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# Tifton 419' Bermudagrass (*Cynodon dactylon* × *C. transvaaliensis*) response to plant grow inhibitors

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**Abstract**

'Tifton 419' bermudagrass cultivar [*Cynodon dactylon* (L.) Pers. × *C. transvaalensis* Burtt-Davy] is the most preferred turfgrass for sportive, commercial and residential lawns. On similar species, such as *Stenotaphrum secundatum* and *Zoysia japonica*, gibberellic acid–inhibiting plant growth regulators (PGRs) are used to decrease mowing frequency. A very limited research has been reported yet on the PGRs regarding seasonal effects of single vs. multiple applications of these products on turfgrass quality and clipping production on South America. This study aimed to evaluate the effect of sequential applications of different plant growth inhibitors during re-growth and flower rachis emission of 'Tifton 419' Bermudagrass. The treatment pattern includes an initial application followed by one sequential application at 14 days intervals, according to the following: prohexadione-calcium at 100+100 or 200+200 g a.i. $ha^{-1}$, bispyribac-sodium at 40+40 or 60+60 g a.i. $ha^{-1}$, trinexapac-ethyl at 113+113, 226+113, 226+226, 452+113, 452+226, 452+452, 678+0 or 904+0 g a.i. $ha^{-1}$, and untreated control. The treatment effect was evaluated based on measurements of visual injury, height of plants, height and number of flower rachis, and clipping total dry mass production. The results showed that only bispyribac-sodium provided visual injury on 'Tifton 419' Bermudagrass, but the symptoms quickly tend towards zero at 21 days after second application (DASA). 'Tifton 419' Bermudagrass greens could be better handle by sequential application of trinexapac-ethyl, or prohexadione-calcium or bispyribac-sodium, once the height of plants, seedhead emission and total clipping dry mass reduction were over than 37%, 91% and 88%, respectively, for a period up to 60 DASA.

**Keywords:** Bispyribac-sodium; *Cynodon dactylon*; Prohexadione-calcium; Sequential application, Trinexapac-ethyl.
**Abbreviation:** PGR_plant growth regulator; g a.i. $ha^{-1}$_grams of active ingredient per hectare, DASA_days after second application, TCDM_total clippings dry mass; C org._organic carbon, CV_coefficient of variation.

## Introduction

Some of the most important perennial grasses of the world are components of the *Cynodon* genus, which integrates the Chlorideae family. The most widely important grasses of this genus are those known as 'Common Bermudas', represented by the species *Cynodon transvaalensis* Burtt-Davy, *Cynodon magenissii* Hurcombe, and *Cynodon dactylon* (L.) Pers. These grasses have originated in Africa then rapidly spread all over the American continent due to its possibility of being used as a forage crop and also for ornamental or sports purposes (Qu and Chaudhury, 2001). In general, these three species may be used for industrial plants courtyard, highway margins, and polo fields.

The hybrid Bermudagrases in comparison with the common ones are more resistant to diseases, the leaves have higher density, the coloration is more uniform, the plants emit a lower number of flower rachides, and the leaves surface is of a finer and smoother texture (Kojoroski-Silva et al., 2011). The hybrids Bermudagrases were obtained from the cross between *Cynodon dactylon* (36 n) x *Cynodon transvaalensis* (18 n), resulting hybrids having 27n chromosomes. One of the most famous varieties to be released was 'Tifton 419', which is nowadays the most widely cultivated Bermudagrasses hybrid.

'Tifton 419' Bermudagrass is characterized by a fine texture, giving origin to a dead and none decomposed material known as 'thatch' or 'mattress' (Turgeon, 2000). It is well adapted to high temperatures, and drought stress (Kojoroski-Silva et al., 2011). It has been for more than 40 years as a preferred one for sportive fields due to its smoothness and high visual quality (Guertal and Hicks, 2008). 'Tifton 419' Bermudagrass needs intensive care to keep its quality (Trenholm et al, 1999). It does not tolerate shaded areas and requires high nutrients and moisture on soil due to its high growth ability and potential consumption. It does not grow well in areas of poor drainage or in compacted soils. It is also susceptible to low temperatures, in which becomes brown color (dormancy beginning) when growing under temperatures up to 8 °C (Fagerness et al., 2004).

The main factor influencing the preservation of its quality is exactly the frequency, in which this grass is mowed. Several researchers maintain that the vertical cutting of the 'Tifton 419' Bermudagrass stimulates the emission of new stolons and the plant horizontal growth, and helps to prevent the formation and accumulation of 'thatch' (Turgeon, 2000; Qu and Chaudhury, 2001; McCullough et al., 2004; McCullough et al., 2006; Kojoroski-Silva et al., 2011).

But, the plant vigorous growth demands its cutting at weekly intervals or sometimes daily intervals. The high frequency which the cuttings are made keeps the lawn high quality but it also means the removal of nutrients simultaneously with the removal of the clippings. However, the succeeding cutting operations, mainly during the spring and summer months, become the main cost factor to preserve lawns of 'Tifton 419' Bermudagrass. These costs and the tiring operations of heaping up and transporting the clippings outside the field are the main cause for the search of techniques allowing reducing the number of cutting operations (Fagerness and Yelverton, 2001; Liu and Huang, 2002; McCullough et al., 2004). Another important factor affecting the lawn field visual aspect is the intense flower rachis emission. The seedhead usually has a color, somewhat different from the leaves, which results in a sort of displeasing coloration. In addition, leaves and seedhead may reach considerable heights and this makes sports practice more difficult, less comfortable, and less appealing to sports fans (Marchi et al., 2013a).

A possible solution for the problems arising from plant cutting is the use of plant growth regulators (PGRs). This is already a common practice in lawn management in the USA, especially PGRs of Type II witch acts by inhibiting gibberellic acid production and consequently the cell division. Trinexapac-ethyl, prohexadione-calcium, and paclobutrazol are examples of that type of PGR (McCullough et al., 2004; Ervin and Zhang, 2007).

However, PGRs may have some undesirable effects when managed without due care, where bad visual results are frequently reported as injury leaf. Leaf injuries vary according to environmental conditions. The leaf dark green stains is common under temperate climatic conditions (Ervin and Koski, 2001; Heckman et al., 2005; McCullough et al, 2006) and leaf yellowing are frequent under tropical conditions (Heckman et al., 2001; McCullough et al, 2005a; McCarty et al., 2011).

Single application of PGR at lower doses results in lower levels of injury and short control periods of growth and seedhead emission. In contrast, the higher doses result in higher control ability and periods of plant growth but increase the injury levels substantially. This conflicting situation between efficiency and injury is likely to be solved by the sequential applications of more adjusted PGR doses (Fagerness and Yelverton, 2000; Lickfeldt et al., 2001; McCarty et al., 2004; Waltz Jr. and Whitwell, 2005; Ervin and Zhang, 2007; McCullough et al., 2007; Wherley and Sinclair, 2009). Our study seeks to evaluate the effect of sequential application of different plant growth inhibitors during re-growth and flower rachis emission of 'Tifton 419' Bermudagrass.

## Results and Discussion

### *Grass injury*

All rates of trinexapac-ethyl and prohexadione-calcium were safe to Tifton 419 Bermudagrass plants since the damage levels caused were lower than 4% seven days after second application (7 DASA) and practically disappeared at 14 DASA (Table 3).

The second application of bispyribac-sodium at 40 and 60 g $ha^{-1}$ resulted in visual damages close to 10% as observed in the evaluation done at 7 DASA. The injuries where characterized by leaves yellowing, symptom similar to those frequently caused by ALS inhibiting herbicides. The initial symptom though tended to disappear rapidly. It was practically absent at 14 DASA and completely absent at the 21 DASA (Table 3).

Type II plant growth inhibitors usually cause toxicity symptoms when applied to grasses (Heckman et al., 2001; McCarty et al., 2011; McCullough et al., 2005a) as well as ALS inhibitors herbicides.

Some research works have shown that the deleterious effects of trinexapac-ethyl and bispyribac-sodium may be quickly reverted by an additional supplying of either iron or nitrogen to the plants which are important in chlorophyll synthesis so that the plants recover their original green color (Marchi et al., 2013a; Zhang et al., 2002; Ervin et al., 2004). In this study, the quick recovery of Tifton 419 Bermudagrass plants is related to the high level of iron [176 g $kg^{-1}$ of iron oxide ($Fe_2O_3$) - Table 1] in the soil, where the experiment was conducted.

### *Grass height*

The vegetative growth of Tifton 419 Bermudagrass plants was significantly inhibited by growth regulators and the effects on plant height lasted up to 60 DASA. After that period, the evaluations were called off since plant growth had stabilized due climatic modifications such as temperature and luminosity reductions. It is important to point out that the period of time between the first applications of plant growth regulators and the final evaluation was 74 days (Table 4).

The sequential application of trinexapac-ethyl at 452 + 226, 452 + 452 g a.i. $ha^{-1}$ and bispyribac-sodium at 60 + 60 g a.i. $ha^{-1}$ were the most effective in blocking the vertical growth of Tifton 419 Bermudagrass plants. The measurements at 7 and 60 days after the second application showed differences lower than 1.8 cm. It is necessary to add that the height increments resulting from the other treatments were between 2.1 and 3.3 cm, while the difference obtained on untreated plants were 3.6 cm (Table 4).

Trinexapac-ethyl at sequential applications of 113 + 113 and 452 + 113 g a.i. $ha^{-1}$, bispyribac-sodium at the rate of 40 + 40 g a.i. $ha^{-1}$ efficiently controlled Tifton 419 Bermudagrass plants growth only up to 21 DASA. In addition, the highest plant height (7.5 cm) among the plant growth regulators was obtained on the same three treatments at 60 DASA, meaning a reduction of 37% in comparison with the height of the untreated plants (Table 4). The single rate of trinexapac-ethyl at 678 or 904 g a.i. $ha^{-1}$ and prohexadione-calcium at sequential application of 100 + 100 and 200 + 200 g a.i. $ha^{-1}$ resulted in intermediate reductions, in which the treated plants grew approximately 40% less than those of the untreated plants (Table 4).

Although no significant differences was found in plant height between treatments (products and rates), all of them resulted in statistically significant reductions in plant height in comparison with the plants of the untreated check during the whole experimental period (Table 4).

Tifway Bermudagrass [*Cynodon dactylon* X *Cynodon transvaalensis*] plants was inhibited for a period of two and four weeks when trinexapac-ethyl was applied at single rates of 71 and 108 g a.i. $ha^{-1}$, respectively. The sequential application of trinexapac-ethyl at 107+107 g a.i. $ha^{-1}$ protracted the inhibition period to seven weeks while the triple application of 71 g a.i. $ha^{-1}$ extended the inhibition

**Table 1.** Soil chemistry characteristics at 0-200 mm depth band Table 1.

| pH $CaCl_2$ | C org. | P | Ca | Mg | K | Al | H+Al | CTC | V | $Fe_2O_3$ |
|---|---|---|---|---|---|---|---|---|---|---|
| (0.01 mol $L^{-1}$) | g $kg^{-1}$ | mg $kg^{-1}$ | -------------------mmol$_c$ $kg^{-1}$------------------- | | | | | | % | g $kg^{-1}$ |
| 5.9 | 15 | 12 | 27 | 13 | 9.6 | 0.3 | 32.9 | 82.9 | 60 | 176 |

**Table 2.** Growth inhibitors and rates used in the first and second applications on 'Tifton 419' Bermudagrass.

| Treatment | Rates (g a.i. $ha^{-1}$) | | |
|---|---|---|---|
| | 1st Application | 2nd Application\1 | Total |
| Trinexapac-ethyl | 113 | 113 | 226 |
| Trinexapac-ethyl | 226 | 113 | 339 |
| Trinexapac-ethyl | 226 | 226 | 452 |
| Trinexapac-ethyl | 452 | 113 | 565 |
| Trinexapac-ethyl | 452 | 226 | 678 |
| Trinexapac-ethyl | 452 | 452 | 904 |
| Trinexapac-ethyl | 678 | 0 | 678 |
| Trinexapac-ethyl | 904 | 0 | 904 |
| Prohexadione-calcium | 100 | 100 | 200 |
| Prohexadione-calcium | 200 | 200 | 400 |
| Bispyribac-sodium | 40 | 40 | 80 |
| Bispyribac-sodium | 60 | 60 | 120 |
| Untreated | 0 | 0 | 0 |

\1 – Second application at 14 days interval after the first.

**Table 3.** Means of the signs of injury observed in Tifton 419 Bermudagrass after the second application of growth inhibitors.

| Treatment | Injury[a] (%) – DASA[b] | | | | |
|---|---|---|---|---|---|
| | 7[c] | | 14[c] | | 21 |
| Trinexapac-ethyl 113+113 | 2,1 (3,8) | b | 1,4 (1,3) | ab | 0 |
| Trinexapac-ethyl 226+113 | 1,0 (0,0) | a | 1,0 (0,0) | a | 0 |
| Trinexapac-ethyl 226+226 | 1,0 (0,0) | a | 1,0 (0,0) | a | 0 |
| Trinexapac-ethyl 452+113 | 1,0 (0,0) | a | 1,0 (0,0) | a | 0 |
| Trinexapac-ethyl 4521+226 | 1,0 (0,0) | a | 1,0 (0,0) | a | 0 |
| Trinexapac-ethyl 452+452 | 1,0 (0,0) | a | 1,0 (0,0) | a | 0 |
| Trinexapac-ethyl 678 | 1,0 (0,0) | a | 1,0 (0,0) | a | 0 |
| Trinexapac-ethyl 904 | 1,4 (1,3) | ab | 1,1 (0,3) | a | 0 |
| Prohexadione-calcium 100+100 | 1,0 (0,0) | a | 1,0 (0,0) | a | 0 |
| Prohexadione-calcium 200+200 | 1,0 (0,0) | a | 1,0 (0,0) | a | 0 |
| Bispyribac-sodium 40+40 | 3,2 (9,8) | c | 1,7 (2,5) | ab | 0 |
| Bispyribac-sodium 60+60 | 3,3 (10,0) | c | 2,0 (3,0) | b | 0 |
| Untreated | 1,0 (0,0) | a | 1,0 (0,0) | a | 0 |
| F Treatment | 17,71* | | 3,82* | | - |
| F Block | 0,95$^{NS}$ | | 0,38$^{NS}$ | | - |
| DMS | 1,01 | | 0,83 | | - |
| CV (%) | 27,68 | | 28,40 | | - |

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.
a – DASA = days after the second application.
b – Means transformed to $\sqrt{Y+1.0}$.
c - Original means between brackets.

period to ten weeks (70 days) (Fagerness and Yelverton, 2000).

Trinexapac-ethyl at 17. 33 and 50 g a.i. $ha^{-1}$ applied to plants of Dwarf Bermudagrass (*Cynodon dactylon x C. transvaalensis*) at intervals of one, two, and three weeks during a three month period, added 25 cm to the distance that a golf ball could roll over the lawn in comparison with the check treatment. According to the authors, the shorter distance the ball could roll over the check plants was due to their higher vertical growth (McCullough et al., 2007).

***Seedhead height and number***

Table 5 shows that all plant growth regulators and rates were capable of significant reductions in height and number of seedhead at 60 DASA. The lowest inflorescence heights (1.9 cm) were attained when bispyribac-sodium and trinexapac-ethyl were sequentially applied at 60-60g a.i. $ha^{-1}$ and at 226 + 113 g a.i. $ha^{-1}$, respectively, or when trinexapac-ethyl was applied at single rate of 678 g a.i. $ha^{-1}$, which represented plant height reductions above 77%, compared to untreated plants.

The inflorescence emission was not totally inhibited by the plant growth regulators. On the other hand, the number of inflorescences resulting from all treatments was lower than 50 per square meter, a value significantly lower than that of the untreated, which is around 570 inflorescences per square meter (Table 5).

Several research works highlight the fact that the application of trinexapac-ethyl may retard or reduce the emission of inflorescences and prolong the visual aspect of the lawn without the need of further plant cuttings

(Mittlesteadt, 2009; Costa et al., 2009). The sequential application of trinexapac-ethyl on TifEagle Bermudagrass (*Cynodon dactylon* x *Cynodon transvaalensis*) caused 81% reduction in seedhead emission when three rates equivalent to 50 g a.i. $ha^{-1}$ were applied at weekly intervals (McCullough et al., 2007). Seedhead emissions reductions above 76% were registered in *Zoysia japonica* when two different rates of trinexapac-ethyl were sequentially applied at 14 day intervals (Marchi et al., 2013b).

A commercially acceptable plant growth regulator should be capable of reducing seedhead emission of at least 70% (Johnson, 1994). In this experiment, the reduction in head flower emission, using plant growth regulators, was larger than 91%, compared to check treatment (Table 5).

Plant growth inhibitors of the type II, such as trinexapac-ethyl and prohexadione-calcium, usually applied to lawns, are not efficient to suppress seedhead emission because they interfere with the biosynthesis of gibberellins and consequently with the reduction of cellular elongation (Mittlesteadt, 2009; Marchi et al., 2013b). But, the high reductions in inflorescence emission observed in this experiment are probably due to the physiological alterations caused by the sequential application of products (Ervin and Zhang, 2007).

### *Grass clippings production*

The total clippings dry matter production (TCDM) of Tifton 419 Bermudagrass was significantly reduced by the plant growth regulators at the rates used in this study. The least amount of clippings (39.9 g $m^{-2}$ produced by the plants during a period of 74 days) was provided by the plants treatment with trinexapac-ethyl at sequential rate of 452 + 452 g a.i. $ha^{-1}$ (Table 5). Untreated plants produced a total of 648.8 g $m^{-2}$ during the same period, a value significantly larger than the one previously pointed. It is also possible to observe that the applied products had a general effect of reducing TCDM by values above 86%. This indicates that the number of needed plant cuttings is also reduced (Table 5).

Beam (2004) detected a direct relation between the increment of sequential prohexadione-calcium application (140 + 140, 270 + 270, 410 + 410, 540 + 540, and 670 + 670 g a.i. $ha^{-1}$) and the percentage reduction of clipping dry mass of Emerald grass. Reductions of 35-75% in the Emerald grass clippings production was detected when the lawn was treated with trinexapac-ethyl (Ervin and Ok, 2001; Ervin et al., 2002). Sequential applying rates (55.6 + 55.6 and 113 + 113 g a.i. $ha^{-1}$) of trinexapac-ethyl on Emerald grass registered reductions in plant dry matter production of 49.2 and 55.6%, respectively (Costa et al., 2009). Reductions above 84% was observed (in comparison with the check treatment) in dry matter production of Emerald grass plants when they were sequentially treated with either trinexapac-ethyl at the doses of 113 + 113, 226 + 226, 453 + 226, and 904 + 452 g a.i. $ha^{-1}$ or with prohexadione-calcium at the dose of 100 + 100 g a.i. $ha^{-1}$ (Marchi et al., 2013b).

With a special interest in the hybrid Bermudagrasses, a single application of trinexapac-ethyl to Tifway Bermudagrass plants at 107 g a.i. $ha^{-1}$ resulted in a tissue production reduction of 40% (Fagerness and Yelverton, 2000). A triple sequential application of trinexapac-ethyl at 71 g a.i. $ha^{-1}$ has given much better results than those from the double sequential application at rate of 107 g a.i. $ha^{-1}$ (Fagerness and Yelverton, 2000).

Four applications of trinexapac-ethyl at 12.5 g a.i. $ha^{-1}$ at 10 days intervals led to reductions in clippings production 60 days after the application by plants hybrids 'Champion', 'FloraDwarf', 'MiniVerde', 'MS Supreme', 'Tifdwarf', and 'TifEagle', of 63, 63, 69, 62, 64, and 46%, respectively, compared to check treatment (McCullough et al., 2005b). The plants had not their visual aspect impaired by the sequential application of reduced rates of the product during the 60 days the experiment lasted (McCullough et al., 2005b).

## Materials and Methods

### *Site description and trial establishment*

The study was carried out at latitude of 22° 07'56'' South and longitude of 74° 66'84'' West and with a mean altitude of 760 m above sea level. The 15-months-old lawn was formed from Tifton 419 Bermudagrass carpets and irrigated by a sprinkler system. The soil was classified as a typical red dystroferric Nitosoil A moderate, with a clayish texture, treated with 2.6 t $ha^{-1}$ of lime. The results of a chemical analysis indicated in Table 1.

The lawn height was kept at a mean of 3.0 cm above the soil surface by successive cutting operations with the help of a mechanical mower containing a revolving cutting blade and a special compartment to collect the resulting clippings.

### *Treatment and application facilities*

The treatment pattern (Table 2) includes an initial application followed by one sequential application at 14 days intervals, and untreated control. The area of each plot had a width of 1.5 m by a length of 2.5 m, thus equalizing 3.75 $m^2$. An untreated lateral 0.5 $m^2$ band to each experimental block was kept with the objective of helping the injury visualization by the PGRs.

The products were applied by a $CO_2$ pressurized sprayer with a spray boom bearing two flat spray nozzles TP 8002 VS mounted at a distance of 50 cm one from another. The equipment was kept working under a pressure of 2.0 bar, resulting in a tank mix consumption of 200 L $ha^{-1}$.

The first application took place at the end of January with a partially cloudy sky, air temperature at 26.3 °C, air relative humidity of 69%, with a southeast wind at a speed of 9.0 km $h^{-1}$. The plots had their lateral side protected with a movable folding screen during the treatments applications just to avoid product drifting. The study lasted from January through the beginning of May, this being a period during which the 'Tifton 419' Bermudagrass grows vegetative and reproductively in the region where the experiment was conducted.

The second PGR applications were planned to happen 14 days after the previous application. At that moment, the lawn was again mowed to a height of 3.0 cm above the soil surface and the second dose of the PGRs applied.

The clippings were collected after the cutting operation, placed inside paper bags and kept in a forced ventilation oven at a temperature of 65 °C until a constant weight was reached.

**Table 4.** Mean height values of 'Tifton 419' Bermudagrass obtained after the second application of the growth regulators.

| Treatments | Grass height (cm) – DASA[a] | | | | | | Reduction |
|---|---|---|---|---|---|---|---|
| | 7 | 14 | 21 | 35 | 42 | 60 | (%)[b] |
| Trinexapac 113+113 | 4.4b | 5.0b | 6.7b | 7.4b | 7.4b | 7.5b | 37.5 |
| Trinexapac 226+113 | 4.0b | 4.7b | 6.6b | 6.6b | 6.8b | 6.9b | 42.5 |
| Trinexapac 226+226 | 3.7b | 4.2b | 5.4b | 6.4b | 6.5b | 6.6b | 45.0 |
| Trinexapac 452+113 | 5.4b | 5.6b | 7.1ab | 7.4b | 7.4b | 7.5b | 37.5 |
| Trinexapac 452+226 | 4.9b | 5.2b | 5.3b | 5.7b | 5.9b | 6.3b | 47.5 |
| Trinexap 452+452 | 5.1b | 5.8b | 5.9b | 6.0b | 6.3b | 6.5b | 45.8 |
| Trinexapac 678 | 4.5b | 5.1b | 6.4b | 7.0b | 7.0b | 7.1b | 40.8 |
| Trinexapac 904 | 4.4b | 5.4b | 6.8b | 6.9b | 7.0b | 7.1b | 40.8 |
| Prohexadione 100+100 | 4.3b | 4.5b | 5.6b | 6.1b | 6.6b | 7.2b | 40.0 |
| Prohexadione 200+200 | 4.5b | 5.4b | 6.3b | 6.5b | 6.6b | 7.1b | 40.8 |
| Bispyribac 40+40 | 4.2b | 5.0b | 6.6b | 7.0b | 7.1b | 7.5b | 37.5 |
| Bispyribac 60+60 | 4.8b | 4.8b | 6.3b | 6.5b | 6.6b | 6.6b | 45.0 |
| Untreated | 8.4a | 9.9a | 10.9a | 11.3a | 11.6a | 12.0a | - |
| F Treatment | 6.17* | 5.69* | 2.85* | 2.96* | 2.94* | 2.91* | - |
| F Block | 3.76* | 5.56* | 5.22* | 2.13[NS] | 2.03[NS] | 1.99[NS] | - |
| CV (%) | 19.40 | 21.53 | 23.07 | 20.77 | 21.27 | 21.45 | - |

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.
a – DASA = days after the second application.
b – Reduction calculated as compared to the control.

**Table 5.** Height and number of inflorescences and total clipping dry mass (TCDM) produced by Tifton 419 Bermudagrass at 60 days after the second application of growth regulators.

| Treatment | Seedhead | | | | TCDM | |
|---|---|---|---|---|---|---|
| | Height (cm) | %[a] | Number ($m^{-2}$) | %[a] | (g $m^{-2}$) | %[a] |
| Trinexapac 113+113 | 2.7a | 67.5 | 23.7a | 95.9 | 58.6a | 90,1 |
| Trinexapac 226+113 | 1.9a | 77.1 | 20.0a | 96.5 | 43.6a | 93.3 |
| Trinexapac 226+226 | 3.0a | 63.9 | 12.5a | 97.8 | 55.4a | 91.4 |
| Trinexapac 452+113 | 2.8a | 66.3 | 33.8a | 94.1 | 84.8a | 86.9 |
| Trinexapac 452+226 | 3.4a | 59.0 | 50.0a | 91.2 | 57.9a | 91.0 |
| Trinexap 452+452 | 3.8a | 54.2 | 40.0a | 93.0 | 39.9a | 93.8 |
| Trinexapac 678 | 1.9a | 77.1 | 37.5a | 93.4 | 47.1a | 92.7 |
| Trinexapac 904 | 2.8a | 66.3 | 21.3a | 96.3 | 59.5a | 90.8 |
| Prohexadione 100+100 | 3.4a | 59.0 | 16.2a | 97.2 | 55.7a | 91.4 |
| Prohexadione 200+200 | 2.7a | 67.5 | 20.0a | 96.5 | 67.7a | 89.5 |
| Bispyribac 40+40 | 2.8a | 66.3 | 18.8a | 96.7 | 62.1a | 90.4 |
| Bispyribac 60+60 | 1.8a | 78.3 | 12.5a | 97.8 | 74.3a | 88.5 |
| Untreated | 8.3b | - | 571.3b | - | 646.8b | - |
| F Treatment | 8.30* | | 68.05* | | 71.66* | |
| F Block | 1.58[NS] | | 1.13[NS] | | 4.13* | |
| CV (%) | 36.11 | | 54.52 | | 34.36 | |

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.
a – Reduction calculated as compared to the control.

***Data collection and sampling procedure***

Plant injuries and growth reduction were evaluated once a week up to middle April when both the check and treated plants no longer showed alterations in height as a consequence of climatic temperature reductions and the shortening of the photoperiod.

The injuries caused by the treatments were visually evaluated according to a 0 – 100% scale, in which 0% represents absence of injury and 100% is represented by a dead plant. Height reduction was directly determined by measuring plant height with a normal, decimal, rule. The number and height of seedhead were evaluated by means of a sampling carried out in a 0.25 $m^2$ area in the middle of each plot at the experimental period end. The total clippings dry matter content (TCDM) resulted from the sum of the dry matter of all the clippings that were collected during the experiment.

***Statistical analysis***

The experiments were designed by randomized complete block design with four replications. The data were first submitted to the analysis of variance (ANOVA) and, when F was significant, the treatment means were compared by Tukey's test at the level of 5% of probability.

**Conclusion**

It is possible to conclude that the sequential application of trinexapac-ethyl, prohexadione-calcium, or bispyribac-sodium are promising as vegetative growth retarding and seedhead emission suppressing technique and may contribute for lawns management to reduce the need of plant cuttings at periods up to 70 days after the sequential application of the plant growth regulator.

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