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Emergence of Weed Species (*Brachiaria*) Under Sugarcane Straw[1]

Emergência de Espécies de Plantas Daninhas do Gênero Brachiaria sob Palha de Cana-de-Açúcar

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ABSTRACT - The objective of this study was to evaluate the effects of soil cover with sugarcane residue on weed emergence of four weeds from the genus *Brachiaria*. The study was conducted in an area whose soil was classified as Red Nitosol. Seven different amounts of sugarcane residue (0, 3, 6, 9, 12, 15 and 18 ton ha^{-1}) were used as soil cover. The residue of variety SP832847 was used upon four weed species: *Brachiaria decumbens*, *B. brizantha*, *B. ruziziensis*, and, *B. humidicola*. The experimental design was a randomized block with four replications. The weeds were sown 1 cm deep and covered by the residue. The seeding rate in use was 1,200 plants m^{-2}. The study was comprised of two phases: the first phase was an evaluation of plant emergence (more than 1 cm for shoots) at 9, 12, 19, 34 and 43 days after sowing (DAS), and in the second phase, plant emergence was evaluated after removal of the straw residue at 89, 130, 175, 196, 217 and 234 DAS. The amount of sugarcane residue used as soil cover influenced the emergence pattern of *Brachiaria* spp. Minor germination was noticed after residue removal. Amounts greater than 9 ton ha^{-1} decreased the total number of seedlings in all species, except for *B. ruziziensis*, whose emergence decreased at 12 ton ha^{-1}.

Keywords: *Brachiaria brizantha, Brachiaria decumbens, Brachiaria humidicola, Brachiaria ruziziensis*, no-burn sugarcane, mulch.

RESUMO - O objetivo deste trabalho foi avaliar os efeitos da cobertura do solo com palha de cana-de-açúcar sobre a emergência de plantas daninhas do gênero ***Brachiaria*** *spp. O estudo foi conduzido em uma área pertencente à Fazenda Experimental da UNESP, campus Botucatu/SP, em um solo classificado como Nitossolo Vermelho de textura argilosa. Foram avaliadas sete diferentes quantidades de palha de cana-de-açúcar (0, 3, 6, 9, 12, 15 e 18 t ha^{-1}) utilizadas como coberturas do solo. Utilizou-se a palha da variedade SP832847 sobre quatro espécies de plantas daninhas:* ***Brachiaria decumbens*****,** ***B. brizantha, B. ruziziensis*** *e* ***B. humidicola****. O delineamento experimental utilizado foi de blocos casualizados com quatro repetições. As plantas daninhas foram semeadas a 1 cm de profundidade e posteriormente cobertas pela palha. A taxa de semeadura utilizada foi 1.200 plantas m^{-2}. O estudo foi compreendido por duas fases distintas: na primeira, foram avaliadas as plantas emersas (mais de 1 cm de parte aérea) aos 9, 12, 19, 34 e 43 dias após a semeadura (DAS) e, na segunda, a emergência das plantas após a remoção da palha aos 89, 130, 175, 196, 217 e 234 DAS. A quantidade de palha de cana-de-açúcar usada como cobertura do solo influenciou a dinâmica de germinação das diferentes espécies de* ***Brachiaria****. Após a remoção do palhiço de cana-de-açúcar utilizado como cobertura do solo, houve pouca germinação dessas espécies. Quantidades superiores a 9 t ha^{-1} proporcionaram redução do número total de plântulas em todas as espécies, com exceção de* ***B. ruziziensis*** *que apresentou redução a partir de 12 t ha^{-1}.*

Palavras-chave: *Brachiaria brizantha, Brachiaria decumbens, Brachiaria humidicola, Brachiaria ruziziensis*, cana-crua, cobertura morta.

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INTRODUCTION

One of the main factors affecting sugarcane crop yield is weed interference, as a result of competition against a crop for biotic factors of the environment, which is a major factor of reduction of sugarcane yield. Moreover, weed control represents a large portion of production costs (Pitelli, 1985).

As there are restrictions on sugarcane straw burning, imposed by environmental laws (São Paulo, 2002), areas with mechanized harvesting without prior burning of straw have increased significantly over the last decade. In the 2006/2007 crop, the mechanically harvested area accounted for 34.2% of the total area produced in the state of São Paulo, which represented 1.11 million hectares, while in the 2013/2014 crop, this area accounted for 83.7% of the total area, around 4.03 million hectares (UNICA, 2016).

This new harvesting method is called no-burn sugarcane, wherein the plant material left on the soil after harvest consists mainly of green leaves, straw, tops, stem and root fractions; the amount of such residue may vary between 10 and 20 ton ha^{-1} (Ripoli and Ripoli, 2009).

When these structures remain on the soil, they can change the environment for crop regrowth (Judice et al., 2007) and the diversification of weed plants, when compared with areas where sugarcane is burned for harvesting purposes (Martins et al., 1999; Azania et al., 2002). Out of the 79 most relevant weed species for the main crops in the different regions of the world, 49 are present in the sugarcane agroecosystem, which directly or indirectly compromises sugarcane yield (Holm et al., 1991).

Weed germination in the no-burn sugarcane system may undergo changes due to physical, chemical and biological constraints placed by straw residue on the soil. The straw residue that remains on the soil after the harvest of no-burn sugarcane provides a cover that hinders weed emergence and the qualitative and quantitative passage of solar radiation. In addition, it also alleviates temperature ranges and variation in soil surface moisture, and helps maintain the microbial population, which may lead to changes in the weed flora in these sugarcane fields (Correia and Rezende, 2002; Fleck et al., 2001; Pitelli and Durigan, 2001).

Regardless of the amount of residues after harvest of no-burn sugarcane that remains on the soil, some species, such as *Cyperus rotundus*, are not affected by this barrier. This characterizes the species as a problematic weed in areas of no-burn sugarcane, and integrated management is required when this species is found in sugarcane fields (Silva et al., 2003). In areas infested with *Brachiaria decumbens*, there may be up to 82% yield reduction (Kuva et al., 2001).

Knowledge is required of the germination behavior of weed species of the genus *Brachiaria*. The expansion of new crop cultivation areas commonly occurs in grazing lands, where the seed bank is normally large. This favors high infestation, especially with the adoption of new management systems, such as crop harvest without previous burning of straw.

Thus, the presence of residues of harvested sugarcane on the soil can change the weed community of that agrosystem. The present study was aimed at evaluating the effect of different amounts of sugarcane straw on the soil after emergence of different species of *Brachiaria* in the field.

MATERIAL AND METHODS

The study was conducted in an area of the Experimental Farm of the School of Agronomic Sciences/UNESP, located in Botucatu/SP, in soil classified as a Red Nitosol (Embrapa, 2013). No fertilizers or correctives were used in the experimental area. Table 1 shows the chemical characteristics of the soil in the area, and the physical characteristics were (g ha^{-1}): sand (414), silt (152) and clay (434).

The experimental area was prepared by plowing and harrowing. After these operations, a seedbedder was used to make the seedbeds and, thus, delimit the experimental units, measuring 1.2 x 4.5 m. The experiment used a randomized block design with four replications.

Table 1 **-** Result of soil chemical analysis of the study site, with soil collected at the 0-20 cm layer. Botucatu/SP, 2013/2014

pH	MO	P_{resin}	Al^{3+}	H+Al	K	Ca	Mg	SB	CTC	V
($CaCl_2$)	(g dm^{-3})	(mg dm^{-3})	($mmol_c$ dm^{-3})							(%)
5.1	28	25	---	42	3.0	36	17	55	97	57

Different amounts of sugarcane straw were used as soil cover (0, 3, 6, 9, 12, 15 and 18 ton ha^{-1}) on four monocot weed species that are important to sugarcane crops: *Brachiaria brizantha*, *B. decumbens*, *B. humidicola* and *B. ruziziensis*. The sugarcane straw in use was from the SP83-2847 variety (first cut), collected in a commercial area in the city of Dois Córregos/SP, after mechanical harvesting and before pesticide application. The experimental area showed no infestation of the species under study.

The weeds were sown in the first half of September 2013, using 0.5 m x 0.5 m metal templates, dug into the ground up to 10 cm deep in the center of the plots. The *Brachiaria* species were sown in each square. The seeding rate was adjusted so that there were 300 viable seeds within each template (1,200 plants m^{-2}), and they were manually buried at 1 cm depth from the soil surface.

After the weed species were sown in each plot, sugarcane straw residue was distributed in uniform layers and in particular amounts for each treatment. The straw residue had been previously dried in a forced air circulation oven at 65 °C to constant weight. The area was irrigated on the day of seeding and maintained when there was no rain, every three days, until the end of the study, with an average of 15 mm per operation so that the seeds could have water availability for germination. Soil temperature was measured at 5 cm depth for all treatments in the morning (7:30 a.m.) and in the afternoon (2:30 p.m.) during the first phase of the study (Figure 1) by means of a digital skewer thermometer with a stainless steel probe and resolution of 0.1 °C.

The study had two different phases. In the first phase, the seedlings were evaluated in the soil with sugarcane straw cover and in the second, emergence was assessed after straw removal. Both phases were conducted in the same experimental units. The number of emerged seedlings in the soil with straw sugarcane was evaluated at 9, 12, 19, 34 and 43 days after sowing (DAS). The species were identified and counted, and the seedlings were pulled out. The seedlings were considered emerged when they were visible in each evaluation, with more than 1 cm of shoot above the level of the straw.

After stabilization of seedling emergence, which occurred at 43 DAS (last evaluation), we waited until 77 DAS to confirm that there was no emergence of new seedlings - all layers of sugarcane straw were removed from the soil surface. The straw was weighed after being dried in a forced air ventilation oven at 65 °C. Based on values for final weight (f) and initial weight (i) of straw, the amount of decomposed straw (d) was calculated by using the formula: d = i - f, and the rate of decomposition (Rd), with the formula: (%) = 100d/i. To determine the carbon-nitrogen ratio (C/N) of the removed sugarcane straw, a different sample was separated for each parcel after weighing. The straw was ground in a Wiley mill with a 20 mesh sieve and subsequently analyzed through dry combustion with a LECO analyzer (LECO CHN 2000, LECO Corporation, St. Joseph, Michigan).

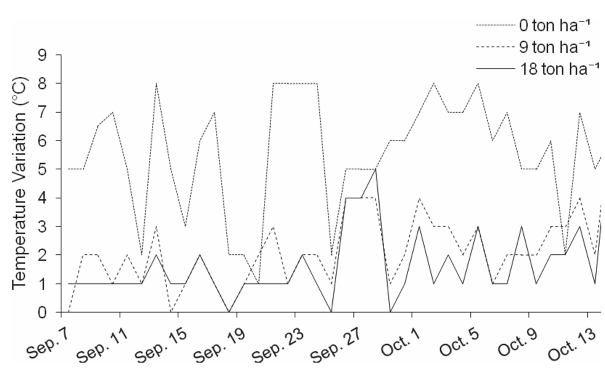


Figure 1 **-** Soil temperature variation at 5 cm depth throughout the day with 0 ton ha^{-1}, 9 ton ha^{-1} and 18 ton ha^{-1} of straw on the soil, during the first phase of the experiment.

The second phase of the study started after straw removal. The evaluations were resumed at 89, 130, 175, 196, 217, 234 DAS until germination stopped again. The same assessment procedures for seedling emergence used in the first phase of the study were applied in the second phase. The assessments were completed when there was no weed emergence in the parcels, at 234 DAS (157 days after straw removal.)

Based on the total numbers of emerged seedlings before removal of the straw cover, calculations were performed for the start of field emergence, stabilization of emergence and average germination time ($\bar{t}$). The initial period of field emergence was considered to occur when at least one seedling emerged in at least one of the replications, and emergence was considered to be stabilized when there was no emergence in any of the replications. Thus, average germination time ($\bar{t}$) for each species was calculated with the formula proposed by Santana and Ranal (2004).

$$\bar{t} = \frac{\sum_{i=1}^{k} n_i t_i}{\sum_{i=1}^{k} n_1}$$

where: t_i = time between the start of the experiment and the i-th observation; n_i = number of seeds germinating at time t_i (not the cumulative number, but the number relative to the i-th observation); and k = last time of seed germination.

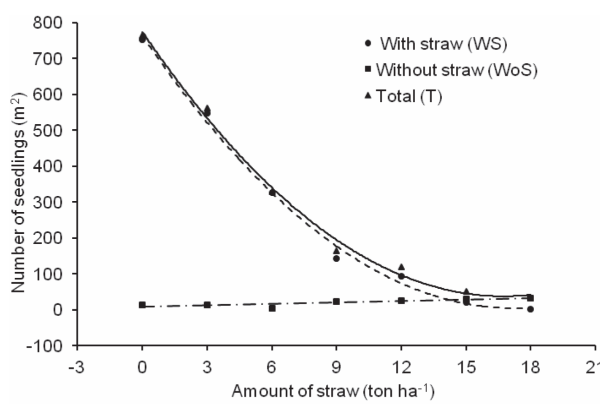
The total numbers of emerged seedlings in the two phases of the study and their sum were submitted to analysis of variance by the F-test, and the data were fitted by regression analysis (p>0.05).

RESULTS AND DISCUSSION

Analysis of variance showed difference in the levels of sugarcane straw in the emergence of seedlings of *Brachiaria brizantha*, *B. decumbens*, *B. ruziziensis* and *B. humidicola* in both phases of the study. Infestation behavior was similar in the four species. In the first phase (with straw), the quadratic model was used for fitting, while in the second phase (without straw), the linear model was used; the quadratic model was used for the total number of plants which emerged during the experimental period.

In the first phase of the study with straw, by increasing the amount of sugarcane straw on the ground to 18 ton ha^{-1}, there was a marked decrease in the number of emerged seedlings of *B. brizantha* (Figure 2). The larger amount of straw deposited on the soil caused a reduction of 99.7% in seedling emergence compared with the treatment without straw. It should be noted that, in year-round commercial production areas of sugarcane, the period of 77 days during which the area was covered with straw should be enough to reduce productivity losses during the critical period of weed interference, which ranges from 15 days to two months after emergence of the crop (Blanco et al., 1981).

In general, after straw removal, emergence of seedlings of *B. brizantha* in the field was low in all the amounts tested; in the treatments that had the highest amounts of straw on the soil, there were the highest emergence rates of this weed- this fact has possibly occurred because of break in the dormancy of seeds that have remained under sugarcane straw. Maintaining straw sugarcane on the ground in an amount greater than 9 ton ha^{-1} provides greater inhibition of the total number of seedlings of *B brizantha*, with reductions of up to 84.5% (Figure 2).



$Y_{WS} = 2.567x^2 - 88.321x + 763.79$ $R^2 = 0.995$ $F = 14.68^{**}$
$Y_{WoS} = 1.411x + 7.661$ $R^2 = 0.727$ $F = 7.30^{*}$
$Y_T = 2.636x^2 - 88.155x + 774.52$ $R^2 = 0.995$ $F = 15.42^{**}$

Figure 2 - Number of seedlings of *Brachiaria brizantha* emerged before (WS) and after (WoS) removal of different amounts of sugarcane straw on the soil. Botucatu/SP, 2013/2014.

Seed germination of *B. brizantha* was distributed differently, depending on the amounts of sugarcane straw throughout time of permanence on the soil (Table 2). Labouriau (1983) stresses that the extreme periods of start of germination and stabilization of germination are only focused on the seeds with the fastest and the slowest germination rates, while ignoring the behavior of most of the seeds. Thus, we propose an analysis of the average tendency of germination measurements.

In the treatment in which there was no sugarcane straw on the soil (Table 2), mean germination time (MGT) was similar to that of the treatment with 12 ton ha^{-1} of straw, but initial emergence where there was no cover happened before this treatment (9 DAS). With a cover of 3 ton ha^{-1} of straw, MGT was lower than in the other treatments, probably due to a break in dormancy caused by the radical NO_3^- (nitrate) or by NO_2^- (nitrite). Substances with the radicals NO_3^- and NO_2^- can be derived from the highest decomposition rate and high nitrogen release by the straw, given the high C/N ratio of the straw in this treatment (3 ton ha^{-1}) (Table 3). It is noteworthy that KNO_3 is widely recommended by the Rules for Seed Analysis to assist in the germination of grasses (Brasil, 2009; Carvalho and Nakagawa, 2012).

The highest seedling emergence of *B. decumbens* occurred in the amount of 0 ton ha^{-1} straw on the soil, and the lowest, when using 18 ton ha^{-1} in the first phase of the study. It should be noted that, in the presence of straw in an amount exceeding 12 ton ha^{-1}, reductions in the emergence of this plant are over 90%, compared with the treatment that had no sugarcane straw during the period of 77 days after the first stage of the study, and it may reach 100% when maintained at 18 ton ha^{-1} (Figure 3). When there are high amounts of straw on the soil, physical, chemical and/or biological impediments may occur, thus hindering the emergence of these seedlings. Velini et al. (2000) found similar behavior for emergence of *B. decumbens* when the soil was covered with sugarcane straw, but it was zero in the amount of 15 ton ha^{-1}, which does not corroborate the results found herein, as the emergence of seedlings of signal grass was zero only with 18 ton ha^{-1} of straw on the soil.

Table 2 **-** Period after *B. brizantha* sowing required for the beginning, stabilization and average time of seedling germination in the field under different amounts of sugarcane straw cover. Botucatu/SP, 2013/2014

Amount of straw (ton ha^{-1})	Seedling emergence (DAS)		
	Beginning	Stabilization	Mean germination time
0	9	43	27
3	12	43	20
6	12	43	22
9	12	43	23
12	12	43	27
15	12	43	26
18	43	43	43

Table 3 **-** Amount of initial, final and decomposed sugarcane straw (variety SP83-2847) on the soil surface, decomposition rate and C/N ratio of such straw. Botucatu/SP, 2013/2014

Amount of straw (ton ha^{-1})			Decomposition rate (%)	C/N[1/]
Initial	Final	Decomposed		
3	2.375	0.625	20.83	191.0 ab
6	5.625	0.375	6.25	192.6 ab
9	7.445	1.01	11.22	186.3 b
12	10.66	1.34	11.17	256.3 ab
15	12.705	2.295	15.30	255.6 ab
18	17.35	1.08	6.00	292.3 a

Means followed by the same letter in the column do not differ significantly by the 't' test (P>0.05).[1/] Coefficient of variation: 25.97%; Least Significant Difference: 105.83.

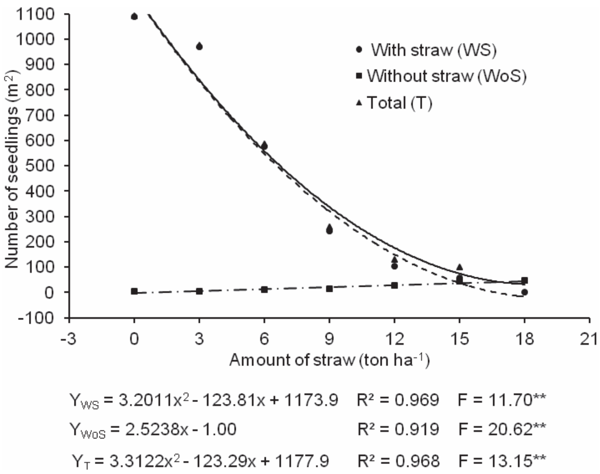


Figure 3 **-** Number of seedlings of *Brachiaria decumbens* emerged before (WS) and after (WoS) removal of different amounts of sugarcane straw on the soil. Botucatu/SP, 2013/2014.

After removal of straw that was on the soil, there was a linear increase in emergence of *B. decumbens* with increased amount of straw, and the maximum flow (45 plants m^{-2}) occurred with 18 ton ha^{-1} of straw on the soil (Figure 3).

Probably, the amount of compounds released by decomposition or the climate conditions in the period prior to removal did not influence the break in seed dormancy, or the seeds died while they were under the sugarcane straw. Correia and Durigan (2004) did not observe significant flow in the emergence of seedlings of *B. decumbens* after sugarcane straw removal with an amount up to 15 ton ha^{-1}, as found in the present study.

Under increasing amounts of cover, up to 15 ton ha^{-1}, emergence started later, probably due to lower thermal variation provided by different amounts of straw compared with the treatment without straw (Figure 1). *B. decumbens* usually has higher emergence percentage in periods with higher rates of temperature and humidity (Kissmann, 1997); thus, the existence of mulch on the soil reduces the temperature range, which will affect the germination of this species.

Whe the period of higher seedling emergence rate was assessed, in the treatment without soil cover (0 ton ha^{-1}), MGT of the seedlings of *B. decumbens* occurred at 26 DAS, and germination stabilized at 43 DAS (Table 4). In the treatment where there was a smaller amount of straw (3 ton ha^{-1}), the seedling emergence interval was 34 days and the highest emergence rate occurred at 17 DAS. For amounts of cover of 6, 9 and 12 ton ha^{-1}, the emergence interval was 31 days, but MGT was 22, 23 and 25 DAS, respectively.

Only in the treatment with 15 ton ha^{-1} sugarcane straw on the soil, the emergence interval of the seedlings was nine days, which shows that in this amount of cover, the interference of this grass species in the sugarcane crop can be decreased with the late start of emergence of this weed plant (Table 4). This is because Kuva et al. (2008), when studying interference periods of plants of *B. decumbens* on sugarcane crops, found that the crop can coexist with these weeds for 89 days after planting, without significant yield reduction. Thus, weed management performed within a nine-day interval would be sufficient to eliminate the problem of this weed in sugarcane crops.

Data on the number of seedlings of *B. humidicola* that emerged under different amounts of straw on the soil showed a quadratic effect in regression analysis; amounts greater than 9 ton ha^{-1} gave reductions of more than 90% in the total number of seedlings compared with the treatment without straw on the soil (Figure 4). Probably, this fact occurred due to lower

Table 4 **-** Period of time after sowing of *Brachiaria decumbens* required for beginning, stabilization and average time of seedling germination in the field under different amounts of sugarcane straw cover. Botucatu/SP, 2013/2014

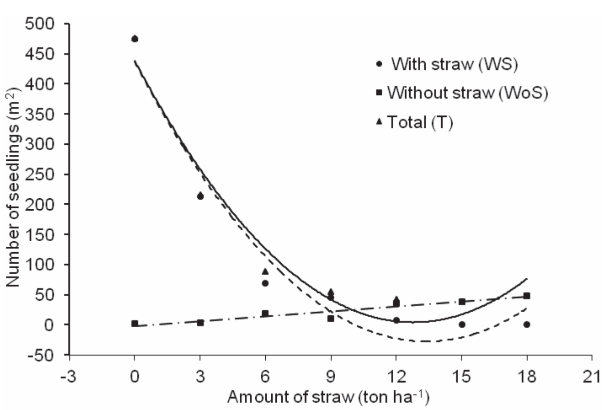
Amount of straw (ton ha^{-1})	Seedling emergence (DAS)		
	Beginning	Stabilization	Mean germination time
0	9	43	26
3	9	43	17
6	12	43	22
9	12	43	23
12	12	43	25
15	34	43	36
18	0	0	0

DAS: days after sowing.

temperature variation as the amount of straw mass on the soil was increased (Figure 1) and/or as a result of the mechanical effect of the cover. Tomaz et al. (2016), when studying the reduction of germination time for *B. humidicola*, noted that the temperature range between 15 and 35 °C caused the seeds to express their highest germination (74%), because temperature influences the biochemical reactions that determine all the germination process.

Germination is a complex sequence of biochemical reactions, through which reserve substances stored in the supporting tissue broken down, transported and resynthesized in the embryonic axis because, as in any chemical reaction, germination can be faster and more efficient with higher temperatures, within the limit of each species (Carvalho and Nakagawa, 2012).

After removal of the sugarcane straw that was on the soil, there was a linear trend for increased emergence of seedlings of *B. humidicola* in response to the increase in the amount of existing straw, which represents an increase of approximately 27,000 plants ha^{-1} in the total removal of each ton of straw that was on the soil (Figure 4). The largest number of emerged seedlings may be due to the high rate of straw decomposition in the treatments with a greater amount of straw (Table 3). Thus, ammonium (NH_4^+) may have been released by straw and oxidized to nitrate (NO_3), in view of the action of the nitrate radical, and dormancy would be broken by stimulating the pentose phosphate pathway, and activated by forms of oxidized nitrogen (N) that are electron acceptors; the germination process is thus started (Roberts, 1974; Carvalho and Nakagawa, 2012).



$Y_{WS} = 2.5952x^2 - 69.452x + 436.86$ $R^2 = 0.959$ $F = 27.81^{**}$

$Y_{WoS} = 2.6667x - 1.8571$ $R^2 = 0.889$ $F = 22.65^{**}$

$Y_T = 2.6587x^2 - 67.929x + 437.86$ $R^2 = 0.953$ $F = 28.94^{**}$

Figure 4 - Number of seedlings of *Brachiaria humidicola* emerged before (WS) and after (WoS) removal of different amounts of sugarcane straw on the soil. Botucatu/SP, 2013/2014.

The germination behavior of tropical forage grasses, such as *B. humidicola*, as regards the expression of dormancy, is associated with physiological causes present in freshly harvested seeds, which are progressively eliminated during storage. The most likely causes in this study are physical and relate to the inhibition of oxygen diffusion by the seed cover (Whiteman and Mendra, 1982).

Keeping the straw sugarcane on the soil for 77 days, combined with new emergence flow of *B. humidicola* plants for up to 234 days after deposition of straw sugarcane, resulted in a quadratic behavior for the total decrease of this weed with increasing amount of straw on the soil (Figure 4).

The presence of straw cover on the soil delayed the germination of *B. humidicola* compared with the soil without straw (Table 5). In the treatment with 3 ton ha^{-1} of straw, germination range of *B. humidicola* seeds was 31 days, a similar result to that of treatments with 6 and 9 ton ha^{-1}; however, MGT was lower; probably the wide variation of climatic conditions, combined with high decomposition of organic material, provided greater availability of organic compounds that contributed to the rapid germination of this species. When 6 ton ha^{-1} was used, MGT was higher, compared with the other treatments (3 and 9 ton ha^{-1}), whose germination range was 31 days. This may be due to the low decomposition rate (6.25%) of the cover on the soil (Table 3), which caused the germination to last longer because there were fewer compounds that could foster earlier germination. By using 12 ton ha^{-1}, the seedlings of *B. humidicola* had maximum germination in the first observation, and they were distributed up to their stabilization, which occurred at 43 DAS.

Table 5 - Period of time after sowing of *Brachiaria humidicola* required for beginning, stabilization and average time of seedling germination in the field under different amounts of sugarcane straw cover. Botucatu/SP, 2013/2014

Amount of straw (ton ha^{-1})	Seedling emergence (DAS)		
	Beginning	Stabilization	Mean germination time
0	9	43	28
3	12	43	25
6	12	43	32
9	12	43	27
12	34	43	34
15	0	0	0
18	0	0	0

DAS: days after sowing.

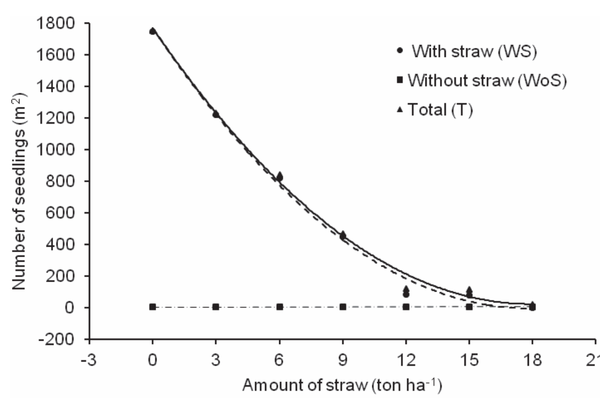
Bogdan (1977) states that, despite good flowering, seed formation for *B. humidicola* is spaced apart, which leads to a lower seed bank in comparison with other grass species. The use of grazing lands with *B. humidicola* is due to the fact that this grass species demands little soil fertility, is tolerant to aluminium, and does not require high phosphorus content (Botrel et al., 1999). This may become a problem in future areas for expansion of sugarcane cultivation in these pastures, because the seed bank of this species will be more persistent.

B. ruziziensis showed similar emergence patterns to those of other species in this study (*B. brizantha*, *B. decumbens* and *B. humidicola*), where the number of emerged seedlings showed quadratic reduction in response to the increase of sugarcane straw deposited on the soil, where it could be seen that for the highest amount of straw on the soil, emergence of this weed is completely inhibited (Figure 5).

There was a high number of *B. ruziziensis* seedlings in the absence of straw or with 3 ton ha^{-1} of straw on the soil: 1,784 and 1,223 seedlings m^{-2}, respectively (Figure 5). This fact is probably due to the break in seed dormancy by alternation of soil temperature because in the absence of cover, the temperature gradient was high compared with the other treatments with straw (Figure 1). Tomaz et al. (2016) found, under laboratory conditions, that maximum germination percentage for *B. ruziziensis* occurred when the seeds were submitted to a 15-35 °C temperature regime.

The reduction of emergence of this species in the largest amounts of straw was probably due to the lack of dormancy break as a result of low thermal variation during these treatments and/or reduction in straw decomposition rate (Table 3), with consequent reduction of nitrogen compounds as well as the mechanical effect of straw on seedling emergence (Figure 5). Germination occurs only in certain limits of temperature, in which the germination process can occur with maximum efficiency, with maximum germination taking place in the shortest possible time (Carvalho and Nakagawa, 2012).

After removal of the straw, the number of *B. ruziziensis* seedlings increased linearly in response to an increase of crop residues that were left in the area (Figure 5). This low number of seedlings which emerged after straw removal may be the result of a few seeds whose dormancy was broken because of the difference in temperature variation as well as by the action of nitrogenous compounds stemmed from decomposing straw. This was observed in the cover with 18 ton ha^{-1} straw, both in the presence of straw, which inhibited



$Y_{WS} = 5.582x^2 - 198.87x + 1765.94$ $R^2 = 0.994$ $F = 35.78^{**}$

$Y_{WoS} = 0.1778x + 2.3525$ $R^2 = 0.722$ $F = 12.10^{**}$

$Y_T = 5.4431x^2 - 194.98x + 1767.6$ $R^2 = 0.995$ $F = 33.81^{**}$

Figure 5 - Number of seedlings of *Brachiaria ruziziensis* emerged before (WS) and after (WoS) removal of different amounts of sugarcane straw on the soil. Botucatu/SP, 2013/2014.

emergence, and in the absence of it, which also caused a reduction, resulting in smaller total number of emerged plants.

Given the scarce amount of information in the literature on *B. ruziziensis* as a weed, similar studies should be conducted with a view to increasing the use of this species as forage in crop-livestock integration, and especially in succession cropping.

As shown in Table 6, similarly to *B. decumbens* (Table 4), seed emergence for *B. ruziziensis* also started at 9 DAS, both in the absence and in the presence of sugarcane straw (3 ton ha^{-1}) of on the soil, but with different MGT: it was shorter in the presence of straw coverage (19 DAS) than in the absence of straw (27 DAS). One possible explanation for the lower TMG in the amount of 3 ton ha^{-1} of straw would be the fact that this treatment provided greater availability of organic compounds derived from straw decomposition, which aid germination because they provide nutrients in the topsoil, mainly Ca, Mg, K and P (Pavinato and Rosolem, 2008).

For 6, 9, 12 and 15 ton ha^{-1}, the start of emergence was similar for all amounts of straw; only MGT increased for each amount of straw with greater amount of cover deposited on the soil. This behavior might have been due to temperature variations provided by each amount of straw (Figure 1).

Table 6 - Period of time after sowing of *Brachiaria ruziziensis* required for beginning, stabilization and average time of seedling germination in the field under different amounts of sugarcane straw cover. Botucatu/SP, 2013/2014

Amount of straw (ton ha^{-1})	Seedling emergence (DAS)		
	Beginning	Stabilization	Mean germination time
0	9	43	27
3	9	43	19
6	12	43	20
9	12	43	22
12	12	43	26
15	12	43	28
18	0	0	0

DAS: days after sowing.

The amount of straw sugarcane used as ground cover influenced the dynamics of germination of different species of *Brachiaria.* After removing the straw used as soil cover, there was little germination. Amounts exceeding 9 ton ha^{-1} resulted in reductions in the total number of seedlings of the *Brachiaria* species being studied, with exception of *B. ruziziensis*, which showed reductions after 12 ton ha^{-1}.

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