Soybean productivity under different grazing heights of *Brachiaria ruziziensis* in an integrated crop-livestock system[1]

Produtividade da soja sob alturas de pastejo de *Brachiaria ruziziensis* em sistema de integração lavoura-pecuária

Gilberto Alves Ferreira[2]*, Paulo Sérgio Rabello de Oliveira[3], Sérgio José Alves[4] e Antonio Carlos Torres da Costa[3]

ABSTRACT - The aim was to evaluate the effects of grazing height of *Brachiaria ruziziensis* on the production of straw, and the establishment and grain yield of a soybean crop, under an integrated crop-livestock system, on a typic dystrophic Red Latosol at the Experimental Farm of the Agronomic Institute of Paraná (IAPAR), in Xambrê, in the state of Paraná, Brazil (PR). The study was carried out between September of 2010 and April of 2012. The experimental design was of randomised blocks, in lots split over time, with five treatments and three replications. The following were determined for the *Brachiaria ruziziensis*: shoot dry matter weight, plant residue dry matter weight, and total dry matter weight (*Brachiaria ruziziensis* shoot weight + plant residue weight). Also determined were variables related to the yield of the soybean crop (number of plants per metre, plant height and grain productivity), for the crop years 2010/2011 and 2011/2012. Straw production is greater in areas of *Brachiaria ruziziensis* where there is no grazing compared to areas where grazing occurs; the high production seen in areas with greater grazing heights should also be noted. The final number of plants, plant height and productivity in the soybean were not affected by the grazing height of the *Brachiaria ruziziensis*.

Key words: Establishment. Straw. No tillage. C/N ratio.

RESUMO - Objetivou-se avaliar os efeitos da altura de pastejo de *Brachiaria ruziziensis* na produção de palha, estabelecimento e rendimento de grãos da cultura da soja, em sistema de integração lavoura-pecuária, em Latossolo Vermelho distrófico típico, na Fazenda Experimental do Instituto Agronômico do Paraná (IAPAR), em Xambrê-PR. O estudo foi realizado entre setembro de 2010 e abril de 2012. O delineamento experimental utilizado foi em blocos ao acaso, em parcelas subdivididas no tempo, com cinco tratamentos e três repetições. Foram determinadas a massa de matéria seca da parte aérea de *Brachiaria ruziziensis,* massa de matéria seca de resíduo vegetal e massa de matéria seca total (massa da parte aérea de braquiária + massa de resíduo vegetal) e as variáveis relacionadas ao rendimento da cultura da soja (número de plantas por metro, altura das plantas e produtividade de grãos), nos anos agrícolas 2010/2011 e 2011/2012. A produção de palhada é maior em área sem pastejo de *Brachiaria ruziziensis* em comparação com as suas áreas pastejadas, com destaque também para a elevada produção nas áreas de maiores alturas de pastejo. O número final de plantas, a altura das plantas e a produtividade da cultura da soja não foram afetados pela altura de pastejo de *Brachiaria ruziziensis*.

Palavras-chave: Estabelecimento. Palha. Plantio direto. Relação C/N.

INTRODUCTION

The soils in the northwest of the State of Paraná, in Brazil (PR), derive from Caiuá sandstone, and are characterised by their medium to sandy texture, being highly susceptible to erosion and often having low levels of organic matter of around 1% (OLIVEIRA *et al.*, 2000). The correct management of these soils, employs forage species in production systems such as for example, crop-livestock integration, and can also be crucial in improving the fertility and increasing the productivity of pastures and crops.

Brachiaria ruziziensis is a forage species that has been used for grazing, intercropping or as groundcover in integrated crop-livestock systems. It excels as a cover crop, due to its capacity for the production of straw during the off-season in the Cerrado, when overseeded into crops of soybeans (PACHECO *et al.*, 2008). Machado and Assis (2010), evaluating the production of straw and forage in annual and perennial forage crops planted in succession to soybeans, and the effect on grain productivity in the following crop, found that *Brachiaria ruziziensis* and *Brachiaria decumbens* performed better in straw production, and that cultivation of forage species in succession to soybeans did not affect crop productivity.

According to Cunha *et al.* (2007), *Brachiaria ruziziensis* is a grass (poaceae) with a high carbon to nitrogen ratio (C/N), an important feature, since the rate of decomposition of vegetable residue is associated with the C/N of the tissue (CERETTA *et al.*, 2002). In the winter preceding the planting of a commercial crop in two seasons under evaluation, Pacheco *et al.* (2011) obtained for this grass as a cover crop, a C/N of 30 and 34 at the time of desiccation. This high ratio of C to N in brachiaria extends the period of decomposition (NEPOMUCENO *et al.*, 2012) and the time the straw remains on the soil surface.

In crop-livestock systems, a balance is needed between the supply of forage for the production of livestock, and the amount of groundcover that remains for the crop following grazing. In an area of winter pasture with frequent grazing, Nicoloso *et al.* (2006) found a reduction in soybean productivity after succession cropping compared to an area of no grazing. Knowledge and understanding of the action of animals, and the amount of straw left by their management are therefore important for the consolidation of an integrated crop-livestock system.

The soybean plays an important role in developing crop-livestock integration, as it is an excellent commercial crop, and from an environmental point of view, being a legume (Fabaceae), fixes nitrogen and participates in improving the fertility of the production system, contributing to its sustainability (FRANCHINI *et al.*, 2010). According to Salton, Fabricio and Hernani (2001), the soybean is a basic crop in an integrated crop-livestock system, whose effects are favourable to the forage crop which follows in the same way that the effects of the forage crop on the soybean are also satisfactory. The present study was carried out with the aim of evaluating the effects of grazing height in *Brachiaria ruziziensis* on both the production of straw and the establishment and grain yield in a soybean crop under an integrated crop-livestock system.

MATERIAL AND METHODS

The experiment was conducted in an area of the Experimental Farm of the Agronomic Institute of Paraná (IAPAR), in the town of Xambrê, PR, from September 2010 to April 2012. According to the Köppen classification, the predominant climate in the region is type Cfa (IAPAR, 1987). The experimental units consisted of 15 paddocks, with an area of 1.0 ha for the paddocks under grazing, and 0.5 ha for the paddocks with no grazing, giving 13.5 hectares for the experimental area. The paddocks were separated by an electric fence in the winter, which was removed during cultivation of the soybean crop.

The soil was classified as a typic dystrophic Red Latosol (SANTOS *et al.,* 2006, apud FIDALSKI; TORMENA; ALVES, 2013), with a medium/sandy texture (EMBRAPA, 1984; FASOLO *et al.,* 1998, apud FIDALSKI; TORMENA; ALVES, 2013). Levels of sand, silt and clay are shown in Table 1.

The chemical characteristics (phosphorus, organic matter, pH, hydrogen, aluminium, potassium, calcium, magnesium, sum of bases, cation exchange capacity, base saturation and aluminum saturation) were analysed according to methods described in Pavan *et al.* (1992) (Table 2). Soil samples were taken in September 2010, at depths of 0-10 cm, 10-20 cm and 20-30 cm.

The area had previously been cultivated with oats in the winter planted in succession to soybeans in the summer. The experimental design was of randomised blocks, with five treatments and three replications. The treatments consisted of different grazing heights of *Brachiaria ruziziensis*: 10, 20, 30 and 40 cm, and another area of B*rachiaria ruziziensis* with no grazing (NG) as control. Proposed heights were maintained by animal grazing.

The pasture of *Brachiaria ruziziensis* was planted in March of 2010 and 2011. In April, the pasture was fertilised with 40 kg ha^{-1} of nitrogen, using ammonium nitrate as the source. The animals went into the experimental area

Table 1 - Particle size characterisation of a Red Latosol in the experimental area

Depth (cm)	Sand			Silt	Clay
	Total	Fine	Course		
	--g kg^{-1}--				
0-10	870	350	650	30	100
10-20	860	350	650	20	120
20-50	830	340	660	10	160
50-200	820	360	640	10	170

Source: Fidalski *et al.* (2013)

Table 2 - Chemical characterisation of the profile of a Red Latosol in the experimental area [1]

Depth (cm)	P[2]	OM[3]	pH CaCl$_2$	H+Al	Al^{+3}	K$^+$	Ca^{+2}	Mg^{+2}	SB	CTC	V[4]	Al[5]
	mg dm^{-3}	g kg^{-1}	0,01mol L^{-1}	------------------------cmol$_c$ dm^{-3}---------------------								%
0-10	39.9	12.0	5.1	2.7	0.01	0.4	1.6	0.8	2.8	5.5	50.9	0.4
10-20	12.0	9.3	5.2	2.6	0.03	0.2	1.6	0.6	2.4	5.0	48.0	1.2
20-30	4.0	7.4	5.2	2.6	0.05	0.1	1.3	0.7	2.1	4.7	44.7	2.3

[1]Chemical analysis carried out in the Environmental Chemistry and Instrumental Analysis Laboratory of the West Paraná State University (UNIOESTE), Marechal Cândido Rondon Campus, PR; [2]P: phosphorus obtained by Mehlich extraction. [3]OM: organic material. [4]V: base saturation. [5]Al: aluminium saturation

in May, and left at the end of August or beginning of September, in 2010 and 2011 respectively.

Two permanent animals, defined as "testers", were used in each experimental unit (24 cattle), and a varying number of regulator animals of inter-racial Purunã stock, with an average weight of 200 kg and age of 10 months. A variable-load, continuous stocking (put-and-take) grazing system was used, (MOTT; LUCAS, 1952).

The stock was adjusted weekly, adding or removing regulator animals to keep the pasture at the desired height for each treatment. Pasture height was checked using the sward stick method (BARTHRAM, 1985). Each experimental plot was measured in 50 places to determine the average height of each paddock.

The soybean crop was planted under a no-till system, in succession to a pasture of *Brachiaria ruziziensis*, for two seasons. In the present study, after the animals were removed from the pasture for the winter, desiccation of the brachiaria was carried out using 2.4 L of the active ingredient Glyphosate + 0.5% boric acid, on 18 and 19 September of 2010 and 2011 respectively. The soybean crop was sown on 19 October in 2010 and 2011, using the BMX Potência RR cultivar, which has a semi-early cycle and indeterminate growth habit. A basic fertiliser of 250 kg ha^{-1} single superphosphate was used when planting, and a topdressing of 100 kg ha^{-1} potassium chloride was given 30 days after sowing. A spacing of 45 cm was used between rows, with 22 and 18 seeds per linear meter in 2010 and 2011 respectively. When planting the soybeans in 2010, the seeds were inoculated with a strain of *Bradyrhizobium japonicum* (SEMIA 5079) and *B. elkani* (SEMIA 587), and treated with the insecticide Imidacloprid (200 mL 100 kg^{-1} commercial seed) and the fungicide Carboxin + Thiram (300 mL 100 kg^{-1} commercial seed).

Any remaining *Brachiaria ruziziensis* was collected in September of 2010 and 2011, after the animals were removed from the paddocks, with 30 random samples being taken per plot from a 0.25 m^2 (50 x 50 cm) square. Shoots of the brachiaria, (shoot dry matter weight), were collected from each sampling point, together with any plant-residue (dead material) on the soil surface, (plant-residue dry matter weight). The samples were then placed in a forced ventilation oven at 65°C for 72 hours to determine dry matter production. The shoot dry matter weight was summed with the plant-residue dry matter weight, to give the total dry matter weight (straw). The dry matter weight was expressed in kg ha^{-1}.

The final number of plants per linear metre, the plant height and the soybean yield were determined after physiological maturity, taking ten random samples per plot (paddock), but avoiding the entrance to the paddock, the terraces and proximity to the salt-water troughs. Each point sampled consisted of three rows

of 1.5 metres. The number of plants in each row was counted (expressed in number of plants per metre) and three readings of plant height taken with a ruler marked in cm. Soybean yield was determined by cutting the plants down to ground level, the grain being packaged and later threshed by hand, and then cleaned and weighed to determine the moisture content of the seeds as per BRASIL (2009). The grain yield was adjusted for 13% moisture and expressed in kg ha^{-1}.

The variables being studied were submitted to variance analysis by F-test, in a scheme of lots split over time, as per Pimentel (2000) and Pimentel and Garcia (2002). The factor grazing height (10 cm, 20 cm, 30 cm, 40 cm and NG), was considered as the lots, and the factor sampling period, with assessments carried out successively over time, being allocated to the sub-lots (sub-lot treatment). A breakdown was made where there was significant interaction, with each factor being studied within the other. Comparison between the mean values under study was carried out by Tukey's test at 5% probability. The SISVAR software was used for the statistical analysis (FERREIRA, 2011).

RESULTS AND DISCUSSION

In Table 3 can be seen a summary of the variance analysis of the *Brachiaria ruziziensis* variables: shoot dry matter weight, plant-residue dry matter weight, and total dry matter weight (shoot weight + plant-residue weight). The grazing height (10, 20, 30 and 40 cm, and NG), the period (September 2010 and September 2011) and the interaction between the grazing height and the period of data collection significantly altered these variables, with the exception of grazing height in relation to plant-residue dry matter weight (F = 1.1694).

Table 4 shows the mean values in *Brachiaria ruziziensis* for shoot dry matter weight, plant-residue dry matter weight and total dry matter weight.

From the breakdown of the interaction (Table 4), it can be seen that shoot dry matter weight and total dry matter weight in *Brachiaria ruziziensis* were significant (P<0.05) for grazing height in both periods under evaluation. The plant-residue dry matter weight however, was not significant (P>0.05) in September 2010, but was significant in September 2011 (P<0.05).

For the first collection period (September 2010) (Table 4), the shoot dry matter weight in brachiaria for the no-grazing treatment, was greater than for the grazing treatments (P<0.05). Whereas, among the treatments, heights of 30 cm and 40 cm appear more frequently (P<0.05) than the grazing height of 10 cm, which in turn, was no different from the height of 20 cm (P>0.05). When considering total dry matter weight, there was also greater production in the area of no grazing in relation to grazing (P<0.05). There was however, no difference between grazing area (P>0.05) for total dry matter weight.

For the second collection period (September of 2011) (Table 4), a greater weight for shoot dry matter was also found in brachiaria under the NG treatment (P<0.05) compared to the areas with grazing, with the highest production among grazing treatments being at heights of 30 and 40 cm. In relation to plant-residue dry matter weight, the 10 cm treatment did not differ from the 30 cm treatment, and had less production compared to the 20 cm, 40 cm and NG treatments, with these not differing between themselves. However, the 30 cm treatment showed no difference to 20 and 40 cm, being inferior to the NG.

In a comparison between the periods of collection (September 2010 and September 2011) (Table 4), the *Brachiaria ruziziensis* variables of shoot dry matter weight, plant-residue dry matter weight and total dry matter weight showed significant differences (P<0.05) for grazing heights of 20, 30 and 40 cm, and the NG treatment, without being significant at a grazing height of 10 cm. Mean values for total dry matter weight under the no-grazing treatment were 10,399.8 and 12,058.9 kg ha^{-1} respectively for the collection periods

Table 3 - Summary of variance analysis for *Brachiaria ruziziensis* shoot dry matter weight, plant-residue dry matter weight and total dry matter weight (shoot weight + plant-residue weight) under different grazing heights and an area of no grazing, in September 2010 and September 2011

Variable	Calculated value for F		
	Grazing height	Period	Interaction Height x Period
Shoot dry matter weight in *Brachiaria ruziziensis*	509.8745**	46.1340**	16.8733**
Plant-residue dry matter weight	1.1694[ns]	127.4437**	7.8976**
Total dry matter weight	113.1525**	113.8823**	7.1618**

[ns]not significant; **significant at 1% probability by F-test

Table 4 - Mean values in *Brachiaria ruziziensis* for shoot dry matter weight, plant-residue dry matter weight and total dry matter weight (shoot dry matter weight + plant-residue dry matter weight) under different grazing heights and an area of no grazing, in September 2010 and September 2011

	Shoot dry matter weight in *Brachiaria ruziziensis* (Kg ha^{-1}) CV$_1$ = 4.21%, CV$_2$ = 6.96%					
Period	Grazing height (cm)					
	10	20	30	40	NG[1]	Mean
September 2010	3,329.7 dA	3,767.0 cdB	4,235.1 bcB	4,737.7 bB	9,379.2 aA	5,089.8 B
September 2011	3,408.8 dA	4,752.0 cA	6,405.0 bA	7,020.6 bA	8,672.3 aB	6,051.8 A
Mean	3,369.2 e	4,259.5 d	5,320.3 c	5,879.1 b	9,025.7 a	
	Plant-residue dry matter weight (Kg ha^{-1}) CV$_1$ = 16.54%, CV$_2$ = 15.22%					
Period	Grazing height (cm)					
	10	20	30	40	NG[1]	Mean
September 2010	1,639.1 aA	1,516.4 aB	1,622.1 aB	1,414.5 aB	1,020.6 aB	1,442.5 B
September 2011	2,057.4 cA	2,902.3 abA	2,503.3 bcA	2,950.3 abA	3,386.7 aA	2,760.0 A
Mean	1,848.3 a	2,209.3 a	2,062.7 a	2,182.4 a	2,203.6 a	
	Total dry matter weight (Kg ha^{-1}) CV$_1$ = 6.77%, CV$_2$ = 7.63%					
Period	Grazing height (cm)					
	10	20	30	40	NG[1]	mEAN
September 2010	4,968.8 bA	5,283.4 bB	5,857.2 bB	6,152.1 bB	10,399.8 aB	6,532.3 B
September 2011	5,466.2 dA	7,654.2 cA	8,908.9 bcA	9,971.0 bA	12,058.9 aA	8,811.8 A
Mean	5,217.5 d	6,468.8 c	7,383.0 bc	8,061.5 b	11,229.3 a	

[1]NG: area of no grazing. Different lowercase letters in a row differ by Tukey's test *(P<0.05)* for grazing height within each variable. Different uppercase letters in a column differ by F-test *(P<0.05)* for collection period within each variable. CV$_1$: coefficient of variation related to grazing height. CV$_2$: coefficient of variation related to period and the interaction height x period

of September 2010 and September 2011. These figures are close to those found by Nepomuceno *et al.* (2012) in an area of no grazing, checked after desiccation of the *Brachiaria ruziziensis*, 10,000 kg ha^{-1} dry weight with 100% ground cover. In another area of the same experiment, those authors obtained 6,000 kg ha^{-1} of dry weight with 80% ground cover. These results show that the production of straw from *Brachiaria ruziziensis* may vary from one location to another, depending on the conditions of soil and climate.

Taking the average over the two periods of collection (Table 4), more shoot dry matter weight was seen in *Brachiaria ruziziensis* for an increase in grazing height, albeit displaying increased production in the area of NG (9,025.7 kg ha^{-1}) compared to the areas of grazing, which showed a variation from 3,369.2 kg ha^{-1} to 5,879.1 kg ha^{-1}. For plant-residue dry matter weight, the average over the two years of collection showed no difference for grazing height (P>0.05). The average for total dry matter weight for the two seasons under evaluation was also higher for the area of NG (11,229.3 kg ha^{-1}). It should be noted therefore, that grazing resulted in less total dry matter weight where crops were grown in succession.

The total amount of dry matter produced with the treatments over the average of the two collecting periods, with the exception of the height of 10 cm (Table 4), was within the amount necessary to maintain proper ground cover under a no-till system with crop succession, as at least 6,000 kg ha^{-1} of dry matter on the soil surface is recommended (DAROLT, 1998).

In general, there was greater production in *Brachiaria ruziziensis* of shoot dry matter weight, plant-residue dry matter weight, and the sum of these weights, for the second period of collection (P<0.05), with a production of 6,051.8 kg ha^{-1}; 2,760.0 kg ha^{-1} and 8,811.8 kg ha^{-1} respectively (Table 4).

Figure 1 shows the residue of *Brachiaria ruziziensis* remaining on the surface of the soil throughout the crop cycle of the soybean.

This can be confirmed by data from Franchini *et al.* (2009), who found 40% of the original tropical forage material after 120 days of the straw being on the soil surface, with *Brachiaria ruziziensis* residue providing good ground cover even nine months after desiccation. Pacheco *et al.* (2011) however, working

Figure 1 - Plant residue of *Brachiaria ruziziensis* on the surface of the soil in the final period of the soybean crop cycle. A, B, C, D and E correspond respectively to grazing heights of 10, 20, 30, and 40 cm and to the area of no grazing (NG) (March 2012)

with cover plants in winter for two consecutive seasons, observed 120 days after dessication, a remaining 1,172 kg ha^{-1} preceding the first crop and 3,900 kg ha^{-1} preceding the second, corresponding to 18.8% and 51.6% of the initial dry matter of *Brachiaria ruziziensis* respectively. Nunes *et al.* (2010) found at 135 days after sowing, and at the end of the soybean cycle, an amount of dry matter of 5,700 and 7,200 kg ha^{-1} for *B. brizantha* and *B. decumbens* respectively, leaving an evident and adequate cover during the soybean cycle.

The result of variance analysis for the final number of plants per metre, plant height and productivity in the soybean is shown in Table 5. It can be seen that the periods (crop years 2010/2011 and 2011/2012) were significant for these variables. On the other hand, grazing height (10, 20, 30 and 40 cm, and NG) and the interaction between height and period produced no changes in the results.

The lack of a noticeable effect of grazing height on the number of plants per metre is probably due to correct seed deposition in the crop row, and to satisfactory soil-moisture conditions when planting.

Lima *et al.* (2009) also found no change in the final stand of soybean plants from ground cover. Nepomuceno

et al. (2012), analysing two experiments with 6,000 and 10,000 kg ha^{-1} dry weight of *Brachiaria ruziziensis* as ground cover, also found that the mulch formed on the surface of the soil had no significant effect on the stand of RR soybeans evaluated at 20 days after sowing. However, contrary to these results, Lopes *et al.* (2009) observed that in a clayey soil, grazing height had a linear influence on the stand of the soybean plants after emergence, obtaining a smaller stand of plants at the lowest grazing height.

In a study by Nunes *et al.* (2010), at the time of sowing the soybean the amount of straw from *Brachiaria brizantha* and *Brachiaria decumbens* was respectively 8,700 and 11,200 kg ha^{-1}; values which had no significant effect on the height of the soybean plants, corroborating with the present study.

Flores *et al.* (2007) also found no significant difference in soybean yield at grazing heights which were the same as in this work (10, 20, 30 and 40 cm) or in an area with no grazing (NG). Nicoloso *et al.* (2006) on the other hand, observed a reduction in productivity of the soybean in areas with a higher grazing frequency, compared to an area of no grazing, which showed no difference to the lowest grazing frequency.

Table 5 - Summary of variance analysis of the final number of plants per metre, plant height and productivity in the soybean under different grazing heights and in an area with no grazing, for the crop years 2010/2011 and 2011/2012

Variable	Calculated value for F		
	Grazing height	Period[1]	Interaction Height x Period
Final number of plants m^{-1}	1.3068^{ns}	285.9886**	1.6912^{ns}
Plant height	1.7591^{ns}	4,846.2044**	0.9483^{ns}
Productivity	0.6743^{ns}	191.3069**	0.4514^{ns}

[1]Crop years 2010/2011 and 2011/2012. ^{ns}not significant; **significant at 1% probability by F-test

Table 6 shows mean values for the final number of plants per metre, plant height and productivity in the soybean crop for the crop years 2010/2011 and 2011/2012, as a function of grazing height in *Brachiaria ruziziensis* and in an area of no grazing (NG).

The final number of plants of the soybean crop per metre in the two evaluation cycles varied from 16.6 to 17.5 and from 13.3 to 14.2, equivalent to a stand of 369,000 to 389,000 and 296,000 to 316,000 plants ha^{-1} respectively for the crop years 2010/2011 and 2011/2012 (Table 6). The lower final number of plants per metre in the second crop year compared to the first (P<0.05), is due to the lower number of seeds used for planting (22.0 and 18.0 seeds per metre respectively for the crop years 2010/2011 and 2011/2012).

The height of the soybean was greater (P<0.05) in 2010 (Table 6). This was because water was limited in 2011 during the production cycle of the crop. According to Farias, Nepomuceno and Neumaier (2007), development of the soybean crop is affected by stress caused by water shortage, resulting in plants of short stature, with small leaves and short internodes.

Table 6 - Mean values for final number of plants per metre, plant height and productivity, in a soybean crop under different grazing heights of *Brachiaria ruziziensis* and in an area of no grazing (NG), for the crop years 2010/2011 and 2011/2012

Final number of plants m$^{-1(1)}$ CV$_1$ = 3,45%; CV$_2$ = 3,50%						
Period[2]	Grazing height (cm)					
	10	20	30	40	NG[3]	Mean
2010/2011	16.6	17.0	17.5	17.0	17.4	17.1 a
2011/2012	13.9	14.2	14.1	13.3	13.3	13.8 b
Mean	15.3	15.6	15.8	15.2	15.3	

Plant height (cm)$^{(1)}$ CV$_1$ = 2.62%; CV$_2$ = 2.91%						
Period[2]	Grazing height (cm)					
	10	20	30	40	NG[3]	Mean
2010/2011	122.4	126.6	125.6	121.4	124.3	124.1 a
2011/2012	56.8	56.5	57.5	56.2	58.5	57.1 b
Mean	89.6	91.5	91.6	88.8	91.4	

Productivity (kg ha^{-1})$^{(1)}$ CV$_1$ = 10.79%; CV$_2$ = 11.55%						
Period[2]	Grazing height (cm)					
	10	20	30	40	NG[3]	Mean
2010/2011	3,052.0	2,963.9	3,193.0	2,959.3	3,240.0	3,081.6 a
2011/2012	1,550.4	1,740.3	1,812.4	1,687.7	1,657.1	1,689.6 b
Mean	2,301.2	2,352.1	2,502.7	2,323.5	2,448.5	

[1]Not significant by F-test *(*P>0.05) for grazing height; [2]Crop years 2010/2011 and 2011/2012; [3]NG: area with no grazing. Different lowercase letters in a column differ by F-test (P<0.05) for collection period within each variable. CV$_1$: coefficient of variation for grazing height. CV$_2$: coefficient of variation for period and the interaction height x period

Soybean yields ranged from 2,959.3 to 3,240.0 kg ha⁻¹ respectively for the 40 cm treatment and the area with no grazing (NG) in the 2010/2011 crop year. However, in the 2011/2012 crop year, productivity in the soybean varied from 1,550.4 to 1,812.4 kg ha⁻¹ respectively for the 10 cm and 30 cm treatments (see Table 6). This low productivity is attributed to a shortage of water during the periods of flowering and grain filling that year, and explains the significant difference for soybean yield between the crop years (P<0.05).

Under a situation of water stress, Lopes *et al.* (2009) obtained lower results, with yields of 1,290; 1,300; 1,195; 1305 and 1,025 kg ha⁻¹ respectively for treatments of 10, 20, 30 and 40 cm and an area of no grazing (NG); but found no statistical difference between the treatments, corroborating the present study. Statistical differences between low and moderate-intensity grazing, with greater soybean yield at lower stocking rates, was found by Lunardi *et al.* (2008) under a situation of water stress, which contradicts the results of this study.

Verification of the results for soybean yield in the two years under evaluation, with problems of water shortage in the second season, shows that even though working with a good volume of straw on the soil surface, there was an average reduction of about 45% in soybean yield.

CONCLUSIONS

1. The production of straw was greater for *Brachiaria ruziziensis* in the area of no grazing compared to the areas with grazing, particularly the high production in areas with greater grazing heights;

2. The final number of plants, plant height and productivity in the soybean crop were not affected by the grazing height of the *Brachiaria ruziziensis*.

ACKNOWLEDGEMENTS

REFERENCES

BARTHRAM, G. T. Experimental techniques: the HFRO sward stick. *In*: BIENNIAL REPORT OF THE HILL FARMING RESEARCH ORGANIZATION, 1984/1985, Penicuik. **Proceedings…**Penicuik: Hill Farming Research Organization, 1985. p. 29-30.

BRASIL. Ministério da Agricultura, Pecuária e Abastecimento. Secretaria de Defesa Agropecuária. **Regras para análise de sementes.** . Brasília, DF: MAPA, SDA, 2009. 399 p.

CERETTA, C. A. *et al*. Produção e decomposição de fitomassa de plantas invernais de cobertura de solo e milho, sob diferentes manejos da adubação nitrogenada. **Ciência Rural**, v. 32, n. 1, p. 49-54, 2002.

CUNHA, E. Q. *et al*. Influência de rotações de culturas nas propriedades físico-hídricas de um Latossolo Vermelho em plantio direto. **Engenharia Agrícola**, v. 27, n. 3, p. 665-674, 2007.

DAROLT, M. R. Princípios para implantação e manutenção do sistema. *In:* DAROLT, M.R. **Plantio direto:** pequena propriedade sustentável. Londrina: IAPAR, 1998, p. 16-45. (IAPAR. Circular, 101).

FARIAS, J. R. B.; NEPOMUCENO, A. L.; NEUMAIER, N. **Ecofisiologia da soja**. Londrina: Embrapa Soja, 2007. 9 p. (Embrapa Soja. Circular técnica, 48).

FERREIRA, D. F. Sisvar: a computer statistical analysis system. **Ciência e Agrotecnologia**, v. 35, n. 6, p. 1039-1042, 2011.

FIDALSKI, J.; TORMENA, C. A.; ALVES, S. J. Intervalo hídrico ótimo de um Latossolo Vermelho distrófico, após o primeiro período de pastejo contínuo de *Brachiaria ruziziensis*, em sistema integração lavoura-pecuária. **Revista Brasileira de Ciência do Solo**, v. 37, n. 3, p. 775-783, 2013.

FLORES, J. P. C. *et al*. Atributos físicos do solo e rendimento de soja em sistema plantio direto em integração lavoura-pecuária com diferentes pressões de pastejo. **Revista Brasileira de Ciência do Solo**, v. 31, n. 4, p.771-780, 2007.

FRANCHINI, J. C. *et al.* **Integração Lavoura-Pecuária**: Alternativa para diversificação e redução do impacto ambiental do sistema produtivo no Vale do Rio Xingu. Londrina: Embrapa Soja, 2010. 20 p. (Embrapa Soja. Circular técnica, 77). Disponível em: http://www.cnpso.embrapa.br/dowload/CT77VE.pdf. Acesso em: 10 Fev. 2011.

FRANCHINI, J. C. *et al.* **Manejo do solo para redução das perdas de produtividade pela seca**. Londrina: Embrapa Soja, 2009. 39p. (Embrapa Soja. Documentos, 314).

INSTITUTO AGRONÔMICO DO PARANÁ. **Cartas climáticas básicas do Estado do Paraná**. Londrina: IAPAR, 1987. 35 p.

LIMA, E. do V. *et al*. Características agronômicas, produtividade e qualidade fisiológica da soja "safrinha" sob semeadura direta, em função da cobertura vegetal e da calagem superficial. **Revista Brasileira de Sementes**, v. 31, n. 1, p. 69-80, 2009.

LOPES, M. L. T. *et al.* Sistema de integração lavoura-pecuária: efeito do manejo da altura em pastagem de aveia preta e azevém anual sobre o rendimento da cultura da soja. **Ciência Rural**, v. 39, n. 5, p. 1499-1506, 2009.

LUNARDI, R. *et al*. Rendimento de soja em sistema de integração lavoura-pecuária: efeito de métodos e intensidades de pastejo. **Ciência Rural,** v. 38, n. 3, p. 795-801, 2008.

MACHADO, L. A. Z.; ASSIS, P. G. G. de. Produção de palha e forragem por espécies anuais e perenes em sucessão à soja. **Pesquisa Agropecuária Brasileira**, v. 45, n. 4, p. 415-422, 2010.

MOTT, G. O.; LUCAS, H. L. The design, conduct and interpretation of grazing trials on cultivated and improved pastures. *In:* INTERNATIONAL GRASSLAND CONGRESS, 6., 1952, Pennsylvania. **Proceedings…**Pennsylvania: State College, 1952. p. 1380-1385.

NEPOMUCENO, M. P. *et al.* Períodos de dessecação de *Urochloa ruziziensis* e seu reflexo na produtividade da soja RR. **Planta Daninha**, v. 30, n. 3, p. 557-565, 2012.

NICOLOSO, R. da S. *et al.* Manejo das pastagens de inverno e potencial produtivo de sistemas de integração lavoura-pecuária no Estado do Rio Grande do Sul. **Ciência Rural**, v. 36, n. 6, p. 1799-1805, 2006.

NUNES, A. S *et al.* Formação de cobertura vegetal e manejo de plantas daninhas na cultura da soja em sistema plantio direto. **Planta Daninha**, v. 28, n. 4, p. 727-733, 2010.

OLIVEIRA, E. de. *et al.* **Recuperação de pastagens no Noroeste do Paraná**: bases para plantio direto e integração lavoura e pecuária. Londrina: IAPAR, 2000. 96 p. (IAPAR. Informe da Pesquisa, 134).

PACHECO, L. P. *et al.* Desempenho de plantas de cobertura em sobressemeadura na cultura da soja. **Pesquisa Agropecuária Brasileira**, v. 43, n. 7, p. 1269-1276, 2008.

PACHECO, L. P. *et al.* Produção e ciclagem de nutrientes por plantas de cobertura nas culturas de arroz de terras altas e de soja. **Revista Brasileira de Ciência do Solo**, v. 35, n. 5, p. 1787-1800, 2011.

PAVAN, M. A. *et al.* **Manual de análise química do solo e controle de qualidade**. Londrina: IAPAR, 1992. 40 p. (IAPAR. Circular, 76).

PIMENTEL-GOMES, F. **Curso de estatística experimental.** São Paulo: Nobel, 2000. 477 p.

PIMENTEL-GOMES, F.; GARCIA, C. H. **Estatística aplicada a experimentos agronômicos e florestais**: exposição com exemplos e orientações para uso de aplicativos. Piracicaba: FEALQ, 2002. 309 p.

SALTON, J. C.; FABRICIO, A. C.; HERNANI, L. C. Integração lavoura-pecuária: alternativa de rotação de culturas. *In*: ENCONTRO REGIONAL DE PLANTIO DIRETO NO CERRADO. SUSTENTABILIDADE, SIM!, 5., 2001, Dourados. **Anais...**Brasília: APDC; Dourados: UFMS/Embrapa Agropecuária Oeste, 2001. p. 31-32.