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Article

Residues of Invasive Forage Species Inhibits the Growth of *Caryocar brasiliense*

Resíduos de Espécies Forrageiras Invasoras Inibem o Crescimento do Pequizeiro

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ABSTRACT - Native species seedling growth may be affected by allelopathic substances released by invasive forage species, mainly in natural regrowth areas. Thus, this research aimed to evaluate the growth characteristics of pequi trees influenced by concentrations of plant residues of different forage species (*Urochloa decumbens*, *Melinis minutiflora* and *Paspalum notatum*). A randomized block experimental design was arranged in a factorial 3 x 4 + 1, with four replications. Treatments consisted of incorporating plant shoot residues of three forage species to pequi seedling substrate (soil + fertilizer) at four concentrations (1%, 2%, 3%, and 4% mass/mass), plus pequi seedlings grown in a residue-free substrate (control). Pequi plant height, stem diameter, and leaf number were evaluated at fortnightly intervals. Leaf area, root/shoot ratio, leaf area ratio, specific leaf area, and leaf mass ratio were determined 100 days after transplanting. Forage residues added to substrate inhibited pequi growth, and with increasing residue concentration, this inhibition was intensified. Pequi leaf characteristics proved to be more sensitive to allelopathic effect, especially from *U. decumbens* residues.

Keywords: *Caryocar brasiliense*, *Urochloa decumbens*, *Melinis minutiflora*, *Paspalum notatum*, allelopathy.

RESUMO - O crescimento de mudas de espécies nativas pode ser afetado por substâncias alelopáticas liberadas por espécies forrageiras invasivas principalmente em áreas de recomposição natural. Objetivou-se nesta pesquisa avaliar as características de crescimento do pequizeiro influenciadas por concentrações de resíduos vegetais das espécies forrageiras ***Urochloa decumbens****,* ***Melinis minutiflora*** *e* ***Paspalum notatum****. O delineamento experimental foi de blocos ao acaso em esquema fatorial 3 x 4 + 1, com quatro repetições. Os tratamentos foram compostos pela adição de resíduos vegetais da parte aérea das três espécies forrageiras misturados ao substrato (solo + fertilizante) em quatro concentrações (1%, 2%, 3% e 4% massa/massa), mais o cultivo da muda de pequi na ausência de resíduos vegetais no solo. Em intervalos quinzenais, foram avaliados a altura de plantas, o diâmetro do caule e o número de folhas. Aos 100 dias após o transplantio, determinou-se a área foliar, relação raiz/parte aérea, razão de área foliar, área foliar específica e razão de massa foliar. Os resíduos vegetais das gramíneas forrageiras adicionadas ao substrato inibem o crescimento das plantas de pequi e, com o aumento da concentração destes resíduos, verifica-se a intensificação dessa inibição. As características foliares das plantas de pequi comprovam serem mais sensíveis à atividade alelopática, principalmente à ação dos resíduos de* ***U. decumbens****.*

Palavras-chave: *Caryocar brasiliense*, *Urochloa decumbens*, *Melinis minutiflora*, *Paspalum notatum*, alelopatia.

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INTRODUCTION

Pequi (*Caryocar brasiliense* Camb.) is a tree species from the Caryocaraceae family. It stands among the most important native species of the Cerrado (tropical savannah) because of the nutritional value of its fruits and diverse applications of its by-products in the Brazilian economy (Santos et al., 2010). In addition, it is an important forestry component used in native vegetation restoration areas, favoring biodiversity and soil protection (Camargo et al., 2014; Alves Jr. et al., 2015).

Ecosystem biodiversity is affected by biological invasion, with African forage grasses being the easiest to colonize environments due to their competitive efficiency, enhanced by the production of phytotoxic substances (Barbosa et al., 2008). Allelopathy is the inhibitory and/or stimulatory effects of one plant, either direct or indirect, upon another through chemical compounds produced by itself and released into the environment (Silva et al., 2011; Miranda et al., 2012; Paula et al., 2014).

Knowing allelochemical potential is important to determine the interference of agroecosystem component species with ecological succession and plan forest restoration projects. Allelopathic effects are most commonly observed during early plant growth, showing development changes of different plant parts such as leaves, stem, and roots (Hüller and Sochock, 2011).

The main biological agents of natural characteristic changes in Cerrado native areas are forage grasses, among them stand out *Melinis minutiflora* (P. Beauv.) (molasses grass), *Urochloa decumbens* (Stapf.) (signal grass), and *Paspalum notatum* (Flügge.) (bahiagrass), which have high potential for biomass and seed productions (Martins et al., 2009; Zenni and Ziller, 2011; Spear et al., 2013; Hoffman et al., 2008). In warm and open environments, such as in Cerrado, these forages are likely to become serious threats to biodiversity (Matos and Pivello, 2009). Where there is constant coexistence of these exotic species with native Cerrado species, there is a risk of the latter being excluded by competition and allelopathy (Pivello et al., 1999a; Mack et al., 2000; Del Fabbro et al., 2014). Pivello et al. (1999b) reported evidence of exclusion of native species by interspecific associations between the African grasses *Melinis minutiflora* and *Urochloa decumbens* with tropical savannah species. Biological invasion can affect an entire ecosystem as exotic species replace native species that serve as a food source for local fauna.

Still, little is known about the allelopathic effects of forage grass on the growth of native species seedlings such as pequi tree. Leaf yellowing and subsequent adult plant death in areas with forage grasses emphasize the hypothesis of their interference, in other words, some species may have an inhibitory effect on development of pequi plants. In this context, this study aimed to evaluate the influence on pequi growth characteristics by various plant residue concentrations from different forage species (*U. decumbens*, *M. minutiflora*, and *P. notatum*), in order to detect possible allelopathic effects.

MATERIAL AND METHODS

The experiment was carried out in a greenhouse under controlled humidity from March to July 2014. The area is in southwestern Goiás State at the following geographic coordinates: 17°48'67"S and 50°54'18"W. The forage species *Urochloa decumbens*, *Melinis minutiflora*, and *Paspalum notatum* were sown and grown in land plots. At 75 days after sowing, plant shoot was cut and collected. After, the collected material was dried in a forced-air ventilation oven at 45 ^{o}C until constant weight and then milled and stored. Table 1 presents the results of leaf tissue chemical analysis of the evaluated forage species.

The soil used in the study came from the topsoil layer of a dystroferric Red Latosol (Oxisol), and had the following physicochemical characteristics: pH in $CaCl_2$ of 5.6; 22.84 mg dm^{-3} of P; 190 mg dm^{-3} of K; 5.98 cmol$_c$ dm^{-3} of Ca; 1.80 cmol$_c$ dm^{-3} of Mg; 2.80 cmol$_c$ dm^{-3} of H + Al; 2.45 dag kg^{-1} of organic matter; and 74.7% base saturation. Once collected, the soil was shade-dried and sieved. Then, fertilizers and forage dry matter were added to the pots. Each pot was fertilized with 50 g simple superphosphate and 10 g potassium chloride. The components (soil + fertilizer + dry matter) were mixed in a rotary mixer for each pot. As pequi tree is not a cultivated species, being exploited only by extractivism and forest regrowth, fertilization was defined based on recommendations for perennial species applied in planting furrow.

The pequi seedlings were obtained from a nursery in the city of Guapó, GO (Brazil). At the time of acquisition, the seedlings had one pair of leaves. Treatments consisted of four concentrations (1%, 2%, 3%, and 4% mass/mass) of plant shoot residues of the three forage species (*Urochloa decumbens*, *Melinis minutiflora*, and *Paspalum notatum*) incorporated to substrate (soil + fertilizer) plus a control (without forage residue), constituting a 3x4+1 factorial arrangement. The experimental design was a randomized complete block with four replications. Each pot contained 8 kg substrate, according to treatment, and each one was an experimental unit.

Table 1 - Physicochemical characteristics of *Urochloa decumbens* (URODE), *Melinis minutiflora* (MELMI), and *Paspalum notatum* (PASNO) leaf tissues

Nutrient	Forage species		
	URODE	MELMI	PASNO
N (g kg^{-1})	5.60	5.60	14.00
P (g kg^{-1})	2.50	2.70	2.70
K (g kg^{-1})	20.00	12.00	13.50
Ca (g kg^{-1})	2.60	2.70	2.90
Mg (g kg^{-1})	2.50	1.70	2.00
S (g kg^{-1})	0.80	1.00	1.30
B (mg kg^{-1})	27.34	35.08	45.41
Cu (mg kg^{-1})	1.78	2.77	5.99
Fe (mg kg^{-1})	460.01	759.35	1461.48
Mn (mg kg^{-1})	55.92	92.93	40.23
Zn (mg kg^{-1})	19.87	25.19	14.66

After the pots were filled, the pequi seedlings were transplanted. After transplantation, fertilization was performed every 30 days, using 1 g pot^{-1} of fertilizer containing: N: 13; P2 O5: 5; K_2O: 13; B: 0.04; Ca: 1; Cu: 0.05; S: 5; Fe: 0.2; Mg: 1; Mn: 0.08; Mo: 0.005; and Zn: 0.15, as percentage. Pots were irrigated whenever needed to maintain soil moisture near field capacity. The air temperature inside greenhouse ranged between 22 and 29 ^oC throughout the experimental period, and air relative humidity was between 60 and 75%.

Plant height, stem diameter, and leaf number were assessed at fortnightly intervals. Height was measured using a metric tape, from the soil surface to plant apex, and stem diameter was measured using calipers, near ground surface.

At the end of the experimental period, 100 days after transplantation (DAT), leaf area (LA) was determined by measuring with a millimetric ruler the length of the main-leaflet veins and summing them. These values were applied to the following equation: $LA = 1.218 - 0.012S + 0.0208S^2$ (Oliveira et al., 2002); wherein S is the sum of leaflet vein lengths.

After LA determination, plant organs (leaves, stems, and roots) were separated, packed in paper bags, and brought to a forced-air circulation chamber, regulated at 65 ^oC, and kept until constant weight to be weighed. Root-to-shoot ratio (R/S) was also calculated dividing the root dry mass by the sum of leaf and stem dry mass values.

With dry weight and leaf area data, leaf area ratio (LAR) was also determined by dividing the LA by the total dry mass of plant. Specific leaf area (SLA) was then obtained by dividing the LA by the dry mass of leaves. Finally, leaf weight ratio (LWR) was ascertained dividing the dry mass of leaves by dry mass of the entire plant (Rodrigues et al., 2008).

Data underwent an analysis of variance (ANOVA) by the F-test. When significant, means of treatments were compared among them by the Tukey test and with control by Dunnett test, at 5% significance level. As for residue concentrations, regression equations were fitted to the data, which were chosen for model simplicity, biological significance, and determination coefficient. All variables were subjected to variance normality (Shapiro-Wilks) and homogeneity (Levene test) tests, considering the basic assumptions of variance analysis.

RESULTS AND DISCUSSION

During the evaluation period, pequi plant height, stem diameter, and leaf number had no effects from interaction between plant species residue and concentrations thereof in substrate (Table 2); however, only major effects were verified. Solely in the presence of *P. notatum* residues, pequi growth resembled that in height of the control in all evaluated periods, characterizing an absence of inhibitory effect of this forage species. As from 57 DAT, in the presence of *U. decumbens* and *M. minutiflora* residues, pequi plant heights were lower than the control and than those

Table 2 - Heights (cm) of pequi plants grown in substrates containing residues of the forage species *Urochloa decumbens*, *Melinis minutiflora*, and *Paspalum notatum*, at different concentrations. Rio Verde, GO (Brazil), 2014

Days after transplant	Test.[1]	Species			Regression equation, R^2
		U. decumbens	*M. minutiflora*	*P. notatum*	
15	6.88	6.66 a	6.62 a	6.68 a	-
29	7.91	7.03 a	6.96 a	7.30 a	-
43	9.85	7.93 a	7.25 a	8.93 a	-
57	10.77	8.79 ab (-)	7.73 b (-)	10.06 a	-
71	11.89	9.76 b (-)	7.93 b (-)	11.93 a	-
85	12.57	9.33 b (-)	9.20 b (-)	12.63 a	-
100	13.57	8.27 b (-)	9.85 ab (-)	12.22 a	-
Days after transplant	Concentration (%)				Regression equation, R^2
	1	2	3	4	
15	7.07	7.41	5.63	6.51	$\hat{Y} = \bar{Y} = 6.65$
29	7.34	7.73	6.33	6.99	$\hat{Y} = \bar{Y} = 7.10$
43	8.68	8.23	7.19	8.04	$\hat{Y} = \bar{Y} = 8.04$
57	9.78	9.10	7.94	8.62	$\hat{Y} = \bar{Y} = 8.86$
71	11.32	9.93	9.12	9.13	$\hat{Y} = 11.71 - 0.73x \;\; r^2 = 0.84*$
85	12.70	11.27	9.68	9.53	$\hat{Y} = 13.56 - 1.27x \;\; r^2 = 0.65*$
100	13.44	12.04	8.23	6.75	$\hat{Y} = 16.08 - 2.38x \;\; r^2 = 0.96*$

[1] Control. Means followed by the same letters are statistically equal by the Tukey's test at 5% probability. Means followed by (-) are lower than the control by Dunnett's test at 5% probability.

grown in substrate with *P. notatum* residues (Table 2). This may be related to decomposition of plant residues and release of allelochemicals.

As the residue concentration was increased in the substrate, pequi height was suppressed from 71 DAT. This may be because higher residue concentrations increase release of allelopathic compounds to the environment, having most significant effects with plant age (Table 2). For each percentage unit increase in residue concentration, we observed reductions of 0.74, 1.27, and 2.39 cm at 71, 85, and 100 DAT, respectively. There was then a marked delay in plant growth with increasing concentration, i.e. there was a negative influence of allelopathic compounds on pequi seedlings.

Stem diameter of pequi plants with *U. decumbens* residue was smaller than that of control from 71 DAT and statistically lower than those of plants grown with *M. minutiflora* and *P. notatum* residues at 100 DAT (Table 3). Pequi stem diameter was also affected by increasing residue concentrations in the soil. We observed reductions of 0.397 and 0.961 mm per each unit of residue concentration (%) at 85 and 100 DAT, respectively. Similarly, pequi leaf number was reduced by adding plant residue to the substrate, representing a fall of 0.833 and 1.25 leaves per plant during the same evaluation times (Table 4). However, only pequi seedlings grown with *P. notatum* residues, regardless of the concentration, did not differ in stem diameter if compared to the control (Table 4). This might denote an absence of allelopathic compound releases from residues of the species (*P. notatum*). Nutrient releases from *P. notatum* residues (Table 1) may improve the environment for pequi growth.

Plant growth evaluation is an important method to verify allelopathic effects, as allelochemicals induce onset of abnormal plants, interfering with cell division, organic synthesis, hormonal interactions, nutrient absorption, protein synthesis inhibition, lipid metabolism changes, stomatal conductance, CO_2 assimilation, and photosynthesis, reducing transport of electrons and chlorophyll content in plants, besides leading to changes in water-plant relations (Reigosa et al., 2006; Aslam et al., 2017). Souza et al. (2006) verified initial growth inhibition in maize, rice, wheat, soybean, beans, cotton, and brush grass due to incorporation of *U. decumbens* residues in the soil. In addition to its competitive ability, the success of *U. decumbens* as a biological invader in ecosystems is associated with its allelopathic activity, mainly for the production and release of the metabolite (6R,9S)-3-oxo-á-ionol (Kobayashi and Kato- Noguchi, 2015).

No interactions were observed between forage species and residue concentrations in the substrate for leaf area, total dry mass, and root/shoot ratio (Table 5). Regardless of the

Table 3 - Stem diameter (mm) of pequi plants grown in substrates containing residues of the forage species *Urochloa decumbens*, *Melinis minutiflora*, and *Paspalum notatum,* at different concentrations. Rio Verde, GO (Brazil), 2014

Days after transplant	Test.(1)	Species			Regression equation, R^2
		U. decumbens	*M. minutiflora*	*P. notatum*	
15	3.48	3.36 a	3.50 a	3.32 a	-
29	3.96	3.68 a	3.70 a	3.70 a	-
43	4.59	3.97 a	4.06 a	4.22 a	-
57	4.77	4.19 a	4.34 a	4.63 a	-
71	5.11	4.28 a (-)	4.54 a	5.03 a	-
85	5.68	4.45 b (-)	4.80 ab	5.54 a	-
100	5.87	3.45 b (-)	5.09 a	5.02 a	-
Days after transplant	Concentration (%)				Regression equation, R^2
	1	2	3	4	
15	3.18	3.71	3.12	3.58	$\hat{Y} = \bar{Y} = 3.40$
29	3.50	3.84	3.45	3.99	$\hat{Y} = \bar{Y} = 3.69$
43	4.14	4.24	3.70	4.25	$\hat{Y} = \bar{Y} = 4.08$
57	4.58	4.61	3.92	4.43	$\hat{Y} = \bar{Y} = 4.38$
71	5.22	4.49	4.22	4.54	$\hat{Y} = \bar{Y} = 4.61$
85	5.87	4.83	4.31	4.72	$\hat{Y} = 5.92 - 0.39x \; r^2 = 0.59 *$
100	5.95	5.33	3.45	3.36	$\hat{Y} = 6.92 - 0.96x \; r^2 = 0.89 *$

(1) Control. Means followed by the same letters are statistically equal by the Tukey's test at 5% probability. Means followed by (-) are lower than the control by Dunnett's test at 5% probability.

Table 4 - Leaf number of pequi plants grown in substrates containing residues of the forage species *Urochloa decumbens*, *Melinis minutiflora*, and *Paspalum notatum*, at different concentrations. Rio Verde, GO (Brazil), 2014

Days after transplant	Test.(1)	Species			Regression equation, R^2
		U. decumbens	*M. minutiflora*	*P. notatum*	
15	2.13	2.00 a	2.00 a	2.06 a	-
29	3.63	3.44 a	3.75 a	3.31 a	-
43	5.13	3.94 a (-)	3.94 a (-)	4.44 a	-
57	5.25	4.88 ab	4.06 b (-)	5.19 a	-
71	5.75	6.06 a	4.81 b (-)	5.88 a	-
85	5.50	4.88 a	5.19 a	5.69 a	-
100	7.00	4.25 a (-)	5.50 a	5.12 a	-
Days after transplant	Concentration (%)				Regression equation, R^2
	1	2	3	4	
15	2.08	2.00	2.00	2.00	$\hat{Y} = \bar{Y} = 2.02$
29	3.75	3.50	3.50	3.25	$\hat{Y} = \bar{Y} = 3.50$
43	4.42	3.75	4.08	4.17	$\hat{Y} = \bar{Y} = 4.10$
57	5.00	4.50	4.67	4.67	$\hat{Y} = \bar{Y} = 4.71$
71	6.00	5.50	5.33	5.50	$\hat{Y} = \bar{Y} = 5.58$
85	6.67	5.33	5.00	4.00	$\hat{Y} = 7.33 - 0.83x \; r^2 = 0.95 *$
100	6.67	5.67	4.66	2.33	$\hat{Y} = 8.08 - 1.25x \; r^2 = 0.97 *$

(1) Control. Means followed by the same letters are statistically equal by the Tukey's test at 5% probability. Means followed by (-) are lower than the control by Dunnett's test at 5% probability.

Table 5 - Leaf area, root dry mass, total dry mass, root/shoot ratio of pequi plants grown in substrates with plant residues of the forage species *Urochloa decumbens*, *Melinis minutiflora*, and *Paspalum notatum*, at different concentrations. Rio Verde, GO (Brazil), 2014

Parameter	Test.[1]	Species			Regression equation, R^2
		Urochloa decumbens	*Melinis minutiflora*	*Paspalum notatum*	
Leaf area (cm²)	210.96	114.86 b (-)	108.90 b (-)	211.17 a	-
Root dry mass (g)	7.55	6.84 a	7.24 a	7.12 a	-
Total dry mass (g)	20.90	16.27 b (-)	17.57 ab (-)	18.90 a (-)	-
Root/shoot ratio	0.566	0.833 a (+)	0.719 a	0.656 a	-
Parameter	Concentration (%)				Regression equation. R^2
	1	2	3	4	
Leaf area (cm²)	273.85	218.19	122.29	21.08	$\hat{Y} = 372.40 - 85.42x$ $r^2 = 0.98*$
Root dry mass (g)	7.21	7.17	7.37	6.52	$\hat{Y} = \bar{Y} = 7.06$
Total dry mass (g)	20.10	18.76	17.41	14.05	$\hat{Y} = 22.45 - 1.95x$ $r^2 = 0.93*$
Root/shoot ratio	0.565	0.623	0.798	0.958	$\hat{Y} = 0.39 - 0.13x$ $r^2 = 0.96*$

[1] Control. Means followed by the same letters are statistically equal by the Tukey's test at 5% probability. Means followed by (-) are lower than the control by Dunnett's test at 5% probability.

concentration, *U. decumbens* and *M. minutiflora* residues promoted an inhibitory effect on the leaf area of pequi seedlings when compared to those grown with *P. notatum* and the control, which directly reflected in reduced production of seedling total dry mass. Regarding dry root mass and root/shoot ratio (Table 5), no significant effects were observed among the forage species. When compared to the control, there was only an increment in root/shoot ration in pequi seedlings grown with *U. decumbens* residues, thus, shoot growth is negatively influenced by plant residues of this species in the soil. An increase in root/shoot ratio is a plant reaction to stress, either by increasing root mass to exploit a larger soil volume and increase water and nutrient absorptions, or by reducing shoot dry mass accumulation to decrease perspiration area (Sá et al., 2013); the latter is believed to occur with pequi trees, mainly due to a reduction in leaf area of plants.

Regardless of the plant species, an increase in residue concentration resulted in a linear decrease in leaf area, total dry mass, and root/shoot ratio of 85.42 cm², 1.95 g per plant, and 0.135, respectively, for each percentage unit of residue added to the substrate (Table 5). Among the growth parameters, leaf area, which is related to leaf expansion and formation, was most affected when plants were subjected to some stress. This is because leaf area reduction is one of the plant defense mechanisms to avoid higher water losses due to perspiration (Moraes et al., 2011; Spiassi et al., 2011; Sá et al., 2013; Oliveira et al., 2016).

For leaf and stem dry weights, LWR, LAR, and the SLA, significant interactions were observed between forage species and residue concentrations (Table 6). In general, leaf parameters were the most sensitive to inhibitory action promoted by plant residues added to the substrate, mainly at the highest concentrations, with emphasis on effects of *U. decumbens* and *M. minutiflora* at 3% concentration and for all species at 4% concentration if compared to the control. At this concentration (4%), lower stem dry matter production was observed in plants grown with *M. minutiflora* and *P. notatum* residues (Table 6), but increasing residue concentrations had no effect on this parameter.

Linear decreases were observed for pequi leaf parameters as residue concentration increased in the substrate (Table 6), mainly LAR and SLA of plants with *P. notatum* residue, showing reductions of 5.38 and 12.62 $cm^2\ g^{-1}$, respectively. Also, there was a linear decrease of leaf dry mass and LWR of plants with *U. decumbens* residue, showing reductions of 2.61 g per plant and 0.131 $g\ g^{-1}$, respectively, compared to the other forage species (Table 6). These results corroborate those of Souza et al. (2003) who also verified reductions in growth and establishment of *Eucalyptus grandis* seedlings due to incorporation of *U. decumbens* residues. Allelopathic potential depends on plant residue composition, chemical compound releases and their interactions with the soil (Pereira et al., 2011). Therefore, agricultural techniques should be adopted to monitor and reduce

Table 6 - Dry leaf mass, dry stem mass, leaf mass ratio, leaf area ratio, and specific leaf area of pequi plants grown in substrates with residues of the forage species *Urochloa decumbens*, *Melinis minutiflora*, and *Paspalum notatum* at different concentrations. Rio Verde, GO (Brazil), 2014

Species	Concentration (%)				Regression equation, R^2
	1	2	3	4	
Dry leaf mass (g)					
Urochloa decumbens	7.48 a	6.61 a	2.94 b (-)	0.00 b (-)	$\hat{Y} = 10.78 - 2.61x$ $r^2 = 0.95*$
Melinis minutiflora	6.81 a	5.71 a	4.74 ab (-)	4.56 a (-)	$\hat{Y} = 7.38 - 0.77x$ $r^2 = 0.92*$
Paspalum notatum	8.90 a	7.50 a	7.53 a	2.57 ab (-)	$\hat{Y} = 11.36 - 1.89x$ $r^2 = 0.77*$
Dry stem mass (g)					
Urochloa decumbens	5.17 ab	4.95 a	5.03 a	5.56 a	$\hat{Y} = \bar{Y} = 5.18$
Melinis minutiflora	4.93 b	4.88 a	4.83 a	4.88 b	$\hat{Y} = \bar{Y} = 4.88$
Paspalum notatum	5.40 a	5.13 a	5.06 a	5.04 b	$\hat{Y} = \bar{Y} = 5.16$
Leaf mass ratio ($g\ g^{-1}$)					
Urochloa decumbens	0.38 a	0.36 a	0.18 b (-)	0.00 b (-)	$\hat{Y} = 0.55 - 0.13x$ $r^2 = 0.91*$
Melinis minutiflora	0.36 a	0.32 a	0.27 ab	0.29 a	$\hat{Y} = 0.37 - 0.02x$ $r^2 = 0.73*$
Paspalum notatum	0.41 a	0.37 a	0.37 a	0.15 ab (-)	$\hat{Y} = 0.52 - 0.07x$ $r^2 = 0.73*$
Leaf area ratio ($cm^2\ g^{-1}$)					
Urochloa decumbens	10.29 a	9.48 a	4.72 b (-)	0.00 a (-)	$\hat{Y} = 15.03 - 3.56x$ $r^2 = 0.93*$
Melinis minutiflora	11.24 a	5.06 a	3.90 b (-)	3.39 a (-)	$\hat{Y} = 12.07 - 2.47x$ $r^2 = 0.77*$
Paspalum notatum	18.45 a	10.83 a	10.61 a	0.59 a (-)	$\hat{Y} = 23.57 - 5.38x$ $r^2 = 0.89*$
Specific leaf area ($cm^2\ g^{-1}$)					
Urochloa decumbens	27.12 a	25.90 a	13.48 b (-)	0.00 b (-)	$\hat{Y} = 40.07 - 9.37x$ $r^2 = 0.91*$
Melinis minutiflora	31.37 a	15.45 a	14.65 ab (-)	11.87 a (-)	$\hat{Y} = 33.16 - 5.93x$ $r^2 = 0.75*$
Paspalum notatum	43.98 a	28.71 a	28.86 a	1.86 ab (-)	$\hat{Y} = 57.40 - 12.62x$ $r^2 = 0.86*$

Means followed by the same letters are statistically equal by the Tukey's test at 5% probability. Means followed by (-) are lower than the control by Dunnett's test at 5% probability.

occurrence of exotic species with invasive potential in preservation and recovery areas, and thereby prevent native species growth problems or exclusion such as the case of pequi trees. Allelopathic compound releases make an additional challenge to ecological maintenance and restoration management.

As a conclusion, the addition of *U. decumbens* and *M. minutiflora* residues to the substrate interferes negatively with the initial growth of pequi plants and, with increasing residue concentration, growth inhibition is intensified. Pequi leaf parameters are more sensitive to the effects promoted by allelopathic effects from residues added to the substrate. Overall, the most harmful effect on pequi seedlings was promoted by *U. decumbens* residues.

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