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Article

Biostimulant in the production of lawn seedlings and plant growth regulators in the development of Carpet grass

Bioestimulante na produção de mudas de gramados e reguladores de crescimento no desenvolvimento da grama São Carlos

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Abstract
Biostimulants such as seaweed extract can be strong allies in the formation of lawn plugs, as they assist in several physiological processes in the plant. At the same time, shoot mowing is the main factor in the maintenance cost of turfgrasses, and there is a search for alternatives to mechanical management without compromising aesthetic quality, such as the use of plant growth regulators (PGR). Thus, the objective of this experiment was to evaluate the use of *Ascophyllum nodosum* in the production of lawn seedlings, and growth regulators in the development of Carpet grass. The experiment was carried out between 2020 and 2021, and divided into two parts, the first being the production of seedlings (30 days) of Emerald grass, Bermudagrass Discovery™, Carpet grass and Bahiagrass with the application of seaweed extract, in the second part the development of Carpet grass was evaluated after the application of PGRs (Trinexapac-ethy, Paclobutazol and Glyphosate) in 60 days. The evaluations performed were: green color index (GCI); normalized difference vegetation index (NDVI); root length and dry mass of seedlings. And for the second part: GCI; SPAD; NDVI; visual appearance; coverage rate; shoot height; growth rate and dry mass of clippings. It was observed that the use of the biostimulant increased the production of ornamental lawn plugs, where better values could be observed for Carpet grass. PGRs demonstrated efficient results for controlling the height of Carpet grass in up to 30 days, with emphasis on Trinexapac-ethyl, which reduced growth and maintained the aesthetics of the lawn.
Keywords: Algae extract, Paclobutrazol, Trinexapac-ethyl, Glyphosate, *Axonopus* spp.

Resumo
Bioestimulantes como extrato de algas podem ser fortes aliados na formação plugs de gramados, pois auxilia em diversos processos fisiológicos na planta. Ao mesmo tempo, a poda das folhas é o principal fator no custo de manutenção, existindo a procura por alternativas ao manejo mecânico sem prejudicar a qualidade estética, como o uso de reguladores de crescimento (RC). Assim, objetivou-se com esse experimento avaliar o uso de *Ascophyllum nodosum* na produção de mudas de gramas, e reguladores de crescimento no desenvolvimento da grama São Carlos. O experimento foi realizado entre 2020 e 2021, e dividido em duas partes, sendo a primeira a produção de mudas (30 dias) de grama Esmeralda, Bermuda Discovery™, São Carlos e Batatais com aplicação do extrato de alga, na segunda parte avaliou-se o desenvolvimento da grama São Carlos após aplicação de RC (Trinexapac-ethy, Paclobutazol e Glifosato) em 60 dias. As avaliações realizadas foram: índice de cor verde (ICV); índice de vegetação por diferença normalizada (NDVI); comprimento da raiz e massa seca das mudas. E para a segunda parte: ICV; SPAD; NDVI; aspecto visual; taxa de cobertura; altura do gramado; taxa de crescimento e massa seca das aparas. Observou-se que o uso do bioestimulante incrementou a produção de plugs de gramados ornamentais, onde melhores valores puderam ser observados para a grama São Carlos. **Já o**s RC demonstraram resultados eficientes para o controle da altura da grama São Carlos em até 30 dias, com destaque para o Trinexapac-ethy, que reduziu o crescimento e manteve a estética do gramado.
Palavras chave: Extrato de algas, Paclobutrazol, Trinexapac-ethyl, Glyphosate, *Axonopus* spp.

Introduction

Studies on ornamental lawn management and its technologies have been gaining more attention and recognition due to their functionality and aesthetic value (Santos et al., 2020; Castilho et al., 2020). Among the various areas of study, sod production for ornamental and sporting purposes holds particular relevance, especially in regions like the United States and Europe (Beard and Gibbs, 2017; Villas Bôas et al., 2020; Silva et al., 2020). Therefore, it is necessary to explore alternatives that can integrate production with sustainability (Santos and Carribeiro, 2022).

Biostimulants based on *Ascophyllum nodosum* marine algae emerge as crucial allies in plant development. Composed of macro and micronutrients, these biostimulants enhance plant physiological processes such as nutrient absorption and photosynthesis (Tavares et al., 2020). They are particularly beneficial in sod production (Santos et al., 2024), especially when used in plugs produced in trays. This method offers an alternative to planting turfgrasses without transporting farm soil, making it suitable for concrete floors, high-performance fields, and smaller areas (Oliveira et al., 2018; Castilho et al., 2020). Consequently, it is expected to promote superior seedling development, enhancing nutrition uptake and shortening production time.

The high demand for nitrogen by turfgrass, coupled with elevated temperatures during spring/summer and adequate water supply, leads to excessive shoot growth. This necessitates frequent mowing, which is the primary factor contributing to the cost of turf maintenance and consequently results in increased nutrient export (Mateus et al., 2020; Melero et al., 2020). In this context, there is a significant demand for alternatives to mechanical management, such as the use of plant growth regulators (PGR) (Marchi et al., 2017; Begueline et al., 2021). Ideally, these PGRs should reduce turfgrass height while maintaining the quality of the treated area. This means preserving turf density without causing visible damage such as necrotic spots, phytotoxicity, discoloration, or thinning, and importantly, retaining the characteristic green color and aesthetic appeal (Gazola et al., 2019).

There is limited information available on these products for controlling turfgrass height, highlighting the growing need for research in this area in Brazil (Begueline et al., 2021; Tapia, 2022). This is especially crucial for native Brazilian species such as Carpet grass (*Axonopus* spp.), known for its stoloniferous growth habit (Castilho et al., 2020). Carpet grass has gained prominence in Brazil due to its tolerance to semi-shaded areas and resilience to colder climates in the country (Dias et al., 2018;

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Melero et al., 2020; Villas Bôas et al., 2020). Therefore, this study aims to evaluate the use of a seaweed-based biostimulant in seedling production of various turfgrass species and its effect on the growth rates of Carpet grass.

Material and Methods

The experiment was conducted in a subtropical region of Brazil and carried out in two stages.

First stage of the experiment

The first stage took place in a greenhouse with an average temperature of 25.3 ºC and average relative humidity of 87.6%. Four turfgrass species were used: Emerald grass (*Zoysia japonica*), Bermudagrass Discovery™ (*Cynodon dactylon*), Carpet grass (*Axonopus fissifolius*), and Bahiagrass (*Paspalum notatum*).

During September 1st to 30th, 2020, plugs of different turfgrass species were produced with and without the application of a biostimulant based on algae extract (*Ascophyllum nodosum*) at a dose of 15 mL L^{-1}. Vegetative parts (rhizomes and/or stolons) of the four turf species were planted in plastic polyethylene trays (128 cells) filled with commercial substrate (Table 1). for treatments with biostimulant each tray received 10 mL of the extract in the treatment groups, while the other treatments were irrigated with tap water. The experimental design was a 4x2 factorial scheme (turf species x use of biostimulant), with 10 replications (10 plugs per replication).

Table 1. Characterization of the substrate used in the experiment.

N	P_2O_5	K_2O	Ca	Mg	S	humidity	O.M.	O.C.	Na	Cu	Fe	Mn	Zn	C/N	pH
--------------------- % (natural) ---------------------								dry	-------mg kg^{-1} natural) -------					----	natural
0.79	0.4	0.15	1.14	2.55	0.15	8	59	36	1369	24	9133	138	44	42/1	5,8

Substrate composed of: Sphagnum peat, expanded vermiculite, roasted rice husk and macro and micronutrients.

Once daily in the mornings, the treatments were irrigated, and evaluations were conducted after 30 days. The evaluations included measurements of the following parameters: Green color index (Field Scout CM-1000 Chlorophyll Meter); Normalized Difference Vegetation Index (NDVI); root system length and dry mass of the plugs.

Second stage of the experiment

The second part of the experiment was conducted in the field, beginning in October 2020. Carpet grass plugs were initially produced in trays and transplanted into 5 L pots after 30 days, with one plug per pot. The pots were filled with Red Oxisol Dystrophic soil. Thirty days prior to the experiment's setup, the soil underwent chemical analysis (Table 2) and was amended accordingly. The soil amendments aimed to achieve 70% base saturation (V%) as recommended for establishing lawns by Godoy et al. (2022). Additionally, potassium chloride (KCl) was added to increase potassium (K) content to 3 $mmol_c$ dm^{-3}, and a commercial product was used to enhance phosphorus pentoxide (P_2O_5) and micronutrient levels, in order to correct these nutrients.

Table 2. Chemical analysis of the Red Oxisol Dystrophic soil for the experimental area used to fill the pots.

pH	O.M.	P_{resin}	Al^{3+}	H+Al		K	Ca	Mg	SB	CEC	V
$CaCl_2$	g dm^{-3}	mg dm^{-3}	-------------$mmol_c$ dm^{-3}---------------								%
4.3	176	4	4	30		0.4	53	1	6	36	16

The irrigation with tap water at the site was performed using surface drip irrigation, adjusted daily based on the previous day's evapotranspiration. In February 2021, after the lawn had fully established, it was mowed to a height of 3 cm, and subsequently, the experiment was initiated. on February 1st, 2021, different PGRs were applied in a completely randomized experimental design with four treatments: Control (no application); Paclobutrazol (2,200 g a.i. ha^{-1}) (Melero et al., 2020); Trinexapac-ethyl (226 g a.i. ha^{-1}) (Marchi et al., 2017); and Glyphosate (400 g a.i. ha^{-1}) (Gazola et al., 2019). Each treatment had five replications. The choice of PGRs and their respective application rates followed recommendations found in the literature. No reapplication of the PGRs was done during the experiment.

The experiment spanned 60 days, from February 1st to April 2nd, 2021. Assessments were conducted every 30 days, evaluating several the parameters:

- Green Color Index (GCI) by SPAD Index: Measured with a portable Chlorophyll Meter (SPAD-502, Soil and Plant Analysis Development);
- GCI assessed using a portable Field Scout CM-1000 Chlorophyll Meter.
- Normalized Difference Vegetation Index (NDVI): Evaluated with a GreenSeeer device to estimate lawn vigor and density.
- Shoot height (SH): Measured with a graduated ruler.
- Growth rate (GR): Calculated as a percentage per day Dry mass of $clippings^{-1}$: Determined after mowing the lawn to 3 cm height, with samples dried in an oven at 60 °C for 72 hours.
- Green coverage rate (GCR) and visual appearance: Assessed through photographs taken with a 12Mp camera fixed in a "light box" structure, similar to that described by Peterson et al. (2011) to standardize luminosity. Image analysis was performed using Canopeo® software.
- Dark Green Color Index (DGCI): Determined using digital image analysis based on the methodology by Karcher and Richardson (2003).

Subsequently, the results were submitted by analysis of variance and Tukey test at a 5% probability level for comparison of means, using the statistical program "Statistix 10".

Results and discussion

Biostimulant in seedling production

The results indicated a statistically significant difference between the treatments in the first stage of the experiment (Table 1). While there was no interaction between the factors, isolated data from the use of the biostimulant and the species studied revealed substantial benefits. Specifically, the Green Color Index (GCI) showed increases with the application of the algae extract for Emerald grass, Carpet grass, and Bahiagrass. However, no significant difference was observed for Discovery™ Bermudagrass. This outcome may be attributed to the composition of seaweed-based biostimulants, which enhance plant metabolism, including chlorophyll synthesis (Santos et al., 2019). GCI indirectly reflects the relative chlorophyll content in turfgrass leaves (Santos et al., 2022), thus supporting the findings of this study. Discovery™ Bermudagrass, with its thinner leaves compared to the other species studied (Silverio et al., 2020; Prates et al., 2020), may not experience as pronounced an influence on chlorophyll content in plugs grown in trays. However, Santos et al. (2024), in a study on the initial growth of Discovery™ Bermudagrass using *A. nodosum*, observed excellent green color results with a dose of 15 mL L^{-1}, which contrasts with the findings of the present study.

Table 3. Green color index (GCI), NDVI, root length and dry mass of seedlings in different turf species with or without the application of algae extract (AE) **(***Ascophyllum nodosum***).**

Espécie	GCI		NDVI		Root length		Dry mass	
	Scout CM1000		----------		----- cm ------		---- g plug^{-1}----	
	----------------------------- Humic acid -----------------------------------							
	with	without	with	without	with	without	with	without
Emerald grass	81 cA	66 cB	0.24 cA	0.18 bA	6.2 abA	5.3 abB	0.55 cA	0.29 cB
Carpet grass	115 aA	103 aB	0.48 aA	0.38 aB	5.7 bA	5.0 Bb	0.85 bA	0.64 bB
Bahiagrass	99 bA	90 bB	0.38 bA	0.32 aA	5.8 abA	5.0 bB	1.71 aA	1.02 aB
Discovery^{TM} Bermudagrass	71 cA	70 cA	0.27 cA	0.23 bA	6.3 aA	5.8 aB	0.77 bcA	0.53 bcB
MDS $_{\text{line}}$	8		0.07		0.4		0.21	
MSD $_{\text{column}}$	10		0.09		0.6		0.28	
F$_{\text{Species}}$	92.234**		37.600**		9.296**		60.636**	
F$_{\text{AE}}$	25.084**		15.488**		44.913**		45.693**	
F$_{\text{Species x AE}}$	2.650^{ns}		0.484^{ns}		0.334^{ns}		4.792**	
CV (%)	6.14		14.94		5.20		18.51	

Averages followed by the same lowercase letter in the column and uppercase in the row, do not differ from each other, by Tukey's test at a level of 5%. ** - significant at 1%, * - significant at 5%, ns - not significant. MSD - Minimum Significant Difference

When comparing Green Color Index (GCI) values among species (Table 3), Carpet grass consistently exhibits a richer green color compared to other turfgrasses, while Discovery^{TM} Bermudagrass shows the lowest results. This difference can be attributed to several factors. According to Dias et al. (2018), Carpet grass is characterized by its high density and vibrant green color, which remains consistent even under stressful conditions, as noted by Dias et al. (2019) and Melero et al. (2020). Additionally, Carpet grass is known for its tolerance to semi-shaded areas. Its thicker leaves enable it to maintain higher levels of leaf chlorophyll, thereby optimizing light utilization and sustaining a deeper green hue compared to other species (Dias et al., 2018; Castilho et al., 2020).

The NDVI results indicated that only Carpet grass showed a significant difference in response to the biostimulant, exhibiting the highest values compared to other turfgrasses. This may be attributed to Carpet grass having wider leaves compared to the other studied lawns, resulting in greater plant biomass and density (Castilho et al., 2020), thereby yielding higher NDVI results. According to Santos et al. (2024), NDVI strongly correlates with turfgrass coverage rate and the intensity of green color, a finding supported by Nascimento et al. (2020), which aligns with the findings of this study.

The root length measurements demonstrated that the application of algae extract to lawns resulted in increased root development across all studied species compared to when the biostimulant was not used (Table 3). Discovery^{TM} Bermudagrass consistently exhibited the highest values, possibly due to its faster root system development compared to other species (Silva et al., 2020; Castilho et al., 2020). The biostimulant likely exerted greater influence on root growth rather than shoot development, as evidenced by its lower impact on green color (Table 3). These findings are consistent with observations by Tavares et al. (2020), who noted that seaweed extract contains auxins — a hormone known to promote root development (Taiz et al., 2017). Additionally, auxins in conjunction with cytokinins accelerate and stimulate root formation (Santos et al., 2019; Tavares et al., 2020). Therefore, application of the extract can enhance the physiological performance of lawns, facilitating seedling development and turf establishment.

Similarly, to the increase observed in root development with the use of algae extract, the dry mass of the plugs showed significant augmentation when treated with the biostimulant, particularly notable in Bahiagrass, which exhibited the highest results. This could be attributed to Bahiagrass's superficial rhizomes, which accumulate substantial reserves, as reported by Lima et al. (2020). The enhanced dry mass observed with the biostimulant is likely due to its composition of macro and micronutrients, which enhance physiological processes such as nutrient absorption and photosynthesis (Santos et al., 2024). Similar biomass increases have been reported in the production of ornamental sunflower seedlings (Santos et al., 2019) and marigold seedlings (Tavares et al., 2020) following the application of *A. nodosum*, supporting these findings.

Plant growth regulators in the development of Carpet grass

The results of the present study demonstrated that after 30 days of applying growth regulators, there was a statistically significant difference for all evaluated parameters (Table 4). When assessing the SPAD Index, treatments with Glyphosate and Trinexapac-ethyl showed the highest values, with no statistical difference between them (43.2 and 38.4, respectively). The control treatment had the lowest value (26.3) and was significantly different from all other PGRs. Similarly, the results from the ICV Scout CM1000 showed that the control treatment had a significant difference compared to all other treatments, with the three PGRs remaining statistically similar to each other.

Table 4. Green color index (GCI), NDVI, Shoot height (SH), Growth Rate (GR), Green Cover Rate (GCR) and Dark Green Color Index (DGCI) of Carpet grass, 30 days after application of plant growth regulators.

Plant growth regulators	GCI	GCI	NDVI	SH	GR	GCR	DGCI
	SPAD	Scout CM1000	-----	cm	% day^{-1}	%	----
Control	26.3 c	161 b	0.73 a	8.7 a	9.69 a	81.75 a	0.32 c
Paclobutrazol	35.2 b	234 a	0.51 c	4.2 b	4.67 b	71.50 bc	0.43 a
Trinexapac-ethyl	38.4 ab	241 a	0.62 b	4.1 b	4.56 b	74.75 b	0.46 a
Glyphosate	43.2 a	217 a	0.35 d	4.5 b	5.00 b	67.75 c	0.38 b
MSD	5.6	30	0.08	1.3	1.47	4.67	0.04
F	28.36**	25.81**	67.46**	50.53**	50.53**	28.6**	39.58**
CV (%)	7.45	6.74	7.21	11.69	11.69	3.01	4.73

Averages followed by the same letter in the column do not differ from each other, by Tukey's test at 5% level. ** - significant at 1%, * - significant at 5%, ns - not significant. MSD - Minimum Significant Difference.

The increase in GCI from growth control treatments is attributed to physiological responses in the plant. Specifically, chlorophyll becomes concentrated in a smaller volume of cells because the PGRs inhibit cell elongation, resulting in a more compact leaf structure (Melero et al., 2020; Tapia, 2022). In this study, Trinexapac-ethyl and Glyphosate resulted in higher SPAD index increments compared to the other treatments, although Trinexapac-ethyl did not differ statistically from Glyphosate. Trinexapac-ethyl affects gibberellin biosynthesis by interfering with phase 3 of the process, inhibiting the conversion of GA$_{20}$ to GA$_{1}$ by targeting the enzyme gibberellin 20 oxidase (Marchi et al., 2017; Mykhalska et al., 2020). This disruption prevents the formation of active gibberellins, leading to the synthesis and accumulation of less biologically effective gibberellins such as GA$_{8}$, GA$_{17}$, GA$_{19}$, and GA$_{24}$, which reduces cell elongation (Marchi et al., 2017). This effect was observed in the present study. In contrast, Paclobutrazol influences gibberellin synthesis by interfering with phase 2, specifically blocking the action of the enzyme Caurene Oxidase (CO) (Melero et al., 2020; Lima et al., 2020), which also contributes to reduced cell elongation. Products that act in phase 3, such as Trinexapac-ethyl, are generally considered safer for maintaining lawn quality compared to those affecting phases 1 and 2. This is because phase 3 inhibitors, like Trinexapac-ethyl, specifically target the synthesis of GA$_{1}$ while allowing other gibberellins to be synthesized normally. In contrast, PGRs that interfere with the synthesis of all types of gibberellins can cause injuries and increase susceptibility to environmental stresses (Marchi et al., 2017; Mykhalska et al., 2020; Melero et al., 2020). Therefore, the results of the present study suggest that using the respective PGRs would be an excellent choice due to its favorable outcomes.

Glyphosate is an herbicide that targets the shikimic acid pathway by inhibiting the enzyme EPSPs. This enzyme is responsible for the synthesis of aromatic amino acids such as tryptophan, tyrosine, and phenylalanine, crucial for plant growth and development (Gazola et al., 2019; Dias et al., 2019). Additionally, the inhibition of these enzymes disrupts the production of various compounds involved in plant growth, including indolylacetic acid, leading to reduced plant height, as observed in our study (Gazola et al., 2019; Begueline et al., 2021).

At 30 days after applying the PGRs, all treatments showed statistically significant differences compared to the control across all analyzed variables. The growth rate under all PGRs reached up to 5% per day, with Trinexapac-ethyl particularly notable for its significant increases in GCI (Green Color Index), Green Coverage Rate, and DGCI (Digital Green Color Index), accompanied by minimal height and growth rate increases. This underscores the effectiveness of PGRs as alternatives to mechanical management, as all products used successfully reduced lawn growth within 30 days of application. After 60 days from application, the results (Table 5) showed promising outcomes, with Paclobutrazol, Trinexapac-ethyl, and Glyphosate effectively controlling growth and minimizing height and biomass production. However, the growth rate (GR) increased under all PGRs, possibly due to the diminishing effects of the products after 30 days, leading to a rebound effect. This suggests the need for reapplication, as described by Tapia (2022). Overall, PGRs demonstrated efficient results up to 60 days post-application, with Paclobutrazol and Trinexapac-ethyl standing out. Notably, Trinexapac-ethyl showed high efficiency at a low dosage compared to other chemicals. Marchi et al. (2017), have observed promising results with the use of Trinexapac-ethyl in controlling various turf species. This PGR promotes a denser turf canopy by reducing cell elongation, thereby minimizing the need for frequent mowing. The low production of clippings and reduced height, coupled with high rates of GCI, DGCI, and GCR, highlight the potential of this product for effective lawn height management.

Table 5. Green color index (GCI), NDVI, Shoot height (SH), Growth Rate (GR), Green Cover Rate (GCR) and Dark Green Color Index (DGCI) and clippings Dry Mass (DM) of Carpet grass, 60 days after application of plant growth regulators.

Plant growth regulators	GCI	GCI	NDVI	SH	GR	GCR	DGCI	DM
	SPAD	Scout CM1000	-----	cm	% day^{-1}	%	----	g m^{-2}
Control	20.3 b	139 b	0.75 a	10.8 a	4.13 b	87.25 a	0.29 b	192.1 a
Paclobutrazol	25.9 ab	213 a	0.64 b	6.3 b	5.00 a	80.75 b	0.37 a	150.7 b
Trinexapac-ethyl	27.9 a	210 a	0.65 b	6.0 b	4.89 a	78.00 b	0.38 a	143.8 b
Glyphosate	23.4 ab	199 a	0.41 c	6.4 b	4.74 a	71.75 c	0.33 ab	133.0 b
MSD	6.3	23	0.05	1.5	0.60	4.21	0.06	22.65
F	4.71*	39.37	138.37	41.36	7.47	41.09	9.34	22.98
CV (%)	12.3	5.81	3.95	9.76	6.08	2.52	7.78	6.96

Averages followed by the same letter in the column do not differ from each other, by Tukey's test at 5% level. ** - significant at 1%, * - significant at 5%, ns - not significant. MSD - Minimum Significant Difference.

Ornamental lawns require consistent aesthetic quality, characterized by a lush, uniform turf that maintains sensory appeal (Santos et al., 2020). Conversely, residential and industrial lawns often maintain lower to moderate levels of quality due to varying levels of owner care (Castilho et al., 2020; Villas Bôas et al., 2020). Therefore, the use of PGRs presents an ideal solution for managing Carpet grass, specifically those that reduce height while preserving the overall quality of the treated area. This includes maintaining density and avoiding visible damage such as necrotic spots, discoloration, or thinning, thereby preserving its beauty and characteristic green color (Gazola et al., 2019). Images (Fig. 1) demonstrate that PGRs effectively maintained lawn aesthetics and green coverage rate over 60 days, with Paclobutrazol and Trinexapac-ethyl particularly noteworthy.

According to Melero et al. (2020), after using a PGR, the visual appearance of the grass must be maintained and visible, as observed in the present study. Lima et al. (2020) observed a more compact leaf structure after using Paclobutrazol, which resulted in exposed rhizomes and reduced green density of the Bahiagrass lawn. Similarly, Dias et al. (2019) found that applying glyphosate as a PGR at a dose of 45 g a.e. (equivalent acid) ha^{-1} led to a reduction in the visual quality of Bahiagrass green. However, Melero et al. (2020) also observed good density in Carpet grass following the use of Paclobutrazol, consistent with the findings of the present study. The loss of visual aesthetics was evident for glyphosate, which compromises its effectiveness as a PGR. This issue may be related to the width of the Carpet grass leaf. For instance, Begueline et al. (2021) and Gazola et al. (2019) observed positive results with Bermudagrass and Emerald grass, respectively, using a dose of 400 g a.i. ha^{-1}. These turfgrasses have thinner leaves compared to the Carpet grass in the present study, suggesting that Carpet grass may be more sensitive to glyphosate when used as a PGR. Additionally, Dias et al. (2019) found that smaller doses of glyphosate resulted in better outcomes for Carpet grass, whereas higher concentrations led to a decline in the aesthetic quality of the lawn.

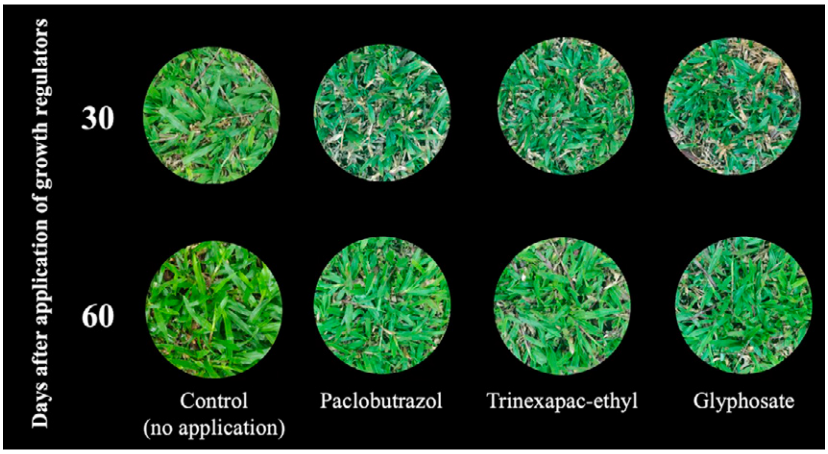

Fig. 1. Visual aspect of Carpet grass at 30 days and 60 days after application of plant growth regulators.

Conclusions

The use of a biostimulant based on *Ascophyllum nodosum* seaweed is recommended for the production of seedlings for ornamental lawns, particularly due to the notable benefits observed, with the greatest increases seen in Carpet grass than in Emerald grass, Bermudagrass Discovery^{TM}, and Bahiagrass.

Plant growth regulators (PGR) have proven effective in controlling the height of Carpet grass for up to 30 days. However, for maintaining control beyond this period, up to 60 days after application, the use of Trinexapac-ethyl is advised. This is because Trinexapac-ethyl, at the low dose used, compared to other plant growth regulators, effectively maintains lawn aesthetics with minimal increase in biomass.

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Author Contribution

PLFS: experiment idea, field analysis, data collection and analysis, interpretation, preparation and writing of the article, critical review and translation. **ART**: methodology, validation, writing-original draft, writing-review and editing. **ARP:** field analysis and data collection. **MVLN:** field analysis and data collection. **JVC:** field analysis and data collection. **LJGG:** critical review, analysis and interpretation of data, co-supervisor of the work. **ARZ:** validation, writing-original draft, writing-review and editing. **RLVB:** critical review, approval of the final version, work advisor.

Conflict of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data Availability Statement

Data will be made available on request.

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