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CAN PHYTOHORMONES STIMULATE INITIAL GROWTH OF BRAZILIAN SAVANNA TREES?

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ABSTRACT – The initial growth of Cerrado tree species is slow, which impairs large scale seedling production for planting. The effect of plant hormones is well known for crop species, in this study we aimed to test the effect of two commercial biostimulants on the initial growth of six native tree species widely distributed and abundant in the Cerrado. We applied nine treatments using foliar spray: T_0 – control (water); commercial Progibb® (gibberellic acid) T_1 – 0,8 $mL.L^{-1}$; T_2 – 1,6 $mL.L^{-1}$; T_3 – 2,4 $mL.L^{-1}$ and T_4 – 3,2 $mL.L^{-1}$; commercial Stimulate® (gibberellic acid, cytokinin and auxin): T_5 – 6,0 $mL.L^{-1}$; T_6 – 8,0 $mL.L^{-1}$; T_7 – 12,0 $mL.L^{-1}$; T_8 – 18,0 $mL.L^{-1}$ and T_9 – 24,0 $mL.L^{-1}$. Plant height and diameter were measured every other week and recorded root and shoot biomass and leaf area after 111 growing days. No treatment significantly increased plants initial growth, which may only happen after higher and/or repeated use of these two biostimulants, especially Progibb® for *Anacardium humile* and *Jacaranda cuspidifolia* and Stimulate® for *Hymenaea stignocarpa* and *Copaifera langsdorfii.*

Key words: bioestimulants, gibberellic acid, Cerrado.

RESUMO (Fitohormonios podem estimular o crescimento inicial de espécies arbóreas da savana brasileira?) - O crescimento inicial de espécies arbóreas do Cerrado é lento, o que prejudica a produção de plântulas em larga escala para plantios. O efeito de hormônios vegetais é bem conhecido para espécies cultivadas. Nesse estudo, foi testado o efeito de dois bioestimulantes no crescimento inicial de seis espécies arbóreas nativas, amplamente distribuídas e abundantes no Cerrado. Foram feitos nove tratamentos aplicando spray foliar: T_0 – controle (água); Progibb® comercial (ácido giberélico) T_1 – 0,8 $mL.L^{-1}$; T_2 – 1,6 $mL.L^{-1}$; T_3 – 2,4 $mL.L^{-1}$ and T_4 – 3,2 $mL.L^{-1}$; Stimulate® comercial (ácido giberélico, citocinina e auxina): T_5 – 6,0 $mL.L^{-1}$; T_6 – 8,0 $mL.L^{-1}$; T_7 – 12,0 $mL.L^{-1}$; T_8 – 18,0 $mL.L^{-1}$ and T_9 – 24,0 $mL.L^{-1}$. O comprimento da planta e o diâmetro foram medidos quinzenalmente e a biomassa aérea e radicular e a área foliar foram verificadas ao final de 111 dias de crescimento. Nenhum dos tratamentos aumentou significativamente o crescimento inicial das plantas, o que pode acontecer somente após a aplicação de doses maiores e/ou repetitiva desses dois bioestimulantes, especialmente Progibb® para *Anacardium humile* e *Jacaranda cuspidifolia* e Stimulate® para *Hymenaea stignocarpa* e *Copaifera langsdorfii.*

Palavras-chave*:* bioestimulantes, ácido giberélico, Cerrado.

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INTRODUCTION

The need for restoration of degraded areas in both rural and urban regions has largely increased in recent decades. In Brazil, both state and federal level legislation are clear about the rules to restore degraded areas after illegal deforestation or infrastructure construction (e.g. Federal Law 12.651/ 2012; state law of the Federal District 14.783/1993).

Planting seedlings of native tree species is the most commonly applied technique for restoration of degraded areas, which generates a commercial demand for seedling production in nurseries. The initial growth of these seedlings is important for economic reasons, as faster initial growth rates allows faster seedling production and selling; and for ecological reasons, since taller seedlings are more likely to survive in field conditions, especially when competing with exotic fast-growing grasses (Giotto *et al*., 2009). For these reasons, even in regions dominated by savanna ecosystems, most seedlings produced in nurseries are from forest fast-growingtree species.

Species from forest ecosystems (mostly riparian forests) within savanna biomes have higher growth rates than savanna trees from the same regions (Hoffman & Franco, 2003). These forest species are native from the region and therefore, legally, they can be used in restoration projects. However, forest tree species are ecologically not appropriated to be used for the restoration of savanna ecosystems, especially because they are mostly fire-sensitive and likely to die after fire events, which are common in savanna ecosystems (Hoffmann *et al*, 2000).

In contrast, tree species from savanna ecosystems usually present slow shoot growth (Caldas *et al*., 2009; Scalon *et al*., 2009), associated with a large root system development (Ratnam *et al*., 2011). These characteristics, associated with low natural tree densities and variable seed production over the years (Macedo *et al*., 2009), constrain production of seedlings in commercial nurseries within the Brazilian savanna, the Cerrado.

In this context, the use of phytohormones can help to overcome the slow initial growth of savanna tree seedling (Scalon *et al*., 2009). Phytohormones are chemicals naturally produced by plants; they regulate plant growth and development and can be artificially synthetized (Vieira & Castro, 2001). Gibberellic acid, auxin and cytokinin are among the most commonly used and studied plant hormones (Taiz & Zeiger, 2006).

Gibberellic acid is mostly produced in young plant shoot tissues and in maturating seeds (Paulilo *et al*., 2010). In seedlings, gibberellic acid stimulates plant shoot elongation, commonly increasing internode length, foliar area and plant dry mass (Vieira & Castro, 2001; Taiz & Zaiger, 2006; Dantas *et al*., 2012). Auxin is naturally produced by apical shoot meristems and regulates phototropism, geotropism, fruit development as well as secondary root and shoot growth. Cytokinins are produced mostly in plant roots and transported via xylem to the whole plant. They regulate senescence in plant tissues, stimulate shoot dominance, flower production and seed germination (Taiz & Zeiger, 2006). These three phytohormones are commercially produced, for instance, Progibb® is a commercial gibberellic acid compound, whereas Stimulate® combines gibberellic acid, auxin and cytokinin.

Phytohormones are commonly applied in commercial fruit trees (Wagner Júnior *et al*., 2008; Dantas *et al*., 2012; Pereira *et al*., 2014). The initial growth of *Tamarindus indica* (Fabaceae, tamarin), for example, was reported to increase 11 and 13% in response to the application of gibberellic acid (2.4 $mL.L^{-1}$ of GA_3 at 4% concentration) and Stimulate® (24 $mL.L^{-1}$), respectively (Dantas *et al*., 2012). Wagner Júnior *et al*. (2008) reported significant growth increases of *Prunus persica* (Rosaceae, common peach) seedlings after gibberellic acid spraying, at concentrations of 200 $mg. L^{-1}$.

Studies have recently tested the effects of phytohormones in the initial growth of tree species from savanna ecosystems within the Cerrado and the results appear to be species-specific, differing even among species of the same family. *Hancornia speciosa* (Apocynaceae) presented a 30 cm increase in shoot growth in 105 days after GA_3 application (Caldas *et al*., 2009). *Dimorphandra mollis* (Fabaceae) seedlings also had 60% increase in growth rates after the application of Stimulate® in seeds (20 $mg.L^{-1}$ in 500 g of seeds), compared to untreated seeds (Canesin *et al*., 2012). In contrast, *Myracrodruon urundeuva* (Anacardiaceae) and *Entorolobium contortisiliquum* (Fabaceae) seedlings did not respond to the application of gibberellic acid (Scalon *et al*., 2006). Additionally, the application of Stimulate® (15, 25 and 35 $mL.L^{-1}$ in 500 g of seeds) in *Hymenaea courbaril* (Fabaceae) seeds inhibited seedling growth (Pierezan *et al*., 2012).

These results indicate that phytohormones might have only a small influence on the growth of Cerrado tree seedlings; however only a few species have been tested. In this work, we aim to increase the knowledge on the effects of commercial phytohormones in seedlings. Herein, the effects of a range of concentrations of two commercial biostimulants in seedlings of six Cerrado native tree species were tested.

MATERIAL AND METHODS

Six widely and abundant Cerrado tree species were selected (Table 1), which usually have high seed production and therefore can be of interest for commercial seedling production. The fruits were collected at the Contagem Biological Reserve, Distrito Federal, in Central Brazil (15°41’00’’S e 47°50’00’’W) from June to October 2015 (according to fruit production phenology). The seeds were cleaned and stored in kraft paper bags at room temperature until the sowing, at the following wet season, in December 2015. The seeds were then disposed in plastic trays filled with yellow-red latossols for germination tests and seedlings were transferred to black polyethylene bags (10 cm diameter and 25 cm depth) containing yellow-red latossols and sand (mixture 3:1). Next polyethylene bags were disposed randomly in a nursery covered with a shade cloth (50% sun light) and watered seedling twice a day for 70 days.

After this nursery-growing period, five

seedlings per species were randomly assigned to receive one of the nine experimental treatments; four of them using Progibb®: T_1– 0,8mL.L^{-1} ; T_2 – 1,6 mL.L^{-1}; T_3 – 2,4 mL.L^{-1} e T_4 – 3,2 mL.L^{-1} in aqueous solution; four using Stimulate®: T_5 – 6,0 mL.L^{-1}; T_6– 8,0 mL.L^{-1}; T_7– 12,0 mL.L^{-1}; T_8 – 18,0 mL.L^{-1}; T_9 – 24,0 mL.L^{-1} in aqueous solution; and one control treatment, T0, with water.

The two commercial plant growth regulators were applied according to label recommendations. According to Valent BioSciences Corporation, Progibb® 4% (gibberellic acid, GA_3 at 4% concentration) can be a growth promoter and also help plants to overcome stress and stimulate rapid growth even in difficult weather conditions (Valent Biosciences, 2014). Stimulate® is a biostimulant from Stoller Interprises Inc. containing plant growth regulators and traces of chelated minerals (Castro *et al*., 1998). It is composed of IBA (auxin) 0.005%, kinetin (cytokinin) 0.009% and gibberellic acid (gibberellin) 0.005% (Stoller Brazil, 1998). Stimulate® acts increasing plant growth and development by enhancing cell division, enlargement and differentiation and by improving nutrient uptake (Stoller Brazil, 1998).

Table 1. Physiological and biogeographical characteristics of the study trees for seedling production. Different numbers (1 to 7) indicate the references**:** 1: Carvalho *et al*., 2012, 2: Silva Junior, 2012, 3: Carvalho, 2007, 4: Oliveira *et al*., 2011, 5: Fagundes *et al*., 2013, 6: Scalon *et al*., 2006, 7: Giotto *et al*., 2009.

Species	**Seed description**	**Habitat and distribution**	**Seed viability for storage**	**Height of adult tree (m)**	**Growth speed**
Anacardium humile (Anacardiaceae)	Up to 2.5 cm in length and 1.6 cm in width; kidney-shaped [1], oleaginous, one per fruit [2]	Open to dense savana [3]	Orthodox [1] Seeds	3 to 4	Slow
Aspidosperma tomentosum (Apocynaceae)	Fruit up to 4 cm in width; rounded and flattened; winged; several seeds per fruit [2]	Savanna and dense savanna [2]	Orthodox seeds	5 to 8 [4]	Slow
Copaifera langsdorffii (Fabaceae)	Up to 2 cm in length and 1 cm in width; elliptical, exalbuminous, hard [3]	Savanna, deciduous forest, gallery forest [3]	Orthodox seeds [5]	5 to 15 [3]	Slow or moderate [3]
Hymenaea stignocarpa (Fabaceae)	Up to 5cm in lenght and 2 cm in width, oblong	Savanna and dense savanna [3,2]	Orthodox seeds	8 to 15 [3]	Slow or moderate [3]

Jacaranda cuspidifolia (Bignoniaceae)	Up to 1.2 cm in length and 2 cm in width; light, flattened, rounded [3]	Riparian forests, dry forests, savanna	Orthodox seeds (Scalon *et al*., 2006)	3 to 10 [6]	Slow [3]
Magonia pubescens (Sapindaceae)	Up to 4 cm in length and 8cm in width, winged; light brown color; several per fruit [2]	Savanna, dense savanna, deciduous forest [2]	Orthodox seeds	Up to 10 [7]	Slow

The experimental concentrations were chosen in order to achieve both supra-optimal and suboptimal doses according to products labels, intending to check for a dose-dependent response. The aqueous solutions were sprayed directly at the apex of each plant only once at the beginning of the experiment. The seedlings had been watered prior to treatment application and no plant was watered for 24 hours after treatment to ensure product fixation on plants. Plants were allowed to grow for 111 days in a greenhouse with light protection (sombrite 50%) and daily irrigation.

Plant height and steam base diameter were measured every 15 days with a millimeter ruler and a digital caliper respectively. Plant growth was calculated using relative growth rate due to the natural variation on the seedling size at the time of biostimulants application (Pommenering & Muszta, 2016).

Average rates of relative growth in height and diameter were calculated using the formula: $\overline{RGR} = (\ln y_k - \ln y_{k-1}) / (t_k - t_{k-1})$, where RGR is the average relative growth rate (in mm.day^{-1}) and y_k e y_{k-1} are the height or the diameter accumulated from time t_k to t_{k-1}.

At the end of the experiment (111 growing days) all seedlings were uprooted and separated into root, leaves and stem parts. Leaf area was measured with a flatbed scanner to assess the photosynthetic capacity of each plant (Varma & Osuri, 2013). After that, all plant tissues were oven-dried separately at 70 ^oC for 72 hours and then each plant part was weighed in a digital scale.

Differences across treatments were compared within each species considering plant relative growth (height and diameter), shoot and root dry mass and leaf area using non-parametric analysis of variance. Means were compared using Mann-Whitney test (α = 0.05), all analyses were performed in R program version 3.0.2 (R Development Core Team 2016).

RESULTS AND DISCUSSION

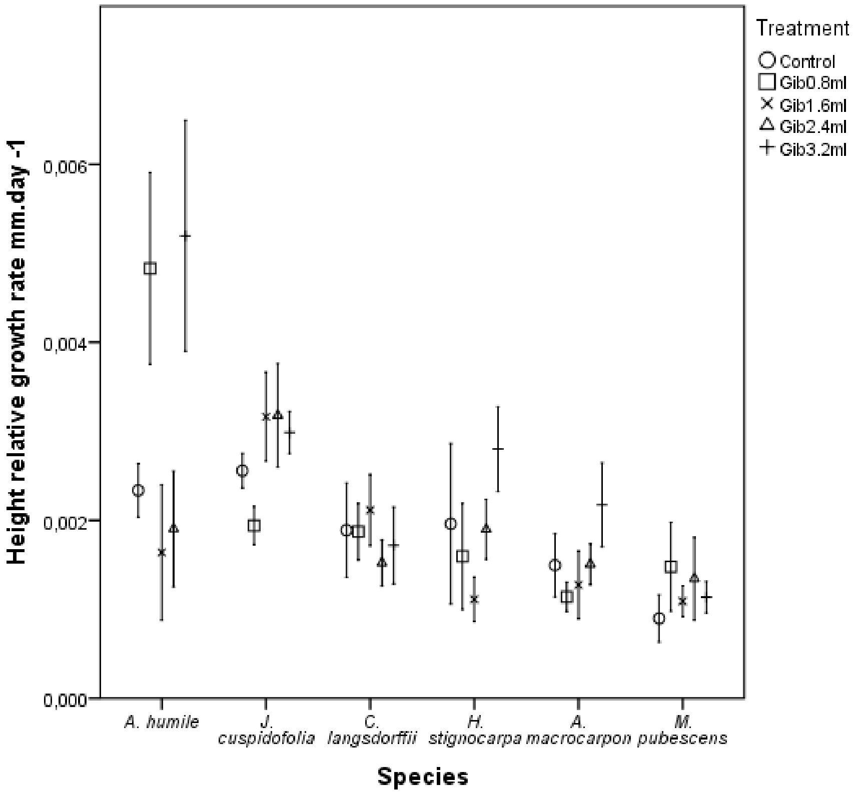
All species had slow seedling growth (Table 1), which is a characteristic of savanna species, including Cerrado (Moreira et Klink, 2000; Caldas *et al*., 2009). No significant effect of the treatments was found on seedling initial growth in any of the analyzed parameters (Table 2). In general, the seedlings treated with different phytohormone concentrations had similar growth rates and biomass allocation patterns to the untreated (control) seedlings. The effect of.

phytohormones in different concentrations varied among different species inconsistently. Additionally, there was a considerable individual variation in seedling growth (Figure 1), which can be related to individual genetic variations and not to the treatments.

Table 2. General data of the different parameters evaluated in the growth of the six tree species from Cerrado submitted to different types of plant hormone and their respective doses.

	Tratament	*Anacardium humile*	*Aspidosperma tomentosum*	*Copaifera langsdorffii*	*Hymenaea stignocarpa*	*Jacaranda cuspidifolia*	*Magonia pubescens*
Plant relative growth (diameter)	Control	0.0035 ± 0.0029	0.0069 ± 0.0010	0.0036 ± 0.0018	0.0024 ± 0.0014	0.0025 ± 0.0011	0.0030 ± 0.0023
	Progib 0.8	0.0037 ± 0.0029	0.0053 ± 0.0032	0.0060 ± 0.0059	0.0029 ± 0.0016	0.0030 ± 0.0014	0.0022 ± 0.0012
	Progib 1.6	0.0043 ± 0.0014	0.0058 ± 0.0017	0.0026 ± 0.0015	0.0035 ± 0.0016	0.0038 ± 0.0012	0.0028 ± 0.0012
	Progib 2.4	0.0042 ± 0.0013	0.0085 ± 0.0021		0.0026 ± 0.0013	0.0028 ± 0.0017	0.0013 ± 0.0011
	Progib 3.2	0.0039 ± 0.0024	0.0070 ± 0.0026	0.0029 ± 0.0014	0.0022 ± 0.0013	0.0040 ± 0.0026	0.0012 ± 0.0012
	Stimulate 6	0.0030 ± 0.0009	0.0047 ± 0.0013	0.0028 ± 0.0013	0.0021 ± 0.0010	0.0029 ± 0.0023	0.0031 ± 0.0017
	Stimulate 8		0.0055 ± 0.0013	0.0035 ± 0.0005	0.0024 ± 0.0010	0.0029 ± 0.0006	0.0030 ± 0.0012
	Stimulate 12	0.0060 ± 0.0022	0.0066 ± 0.0021	0.0030 ± 0.0012	0.0028 ± 0.0017	0.0026 ± 0.0010	0.0030 ± 0.0015
	Stimulate 18	0.0057 ± 0.0030	0.0039 ± 0.0008	0.0032 ± 0.0013	0.0031 ± 0.0005	0.0023 ± 0.0003	0.0027 ± 0.0012
	Stiumlate 24	0.0048 ± 0.0017	0.0081 ± 0.0032	0.0045 ± 0.0021	0.0026 ± 0.0016	0.0021 ± 0.0008	0.0020 ± 0.0004
Plant relative growth (Height)	Control	0.0023 ± 0.0006	0.0026 ± 0.0004	0.0019 ± 0.0011	0.0024 ± 0.0020	0.0015 ± 0.0007	0.0009 ± 0.0005
	Progib 0.8	0.0048 ± 0.0022	0.0019 ± 0.0004	0.0019 ± 0.0006	0.0016 ± 0.0012	0.0011 ± 0.0003	0.0015 ± 0.0010
	Progib 1.6	0.0020 ± 0.0014	0.0032 ± 0.0010	0.0021 ± 0.0008	0.0011 ± 0.0005	0.0013 ± 0.0008	0.0011 ± 0.0003
	Progib 2.4	0.0019 ± 0.0013	0.0032 ± 0.0012		0.0019 ± 0.0007	0.0015 ± 0.0005	0.0013 ± 0.0009
	Progib 3.2	0.0052 ± 0.0026	0.0030 ± 0.0005	0.0017 ± 0.0009	0.0028 ± 0.0010	0.0022 ± 0.0009	0.0011 ± 0.0004
	Stimulate 6	0.0018 ± 0.0006	0.0015 ± 0.0004	0.0034 ± 0.0016	0.0016 ± 0.0004	0.0012 ± 0.0004	0.0013 ± 0.0002
	Stimulate 8		0.0018 ± 0.0006	0.0020 ± 0.0006	0.0023 ± 0.0015	0.0022 ± 0.0007	0.0025 ± 0.0017
	Stimulate 12	0.0019 ± 0.0011	0.0017 ± 0.0004	0.0020 ± 0.0010	0.0017 ± 0.0007	0.0019 ± 0.0007	0.0015 ± 0.0008
	Stimulate 18	0.0020 ± 0.0006	0.0021 ± 0.0003	0.0030 ± 0.0019	0.0057 ± 0.0044	0.0014 ± 0.0005	0.0017 ± 0.0010
	Stiumlate 24	0.0018 ± 0.0008	0.0027 ± 0.0007	0.0020 ± 0.0007	0.0014 ± 0.0007	0.0012 ± 0.0006	0.0009 ± 0.0004
Leaf area	Control	344.57 ± 315.76	---	52.18 ± 10.22	224.72 ± 178.39	84.18 ± 31.21	159.40 ± 82.44
	Progib 0.8	293.53 ± 247.11	---	48.95 ± 11.42	291.03 ± 323.61	96.69 ± 18.59	257.79 ± 155.02
	Progib	296.14 ±	---	57.88 ±	278.04 ±	87.22 ±	167.10 ±

	1.6	303.71		10.56	311.63	13.87	58.65
	Progib 2.4	274.20 ± 217.97	---		586.90 ± 309.24	94.32 ± 14.77	350.65 ± 309.93
	Progib 3.2	215.57 ± 238.37	---	56.47 ± 15.14	629.10 ± 290.84	107.15 ± 8.26	194.23 ± 49.36
	Stimulate 6	293.46 ± 351.15	---	53.43 ± 13.05	394.36 ± 374.79	86.68 ± 14.71	126.33 ± 30.90
	Stimulate 8		---	47.73 ± 12.86	258.55 ± 203.96	77.61 ± 21.17	340.72 ± 226.87
	Stimulate 12	242.31 ± 132.08	---	44.48 ± 12.49	498.43 ± 291.82	82.16 ± 19.74	497.77 ± 381.21
	Stimulate 18	117.10 ± 50.42	---	61.81 ± 14.97	217.98 ± 210.11	77.34 ± 22.22	208.07 ± 46.32
	Stiumlate 24	157.35 ± 25.96	---	43.18 ± 16.75	471.22 ± 246.06	98.20 ± 12.41	200.95 ± 113.19
Shoot mass	Control	2.13 ± 0.82	1.06 ±0.31	0.58 ± 0.11	2.70 ± 1.92	1.03 ± 0.33	2.87 ± 1.47
	Progib 0.8	2.01 ± 0.87	0.63 ± 0.25	0.57 ± 0.14	3.36 ± 1.41	1.29 ± 0.27	1.52 ± 0.79
	Progib 1.6	1.67 ± 0.53	0.67 ±0.46	0.72 ± 0.15	2.35 ± 0.61	1.19 ± 0.23	3.07 ± 2.10
	Progib 2.4	1.66 ± 1.00	1.40 ±0.69		2.10 ± 0.61	1.09 ± 0.46	2.21 ± 0.87
	Progib 3.2	1.68 ± 0.52	0.77 ± 0.54	0.67 ± 0.18	1.76 ± 0.44	1.56 ± 0.14	1.92 ± 0.39
	Stimulate 6	1.73 ± 0.31	0.54 ± 0.12	0.58 ± 0.11	2.89 ± 1.62	0.98 ± 0.38	1.87 ± 0.44
	Stimulate 8		0.81 ± 0.82	0.59 ± 0.14	1.57 ± 0.35	1.15 ± 0.34	1.34 ± 0.66
	Stimulate 12	2.02 ± 1.16	0.61 ± 0.23	0.58 ± 0.21	1.63 ± 0.39	1.21 ± 0.43	1.71 ± 0.43
	Stimulate 18	2.10 ± 0.63	0.81 ± 0.27	0.82 ± 0.21	2.45 ± 0.82	0.93 ± 0.38	1.94 ± 0.47
	Stiumlate 24	2.09 ± 0.30	1.03 ± 0.72	0.45 ± 0.07	3.01 ± 1.83	1.18 ± 0.27	2.56 ± 0.44
Root mass	Control	2.16 ± 0.65	1.72 ± 0.53	1.01 ± 0.22	4.48 ± 2.15	1.59 ± 0.39	4.95 ± 1.14
	Progib 0.8	2.14 ± 1.03	1.42 ± 0.65	1.06 ± 0.23	5.22 ± 2.20	1.64 ± 0.39	4.23 ± 1.72
	Progib 1.6	2.18 ± 0.79	0.78 ± 0.20	1.50 ± 0.36	4.11 ± 0.81	1.37 ± 0.72	4.88 ± 2.48
	Progib 2.4	2.82 ± 1.06	2.68 ± 1.28		3.54 ± 1.44	1.53 ± 0.58	2.85 ± 1.45
	Progib 3.2	1.46 ± 0.70	1.09 ± 0.48	1.21 ± 0.43	3.17 ± 1.57	1.92 ± 0.46	5.51 ± 1.46
	Stimulate 6	2.08 ± 0.57	1.19 ± 0.57	0.92 ± 0.41	4.01 ± 0.78	1.26 ± 0.35	5.17 ± 1.08
	Stimulate 8		1.41 ± 0.92	1.02 ± 0.25	3.83 ± 1.95	1.48 ± 0.15	4.40 ± 1.87
	Stimulate 12	2.60 ± 1.93	1.11 ± 0.35	1.16 ± 0.48	2.96 ± 0.81	1.42 ± 0.30	4.52 ± 0.68
	Stimulate 18	3.40 ± 0.92	1.06 ± 0.31	1.11 ± 0.27	4.76 ± 2.15	1.25 ± 0.43	4.73 ± 2.25
	Stiumlate 24	2.64 ± 1.12	1.61 ± 1.08	0.97 ± 0.31	2.64 ± 1.13	1.47 ± 0.35	5.49 ±2.00



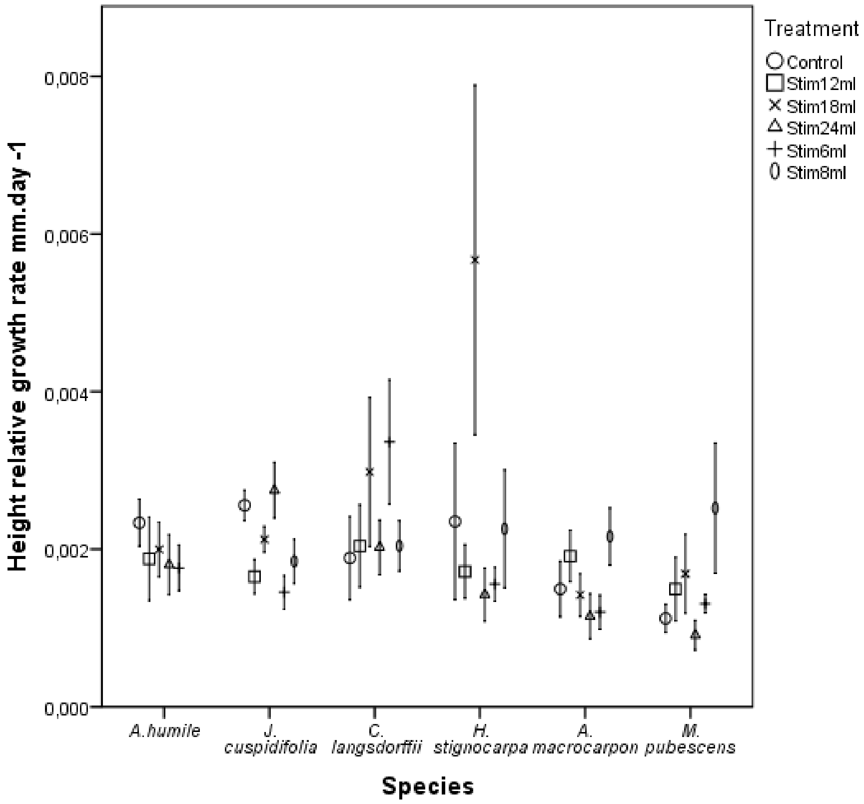


Figure 1. Means and confidence intervals (α=0,05) for the relative growth rates in height (mm.day^{-1}) for the seedlings of each one of the six Cerrado native species studied (*Anacardium humile, Jacaranda cuspidifolia, Copaifera langsdorffii, Hymenaea stignocarpa, Aspidosperma macrocarpum, Magonia pubescens*) submitted to different treatments using two commercial plant growth regulators Progibb® (A) and Stimulate® (B)(the numbers indicate concentrations in mL.L^{-1}).

For most species, the phytohormone concentrations tested did not prevent growth and Progibb® tended to increase seedling growth of *Anacardium humile* and *Jacaranda cuspidifolia*, whereas Stimulate® tended to improve seedling growth of *Hymenaea stignocarpa* and *Copaifera langsdorfii*. We therefore state that these phytohormones, probably in higher concentrations and/or in repeated applications, could be beneficial for the initial growth of these species.

In contrast, Stimulate® can be toxic to the growth of *Jacaranda cuspidifolia*, since the plants in treatment T_5 and T_7 (Stimulate® 6 $mL.L^{-1}$ and Stimulate® 12 $mL.L^{-1}$) had significantly lower relative growth rates than control plants (Kruskal-Wallis H = 25.5, DF = 9, p = 0.002).

Among control plants, *Hymenaea stignocarpa* seedlings presented the higher elongation rates and this species is classified as slow/moderate growth rate (Table 1).This can be attributed to the species larger seeds compared to the other five studied species (Hoffman & Franco, 2003; Fagundes *et al*, 2013).

By day 30 after phytohormone application, the seedlings growing rate declined for all species and treatments, which suggests that hormones reapplication could benefit plant growth as it was described for other Cerrado native species (Canesin *et al*., 2012). Since this also occurred in untreated control seedlings, this slowdown in growth may be due to restricted space of polyethylene bags used for the seedlings development or to photoperiod changes. Photoperiod decreases has been described to affect Cerrado seedling growth in nursery (Costa *et al*., 2011) and in soil conditions in tropical areas (Marimon *et al*., 2008).

The slow growth of native tree species seedlings of Cerrado is one of the barriers to the use of these species in ecological restoration projects. The use of phytohormones to accelerate the growth of these species may be an alternative to overcome this barrier (Caldas *et al*., 2009). Although there has not been a consistent positive effect of growth regulators used on the six species tested, only *Jacaranda cuspidifolia* had a negative effect in response to Stimulate®. This lack of phytotoxicity indicates that higher concentrations and repeated applications can be tested to all species except to *J. cuspidifolia* treated with Stimulate®.

CONCLUSIONS

1. None of the two phytohormones at the tested doses significantly increased initial growth of the six native trees Cerrado species used in the experiments.
2. Stimulate® 6 $mL.L^{-1}$ and 12 $mL.L^{-1}$ affected negatively the growth of *Jacaranda cuspidifolia* indicating possible phytotoxicity.
3. Progibb® tended to improve seedling growth of *A. humile* and *J. cuspidifolia*, whereas Stimulate® improved seedling growth of *H. stignocarpa* and *C. langsdorfii*.
4. The combination of species and phytohormones that did not indicate phytotoxicity should be tested with higher doses and/or repeated applications to promote initial growth of these and other Cerrado tree species,

accelerating and facilitating commercial production of seedlings.

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