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Article

INITIAL DEVELOPMENT OF EUCALYPTUS ACCORDING TO DIFFERENT DESICCATION PERIODS OF SIGNALGRASS

Desenvolvimento Inicial do Eucalipto em Função de Épocas de Dessecação do Capim-Braquiária

GRAAT, Y.[1]
BACHA, A.L.[1]*
NEPOMUCENO, M.P.[1]
ALVES, P.L.C.A.[1]

*** Corresponding author:**
<allan_lb@hotmail.com>

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ABSTRACT - This study aimed at evaluating the effects of different desiccation periods of *Urochloa decumbens* on the initial development of *Eucalyptus urograndis* (clone C-219H). The experiment was conducted in 100 liter concrete boxes, previously filled with Dark-Red Latosol. *U. decumbens* was sown in all plots, except for the control sample without covering. After 95 days from sowing, the herbicide glyphosate (dose of 1,424 g a.e. ha^{-1}) was sprayed at intervals of 0 (Apply-Plant), 7, 14, 21, 28 and 35 days before eucalyptus planting, plus a control sample without covering, totaling seven treatments. A completely randomized design with six replications was used. Eucalyptus plants were evaluated 30, 60 and 90 days after planting (DAP), when the height of the plants and the diameter of the stem were determined. At the end of the experimental period (90 DAP), the leaf area and the dry matter of leaves and stem were measured. It is possible to conclude that the Apply-Plant modality was harmful to some of the eucalyptus characteristics (*E. urograndis* - C-219H), while planting the seedlings in periods over 14 days after the desiccation of *U. decumbens* plants promoted a better development of the culture.

Keywords: *Eucalyptus urograndis*, *Urochloa decumbens*, plant cover, allelopathy.

*RESUMO - Objetivou-se neste trabalho avaliar os efeitos dos diferentes períodos de dessecação de plantas de capim-braquiária (**Urochloa decumbens**) no desenvolvimento inicial de **Eucalyptus urograndis** (clone C-219H). Conduziu-se o experimento em caixas de cimento, com capacidade para 100 litros, previamente preenchidas com solo Latossolo Vermelho-Escuro. A semeadura de **U. decumbens** foi realizada em todas as parcelas, exceto na testemunha sem cobertura. Após 95 dias da semeadura, foi aplicado o herbicida glyphosate (dose de 1.424 g e.a. ha^{-1}) em intervalos de 0 (Aplique e Plante), 7, 14, 21, 28 e 35 dias antes do plantio das mudas de eucalipto, mais a testemunha sem cobertura, totalizando sete tratamentos. Utilizou-se o delineamento inteiramente casualizado com seis repetições. As plantas de eucalipto foram avaliadas aos 30, 60 e 90 dias após o plantio (DAP), nas quais se determinou a altura das plantas e o diâmetro do caule. Ao término do período experimental (90 DAP), foi mensurada a área foliar e a massa seca das folhas e do caule. Conclui-se que a modalidade Aplique e Plante foi prejudicial a algumas características do eucalipto (**E. urograndis** – C-219H), enquanto o plantio das mudas em períodos superiores aos 14 dias após a dessecação das plantas de **U. decumbens** promoveu melhor desenvolvimento da cultura.*

Palavras-chave: *Eucalyptus urograndis*, *Urochloa decumbens*, cobertura vegetal, alelopatia.

[1] Universidade Estadual Paulista "Júlio de Mesquita Filho", Jaboticabal-SP, Brasil.

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INTRODUCTION

According to the Brazilian Tree Industry (Indústria Brasileira de Árvores - IBA) (2015), the area planted with eucalyptus in Brazil in 2014 was 5.56 million hectares, accumulating a 48.3% growth in an area planted between 2004 and 2011. On the other hand, the crop yield, which has grown annually, reached 39 m^3 ha^{-1} $year^{-1}$ in 2014.

This forest sector has expanded to cerrado areas that were previously occupied by signalgrass pastures [*Urochloa decumbens* (Stapf) R. D. Webster (syn. *Brachiaria decumbens*)] (Toledo, 1994), which are dried for eucalyptus planting. It is reported that, when very close to sowing, the desiccation of brachiaria (*U. ruziziensis* and *U. brizantha*) before annual crops such as soybean (Nepomuceno et al., 2012) and sunflower (Giancotti et al., 2013, 2015) is harmful, but there are no reports of this effect on perennial cultures and specifically involving signalgrass. This suppressive effect has been attributed to allelopathy (Nepomuceno et al., 2012).

Allelopathy is characterized as the phenomenon by which one species interferes in the growth and development of others, due to the production and release of chemical compounds that have inhibitory, attractive or stimulatory properties (Rice, 1974). Researchers and reforesters question the possibility that the formation of mulch over soil, resulting from the post-emergence chemical control of *U. decumbens*, could cause or accentuate the allelopathic interference of this weed on eucalyptus plants (Dinardo et al., 1998). The incorporation of signalgrass straw causes an inhibitory effect on the initial growth of eucalyptus, which is proportional to the incorporated amount (Souza et al., 2003).

The forage species *U. decumbens*, due to its easy desiccation (since there is no report of resistance to glyphosate), can be better used for the purpose of soil covering (Machado and Assis, 2010). In order to restore considerable amounts of nutrients to cultivations, the use of groundcover plants is an alternative to increase the sustainability of the agricultural system, since these plants absorb nutrients from the subsurface layers of the soil and release them later by the decomposition of their residues (Duda et al., 2003). However, in order to use straw with a soil covering function, information is needed to clarify the ideal period between desiccation and culture sowing, so that it does not influence negatively the following crop (Nunes et al., 2006).

The management or “desiccation” before no-tillage is fundamental for a good crop performance (Almeida, 1991). In groundcover plant control, total action systemic herbicides are normally used, among which glyphosate has shown good control results (Souza et al., 2000; Mello, 2002).

Many doubts about the interactions between plant covers and herbicides in controlling weeds still need to be clarified so that farmers can enjoy all the benefits of the system (Correia et al., 2005); therefore, it is important to know the effect of this cover on the initial development of crop plants.

Thus, with the hypothesis that there is a negative interference in implanting eucalyptus cultures right after the desiccation of *U. decumbens*, this work was conducted in order to verify the effects of desiccation periods of *U. decumbens* on the initial development of eucalyptus.

MATERIAL AND METHODS

The experiment was conducted during the 2011/12 agricultural year; the experimental unit consisted of concrete boxes with a 100 liter capacity (0.62 m x 0.62 m x 0.26 m depth).

They were filled with soil from the typical clay-textured Dark-Red Latosol arable layer, with clayey texture; a sample was subsequently submitted to routine physical-chemical analysis (Table 1). Considering the results, acidity corrections were not necessary, only fertility ones (K), by adding KCl in order to increase contents to about 3.0 $mmol_c$ dm^{-3}.

After filling the boxes, about 100 signalgrass seeds (*U. decumbens*) were deposited on the soil and then thinned, leaving 25 plants (equivalent to 65 plants m^{-2}), homogeneously distributed over the experimental plot. In order to constitute the experimental treatments, signalgrass sowing occurred every seven days until 35 days after the first sowing, expecting that at the time of desiccation the plants would have similar height (about 80 cm), mass (about 6 t ha^{-1}) and development stage (full flowering), with a control sample without sowing.

Table 1 - Soil analysis at the time of the first *Urochloa decumbens* planting

Plot	Chemical analysis									
	pH	M.O.	P Resin	K	Ca	Mg	H+Al	SB	T	V
	($CaCl_2$)	(g dm^{-3})	(mg dm^{-3})	($mmol_c$ dm^{-3})						(%)
35 DAD	6	30	77	2.8	52	26	22	80.8	102.8	79
28 DAD	5.7	30	62	2.4	41	18	28	61.4	89.4	69
21 DAD	5.7	29	64	1.3	44	20	28	65.3	93.3	70
14 DAD	5.6	28	64	0.8	47	21	28	68.8	96.8	71
7 DAD	5.8	29	64	0.5	51	20	28	71.5	99.5	72
0 DAD	6	26	78	0.2	48	19	22	67.2	89.2	75
Contr.	6.1	26	66	0.7	54	28	20	82.7	102.7	81

Physical analysis				
Clay	Loam	Sand		Textural Class
		Fine	Coarse	
g kg^{-1}				
543	197	160	100	Clayey

Top dressings were performed 60 days after the first sowing of signalgrass; 140 kg ha^{-1} of NPK fertilizer formula 4-14-8 were applied by broadcasting, and there was another application 74 days after the first sowing of signalgrass, with 160 kg ha^{-1} of the formula 4-20-20 and 100 kg ha^{-1} of urea.

Treatments consisted in eucalyptus planted in the absence of straw and eucalyptus planted on day 0, 7, 14, 21, 28 and 35 after the desiccation of signalgrass, totaling seven treatments with six replications, resulting in 42 experimental plots arranged in a completely randomized design. Desiccation, which occurred 95 days after signalgrass planting, was carried out by spraying the herbicide glyphosate (Glizmax®) at a dose of 4.0 L c.p. ha^{-1}, which corresponds to 1,432 g a.e. ha^{-1}. For this purpose, a 2.4 kgf cm^{-2} constant pressure (CO_2) backpack sprayer was used, equipped with a bar with four XR 11002 tips spaced 0.5 m apart, calibrated to spray a spray mixture volume of 200 L ha^{-1}. In the Apply and Plant (0 day) modality, spraying was done in the morning, and in the afternoon, eucalyptus seedlings were planted. The planting of these seedlings (clone C-219H), hybrid of *E. urograndis* (*E. grandis* x *E. urophylla*), about 90 days old, was carried out in the center of each plot. Specifically, in the plots regarding treatments of 0 and 7 days after desiccation, signalgrass plants were manually lowered, in order to avoid the shading effect on eucalyptus seedlings.

After planting the eucalyptus, three treatments were applied: on 21 days after planting (DAP), adding 150 kg ha^{-1} of the formula NPK 4-14-8, and on 57 and 68 DAP, with 135 kg ha^{-1} of urea.

During the experimental period, the substrates of the boxes were kept moist by periodic watering, according to the culture requirement; in order to avoid interferences from any other weed, they were manually removed whenever necessary.

Evaluations were performed 30, 60 and 90 DAP of eucalyptus seedlings, when the height of plants and the diameter of the stem were determined. The stem diameter was obtained by measurements with a digital caliper in the region of the plant collar, and the height was obtained from the length of the main stem. At the end of the experimental period (90 DAP), leaf area (Li-Color 3000A) and the dry matter of leaves and stem were determined, which were obtained after drying the materials in a forced air circulation oven at 70 °C for 96 hours, until reaching constant mass and they were then weighed on a precision scale.

The collected data were submitted to analysis of variance by F test, and the means of the control sample without straw were compared to the other treatments by Dunnett's test at 5% probability. Among the treatments with straw, a regression analysis was performed, following the second order polynomial model.

RESULTS AND DISCUSSION

Comparing treatments with the no-straw control sample, as for the height of eucalyptus 30 days after planting (DAP), except for the treatment on day 28 after desiccation (DAD), it was observed that there was no beneficial effect on the formed covering (Table 2). On 60 DAP, 28 and 35 DAD treatments differed statistically from the control sample without straw and from the others, presenting higher values for height. On the other hand, on 90 DAP, starting from 14 DAD there was a positive effect of the formed plant cover, where treatments differed significantly from the control sample and the Apply-Plant treatments (0 DAD) and 7 DAD.

As for the eucalyptus diameter, 28 and 35 DAD treatments differed statistically from the others in the evaluation performed on 30 DAP (Table 2). On 60 DAP, the Apply-Plant treatment presented a significant decrease in relation to the control sample without straw and on 7 DAD. From 14 DAD, there was a positive effect of soil cover, with an increase in diameter values.

Table 2 - Height (cm) and diameter (mm) of *Eucalyptus urograndis* seedlings (clone C-219H), 30, 60 and 90 days after planting

Treatment	Height 30 DAP	Height 60 DAP	Height 90 DAP	Diameter 30 DAP	Diameter 60 DAP	Diameter 90 DAP
Without straw	38.6 B	57.5 B	112.5 B	3.45 B	6.65 B	12.77 B
0 DAD	35.5 B	46.2 B	94.5 B	3.16 B	4.34 C	9.39 C
7 DAD	38.8 B	54.2 B	126.7 B	3.13 B	5.27 B	12.95 B
14 DAD	42.4 B	70.6 B	145.0 A	3.51 B	9.88 A	15.85 B
21 DAD	45.1 B	81.8 B	117.2 A	4.02 B	10.18 A	19.14 A
28 DAD	46.7 A	99.2 A	164.6 A	4.66 A	10.95 A	18.66 A
35 DAD	45.4 B	93.1 A	152.5 A	4.52 A	10.76 A	18.16 A
F (Treat)	5.31**	9.51**	21.48**	6.88**	26.97**	23.27**
VC (%)	10.59	22.01	10.84	15.01	16.21	12.88

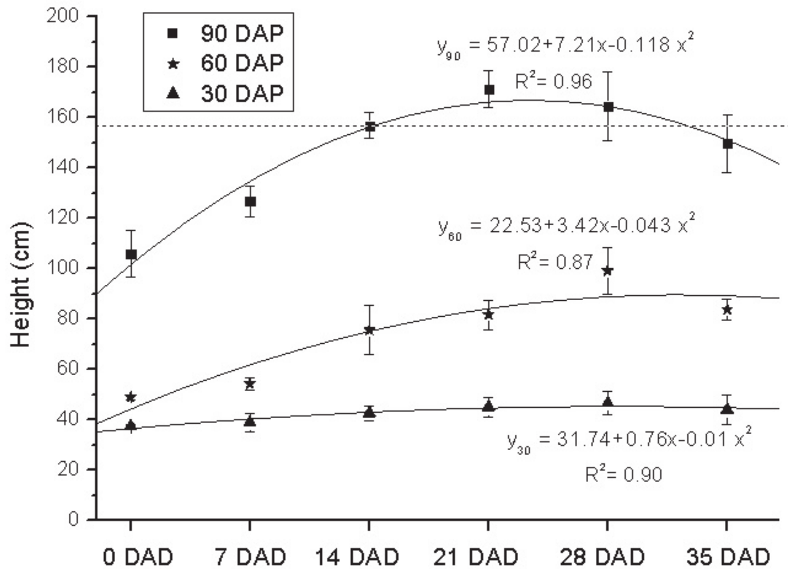
Averages followed by the same letter in the column do not differ from each other by Dunnett's test at 5% probability; DAD = days after desiccation; DAP = days after planting; VC = variation coefficient.

On 90 DAP, 21, 28 and 35 DAD treatments presented an increase in relation to the control sample; as occurred on 60 DAP, the 0 DAD treatment was negatively affected in relation to the treatment without straw, with a 50.94% loss in the diameter value, compared to the treatment that mostly developed (21 DAD) (Table 2).

As for the dry matter of stem, leaves and leaf area, it is possible to observe that from 14 DAD there was a significant increase in relation to the control sample without straw, probably caused by the presence of the plant cover (Table 3). In addition to this, it is possible to notice that, for the leaf dry matter variable, the Apply-Plant treatment was the only one presenting a decrease in relation to the control sample (Table 3).

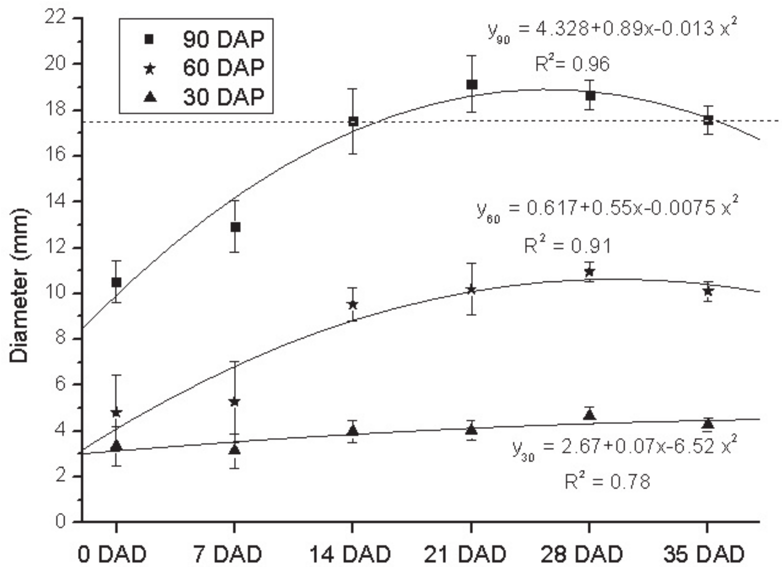
As for treatments with signalgrass cover, it is possible to observe that for height, on 30 DAP, there was no difference between the different desiccation periods (Figure 1). On 60 DAP, the 28 DAD treatment was the greatest and the only one differing from the others, which did not differ between them. On the other hand, on 90 DAP, there was an increase tendency in the height of the eucalyptus planted on 14, 21, 28 or 35 DAD, compared to Apply-Plant treatments and 7 DAD.

As for the stem diameter of eucalyptus plants (Figure 2), on 30 DAP no differences were observed among the treatments. However, from 60 DAP it was already possible to spot a difference between the 0 and 7 DAD treatments, in relation to the 14, 21, 28 and 35 DAD treatments; the lowest plants (treatment on 0 DAD) presented approximately half the diameter of the treatment that mostly developed during this period (28 DAD). On 90 DAP, there was a significant differentiation between the treatments: Apply-Plant and 7 DAD treatments showed the lowest values in relation to eucalyptus trees that were planted 14 or more days after the desiccation of signalgrass (Figure 2).



Bars indicate the standard error of the means.

Figure 1 - Effect of desiccation periods of *Urochloa decumbens* over the height of *Eucalyptus urograndis* (clone C-219H), 30, 60 and 90 days after planting.



Bars indicate the standard error of the means.

Figure 2 - Effect of the desiccation periods of *Urochloa decumbens* over the stem diameter of *Eucalyptus urograndis* plants (clone C-219H), 30, 60 and 90 days after planting.

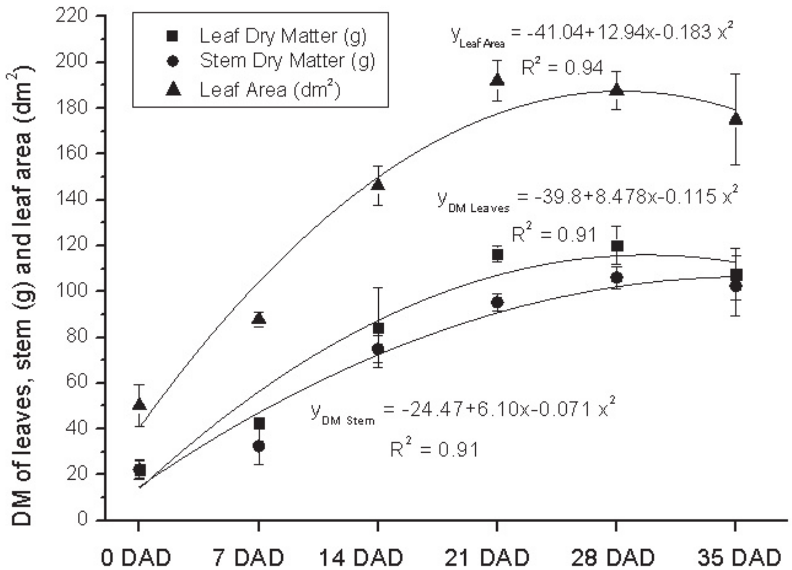
As for the dry matter of leaves, it is possible to observe that on 28 DAD there was an increase of almost five times the value of the Apply-Plant (0 DAD) treatment (Table 3).

As a consequence of the positive effect of the signalgrass cover presence, there was a marked leaf area increase in eucalyptus plants that were planted on 21, 28 and 35 DAD, reaching, on an average, values that were 2.6 times higher than the least developed treatment (0 DAD) (Table 3). In addition to leaf matter and leaf area gain, the stem dry matter for 21, 28 and 35 DAD treatments was also significantly higher than the one from 0 and 7 DAD treatments, with an average increase of 200%.

Table 3 **-** Dry matter of the stem (DMStem - g), dry matter of the leaves (DMLeaves - g) and leaf area (dm^2) of *Eucalyptus urograndis* seedlings (clone C - 219H) 90 days after planting

Variable	Without straw	0 DAD	7 DAD	14 DAD	21 DAD	28 DAD	35 DAD	F (Treat)	VC (%)
DMLeaves	45.8 B	22.3 C	40.6 B	74.8 A	95.2 A	106.0 A	102.4 A	33.06**	21.44
DMStem	45.3 B	35.5 B	42.4 B	84.1 A	116.5 A	120.1 A	107.5 A	20.04**	24.64
Leaf area	84.1 B	50.1 B	87.7 B	146.2 A	192.0 A	187.7 A	175.1 A	35.29**	18.78

Averages followed by the same letter in the line do not differ from each other by Dunnett's test at 5% probability; DAD = days after desiccation; DAP = days after planting; VC = variation coefficient.



Bars indicate the standard error of the means.

Figure 3 **-** Effect of desiccation periods of *Urochloa decumbens* over the dry matter of the stem, leaves and leaf area of *Eucalyptus urograndis* plants (clone C-219H), 90 days after planting.

Analyzing *U. ruziziensis* desiccation periods and their influence on the yield of RR soybean, Nepomuceno et al. (2012) found increases of about 12% for the height of soybean plants 30 and 20 days after the desiccation of this species, in relation to 0 DAD (Apply-Plant treatment). Thus, even if they are about different cultures, the results presented by Nepomuceno et al. (2012) and those found in this study agree about the fact that plants are taller when planted in more distant periods from the desiccation date of *U. ruziziensis*.

In this context, Giancotti et al. (2013), while analyzing the influence of desiccation periods of *U. ruziziensis* and *B. brizantha* on the productivity and development of sunflowers, found 78% and 55% reductions in the leaf area of plants sown 0 and 5 days after the desiccation of coverings, respectively, when compared to the sowing performed on day 27 DAD. For the same treatments, 0 and 5 DAD, leaf dry matter was, respectively, 78% and 32% lower, compared to the 27 DAD treatment. In addition, the authors explain that the longer the period between the desiccation of the plant cover and the sunflower sowing, the higher the dry matter value of the stem; they also concluded that plants from the Apply-Plant treatment presented the lowest stem dry matter among all treatments.

The justification for the lowest values found in this work, in the eucalyptus characteristics evaluated on 0 DAD (Figures 1, 2 and 3), is possibly the competition, mainly for water and nutrients, imposed by signalgrass plants at the time of eucalyptus transplanting, since the product takes a few days to be effective and to cause plant death. During this period of herbicide initial effect, there is the possibility that signalgrass plants were still losing water to the environment through an evapotranspiration process, which could cause stress to eucalyptus plants.

An example of how signalgrass can affect the growth of *E. grandis* by competition can be observed in the work by Toledo et al. (2001), who reported that in a 90 day coexistence, the interference caused by *U. decumbens* reached values of 18.47% for height and 27.78% for diameter, demonstrating that these characteristics of eucalyptus were less affected. They also highlighted that the dry matter of stem and leaf area were more sensitive to the competition imposed by the weed, with 55.22% and 63.26% reductions, respectively, compared to the weed-free treatment.

In addition to this, another possible justification for the lower growth of eucalyptus plants in the Apply-Plant treatment (0 DAD) is due to the fact that the weed covering releases water-soluble allelochemicals, which were found in the soil solution in concentrations that were enough to interfere negatively with the initial growth of eucalyptus. Nepomuceno et al. (2017) has proven that protodioscin is an allelopathic substance found in some weed species – among which, *U. decumbens* (Brum et al., 2007) – and that, as a saponin, it can be easily leached by rain. Thus, this compound may have been the cause of the detrimental effect verified in eucalyptus plants from the Apply-Plant (0 DAD) and 7 DAD treatments.

This negative effect was also observed by Nepomuceno et al. (2012), who noted a reduction in the yield of RR soybean by 31% on 0 DAD (in Colina - São Paulo state) and a 7.1% reduction in Jaboticabal-São Paulo state, when values were compared to the treatment with higher productivity. These authors justify such productivity difference by the fact that the fodder cover was 40% higher in the city of Colina-São Paulo state, which increased the concentration of allelopathic substances in the soil solution, negatively affecting crop plants. Still about allelopathy, Souza et al. (2003), in an experiment conducted with 18 weed species and isolating the possible causes of reduced eucalyptus characteristics due to the lack of nutrients in the soil, suggested that *U. decumbens* may have demonstrated allelopathic effects, when incorporated into the soil, with a significant reduction in the leaf area of *E. grandis* by about 24%.

The fact that eucalyptus seedlings that were planted later, on 14 DAD or after that period, present greater height, diameter, dry matter and leaf area (Figures 1, 2, and 3) may be related to the higher decomposition rate of signalgrass plants and to the release of nutrients to eucalyptus seedlings, which intensify over time.

In these terms, Torres et al. (2008) found that the highest decomposition rate of millet, sorghum, rattlepods, oats, *B. brizantha* and pigeon pea occurred 42 days after desiccation. Similarly, Toledo (1994) reported that one of the causes of the best development of eucalyptus plants with *U. decumbens* covering may be the fact that mulching provides beneficial effects, such as soil protection and conservation; greater water infiltration and storage capacity; greater mobilization, release and absorption of nutrients; nematode control, among others. In the medium and long term, grasses provide nutrients (potassium and phosphorus) to the plants of the culture, mainly in the upper soil layer, which may help their development (Floss, 2000).

In addition to the greater availability of nutrients resulting from the chemical improvement of soil, plant cover also provides physical and biological improvements, such as higher organic matter content, water availability, less extreme temperatures and better soil structure conditions, resulting in a better aeration and biological diversity (Calegari et al., 1998).

Considering the aforementioned, it is possible to infer that the probable justifications for the found result patterns, in which the evaluated characteristics were negatively affected in the Apply-Plant treatment and positively starting from 14 DAD, are: 1 - the eucalyptus planted on day 0 DAD probably suffered an allelopathic effect from the substance existing in *U. decumbens*, which caused growth inhibition; 2 - it is also suggested that this negative effect may have been caused by the competition for water and nutrients with the weeds found in the plots, since the herbicide takes a few days to take effect. In addition, it should be noted that on the field a possible competition for light would also be expected, given the shading caused by signalgrass (it should be emphasized that in this experiment, the grasses were manually lowered in the boxes in the 0 and 7 DAD treatments); 3 - starting from 14 DAD, since the allelopathic substances released by *U. decumbens* had already been possibly leached or degraded, the increase in eucalyptus growth is probably due to the fact that the formed plant cover improves soil characteristics, providing nutrients to the plants of the culture, thus resulting in an increased growth of eucalyptus plants.

Thus, according to the presented data, it is possible to conclude that the Apply-Plant modality was detrimental to some characteristics of eucalyptus (*E. urograndis* - C-219H), while planting seedlings in periods over 14 days after the desiccation of *U. decumbens* plants promoted a better development of the culture.

REFERENCES

Almeida F.S. Efeitos alelopáticos de resíduos vegetais. **Pesq Agropec Bras.** 1991;26:221-36.

Brum K.B. et al. Crystal-associated cholangiopathy in sheep grazing *Brachiaria decumbens* containing the saponin protodioscin. **Pesq Vet Bras.** 2007;27:39-42.

Calegari A. et al. Culturas, sucessões e rotações. In: Salton J.C., Hernani L.C., Fontes C.Z., editores. **Sistema plantio direto:** o produtor pergunta a Embrapa responde. Brasília: Embrapa-SPI, 1998. p.59-80.

Correia N.M. et al. Palha de sorgo associada ao herbicida imazamox no controle de plantas daninhas na cultura da soja em sucessão. **Planta Daninha**. 2005;23:483-9.

Dinardo W. et al. Interferência da palhada de capim-braquiária, sobre o crescimento inicial de eucalipto. **Planta Daninha**. 1998;16:13-23.

Duda G.P. et al. Perennial herbaceous legumes as live soil mulches and their effects on C, N and P of the microbial biomass. **Sci Agric.** 2003;60:139-47.

Floss E.L. Benefícios da biomassa de aveia ao sistema de semeadura direta. **Rev Plantio Direto**. 2000;57:25-9.

Giancotti P.R.F. et al. Desiccation periods of *Urochloa brizantha* 'Piatã' before sunflower sowing. **J Agric Sci.** 2013;5:118-24.

Giancotti P.R.F. et al. Ideal desiccation periods of *Urochloa ruziziensis* for a no-till sunflower crop. **Inter J Plant Produc.** 2015;9:39-50.

Indústria Brasileira de Árvores – IBÁ. **Relatório IBÁ 2015**. [accessed on: Apr. 20 th 2016]. Available at: http://iba.org/images/shared/iba_2015.pdf

Machado L.A.Z., Assis P.G.G. Produção de palha e forragem por espécies anuais e perenes em sucessão à soja. **Pesq Agropec Bras.** 2010;45:415-22.

Mello I. Plantio direto e o agronegócio sustentável na metade sul do Rio Grande do Sul. **B Inf FEBRAPDP**. 2002;6:1-2.

Nepomuceno M.P. et al. Chemical evidence for the effect of *Urochloa ruziziensis* on glyphosate-resistant soybeans. **Pest Manag Sci.** 2017;73:2071-2078.

Nepomuceno M.P. et al. Períodos de dessecação de *Urochloa ruziziensis* e seu reflexo na produtividade da soja RR. **Planta Daninha**. 2012;30:557-65.

Nunes U.R. et al. Produção de palhada de plantas de cobertura e rendimento do feijão em plantio direto. **Pesq Agropec Bras.** 2006;41:943-8.

Rice E.L. **Allelopathy**. New York: Academic Press, 1974.

Souza C.F.L. et al. Eficiência de diferentes herbicidas na dessecação de três espécies vegetais para a cobertura do solo. **R Bras Herbic.** 2000;157-60.

Souza L.S. et al. Efeito alelopático de plantas daninhas e concentrações de capim-braquiária (*Brachiaria decumbens*) no desenvolvimento inicial de eucalipto (*Eucalyptus grandis*). **Planta Daninha**. 2003;21:343-54.

Toledo R.E.B. **Manejo de *Brachiaria decumbens* Stapf. em área reflorestada com *Eucalyptus grandis* W. Hill ex Maiden e seu reflexo no crescimento e nutrição mineral da cultura** [monografia]. Jaboticabal: Universidade Estadual Paulista "Júlio de Mesquita Filho", 1994.

Toledo R.E.B. et al. Efeito da densidade de plantas de *Brachiaria decumbens* Stapf. sobre o crescimento inicial de mudas de *Eucalyptus grandis* W. Hill ex Maiden. **Sci For.** 2001;60:109-17.

Torres J.L.R. et al. Produção de fitomassa por plantas de cobertura e mineralização de seus resíduos em plantio direto. **Pesq Agropec Bras.** 2008;43:421-8.