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Production and nutritive value of ryegrass (cv. Barjumbo) under nitrogen fertilization[1]

Produção e valor nutritivo do azevém (cv. Barjumbo) sob fertilização nitrogenada

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ABSTRACT - Alternative production of forages in periods of scarcity, especially during the winter, is expressively important for grazing of beef and dairy cattle in Brazil. The current work aimed to evaluate the influence of nitrogen fertilization on the production and nutritional value of ryegrass forage (cv. Barjumbo). The experiment was carried out on the winter seasons of 2009 and 2010, at the experimental area of UTFPR, Dois Vizinhos - PR, Brazil. The design consisted of randomized blocks with four N rates (0; 40; 80 and 120 kg ha^{-1}) and three replicates. Each plot measured 5x5 m, with 20 cm row spacing and 2.5 cm between plants, totaling 20 kg ha^{-1} of viable seeds. It was determined the dry matter production, crude protein level, total accumulation of crude protein and neutral detergent fiber, during the whole growth cycle of ryegrass in two crop seasons. Nitrogen fertilization promotes a significant and linear increase in dry matter yield and in accumulation of crude protein, with the best results with the highest rate evaluated (120 kg N ha^{-1}). Nitrogen levels are not capable to promote significant effects in forage neutral detergent fiber content.

Key words: *Lolium multiflorum*. Crude protein. Empty of forage. Neutral detergent fiber.

RESUMO - A produção alternativa de forragens em períodos de escassez, especialmente durante o inverno, é muito importante para o pastejo de bovinos de corte e leite no Brasil. O presente trabalho teve como objetivo avaliar a influencia da fertilização nitrogenada na produção e o valor nutritivo da forragem de azevém (cv. Barjumbo). O experimento foi conduzido durante os invernos de 2009 e 2010, sendo implantado na área experimental da UTFPR, Dois Vizinhos - PR, Brasil. O delineamento foi de blocos ao acaso, com quatro doses de N (0; 40; 80 e 120 kg de N ha^{-1}) e três repetições. As parcelas experimentais foram de 5x5 m, com espaçamento de 20 cm entre linhas e 2,5 cm entre plantas, totalizando 20 kg ha^{-1} de sementes viáveis. Foram determinadas a produção de massa seca, o teor de proteína bruta, o total acumulado de proteína bruta e o teor de fibra em detergente neutro, durante todo o ciclo de crescimento do azevém em dois ciclos de cultivo. A adubação nitrogenada promove um aumento significativo e linear na produção de matéria seca e acúmulo de proteína bruta, com os melhores resultados com a maior dose avaliada (120 kg N ha^{-1}). Maiores níveis de nitrogênio não são capazes de promover efeitos significativos no teor de FDN da forragem.

Palavras-chave: *Lolium multiflorum*. Proteína bruta. Vazio forrageiro. Fibra em detergente neutro.

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INTRODUCTION

Seasonality in forage production has been one of the main responsible by the low production indexes in Brazilian cattle breeding, where climatic factors like rainfall and temperature are the most important ones (GERDES *et al*., 2005). All kinds of forage areas are affected by these factors, which promote variations in cattle weight gain and milk production, since it interfere negatively in feed supply, increasing the price for consumers.

The most restricted season is the winter, characterized by scarcity and loss of food quality supplied to the animals. Consequently, supplementation with conserved feed is required so that production levels could be maintained. Although ensiling and hay are alternatives, frequently both fail to conserve the quality of green forage and it is not profitable. In this case, the use of winter forages for pastures is an important alternative for feed supplementation with high quality (PEREIRA *et al*., 2008). Since the correct exploitation of managed areas requires availability of forage in the pasture, it is highly important to estimate, in a simple but accurate way, the rate of dry matter production and to calculate animal supply and performance for a sustainable and dynamic system.

Ryegrass (*Lolium multiflorum* Lam.) is a winter forage extensively cultivated in Southern Brazil and other South American countries. According to Gerdes *et al*. (2005), ryegrass is characterized by high productivity and excellent nutrition value. This crop is resistant to the cold weather, is capable of guaranteeing natural re-sowing, it has resistance to crop diseases and the animal acceptance is great when cultivated intercropped with other grasses and legumes (CASSOL *et al*., 2011).

When ryegrass is used as pasture with grazing animals, the animal admittance on the area is recommended when the crop is approximately 30 cm high, for a better utilization of the pasture and its management (FLORES *et al*., 2008). The animals should be removed from the area when the plants reach a 10-15 cm residual height, so that a re-shooting occurs and the return of the animals is feasible. The usage period may last up to 80 days and depends on climate, soil fertilization and mainly the management of the area (PELEGRINI *et al*., 2010).

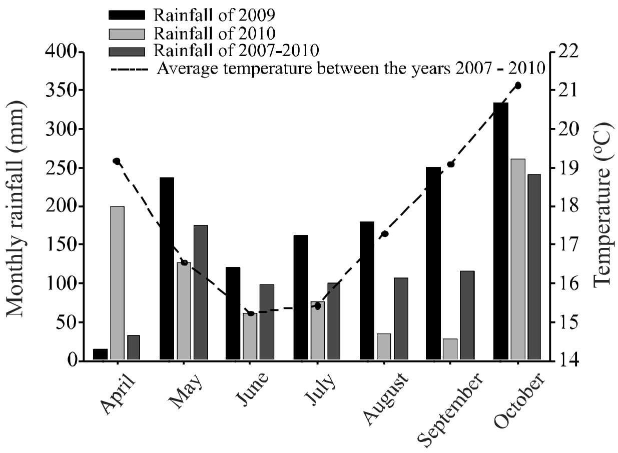
In tropical soils, nitrogen fertilization is responsible by the most significant results in grass production increasing the tillering per plant and, as a result, increasing the dry matter accumulation and better pasture quality, like observed by Canto *et al*. (1997) in black oat. Moreover, nitrogen supply after cutting has an important effect on grass plant recovery under animal grazing, as observed by Soares and Restle (2002) in a ryegrass-triticale mixture.

The establishment of alternatives for forage production in periods of scarcity, especially during the winter, is of paramount importance. The current work aimed to evaluate the influence of nitrogen fertilization on the production and nutritional value of ryegrass forage (cv. Barjumbo), during two consecutive years.

MATERIAL AND METHODS

The experiment was undertaken from May to October of 2009 and 2010. Ryegrass (cv. Barjumbo) was cultivated in an area previously sown with maize for grain harvest in both years, on the experimental farm in Dois Vizinhos, Paraná State, Brazil. The area is located on the third plateau of Paraná State, with an altitude of 520 m, latitude 25°44’ South and longitude 54°04’ West. This region has a mesothermal humid subtropical climate (Cfa) without a dry season, with mean temperatures of 22 °C in Summer and 17 °C in Winter, with average rainfall of 2100 mm per year. The mean rainfall index and temperature during the two crop seasons assessed are presented in Figure 1.

Figure 1 - Mean rainfall and temperature from April to October of 2009 and 2010, and the mean of the period 2007-2010 (meteorologic station only available since 2007)



Soil of the experimental area is characterized as Rhodic Hapludox (SOIL SURVEY STAFF, 1999). Table 1 shows the soil’s chemical characteristics at ryegrass sowing of the first season.

Table 1 - Chemical characteristics of soil on ryegrass sowing of the first season, Dois Vizinhos - PR, 2009

Depth	pH	MO	P-Mehlich	K	Ca	Mg	Al	H+Al	SB	T	V
(cm)	$CaCl_2$	g kg^{-1}	mg dm^{-3}	--------------------------------			$mmol_c$ dm^{-3}			--------------------------------	(%)
0-10	5.3	46.9	3.6	3.0	51.4	24.4	0.0	36.8	78.8	115.6	68.2
10-20	5.2	40.2	2.9	2.0	46.2	26.5	0.0	36.8	74.7	111.5	67.0

The experiment consisted of randomized blocks with four N rates: 0; 40; 80 and 120 kg ha^{-1} $year^{1}$ in three replicates, using urea as nitrogen source (460 g kg^{-1} N). Each experimental units measured 5x5 m, performing 25 m^2. Sowing was handmade at the first fortnight of May in both years, recommended period for ryegrass in this region. It was used 20 kg ha^{-1} of viable ryegrass seeds cv. Barjumbo, with a 20-cm raw spacing and 2.5 cm between seeds on sowing. A rate of 105 kg P_2O_5 ha^{-1} as simple superphosphate and a rate of 40 kg K_2O ha^{-1} as potassium chloride were applied according to crop recommendations and soil analysis (COMISSÃO DE QUÍMICA E FERTILIDADE DO SOLO - RS/SC, 2004).

The application of N rates was held in the quantity of 40 kg ha^{-1} in the ryegrass tillering, a standardized rate to the beginning of the crop cycle. So, the treatment 40 kg ha^{-1} of N received the entire rate at tillering; the treatment 80 kg ha^{-1} N received more 20 kg ha^{-1} each time after the first and second cut; and the treatment 120 kg ha^{-1} of N received more 20 kg ha^{-1} each time after the first, second, third and fourth cut. It was adopted these rates to improve cover N efficiency and to turn uniformly the distribution over the plots, since smaller rates are hard to distribute uniformly.

Samples for forage analysis were performed by-hand in a 0.25 m^2 (0.5 x 0.5 m), each cut randomized inside the plot, when forage was 30 cm tall and stubble height was standardized to 10 cm from surface. The remainder of the plot was harvested using a sickle-bar mower. Samples were collected in five times to determine total dry matter yield (20 july, 10 august, 01 september, 25 september and 20 october, in 2009, and 24 july, 14 august, 06 september, 01 october and 31 october, in 2010). After sampling, it was separated leaves and stem by hand to determine leaf participation in total forage.

Dry matter (DM) was obtained by drying leaves and stem samples of each cut at 55 °C in an air forced oven during 72 hours. Total DM yield at the field was held by the sum of every cut, since the treatments were accomplished only after the fourth cut. Afterward, the DM samples were ground in a Willey mill through a 1.0 mm sieve, and heated at 105 °C during 8 hours to determine the DM for laboratory analysis. The mean values of Crude protein content (CP) were determined by Kjeldahl methodology, following AOAC (1990). Means of neutral detergent fiber (NDF) were determined according to methodology by Silva and Queiroz (2002). It was also calculated the total accumulation of CP by year (kg ha^{-1}) multiplying the mean of DM yield (kg ha^{-1}) by the mean of CP content (g CP kg^{-1} DM).

All data were subjected to a variance analysis by SAS 8.1 (SAS INSTITUTE, 2001) at 5% error probability. When significant, quantitative factors were tested in polynomial regressions considering the greater significant level. The year was considered a variation factor in the analysis, as climatic variations could interfere directly in the results, overestimating or underestimating some variables. The variance analysis proved that the year was significant for DM, CP and accumulated CP, but not interactive with N rates.

RESULTS AND DISCUSSION

One of the main factors to consider in the production of animal fodder is rainfall, which will affect the development and grass tillering. The rainfall index was distinct between years, in 2009, from April to October the rainfall was above average (1297 mm) when compared to the mean of last four years (869 mm), while in 2010 the rainfall was below average (786 mm) (Figure 1). According to Gerdes *et al*. (2005), when the animal production comes from grazing it follows the growth cycles of forage plants, as soon as the pasture growth is related to rainfall, temperature, soil fertility and grazing management. Therefore, the rainfall indexes in August and September 2010 could directly interfere in the final production of forage, as discussed below.

According to the DM yield of ryegrass assessed during the winter of 2009 and 2010 (Figure 2a), the variance analysis ($P<0.05$) showed a significant effect of nitrogen rate (Table 2), for both years evaluated, obtaining a linear response. The highest N rate applied (120 kg N ha^{-1}) presented the highest yields, reaching

Figure 2 - Accumulated DM yield (a) and DM yield by cut (b) of ryegrass under nitrogen fertilization, during the winter crop seasons of 2009 and 2010

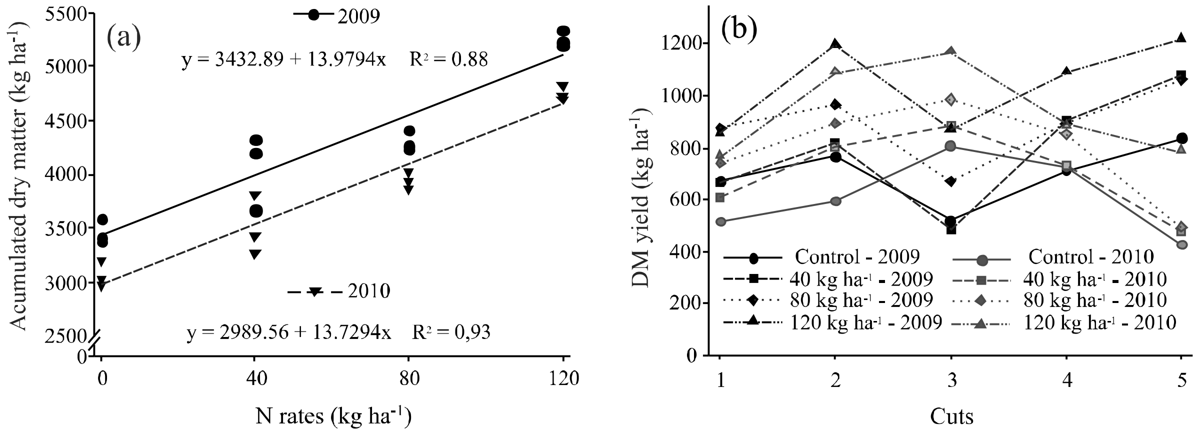


Table 2 - Summary of variance analysis with sources, freedom degree (FD), sum of squares, mean squares, F-ratio and p-value for the variables dry matter (DM) yield, crude protein (CP) concentration, accumulated CP and neutral detergent fiber (NDF) in the ryegrass cv. Barjumbo under four nitrogen fertilization rates, during the years 2009 and 2010

Source	FD	Sum of Squares	Mean Square	F-ratio	p-value
			DM		
Year	1	1260420	1260420	53.91	0.0000
Rate	3	9565910	3188640	136.39	0.0000
Block	2	174989	87495	3.74	0.0499
Year*Rate	3	37917	12639	0.54	0.6623
Residual	14	327295	23378		
			CP level		
Year	1	817.7	817.7	54.70	0.0000
Rate	3	1773.1	591.0	39.53	0.0000
Block	2	5.92	2.96	0.20	0.8226
Year*Rate	3	41.1	13.7	0.92	0.4580
Residual	14	209.3	14.9		
			Accumulated CP		
Year	1	65304	65304	102.75	0.0000
Rate	3	397952	132651	208.71	0.0000
Block	2	3688	1844	2.90	0.0883
Year*Rate	3	1304	434.6	0.68	0.5766
Residual	14	8898	635.6		
			NDF level		
Year	1	23290	23290	146.18	0.0000
Rate	3	662	220.6	1.39	0.2883
Block	2	515	257.5	1.62	0.2334
Year*Rate	3	82.3	27.4	0.17	0.9134
Residual	14	2230	159.3		

an average of 5250 kg DM ha^{-1} in 2009 and 4850 kg DM ha^{-1} in 2010. The difference between years is explained by the low rainfall in the months of August and September in 2010, as mentioned before.

The DM yield by cut was also affected by N rates (Figure 2b), it is possible to detect a distinct behavior between the years evaluated, but the tendency was the same all over the cycles, with higher N rates resulting in higher DM yield.

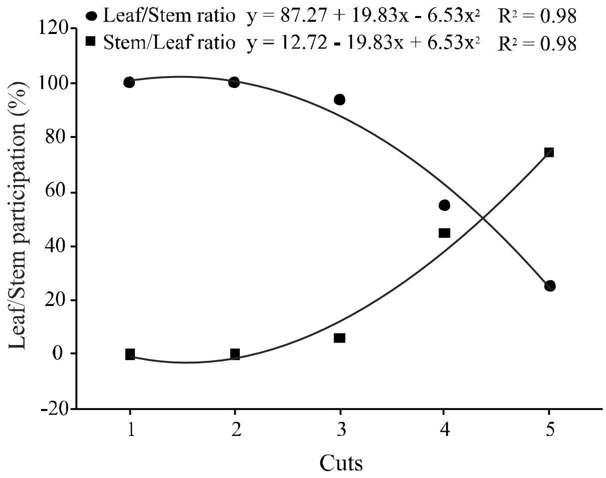
Comparing the current results to the literature (SANTOS *et al*., 2009; SOARES; RESTLE, 2002), it is possible to observe clearly N increasing forage yield even though results were not always similar. Such differences are normally due to climate and soil factors, forage management, type and method of N application and mainly the cultivar, which should be selected and adapted for the specific region. Pereira *et al*. (2008) evaluated 30 ryegrass cultivars obtained DM results varying between 3624 and 8544 kg ha^{-1}. In fact, the choice of a cultivar adapted to the region may directly affect DM production. Flores *et al*. (2008), evaluating seven ryegrass cultivars in two experiments, observed DM yield ranging from 3548 to 6349 kg DM ha^{-1} applying 250 kg N ha^{-1} in one experiment, and 2157 to 4510 kg DM ha^{-1} applying 200 kg N ha^{-1} in another, detaching that is normally observed a great variability within the species, especially regarding the distribution of forage production throughout the growth cycle.

In agreement with these results, Pelegrini *et al*. (2010) highlights that each kg of N in ryegrass promoted an increase of 15.84 kg ha^{-1} of total forage mass, with 7778 kg ha^{-1} of total DM promoted by the highest N rate (225 kg ha^{-1}). This response in biomass increase is explained by plant growth acceleration under nitrogen fertilization (SANTOS JÚNIOR *et al*., 2004), which includes more tillering, more leaf production and more dry mass accumulation.

Leaf/stem participation in the ryegrass forage was not affected by N rates applied ($P<0.05$), but was affected by plant age, or cuts (Figure 3). According to the increase in plant age, the participation of leaves was reduced in a quadratic behavior, what directly influences the forage nutritional value, as observed in the following data.

Besides the DM yield, it is extremely important to know the nutritive value of the forage being produced, so the CP and NDF levels are some of the components used to analyze it. Regarding the CP level of the ryegrass, variance analysis ($P<0.05$) showed significant effect of nitrogen for both years of cultivation (Table 2). Similar to the results of DM yield, the rate of 120 kg N ha^{-1} attained the highest CP levels for both years assessed (Figure 4a), obtaining also a linear response. The levels of CP as a function of N doses

Figure 3 - Leaf/Stem participation in the forage of ryegrass under nitrogen fertilization, mean of the winter crop seasons of 2009 and 2010

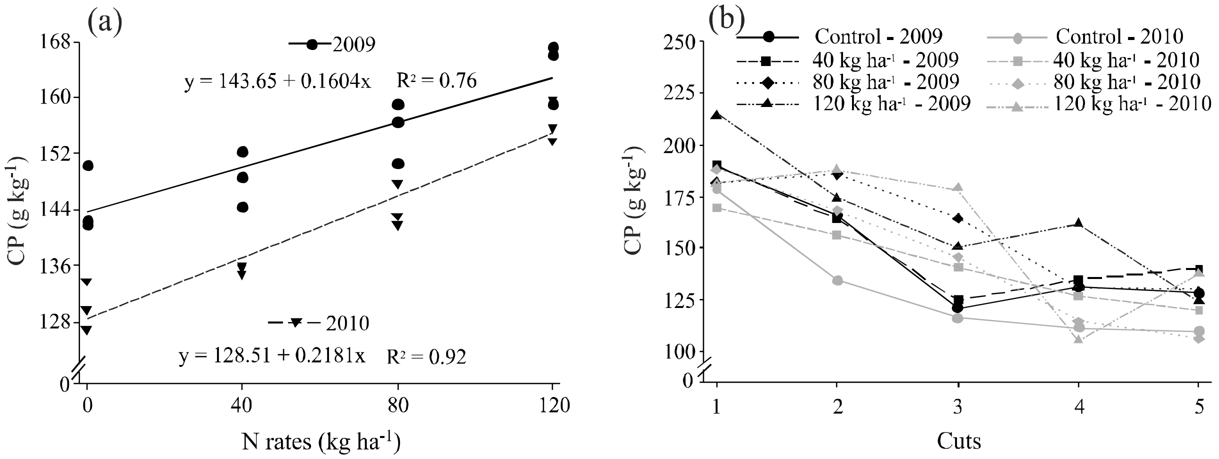


throughout the cycle of ryegrass were 163 g kg^{-1} DM for the year 2009 and 156 g kg^{-1} DM for the year 2010, but it is possible to observe a great variation from the first to the last cut (Figure 4b). It emphasizes that young plants, with great amount of young leaves (Figure 3), are more nutritive for animals than plants in the end of crop cycle, with high participation of stem and old leaves.

According to Difante *et al.* (2006), the application of 100, 200 and 300 kg N ha^{-1} has promoted an average CP level during the crop cycle of 129; 152 and 155 g CP kg^{-1} DM, respectively. These results are similar to those found in this study, where the average CP level was 146, 148, 152 and 163 g CP kg^{-1} DM for the year 2009, and 130, 136, 144 and 156 CP kg^{-1} DM for the year 2010, under 0, 40, 80 and 120 kg N ha^{-1}, respectively. Furthermore, Lupatini *et al.* (1998), testing 0, 150 and 300 kg N ha^{-1}, observed a linear increase (132, 164 and 222 g CP kg^{-1} DM, respectively) in the CP level in grazing oats and ryegrass intercropped, supporting the results of this study.

When is compared the CP levels of this work with the contents obtained by Difante *et al*. (2006), and Lupatini *et al*. (1998), it can be seen that the results are similar, but the N levels tested are different, demonstrating that ryegrass cv. Barjumbo may produce forage with higher protein, especially under higher N rates. Otherwise, Pelegrini *et al*. (2010), evaluating nitrogen fertilization on yield and quality of forage mass in Italian ryegrass (*Lolium multiflorum* Lam), concluded that the CP levels of forage were not influenced by nitrogen fertilization (0; 75; 150 and 225 kg N ha^{-1}), founding expressively higher average levels, of 233; 196; 205 and 217 g PB kg^{-1} DM for the first, second, third and fourth growth period, respectively.

Figure 4 - Mean CP levels by year (a) and CP levels by cut (b) of ryegrass forage under four nitrogen fertilization levels, during the winter crop seasons of 2009 and 2010



Rocha *et al.* (2007) assessed three species of ryegrass with the application of 115 kg N ha^{-1}, found average levels of 185, 189 and 229 g CP kg^{-1} DM to cultivars Estanzuela 284, Titan and Cetus, respectively, the authors concluded that a ryegrass cultivar adapted to a particular region is extremely important to improve quantitative and qualitative forage production. Evaluating the results found in the literature, it can be concluded that the CP level of ryegrass can fluctuate greatly due to several factors, among them, forage management (cut height, age), environmental conditions and particularly soil fertility and nitrogen fertilization. Therefore, it is necessary more research about ryegrass cv. Barjumbo, to be able to communicate whether this new cultivar can be used during the winter in southern Brazil, as a crop with high dry matter accumulation and high CP content.

The knowledge of the amount of protein being produced per area via forage production is another factor that can be considered to estimate the cost of CP production, and thus assess which system is more profitable to supply this protein to animals on pasture, or the need to supply via feed protein. The CP accumulated by ryegrass cv. Barjumbo showed a significant effect ($P<0.05$) of N levels applied (Table 2). The rate of 120 kg N ha^{-1} was the highest, with a CP accumulated of 874 and 759 kg ha^{-1} for the years 2009 and 2010, respectively (Figure 5).

The CP accumulated is an important factor to consider when the intention is the supplementation of nutritious forage for cattle. Ribeiro Filho *et al*. (2009), evaluating the herbage intake and milk production of cows in high yielding grazing ryegrass, found an average accumulation of 584 kg CP ha^{-1} when applied 150 kg N ha^{-1}, therefore the authors concluded that the ryegrass is an excellent alternative for animal feeding during the winter in the western region of the State of Santa Catarina. Difante *et al.* (2006) found a ryegrass CP accumulation of 734, 974 and 1309 kg ha^{-1} when applied 100; 200 and 300 kg N ha^{-1}, respectively, corroborating to the results found in this study, with N doses increasing the accumulated amount of CP, however with lower N rates.

The NDF content in pasture is basically composed of cellulose, hemicellulose, lignin, ash and nitrogen compounds, and the cellulose and lignin are understood as the less portion of digestible plant cell (VAN SOEST *et al.*, 1991). These carbohydrates are the main structural elements that provide support for plants, and one of the main components that influence the dry matter intake (VAN SOEST *et al.*, 1991). However, fiber plays an important role in controlling intake and, consequently, nutrient intake, and foster an conducive environment to the development of ruminal microorganisms, responsible for the digestion of fibrous carbohydrates (VAN SOEST, 1994). It was not observed any effect ($P<0.05$) of N fertilization in NDF content in ryegrass forage (mean of all cuts), throughout the crop cycle as a function of N rates, in both years evaluated (Figure 6a and Table 2), obtaining average content of 631.45 and 693.76 g NDF kg^{-1} DM for 2009 and 2010, respectively. The higher content in 2010, mean of 62.31 g NDF kg^{-1} DM, can be explained by the drought, reducing DM yield and promoting less digestible fiber accumulation in plant tissue, as can be observed when is evaluated by cut (Figure 6b), where the mean values of NDF were much higher in the last two cuts.

Figure 5 - Total crude protein accumulated by ryegrass forage under four nitrogen fertilization levels, during the winter crop seasons of 2009 and 2010

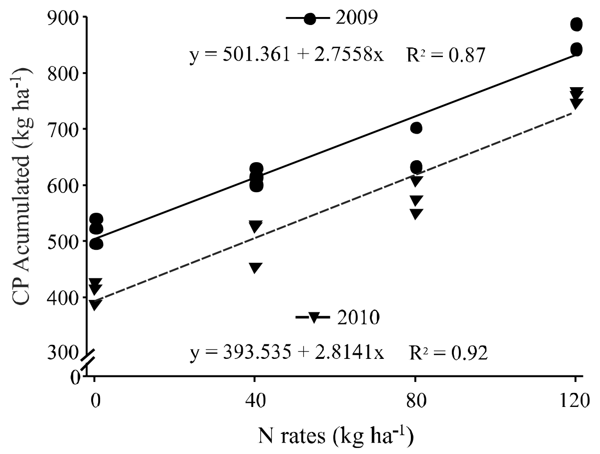
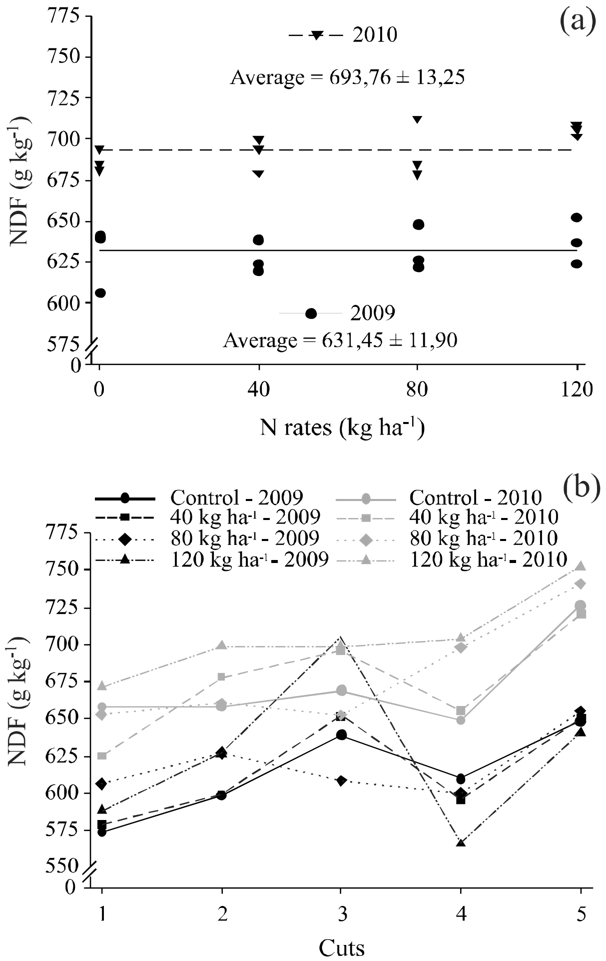


Figure 6 - Mean of neutral detergent fiber (NDF) level of ryegrass (a) and mean of NDF by cut (b) with four nitrogen fertilization levels, during the winter crop seasons of 2009 and 2010



Pelegrini *et al*. (2010), testing rates from zero to 225 kg N ha^{-1}, found an average NDF content of 391 and 759 g kg^{-1} DM in the first and fourth grazing period, respectively, and concluded that the levels of NDF are not influenced by N rates, agreeing to our results. The NDF may be affected by the plant growth cycle, once the crop cycle advances, the cell wall and fiber parts thickens, the amount of leaf blades decreases and the percentage of stems and dead material also increases (ROCHA *et al*., 2007). The loss of forage quality in current research during 2010 may be explained by high temperatures and low rainfall at the end of the ryegrass crop cycle. This situation accelerated the plant's metabolic activities and triggered a decrease in the complex metabolite of cell contents. Photosynthesis products may be converted quickly into structural components by high environmental temperatures, causing an increase in cell walls' internal lignification and elongation (VAN SOEST, 1994).

CONCLUSIONS

Nitrogen fertilization in ryegrass cv. Barjumbo promotes a significant and linear increase in dry matter yield and in accumulation of crude protein, with the best results with the highest rate evaluated (120 kg N ha^{-1}). Nitrogen levels are not capable to promote significant effects in forage NDF content.

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