Acta Agronómica
ISSN: 0120-2812
actaagronomica@palmira.unal.edu.co
Universidad Nacional de Colombia
Colombia

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Acta Agronómica, vol. 66, núm. 1, 2017, pp. 42-48
Universidad Nacional de Colombia
Palmira, Colombia

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Acta Agron. (2017) 66 (1) p 42-48 ISSN 0120-2812 | e-ISSN 2323-0118 doi: http://dx.doi.org/10.15446/acag.v66n1.53420

# Effect of nitrogen fertilization on productivity and quality of Mombasa forage *(Megathyrsus maximum* cv. Mombasa)

## Adubação nitrogenada na produtividade e qualidade do capim Mombaça *(Megathyrsus maximum* cv. Mombaça)

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Rec.:22.02.2016 Acep.: 07.04.2016

## Abstract

Mombasa grass is very demanding and responsive to soil fertility. The objective of the present study was to evaluate forage production and the correlation among crude protein and the green color index of leaves of *Megathyrsus maximum* cultivar Mombasa in function of nitrogen levels. The study was conducted using 5 $dm^{-3}$ pots in a greenhouse at the Universidade Estadual Paulista - UNESP, Jaboticabal, São Paulo. The experimental design consisted of randomized blocks with five treatments and four replications. Treatments were nitrogen rates (0, 62.5, 125, 250 and 500 mg $dm^{-3}$ of N), corresponding to 0, 125, 250, 500 and 1000 kg $ha^{-1}$ of N. We evaluated the production of grass dry matter, the green color index, the accumulation of nitrogen and crude protein content in the shoot. Nitrogen fertilization increased forage production, crude protein, nitrogen accumulation and green color index of Mombasa grass. There is high correlation of the green color index with the crude protein content.

**Keywords**: Chlorophyll, forage, plant nutrition, protein, urea.

## Resumo

O capim Mombaça é muito exigente e responsivo em fertilidade do solo. Objetivou-se avaliar a produção de forragem e a correlação entre a proteína bruta com o índice da cor verde da folha de *Megathyrsus maximum* cultivar Mombaça, em função de doses de nitrogênio. O estudo foi realizado em vasos de 5 $dm^3$ conduzido em casa de vegetação na Universidade Estadual Paulista – UNESP, Jaboticabal, São Paulo. Utilizou-se o delineamento experimental de blocos inteiramente casualizados com cinco tratamentos e quatro repetições. Os tratamentos foram constituídos por doses de nitrogênio (0, 62,5, 125, 250 e 500 mg $dm^{-3}$ de N), correspondentes a 0, 125, 250, 500 e 1.000 kg $ha^{-1}$ de N. Foram avaliados a produção de matéria seca do capim, o índice da cor verde, o acúmulo de nitrogênio e o teor de proteína bruta na parte aérea. A adubação nitrogenada aumentou a produção de forragem, teor de proteína bruta, acúmulo de nitrogênio e índice da cor verde no capim Mombaça. Existe alta correlação do índice da cor verde com o teor de proteína bruta.

**Palavras chave:** Clorofilômetro, forragem, nutrição de plantas, proteína, ureia.

## Introduction

*Megathyrsus maximum* (Jacq.) B.K. Simon & S.W.L. Jacobs is one of the most important forage plant species for cattle production in subtropical and tropical climate regions. The use and interest in plants belonging to the genus *Megathyrsus* has increased in recent years, probably due to its great potential for dry matter production per unit area, wide adaptability, high quality forage, ease of establishment and the fact that it can support high livestock densities (Oliveira, Caione, Camargo, Oliveira, & Santana, 2012). In Brazil, there are several cultivars of *Megathyrsus maximum*, including Mombasa grass (Pietroski, Oliveira, & Caione, 2015).

Mombasa grass belongs to the group of forages considered demanding of soil fertility (Souza, Isepon, Alves, Bastos, & Lima, 2005). Therefore, fertilization is very important for development of plants of this variety and for concentration of nutrients in the leaves, reflected in productivity, where response of the forage to fertilization is quite pronounced, especially in the case of nitrogen (Faria et al., 2015). In this sense, Castagnara *et al.,* (2011), reported the fertilization with nitrogen has a significantly influence on productivity and chemical composition of the forages.

Therefore, there is need for cultivation in soils with suitable fertility due to its demand, which consequently results in greater productivity of dry matter mass with high nutritional values, where these results are obtained mainly through nitrogen fertilization (Mazza *et al.,* 2009; Castagnara *et al.,* 2011; Faria *et al.,* 2015).

With the need to estimate nitrogen concentration in the plants, several studies have demonstrated potential for using the green color index meter (SPAD), called the chlorophyll meter, thus providing better management of nitrogen fertilization. However, most of the results available refer to crops such as corn (Godoy, Fernandes, Souto, & Villas Boas, 2007), cucumber (Pôrto, Puiatti, Fonte, Cecon, & Alves, 2014) coffee (Godoy, Santos, Villas Bôas, & Leite Júnior, 2008), pineapple (Leonardo, Pereira, & Costa, 2013), rice (Pocojeski, Silva, Kaefer, Moro, & Griebeler, 2015) and others. Research information is still scarce for correlating the results of chlorophyll readings with the concentration of nutrients and pasture yields.

In marandugrass grown in field conditions, when allowed to evaluate 12 classes of leaf samples with SPAD index values between 0 and 60 with amplitude variation of five SPAD units among classes, it was found that use of the portable chlorophyll meter showed high correlations with the crude protein content (Guimarães, Matsumoto, Figueiredo, Cruz, & Araújo, 2011). Thus, there is a need to develop studies with nitrogen fertilization and use of the chlorophyll meter, as well as correlate the data from this device with the crude protein of forages and production of forage cultivars of great importance for use in livestock production, such as the Mombasa grass. Thus, with high correlations between green color index and crude protein content of forage, there is a possibility of using the chlorophyll meter to estimate forage protein content and thus manage nitrogen fertilization.

The aim of the present research was to evaluate forage production and the correlation among crude protein and the green color index of *Megathyrsus maximum* cultivar Mombasa, in function of nitrogen application rates.

## Material and methods

The study was conducted in a greenhouse at the Faculty of Agricultural and Veterinary Sciences (FCAV), UNESP in Jaboticabal, São Paulo state, Brazil, with the forage species *Megathyrsus maximum* cv. Mombasa being grown in pots from July to November 2012.

The soil used to fill the pots was classified as Dark Red Latosol (Santos *et al.,* 2006), in the layer from 0 to 0.2 m. Results of the soil chemical analysis, according to the methodologies proposed by Raij, Andrade, Cantarella, & Quaggio, (2001), were: pH in water = 6.4, O.M. = 6 g $dm^{-3}$, $P_{(resin)}$ = 5 mg $dm^{-3}$, K = 0.4 $mmol_c$ $dm^{-3}$, Ca = 12 $mmol_c$ $dm^{-3}$, Mg = 6 $mmol_c$ $dm^{-3}$, (H+Al) = 15 $mmol_c$ $dm^{-3}$, SB = 18.4 $mmol_c$ $dm^{-3}$, V= 55% and CEC = 33.4 $mmol_c$ $dm^{-3}$.

The experimental design was composed of randomized blocks, with five treatments and four replications, in which each experimental unit consisted of one pot with capacity of 5 $dm^3$ of soil. Treatments were composed of nitrogen application rates of 0, 62.5, 125, 250 and 500 mg $dm^{-3}$, which in the 0 - 0.2 m soil depth were equivalent to 0, 125, 250, 500 and 1000 kg $ha^{-1}$ of N.

Basic fertilization was carried out by applying 200 mg $dm^{-3}$ of K, in the form of KCl (Bonfim, Freire, Santos, Silva, & Freire, 2004), and 305 mg $dm^{-3}$ of P, in the form of superphosphate (Mesquita, Pinto, Furtini, Santos, & Tavares, 2004).

Planting was conducted on July 17, 2012, with emergence after four days and at nine days after emergence (DAE) the plants were thinned, leaving only five plants per pot.

At 33 DAE a uniformity cutting was performed followed by application of the treatments to the soil surface of each pot, using nitrogen in the form of urea (45% N). It was applied via broadcast to the soil surface, thus initiating the first cultivation cycle which lasted 49 days.

At the time of the first cutting initial measurements of the green color intensity index were performed, determined with the aid of a CCM 200 device (Opti-Sciences), where reading were made in the middle third of three leaves (first fully expanded) per pot. After obtaining the reading the shoots were cut and sent to the laboratory. The forage collected was weighed and dried in an oven with forced air circulation at a temperature of 65 +/- 2°C until reaching constant mass and acquisition of the dry mass. The plant material was ground and used for the determination of N content to estimate crude protein. From the data of N content in forage and dry matter of the shoot, N accumulation in the shots of the forage produced in each pot was obtained.

After the first evaluation cutting the treatments were again applied to the soil surface of each pot, using urea as a source of nitrogen (45% N). This was the beginning of the second crop cycle that lasted 34 days, where after this period the evaluations were performed according to the same methods proposed for the first cutting.

Data was submitted to analysis of variance by the F-test ($P<0.05$), polynomial regression and simple linear correlation tests between the variables, using the statistical program ASSISTAT, version 7.6 beta.

## Results and discussion

The nitrogen application rates promoted an effect on all variables evaluated. There was a quadratic increase in the dry matter production of shoot mass for the two cuttings (Figures 1A and 1B), which was consequently reflected in the production of total dry matter mass, the sum of the two cuts (Figure 1C).

It was noted that the maximum dry matter yield in the first and second cuts were 52.07 and 51.5 g, obtained with the doses of 382.27 and 315.60 mg dm$^{-3}$ of N, respectively (Figures 1A and 1B); and the maximum total yield was 102.74 g, corresponding to a dose of 342.25 mg. dm$^{-3}$ (Figure 1C). Therefore, increases of 3757.03 and 19874.68% were observed with regards to dry mass productivity in the first and second cuttings, respectively, and the total maximum production was 3406.48% greater in relation to the treatment without N application.

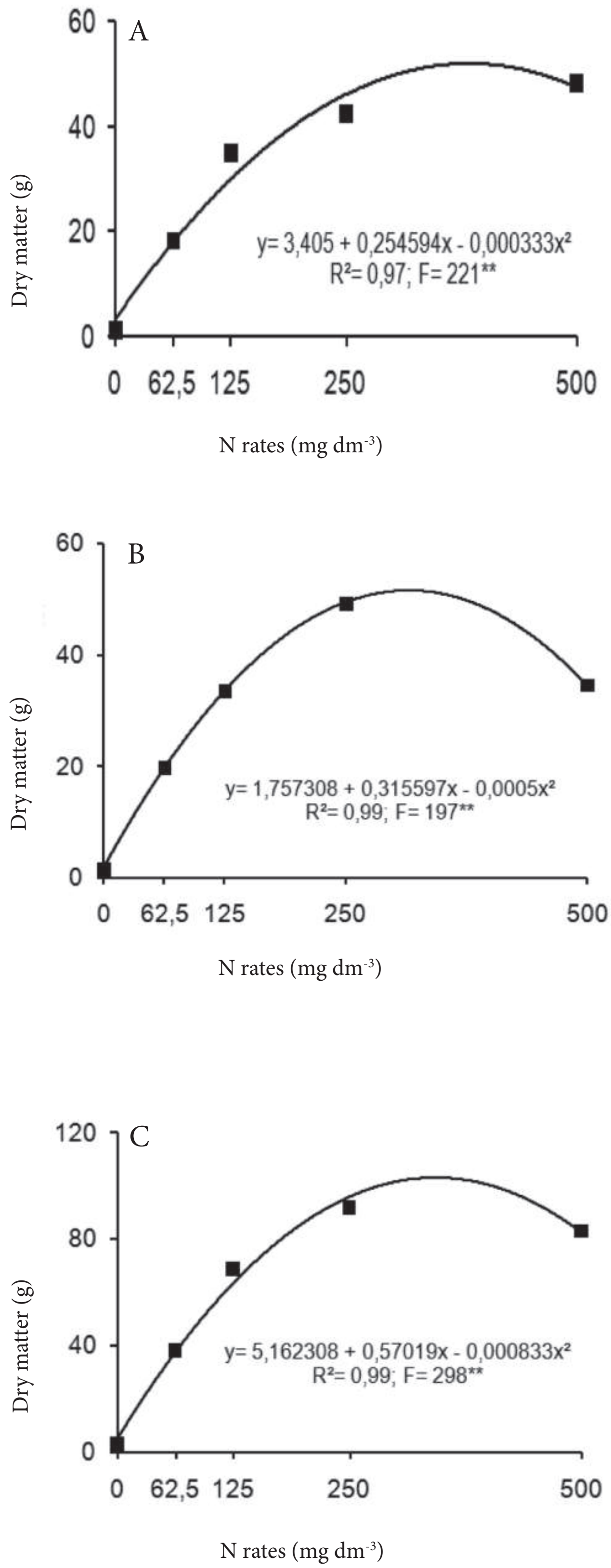


**Figure 1.** Mass production of Mombasa grass shoot dry matter in the first cut (A); second cut (B) and total production (C), in function of the N application rates.

In the absence of N application, the mass production of dry matter was highly compromised, presenting low values. This is explained by the fact that nitrogen fertilization accelerates growth, soil tillage, leaf production and hence expansion of the shoots. These results are in agreement with those found by Mello *et al.* (2008), who observed an increase in dry matter production of the shoots of Mombasa grass cultivated the field with increasing N application rates (0, 100, 300, and 500 kg $ha^{-1}$ $year^{-1}$) with the application of batch treatments, where 80% was applied during the rainy season and the rest distributed during the dry season.

According to Castagnara *et al.* (2011), tropical grasses positively respond to increased N supply in the soil with regards to dry mass production, and this effect was verified in the present study.

Regarding the green color intensity of the leaf it can be noted that readings obtained by the chlorophyll meter showed an increasing linear fit according to the N application rates to the soil (Figures 2A and 2B). Thus, the largest values in the first and second cuts were 20.45 and 27.73, respectively, corresponding to the highest dose applied to both cuttings. In the absence of the N application the value obtained at the first cutting was 3.79 and in the second cutting was 3.48. In the corn crop it is estimated that 50 to 70% of the total N in the leaves is associated with the chloroplasts (Stocking & Ogun, 1962), a fact which explains the linear increase in the chlorophyll meter readings with increasing N doses. This confirms the results reported in literature (Godoy *et al.,* 2007; Godoy *et al.,* 2008; Mazza *et al.,* 2009; Leonardo *et al.,* 2013; Pôrto *et al.,* 2014) who demonstrate the increase of chlorophyll levels with nitrogen fertilization.

Lavres Junior & Monteiro (2006), observed with the increasing N rate in pots containing ground quartz as a substrate there was a higher green color index value of the leaves of aruana grass, determined using the SPAD device, which proved the nitrogen/chlorophyll relationship. More recently, Silva Junior *et al.,* (2013), evaluated the effect of nitrogen application doses (0, 50, 100, 150 and 200 kg $ha^{-1}$ N) in *Brachiaria decumbens* and observed a significant increase in green color of the leaf with the SPAD device in function of the N application rates, ranging from 32 to 54 in the first cutting and 17-42 in the second cutting.

Nitrogen application promoted a linear increase in N accumulation in the shoots of Mombasa grass in the first (Figure 3A) and second cuts (Figure 3B), reflected in the total accumulation (Figure 3C). The increase in N accumulation is due to the increase in this macronutrient content in soil and increased dry matter production. The greatest accumulations of this macronutrient were 1202.3 and 888.9 mg per pot, respectively, in the first and second cuts (Figure 3A and 3B), representing a total of 2091.2 mg per pot (Figure 3C). Comparatively, the accumulated quantity at the highest dose (500 mg. $dm^{-3}$) with accumulation in the control indicated 13947.76 and 7088.5% increases in the first and second cuttings, respectively, and total accumulation indicated a 9882.78% increase of the higher dose compared to absence of N application.

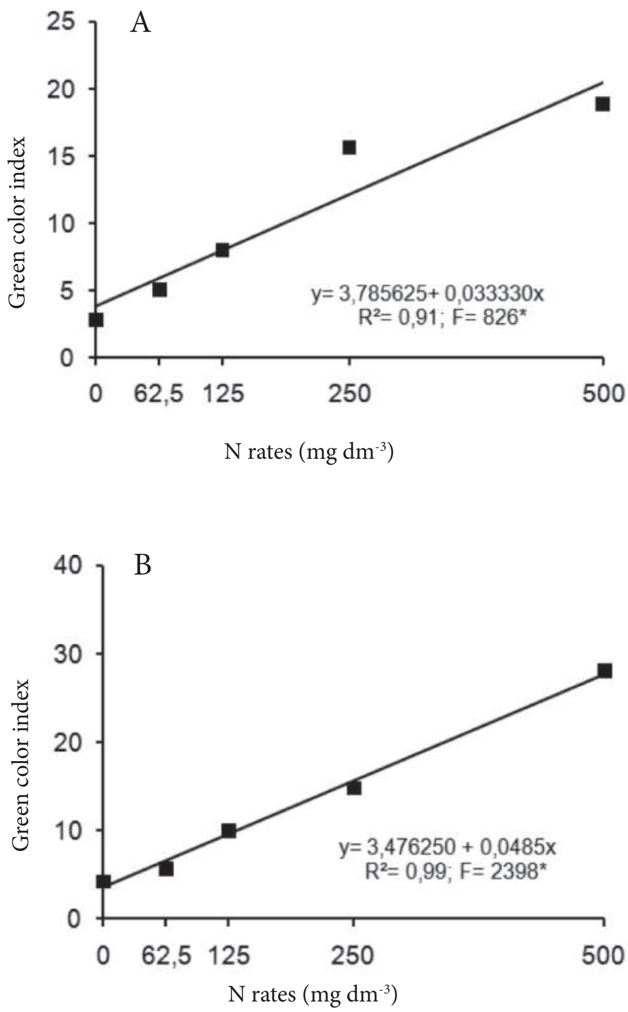


**Figure 2.** Intensity of the green color index in Mombasa grass in the first cut (A) and second cut (B) as a function of the N application rates.

For crude protein there was also a linear increase in function of the N doses applied (Figures 4A and 4B), a result that demonstrates the importance of the nutrient for nutritional quality of the forage since this is one of the attributes of greatest importance of the forage. Nitrogen corresponds to approximately 16% of the protein weight, which indirectly implies that 100 g of protein contains 16 g of N, indicating the relationship between N and crude protein.

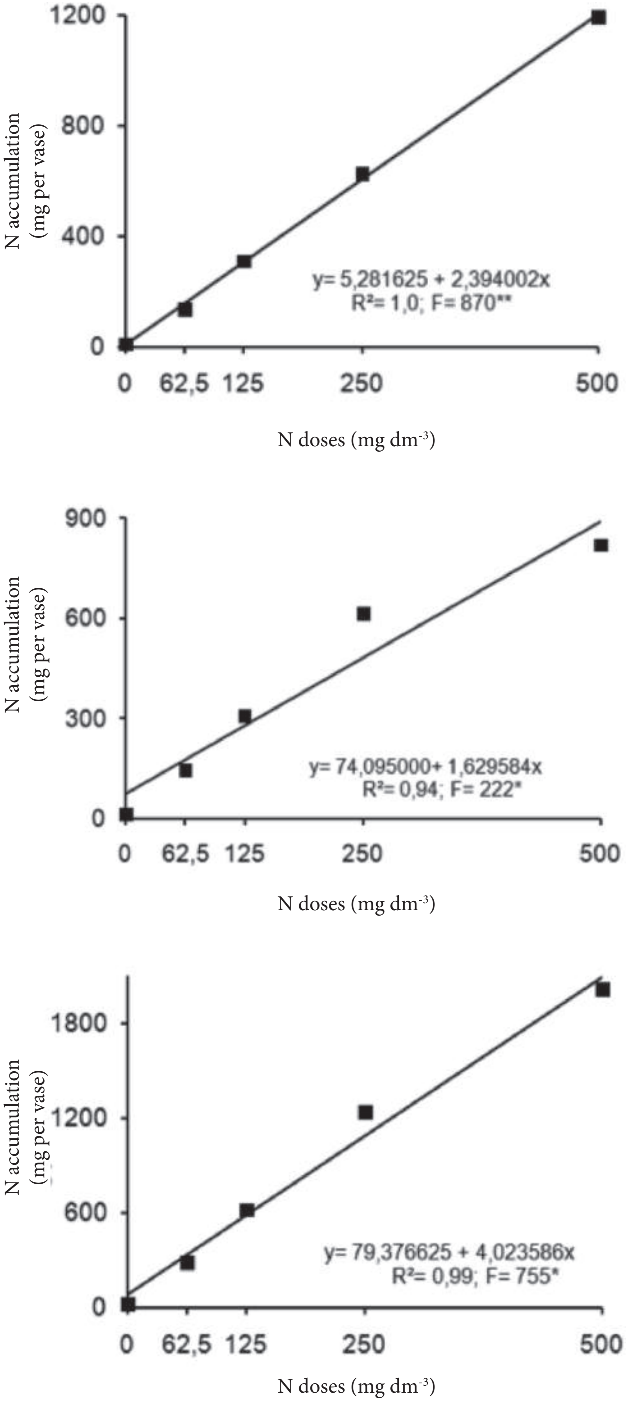


**Figure 3.** Nitrogen accumulation in the Mombasa grass shoots in the first cut (A) second cut (B) and total accumulation (C) as a function of the N application rates.

The critical content of crude protein in the dry matter for animal consumption is 7%. For good performance of dairy cows, forage should contain approximately 15% CP, and for growing animals the level of 11 to 12% is acceptable (Whiteman, 1980). Therefore, in the first cut the highest dose of N resulted in forage with 15.2% CP and in the second cut 14.2%, which are not limiting values even for the animal category of high protein demand, such as dairy cows. Linear increases in crude protein production of Mombasa grass were observed by Mazza *et al.*, (2009), when studying the effect of N application rates (0, 85, 170, 320, 510 kg $ha^{-1}$ N).

High positive correlation coefficients were observed between all variables in the first cut (Table 1). In the second cut there were also high positive correlations between the variables, except for dry matter and crude protein in which there was no significant effect. It was highlighted that in the first and second cut the green color index showed a correlation of 0.91 and 0.57 with the production of dry matter and 0.92 and 0.96 with crude protein, respectively. This result demonstrates that the indirect measurement of chlorophyll using the portable chlorophyll meter can be an efficient tool for estimating forage production, and especially the crude protein content in Mombasa grass. From this data the producer could establish chlorophyll meter reading standards for each edaphoclimatic condition and each grass cultivar, showing the ideal time for application of nitrogen fertilizer.

**Table 1.** Simple linear correlation coefficients between the mass production of dry matter (DM), nitrogen accumulation in the shoots (Ac. N), crude protein of the forage (CP) and green color index (Green Ind.) in the first and second cuttings of Mombasa grass fertilized with different nitrogen application rates. Jaboticabal-SP, 2013.

| Varia-bles | ---------------- 1st cut ---------------- | | | | ---------------- 2nd cut ---------------- | | | |
|---|---|---|---|---|---|---|---|---|
| | DM | Ac. N | CP | Green Ind. | DM | Ac. N | CP | Green Ind. |
| MDMS | 1.00 | 0.86** | 0.78** | 0.91** | 1.00 | 0.80** | 0.41ns | 0.57** |
| Ac. N | | 1.00 | 0.99** | 0.95** | | 1.00 | 0.86** | 0.91** |
| CP | | | 1.00 | 0.92** | | | 1.00 | 0.96** |
| Green Ind. | | | | 1.00 | | | | 1.00 |

**, * and ns – significantly at 1%, 5% and non-significantly, respectively by the t-test.

In both cuttings the response of the forage in crude protein was similar in function of the N doses. For obtaining forage with crude protein of 7%, the critical level for animal consumption, it would be necessary to apply 156 and 158 mg $dm^{-3}$ N prior to the first and second cuttings, respectively (Figures 4A and 4B). The green color index with application of these doses would be 9 and 11 (Figures 2A and

2B) in the first and second cuts. Therefore, when the values determined using the chlorophyll meter are below those mentioned it indicates insufficient levels of crude protein, requiring the application of nitrogen fertilizer. It should be noted that these standards are for each cultivation and cultivar condition, and one should also pay attention to the device model used, since different indices may be obtained.

High correlations of N concentration in the leaf tissues with chlorophyll meter index values (SPAD) in forage plants (marandugrass) were obtained by other researchers (Guimarães *et al.,* 2011). This therefore explains the relationship between the green color index and the crude protein content by the fact that N is in larger proportions in the chloroplasts (Stocking & Ogun, 1962), having influence on the green pigmentation of the leaves and is correlated with the crude protein content, since N corresponds to approximately 16% of the protein weight.

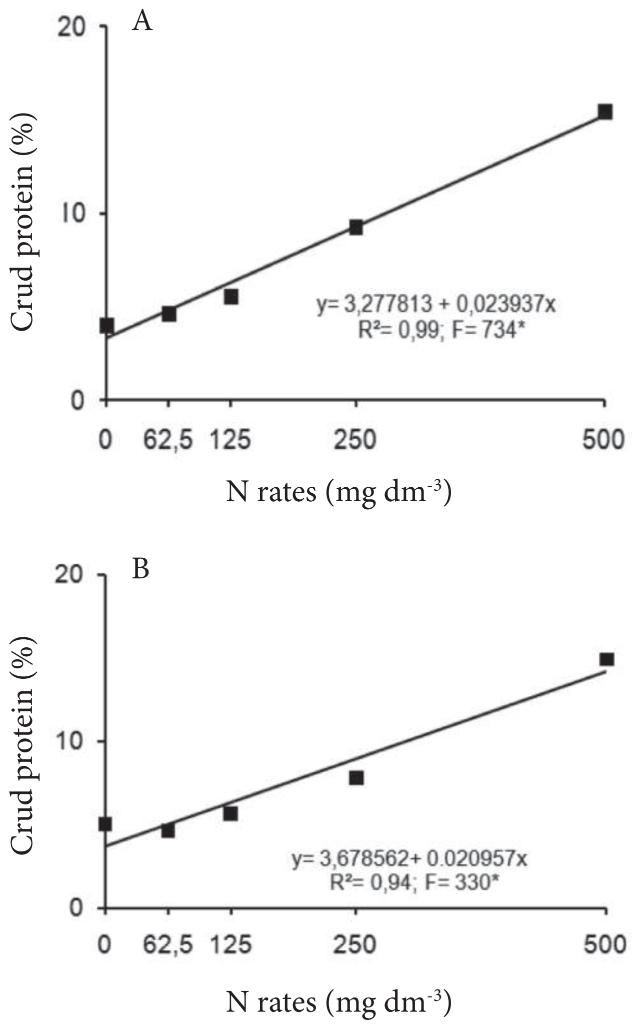


**Figure 4.** Crude protein content in Mombasa grass in the first cut (A) and second cut (B) as a function of the N application rate

## Conclusion

Nitrogen fertilization increased forage production, crude protein content, nitrogen accumulation and green color index in Mombasa grass. There is a high correlation of the green color index with the crude protein content.

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