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Dry matter yield and bromatological composition of gliricidia in different crop densities

Produção e composição bromatológica da massa seca de gliricídia em diferentes densidades de plantio

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ABSTRACT

The objective of this study was to evaluate the effect of different gliricidia planting densities on productive and qualitative parameters. The experiment was carried out at the Experimental Station Pedro Arle, Embrapa Tabuleiros Costeiros (Embrapa Coastal Tablelands), in Frei Paulo, Sergipe, Brazil. The effect of densities of 10,000; 20,000; 30,000 and 40,000 plants ha^{-1} was tested in biomass production (fresh and dry), dry matter content (DM), crude protein (CP), neutral detergent fiber (NDF), and acid-detergent fiber (ADF), in gliricidia leaves and tender stems. The experiment consisted of a randomized block design with four replications. Production of leaf and stem fresh biomass; production of leaf dry matter; percentage of fresh leaves in relation to the total fresh matter; and percentage of leaf dry matter of 13 cuttings were evaluated from September 2nd, 2009 to December 18th, 2013. There was increase in the production of total fresh matter, leaf fresh matter, and leaf dry matter ($P<0.05$) in planting densities greater than 20,000 plants ha^{-1}. Year effect ($P<0.05$) was found only for total production of fresh matter, production of fresh leaves, percentage of leaf fresh matter, leaf dry matter content and crude protein.

Key words: *high-density cultivation, leguminous trees, forage legumes.*

RESUMO

Este estudo teve como objetivo avaliar o efeito de diferentes densidades de plantio de gliricídia sobre parâmetros produtivos e qualitativos. O experimento foi realizado na Estação Experimental Pedro Arle, da Embrapa Tabuleiros Costeiros, em Frei Paulo, Sergipe, Brasil, o efeito das densidades de cultivo de 10.000; 20.000; 30.000 e 40.000 plantas ha^{-1} foi testado nos rendimentos de biomassa (verde e seca), teores de matéria seca (MS), proteína bruta (PB), fibra em detergente neutro (FDN) e fibra em detergente ácido (FDA) em folhas e caules mais tenros de gliricidia. Foi utilizado o delineamento em blocos casualizados com quatro repetições. A Produção de biomassa fresca de folhas e caules, a produção de massa seca de folhas, a porcentagem de folhas frescas relacionados à biomassa fresca total, a porcentagem de matéria seca nas folhas de 13 cortes foi avaliada durante o período de 02/09/2009 e 18/12/2013. As produções de biomassa fresca total, biomassa das folhas frescas, matéria seca de folhas aumentaram ($P<0,05$) com densidades de plantio superiores a 20.000 plantas ha^{-1}. Foi encontrado efeito do ano ($P<0,05$) apenas para a produção total de biomassa fresca, produção de folhas frescas, porcentagem de biomassa de folhas frescas, teor de matéria seca das folhas e PB.

Palavras-chave: *cultivo adensado, leguminosas arbóreas, leguminosas forrageiras.*

INTRODUCTION

The semi-arid region of northeast Brazil has low forage production capacity, and reduced water availability is a limiting factor of productivity. The average rainfall in this region is between 300 and 800mm year^{1}, and may reach 1000mm (ALVES et al., 2007). However, the rain is generally concentrated in few months, which causes water deficit throughout the year.

Under these conditions, forage production is concentrated in 4 to 5 months, causing a marked seasonality of the production. Thus, animal production is conditioned to the intensive use, for most part of

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the year, of forage produced and conserved in the rainy season, and to the purchase of concentrates (OLIVEIRA et al., 2007).

Due to changes in prices, expenses on food concentrates increase production costs. However, according to SANTOS et al. (2010), as an alternative to reduce these costs, producers may use forage with good nutritional value and good yield, which are adapted to the soil and weather conditions of the region.

In this context, the use of legume species appears as an excellent alternative. According to SHELTON et al. (2005), the use of legume species adapted to tropical grazing systems could circumvent both low nitrogen levels in leached tropical soils, and low protein levels in the diet of grazing ruminants.

Among legume species, Gliricidia (***Gliricidia sepium*** (Jacq.) Walp.) is a tree originally from Mexico and Central America, and it stands out for being adapted to the soil and weather conditions of the semiarid region, for having high protein content, ranging from 20 to 30% crude protein in their leaves (RANGEL et al., 2000); great regrowth capacity, enabling to carry out three cuttings per year (BARRETO et al., 2004); good biomass production, reaching 80Mg $ha^{-1}ano^{-1}$ (RANGEL, 2008); and good acceptation by ruminants.

Gliricidia can be easily grown from seeds; however, it can also be easily established by stakes COSTA et al. (2004), in order to evaluate planting methods by cuttings, using different stem fractions to identify those of forage production, observed that 1m cutting vertically planted in pits had the highest leaf dry matter production, and the mean production was 1.29Mg ha^{-1} of total leaf dry matter, with density equivalent to 40,000 plants ha^{-1}.

Although the studies developed with gliricidia have demonstrated its potential as a food supplement in diets for ruminants, and although this legume have been widely used under forage cutting management and transportation in Asia, Africa and Central America (COMBELLAS et al., 2002), there is lack of information regarding optimal cultivation density of this plant with the purpose of forming legume species aimed at biomass production.

Such information could help maintaining the sustainability of animal production in semi-arid regions of northeastern Brazil through a better use of the areas of this activity, since, according to COUTINHO et al. (2013), small farms are predominant in this region.

Thus, this study aimed to evaluate the effect of different gliricidia planting densities on production and chemical composition of fresh and dry biomass (DM).

MATERIALS AND METHODS

The experiment was carried out in Cambisol with clayey texture in the Experimental Field of Pedro Arle, owned by Embrapa Tabuleiros Costeiros, in the municipality of Frei Paulo - SE, located at 10º55 'S lat.; 37º53' W long., 272m asl., with average annual rainfall of 700mm, from September, 2009 to December, 2013. After chemical analysis, the following soil characteristics were observed: pH in water = 6.82; available P = 13.2ppm; K = 225ppm; Ca and Mg = 9.04 and 3.76cmolc dm^{-3}, respectively, and Al + H = 1.62cmolc dm^{-3}.

Gliricidia was planted without the use of irrigation in a simple arrangement of a randomized block design with four replications, in order to test the effect of densities of 10,000 (1.0m x 1.0m), 20,000 (1.0m x 0.5m), 30,000 (1.0m x 0.33m) and 40,000 (1.0m x 0.25m) plants ha^{-1}. Plots of 5.0m x 4.0m were used, and gliricidia was planted by seeds with planting pits according to the treatment, spaced 1.0m between lines, with useful plot of 10m².

The experimental area was established on August 7th, 2008, fertilized with 80kg P_2O_5 ha^{-1} $year^{-1}$, and 60kg K_2O ha^{-1} $year^{-1}$, which were applied between rows, and annually, in the first cutting of the rainy season. A cutting was carried out previously to the evaluation period, on May 22nd, 2009, and standardization cutting was carried out to start the evaluation period on September 9th, 2009.

The estimated growth period was between September 2nd, 2009 and December 18th, 2010. Cuttings were carried out on: March 16th, 2010; May 26th, 2010; August 28th, 2010; December 9th, 2010; March 22nd, 2011; June 10th, 2011; September 28th, 2011; February 1st, 2012; August 1st, 2012; December 5th, 2012; May 29th, 2013; August 28th, 2013; and December 18th, 2013. Cuttings were carried out when the plant reached 1.5m height, by cutting from a height of 0.5m. Four cuttings were carried out in 2010, and three in the years of 2011, 2012 and 2013, totaling 13 cuttings, in which all shoot (stems and leaves) was taken out. After cuttings, shoot was weighed, and samples of the structural components were collected for further analysis.

Laboratory analyses were carried out at the Animal Nutrition Laboratory (ANL) of Embrapa Tabuleiros Costeiros, located in the municipality of Aracaju - SE. The analyzed variables were: leaf and stem biomass (leaves + tender stems), percentage of leaves, dry leaf matter (DLM), total leaf dry matter (TLDM). Regarding the chemical composition, the following contents were determined: dry matter (DM) and crude protein (CP), according to SILVA & QUEIROZ (2002); and neutral detergent fiber (NDF) and acid detergent fiber (ADF), according to Van SOEST (1967), described in SILVA & QUEIROZ (2002).

Figure 1 shows rainfall data on the evaluated years, and the distribution of rainfall throughout each year. Total rainfall for the years 2010, 2011, 2012 and 2013 were 800.5; 651.3; 375.1; and 651.6mm, respectively.

Results were submitted to analysis of variance considering the effects of year and treatment. Duncan test at 5% significance level was applied when the model showed significant difference ($P<0.05$), using the SAS® statistical package (SAS Institute, 2009).

RESULTS AND DISCUSSION

Collected data presented no interaction between cultivated year and treatments. Table 1 shows the means of gliricidia biomass production (total, stem and leaf) and percentage of leaves, percentage of leaf dry matter (LDM), total leaf dry matter (TLDM), CP, NDF, ADF, depending on the planting density. It was observed that planting density significantly influenced the variables of total production, i.e., stem and leaf, and TLDM.

The highest total biomass production per cutting was found in the treatments of 30,000 and 40,000 plants ha^{-1}, with 24.91 and 24.52t Mg ha^{-1}, respectively. This effect can also be observed in stem (8.5 and 8.22Mg ha^{-1}, respectively) and leaf (16.41 and 16.30Mg ha^{-1} respectively) for the same treatments.

When total biomass is divided by the number of plants in each treatment, it is observed a decrease in the mean of production per plant with an increase in density. The observed means were: 2.19; 1.05; 0.83 and 0.61kg $plant^{-1}$ for the treatments of 10,000; 20,000; 30,000 and 40,000 plants ha^{-1}, respectively. This shows that although the lower plant spacing reduced the production of biomass per plant (KARIM & SAVILL, 1991), the largest number of plants per unit area probably outweighed it.

Significant difference was reported ($P<0.05$) in the production of TLDM in function of the planting densities, since treatments with higher plant density obtained higher yield, with 3.35 and 3.33Mg ha^{-1} for treatments of 30,000 and 40,000 plants per hectare, respectively. These results corroborate those report by ELLA et al. (1989), who evaluated the effect of density (5,000, 10,000, 20,000 and 40,000 plantas ha^{-1}) and the cutting frequency on the production of four leguminous trees, and found higher dry matter production of ***Gliricidia sepium*** leaves in the treatment with the greater plant density.

However, these results contradict those reported by MUNIZ et al. (2009) and CASTRO FILHO et al. (2010), who reported no additional gains in the use of densities greater than 10,000 ha^{-1} plants for gliricidia in non-irrigated cultures region in the coastal table land of Sergipe. These results may be related

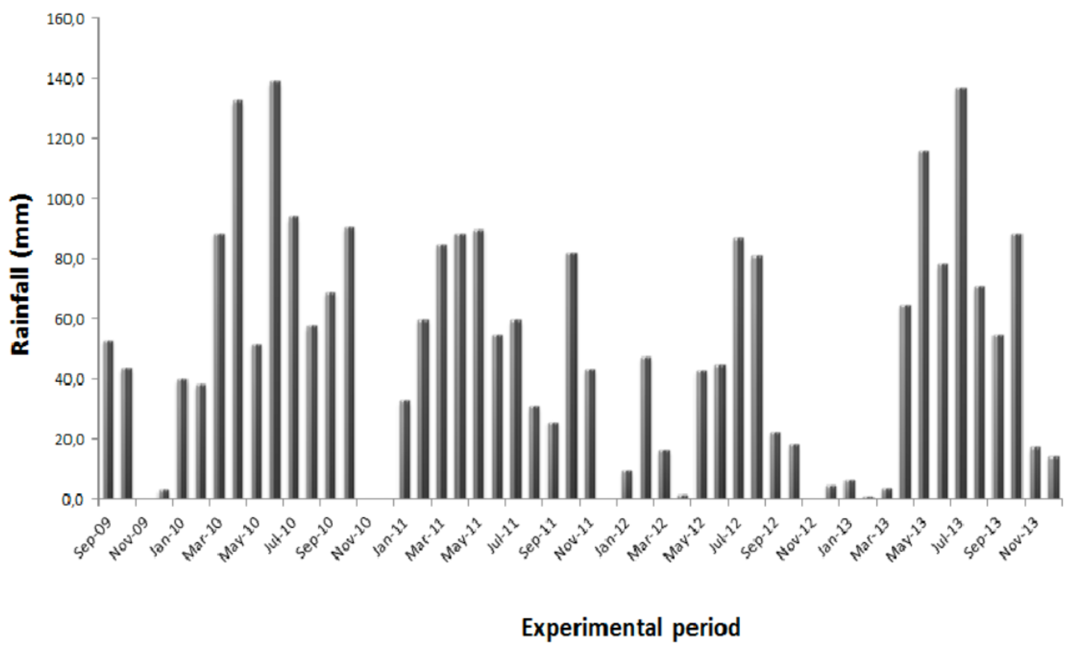

Figure 1 - Annual rainfall during the years of 2010, 2011, 2012 e 2013.

Table 1 - Means of gliricidia biomass yield (total, stems, and leaves) and leaves percentage, leaf dry matter percentage (LDM), total dry matter yield of leaves (TDML), crude protein (CP), neutral detergent fiber (NDF), and acid detergent fiber (FDN) in the different crop densities.

Plant ha^{-1}	Total	Stems	Leaves	Leaves	LDM	TDML	PB	NDF	ADF
	--------Mg ha^{-1} cut^{-1} (fresh biomass)--------			%	%	Mg ha^{-1} cut^{-1}	%	%	%
10000	21.88b	7.70ab	14.17b	66.04	21.61	2.95b	22.65	35.15	26.54
20000	20.99b	7.06b	13.92b	65.77	21.76	2.88b	22.58	34.47	25.66
30000	24.91a	8.50a	16.41a	66.20	21.27	3.35a	22.85	34.25	26.34
40000	24.52a	8.22a	16.30a	66.34	22.27	3.33a	22.58	35.42	26.50
CV%	27.79	34.27	29.52	11.52	12.75	24.44	6.68	10.49	8.56
P	0.0037	0.0422	0.0042	0.8255	0.7458	0.0015	0.7745	0.3247	0.1700

Means in columns followed by different letters are statistically different by Duncan test (P<0.05).

to the lower nutrient quality of the soil used in these experiments, as well as due to a possible increase of intraspecific root competition, for being older plants, and hence having more developed root system.

CP values were not significantly different (P>0.05) between treatments regarding the density, maintaining a mean above 22.0%. This demonstrates the quality of gliricidia as forage, since protein is the most expensive nutrient in the diet. These values are higher than those reported in grasses and higher than the minimum recommended for ruminants, which is around 7% CP (in order to avoid reduction of digestibility and consumption) (Van SOEST, 1994).

Treatments did not influence the % of MDF, NDF and ADF, showing that different densities did not influence (P>0.05) the chemical composition of gliricidia. This makes the total biomass production per area a determining factor in choosing the best planting density.

Furthermore, with respect to fiber, which is an important factor to provide the proper functioning of the rumen (Van SOEST, 1994), means of 34.82 and 26.26% were reported for NDF and ADF fractions, respectively. These values may be considered low and similar to those reported by COSTA et al. (2009), who reported 38.81 and 24.30%, respectively for the same variables. These fractions are related to the potential of forage consume and digestibility, and high NDF are generally related to the reduction in DM voluntary consume.

Although the evaluated data did not present interaction between cultivated year and treatments, there was a significant difference between the years. Table 2 shows the means of gliricidia biomass production (total, stem and leaf), percentage of leaves, leaf dry matter (LDM), CP, NDF and ADF in function of the different years. In this table, it was possible to observe that almost all variables showed significant differences (P<0.05) between the years, except stem production.

Biomass production was higher (P<0.05) in the years of 2010 and 2013, with values of 105.75 and 107.73Mg ha^{-1}, respectively. In the year of 2010, stem production was higher than in the years of 2011 and 2012. The year of 2013 presented results similar to those of the other years. These results can be explained by relating the biomass production to the

Table 2 - Means of biomass yield of gliricidia (total; leaves and stems) and percentage of leaves (LP), leaves dry matter (LDM), crude protein, neutral detergent fiber (NDF), and acid detergent fiber (ADF) according to the experimental year.

	Total	Stems	Leaves	LP	LDM	CP	NDF	ADF
	------------Mg ha^{-1} cut^{-1} (fresh biomass)------------			%	%	%	%	%
2010	105.75a	37.18a	68.57b	64.43b	20.12bc	22.34b	35.82a	26.34ab
2011	89.67b	28.75b	60.92c	67.94a	20.47b	22.95a	34.91ab	26.89a
2012	71.30b	29.51b	41.785d	59.35c	25.22a	22.05b	33.71b	26.35ab
2013	107.73a	33.23ab	74.51a	69.91a	19.84c	23.40a	34.61ab	25.43b
CV%	13.03	20.10	10.51	4.84	2.67	3.01	10.49	8.56
P	0.0001	0.1849	0.0001	0.0001	0.0001	0.0001	0.0268	0.0169

Means in columns followed by different letters are statistically different by Duncan test (P<0.05).

rainfall that occurred in the years (Figure 1), since the highest yields were achieved in the years when there were higher rainfalls.

The year of 2013 obtained the highest percentage of leaves, with 69.91%, and did not significantly differ (P>0.05) from the year of 2011 (67.94%), followed by the years of 2010 (64.43%), and 2012 (59.35%). The lowest percentage of leaves in 2012 may be explained by the lower rainfall in this year, and by the fact that in dry season, gliricidia loses part of the leaves and keeps larger amount of stems. However, LDM was lower in the years of 2013 and 2010, with 19.84 and 20.12%, respectively, being higher in 2012, with 25.22%.

Regarding CP (Table 2), results showed differences between the years. The mean achieved was above 22.0%, and it is in accordance with those reported by RANGEL et al. (2000), between 20 and 30%. However, the highest value was recorded in 2013 (23.40%), and the lowest in 2012 (22.05%). The lowest CP percentage found in 2012 may be related to greater participation of tender stems in leaf biomass fraction, in function of the fall of part of the leaves in the dry season (these tender stems account in the leaf biomass fraction for being consumed together with leaves by ruminants).

NDF and ADF also showed significant differences (P<0.05) between the years. The highest value for NDF was reported in 2010, with 35.82%, and the lowest value was found in 2012, with 33.71%. For ADF, the highest value was reported in 2011, with 26.89%, and the lowest value was reported in 2013, with 25.43%.

CONCLUSION

For production in non-irrigated system under the region's conditions, it is recommended planting density of 30,000 plants ha^{-1}, since it presented the same forage quality of the other treatments. Consequently, it presented increased biomass production, with no significant difference, except for the density of 40,000 plants ha^{-1}, and it required a smaller number of plants than this.

Results also suggest that there was direct influence of rainfall in the years of production and in forage quality, requiring further studies.

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REFERENCES

ALVES, R.N. et al. Produção de forragem pela palma após 19 anos sob diferentes intensidades de corte e espaçamentos. **Revista Caatinga**, v.20, n.4, p.38-44, 2007. Available from: <http://www.redalyc.org/articulo.oa?id=237117664007>. Accessed: Sept. 04, 2014.

BARRETO, A.C. et al. **Cultivo de alamedas de gliricidia (*Gliricidia sepium*) em solos de tabuleiros costeiros**. Aracaju: Embrapa Tabuleiros Costeiros (CPATC), 2004. (Embrapa Tabuleiros Costeiros. Circular Técnica, 36). Available from: <http://www.cpatc.embrapa.br/publicacoes_2004/CT36.pdf>. Accessed: Sept. 04, 2014.

CASTRO FILHO, E.S. et al. Produção de biomassa de ***Gliricidia sepium*** (Jacq.) Kunth ex Walp.) em função da densidade de plantas. In: REUNIÃO ANUAL DA SOCIEDADE BRASILEIRA DE ZOOTECNIA, 47., 2010, Salvador, BA. **Anais...** Salvador: Reunião Anual da Sociedade Brasileira de Zootecnia, 47., 2010. 1 CD-ROM.

COSTA, B.M. et al. Métodos de plantio de Gliricídia (***Gliricidia sepium*** (Jacq.) Walp.) em estacas para produção de forragem. **Revista Brasileira de Zootecnia**, v.33, n.6, p.1969-1974, 2004. (Supl. 2).

COSTA, B.M. et al. Avaliação de folhas de ***Gliricidia sepium*** (jacq.) Walp por ovinos. **Archivos de Zootecnia**, v.58, n.221, p.33-41, 2009. Available from: <http://scielo.isciii.es/scielo.php?pid=S0004-05922009000100004&script=sci_arttext>. Accessed: Nov. 25, 2014. doi: 10.4321/S0004-05922009000100004.

COUTINHO, M.J.F. et al. A pecuária como atividade estabilizadora no Semiárido Brasileiro. **Veterinária e Zootecnia**, v.20, n.3, p.9-17, 2013. Available from: <http://www.fmvz.unesp.br/rvz/index.php/rvz/article/view/579/464>. Accessed: Jul. 09, 2014.

ELLA, A. et. al. Effect of plant density and cutting frequency on the productivity of four tree legumes. **Tropical Grasslands**, v.23, n.1, p.28-34, 1989.

KARIM, A.B.; SAVILL, P.S. Effect of spacing on growth and biomass production of ***Gliricidia sepium*** (Jacq.) Walp. in an alley cropping system in Sierra Leone. **Agroforestry Systems**, v.16, n.3, p.213-222, 1991. Available from: <http://phdtree.org/pdf/28389802-effect-of-spacing-on-growth-and-biomass-production-of-gliricidia-sepium-jacq-walp-in-an-alley-cropping-system-in-sierra-leone/v>. Accessed: Sept. 04, 2014. doi: 10.1007/bf00119318.

MUNIZ, E.N. et al. Efeito da densidade de plantas sobre o desempenho produtivo da gliricídia [***Gliricidia sepium*** (Jacq.) Walp]. In: CONGRESSO BRASILIRO DE FISIOLOGIA VEGETAL, 12., 2009, Fortaleza, CE. **Anais...** Fortaleza: Sociedade Brasileira de Fisiologia Vegetal, 2009. 1 CD-ROM

OLIVEIRA, V.S. et al. Substituição total do milho e parcial do feno do capim-tifT por palma forrageira em dietas para vacas em lactação. Produção, composição do leite e custos com alimentação. **Revista Brasileira de Zootecnia**, v.36, n.4, p.928-935, 2007. Available from: <http://www.scielo.br/scielo.php?pid=S1516-35982007000400024&script=sci_arttext>. Accessed: Sept. 04, 2014. doi: 10.1590/S1516-35982007000400024.

RANGEL, J.H. de A. et al. Sistema silvipastoril: uma alternativa para a produção de ruminantes. In: MUNIZ, E.N. et al. (Ed.). **Alternativas alimentares para ruminantes II**. Aracaju: Embrapa Tabuleiros Costeiros, 2008. Cap.10, p.245-265.

RANGEL, J.H. de A. et al. Experiências com o uso da Gliricidia sepium na alimentação animal no Nordeste Brasileiro. In: SIMPÓSIO INTERNACIONAL SOBRE SISTEMAS AGROFLORESTAIS PECUÁRIOS NA AMERICA DO SUL, 2000, Juiz de Fora, MG. **Anais...** Juiz de Fora: Embrapa Gado de Leite, 2000. 1 CD-Rom.

SANTOS, M.V.F. et al. Potential of caatinga forage plants in ruminant feeding. **Revista Brasileira de Zootecnia**, v.39, p.204-215, 2010. Available from: <http://www.scielo.br/scielo.php?pid=S1516-35982010001300023&script=sci_arttext>. Accessed: Sept. 04, 2014. doi: 10.1590/S1516-35982010001300023.

SAS. **SAS Software**. Cary, North Carolina: SAS Institute, 1999. Version 9.1.

SHELTON, H.M. et al. Adoption of tropical forage legume technology around the world: analysis of success. In: MCGILLOWAY, D.A. (Ed.). **Grassland**: a global resource. Wageningen, The Netherlands: Wageningen Academic, 2005. p.149-166, 2005. Available from: <http://www.tropicalgrasslands.info/public/journals/4/Historic/Tropical%20Grasslands%20Journal%20archive/PDFs/Vol_39_2005/Vol_39_04_2005_pp198_209.pdf>. Accessed: Sept 04, 2014.

SILVA, D.J.; QUEIROZ, A.C. **Análise de alimentos (métodos químicos e biológicos)**. 3.ed. Viçosa, MG: UFV, 2002. 235 p.

VAN SOEST, P.J. Development of a comprehensive system of feed analysis and its application to forage. **Journal Animal Science**, v.26, n.1, p.119-128, 1967.

VAN SOEST, P.J. **Nutritional ecology of ruminant**. 2.ed. Ithaca: Cornell University, 1994. 476 p.