ab	4.5 ab	4.5 Ab	4.5 ab	4.6 ab	66.2
prohexadione 100+100	6.4 B	7.5 bc	7.9 b	8.0 C	9.8 cd	10.4 bc	23.5
prohexadione 200+200	3.2 A	3.5 a	3.6 a	4.0 Ab	5.9 abc	7.4 b	45.6
bispyribac 40+40	3.3 A	5.3 ab	6.2 ab	6.8 BC	7.6 abc	7.9 b	41.2
bispyribac 60+60	3.0 a	5.2 ab	6.1 ab	6.2 Abc	7.4 bc	7.5 b	44.8
Control	10.8 c	11.1 c	12.0 c	13.6 D	13.8 d	13.6 c	-
F Treatment	12.14*	9.04*	21.96*	21.60*	11.70*	18.38*	-
F Block	3.96*	6.30*	11.52*	11.71*	13.87*	9.93*	-
DMS	3.22	3.89	3.50	3.11	4.32	3.08	-
CV (%)	29.50	31.83	26.30	22.49	27.82	21.49	-

^{1/} DAAB = days after the second application. ^{2/} reduction calculated as compared to the control. NS – non-significant. * significant at 5% probability. Means followed by the same letter in the column do not differ by the Tukey's test at 5% probability.

in retaining the vertical growth of 'Meyer' zoysiagrass, since an increase of only 0.3 cm was observed between the assessments at 7 and 110 days after the second application. It should be noted that the increases found in other sequential applications of trinexapac-ethyl ranged between 0.7 and 1.8 cm (Table 4).

The prohexadione-calcium used in the sequential application of 200+200 g a.i. ha⁻¹ was effective in reducing the vertical growth of 'Meyer' zoysiagrass at 63 DAAB, while bispyribac-sodium at the doses of 40+40 and 60+60 g a.i. ha⁻¹ reduced the height of 'Meyer' zoysiagrass only until 28 DAAB (Table 4). Although these three treatments have shown statistically lower height than that of the control throughout the trial period, it was observed that the height of 'Meyer' zoysiagrass obtained at 110 DAAB was almost twice as much as the one observed at 7 DAAB, representing a 43% reduction compared with the height of the control.

In contrast, calcium-prohexadione in sequential applications of 40+40 g a.i. ha⁻¹ was virtually ineffective for retaining the vertical

growth of 'Meyer' zoysiagrass, providing only a 23.5% reduction in the height of the turf, and thus statistically similar to the height of the control in most of the assessments made (Table 4). The reduction in top growth observed in 'Meyer' zoysiagrass corroborates the data obtained by Ervin et al. (2002), Beam (2004) and Costa et al. (2009). Additionally, Ervin et al. (2002) commented that the sequential application of trinexapac-ethyl is a management practice of *Z. japonica*, especially in areas with low light condition.

Table 5 shows that only the prohexadione-calcium applied in the sequential dose of 100+100 did not reduce inflorescence height, which was statistically similar to the control. All other treatments showed significant reductions in the height of inflorescences, with special emphasis on the highest doses of trinexapac-ethyl (452+452, 678+339 and 904+452 g a.i. ha⁻¹), which showed statistically lower heights than the one obtained in the control.

Johnson (1994) suggests that for a growth regulator to be commercially acceptable, it must reduce the emission of the flower

Table 5 - Mean values of height and number of inflorescences and total dry mass of clippings (TDMC) produced by 'Meyer' zoysiagrass at 110 days after the second application of growth regulators

Treatment	Inflorescence ^{1/}			TDMC	
	Height (cm)	Number (m ⁻²)	% ^{2/}	(g m ⁻²)	% ^{2/}
trinexapac 113+113	2.8 (8.6) ab	3.9 (17.0) a	90.1	115.8 a	86.5
trinexapac 226+113	1.9 (3.3) ab	2.8 (11.3) a	93.4	128.4 a	85.0
trinexapac 226+226	2.2 (3.8) ab	4.7 (26.2) a	84.7	125.9 a	85.3
trinexapac 452+113	2.2 (3.9) ab	5.9 (40.0) a	76.7	128.0 a	85.1
trinexapac 452+226	1.9 (2.5) ab	2.5 (6.3) a	96.3	134.9 a	84.2
trinexapac 452+452	1.7 (2.4) a	2.7 (7.5) a	95.6	131.6 a	84.6
trinexapac 678+339	1.7 (2.4) a	3.1 (11.3) a	93.4	129.2 a	84.9
trinexapac 904+452	1.6 (2.2) a	3.8 (21.4) a	87.5	99.6 a	88.4
prohexadione 100+100	3.3 (10.1) b	8.3 (67.8) ab	60.1	151.9 a	82.3
prohexadione 200+200	2.2 (4.6) ab	5.4 (43.0) a	74.9	136.8 a	84.0
bispyribac 40+40	2.6 (5.9) ab	8.1 (66.1) ab	61.4	165.9 a	80.6
bispyribac60+60	2.4 (5.1) ab	6.7 (46.0) a	73.2	153.2 a	82.1
Control	3.3 (10.2) b	13.1 (171.5) b	-	856.2 b	-
F Treatment	2.13*	6.67*		29.15*	
F Block	0.85 ^{NS}	0.30 ^{NS}		18.09*	
DMS	1.51	5.85		186.14	
CV (%)	27.80	43.63		37.77	

^{1/} Means transformed to $\sqrt{Y+1.0}$. Original means between brackets. ^{2/} Reduction calculated as compared to the control. NS – non-significant. * significant at 5% probability. Means followed by the same letter in the column do not differ by the Tukey's test at 5% probability.

stem by more than 70%. The total number of inflorescences was also significantly reduced for most doses of plant growth regulator evaluated, with a reduction rate above 74%. Only prohexadione-calcium at 100+100 g a.i. ha⁻¹ and sodium-bispyribac at 40+40 g a.i. ha⁻¹ were not efficient because the number of inflorescences was similar to the control and reduction of emission of the flower stems around 60%. Several studies point out that the application of trinexapac-ethyl may retard and/or reduce the emission of inflorescences and prolong the visual appearance aesthetics of the turf without the need for a new mowing (Johnson, 1990; Fry, 1991; Costa et al., 2009; Mittlesteadt et al., 2009).

The literature cites that type II growth inhibitors used in turfs, such as trinexapac-ethyl and prohexadione-calcium are ineffective in suppressing the emission of flower stems because they interfere in the biosynthesis of gibberellins and, thus, reduce cell elongation (Johnson, 1990; Fry, 1991; Mittlesteadt, 2009). However, the large

reductions in the emission of flower stems observed in this study probably result from the physiological changes caused by sequential applications of growth regulators (Ervin & Zhang, 2007).

The production of total dry mass (TDMC) of clippings of 'Meyer' zoysiagrass was markedly reduced by growth regulators studied, since all the sequential applications produced significantly lower amounts of clippings than the control. The lowest amount of clippings was observed in plants where trinexapac-ethyl is used in a sequential dose of 904+452 g a.i. ha⁻¹, representing a yield of 99.9 g m⁻² over a period of almost 124 days. It should be noted that reductions in TDMC were above 80%, regardless of the regulator used, which can represent the same rate of reduction in the need for mowing (Table 5).

Beam (2004) observed a direct correlation between increasing dose sequential prohexadione-calcium (140 +140, 270 +270, 410 +410, 540 +540, 670 +670 g a.i. ha⁻¹) and percentage reduction in dry matter clippings



produced by the 'Meyer' zoysiagrass. This author also says that mass reductions were equivalent to sequential applications of trinexapac-ethyl commercially recommended for each species.

Ervin & Ok (2001) and Ervin et al. (2002) reported reductions of 35 to 75% in the amount of grass clippings produced by 'Meyer' zoysiagrass when trinexapac-ethyl was applied. Using sequential applications of trinexapac-ethyl at 55.6+55.6 and 113+113 g a.i. ha⁻¹, Costa et al. (2009) found reductions from 49.2 to 55.6%, respectively, in the production of dry mass of 'Meyer' zoysiagrass.

Fagerness & Yelverton (2000) explained that a single application of trinexapac-ethyl at 107 g a.i. ha⁻¹ caused a 40% reduction in the production of tissues in Tifway bermudagrass. However, the researchers reported that the triple sequential application of trinexapac-ethyl and 71 g a.i. ha⁻¹ presents a clear advantage in reducing the tissues produced, as compared to the double sequential application of the 107 g a.i. ha⁻¹ dose.

It can be concluded that sequential applications of trinexapac-ethyl, prohexadione-calcium and sodium-bispyribac proved promising as regards the retardation of vegetative growth and inflorescence emission, thus contributing in the management of turfs, because it reduces the need for mowing for a period up to 110 days after the sequential application of the growth regulator, and avoids the deleterious effect on the visual appearance aesthetics of 'Meyer' zoysiagrass.

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