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Agricultural yield components of dual purpose wheat cv. BRS Tarumã under cutting and nitrogen fertilization handlings

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This experiment aimed to study the effects on grain and forage productivity in dual-purpose wheat cv. BRS Tarumã under cutting handlings and nitrogen fertilization. The experiment was conducted in area of Rhodic Hapludox in the city of Marechal Cândido Rondon, Paraná State, in a randomized block design with 12 treatments and four replications. The treatments consisted of surface nitrogen levels (0, 60, 120 and 180 kg ha^{-1}) and number of cuttings accomplished (0, 1 and 2). The topdressing was split in two applications for handling of just a cutting (27 and 65 days after sowing - DAS), and three applications for handling with two cuttings (27, 65 and 96 days after sowing - DAS). Data were subjected to analysis of variance (*p*≤0.05). The use of one or two cuttings and the comparison between the first and second cuttings were done by F test (5%) whereas nitrogen doses were studied by regression analysis. For all variables, there was significant interaction of nitrogen doses in surface and the number of cuttings. Grain yield and its yield components were responsive to levels of nitrogen fertilization in surface as well as forage production and its quality, but the same factors were reduced with the use of cuttings. This handling increased the dry matter content and crude protein in grains.

Key words: Crop-livestock integration, *Triticum aestivum*, nitrogen, yield components, proximate composition.

INTRODUCTION

The cultivation of winter cereal enables forage production with low cost and high nutritional value (Scheffer-Basso et al., 2004), and when dual purpose cereals are sown there is also the possibility of grains production. However the forage yield and its quality can be significantly affected due to cuttings and grazing handlings and fertilization adopted.

The nitrogen fertilization is the most limiting factor in the production of grain and forage and appropriate levels of this nutrient increment the forage and grains production of dual-purpose wheat (Zagonel et al., 2002). One of the main factors observed in any crop is the

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fertilization (Lopes, 1996). Nitrogen (N) is an essential element for plants as it participates in a series of metabolic pathways. It is also a constituent of important biomolecules such as Adenosine triphosphate (ATP), nonphosphorylated nicotinamide adenine dinucleotide (NADH), reduced nicotinamide adenine dinucleotide phosphate (NADPH), chlorophyll, storage proteins, nucleic acids and enzymes (Harper, 1994). Rarely, the level with higher production has the highest economic efficiency.

Nitrogen fertilization is particularly important for the wheat crop since among the nutrients that influence its performance, nitrogen is one of the most absorbed during the development cycle of the plant (Scalco et al., 2003). The use of wheat cultivars responsive to nitrogen fertilization is essential to obtain high productivity. However, fertilization requires care regarding the time and levels of application (Teixeira Filho et al., 2009).

The application of nitrogen is essential to increase grain yield (Silva et al., 2005), increasing the number of grains per spike and spike number per area (Sangoi et al., 2007). Oliveira (2009) obtained a grain yield of 2,250 kg ha^{-1} with the wheat BRS Tarumã with two cuttings and surface nitrogen fertilization in the amount of 150 kg ha^{-1}, using urea (45 g kg^{-1}) as a nitrogen source.

We aimed to evaluate different nitrogen levels applied in surface on the yield components of productivity of dual purpose wheat.

MATERIALS AND METHODS

The experiment was accomplished under field conditions, in the Experimental Station Professor Antônio Carlos dos Santos Pessoa, at Universidade Estadual do Oeste do Paraná, *campus* Marechal Cândido Rondon, at the following geographic coordinates: latitude 24° 33' 40'' S, longitude 54° 04' 12'' W and altitude of 420 m.

The local climate is classified according to Koppen as Cfa type, sub-tropical with rains well distributed throughout the year and hot summers (IAPAR, 2012). The average temperature of the coldest quarter vary between 17 and 18°C, of the hotter quarter vary between 28 and 29°C and the annual temperature is between 22 and 23°C. Climatic data were obtained from automatic meteorological station located 200 m from the experimental area.

The experimental area soil was classified as Rhodic Hapludox (EMBRAPA, 2006). Soil samples were collected from 0 to 0.20 m for its chemical analysis. The results were: pH in $CaCl_2$: 5.43; P (Mehlich): 20.20 mg dm^{-3}; K: 0.37 $cmol_c$ dm^{-3}; Ca^{2+}: 4.87 $cmol_c$ dm^{-3}; Mg^{2+}: 0.58 $cmol_c$ dm^{-3}; Al^{3+}: 0.40 $cmol_c$ dm^{-3}; H+Al: 6.48 $cmol_c$ dm^{-3}; SB: 6.82 $cmol_c$ dm^{-3}; CTC: 12.30 $cmol_c$ dm^{-3}, V: 55.28%, organic matter: 25.29 g dm^{-3} and clay: 650 g kg^{-1}. The experiment was accomplished in randomized block design with four replications, and was composed of 48 experimental plots, which had dimensions of 4 × 5 (20 m²), totaling an area of 960 m².

In order to study the chemical composition and forage production in the first and second cuttings as for the sum of both cuttings and the handling system with the use of no one, one or two cuttings, for comparison of one or two cuttings in the wheat handling, we adopted the randomized block design with four surface nitrogen levels (0, 60, 120 and 180 kg ha^{-1}) and three handling systems for forage production (0, 1 and 2 cuttings). Wheat (*Triticum sativum*) cv. BRS Tarumã of dual purpose wassown on 6th May, 2011 with precision seeder attached to the tractor in rows spaced 0.17 m apart. The seed density used was 350 to 400 viable seeds per square meter (CBPTT, 2010). As basis, 200 kg ha^{-1} of 00-20-15 (N - P_2O_5 - K_2O) fertilization was used, following the recommendations of Brazilian Commission for Research in Wheat and Triticale (2011). The nitrogen surface fertilization was held at tillering stage (Zadoks et al., 1974), using urea as a nitrogen source (45 g kg^{-1} of N), and the applications were made under favorable climatic conditions at dosages of 0, 60, 120 and 180 kg ha^{-1}. The nitrogen surface fertilization was split in two applications for the handling with just one cutting (27 and 65 DAS), and three applications for handling with two cuttings (27, 65 and 96 DAS).

During the culture development there was an application of fungicide and insecticide as a preventive method being performed 30 DAS. The active principles Azoxystrobin and Cyproconazole and Lambda-cyhalothrin were used at dosages of 300 and 150 mL ha^{-1} respectively diluted in 180 L ha^{-1} spray volume.

The cuttings were done with a costal mowing at a height of 30 cm and preserving residue at around 8 to 10 cm. After the cuttings the green mass was removed from the plots by using a rake and plastic bags. All samples were transported to the Animal Nutrition Laboratory of Universidade Estadual do Oeste do Paraná at *campus* Marechal Cândido Rondon for subsequent evaluations.

The crop was harvested at 169 DAS after sowing being sampled the four central lines with three feet long (2.04 m^2) with the aid of scissors and the samples were placed in plastic bags until the time of trail. To calculate productivity the samples were weighed on analytical balance, then threshed and after calibration were extrapolated to kg ha^{-1}. To obtain the 1000 grain weight eight samples with 100 grains were collected and the same were weighed on an analytical balance, and their values were extrapolated for 1000 grain weight. For spike weight, 15 samples from each experimental plot were sampled and weighed on an analytical balance.

The number of spikelets per spike was obtained by counting in fifteen spikes collected from base to apex of the spike. For the number of grains present in each spikelet, the spikelets were threshed separately and it was counted, and for weighing the spike grains the same threshed samples were used and weighed in an analytical balance. The dry matter production was estimated with the usage of metallic square with a known area (0.25 m^2) randomly placed once in each plot. The samples were collected using a cleaver and then packed in paper bags, weighed and placed in an oven with forced ventilation and maintained at a temperature of 55ºC for 72 h for drying. After drying, the samples were weighed and from data obtained the dry matter production was calculated, being expressed in kg ha^{-1}.

After drying the samples were ground in a Willey mill with 30 mesh sieve and then were subjected to laboratory procedures for evaluation of crude protein (CP) according to AOAC (1990), neutral detergent fiber (NDF) and acid detergent fiber (ADF) according to Van Soest et al. (1991), neutral detergent insoluble protein (NDIP - expressed in g kg^{-1} of CP), acid detergent insoluble protein (ADIP - expressed in g kg^{-1} of CP), lignin and hemicellulose (Silva and Queiroz, 2006).

Data were subjected to analysis of variance ($p\leq 0.05$). The use of one or two cuttings and the first and second cuttings were compared by F test (5%) and nitrogen doses were studied by regression analysis which regression equations were adjusted by choosing the mean model of highest coefficient of determination (R^2) (Figure 1 and Table 1).

RESULTS AND DISCUSSION

Grains productivity and yield components

There was a significant effect of nitrogen levels for

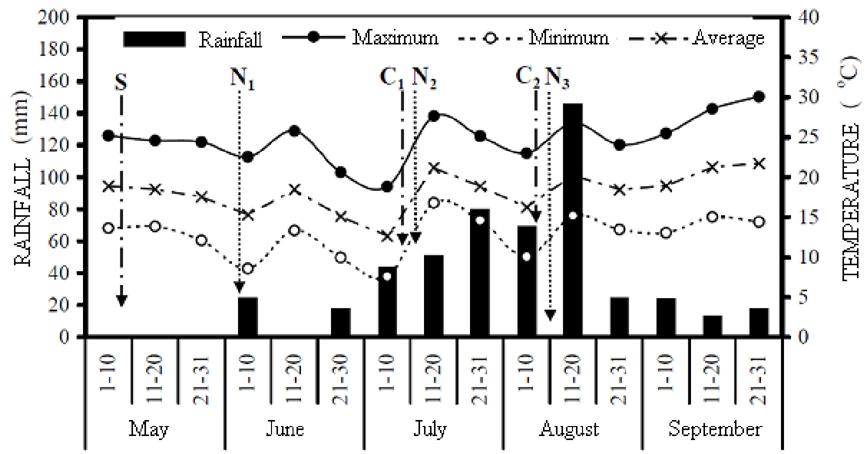

Figure 1. Climatic data of the experimental period. S: sowing; N_1; N_2 and N_3 nitrogen application on tillering, after the first and second cuttings, respectively; C_1 and C_2 first and second cuttings respectively (Marechal Cândido Rondon, 2011).

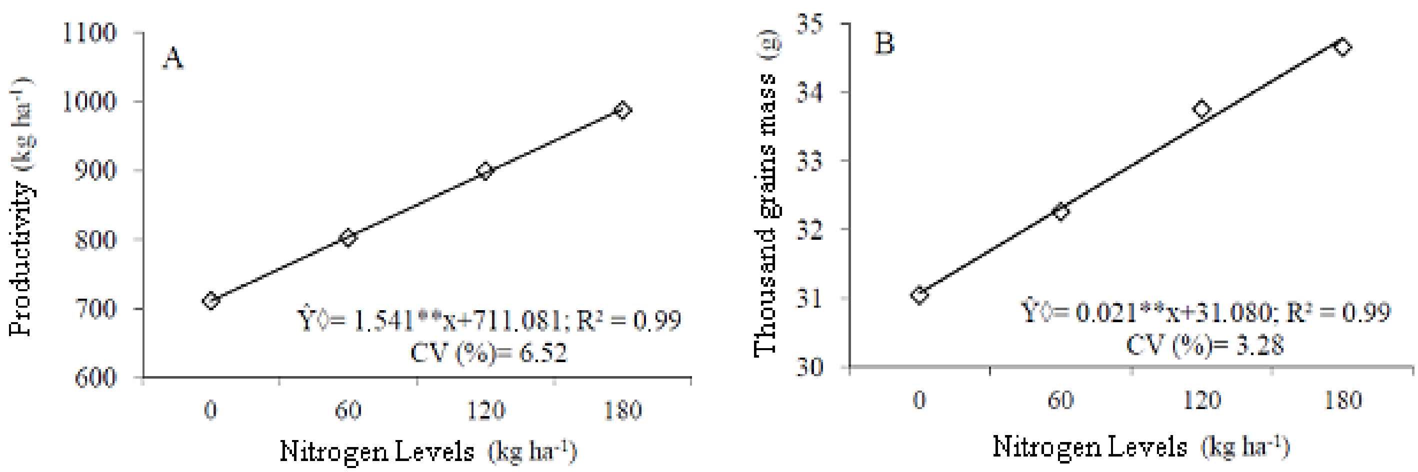

Figure 2. Grains productivity and 100 grains mass of dual purpose wheat BRS Tarumã under increasing levels of nitrogen. ** Significant at 1% of probability by t test. CV (%): Coefficient of variation.

isolated factors on grain productivity, 1000 grains mass, spikes weight, number of spikelets per spike, number of grains per spikelet, number of grains per spike and crude protein content in the grains of dual purpose wheat BRS Tarumã (Figures 2, 3 and 4; and Table 2) and there was no significant difference for interaction.

The grains productivity (Figure 2A) and 1000 grains mass (Figure 2B) had adjustment to the positive linear regression model in response to nitrogen fertilization. This result was expected since nitrogen is among the most absorbed nutrients during the development cycle of wheat (Scalco et al., 2003). Teixeira Filho et al. (2009) also observed positive responses of nitrogen application in wheat, with productivity increases, while Boschini et al. (2011) have observed increases in wheat productivity up to the level of 200 kg ha^{-1}.

The spikes weight (Figure 3A), number of spikelets per spike (Figure 3B), number of grains per spikelet (Figure 3C) and number of grains per spike (Figure 3D) also showed a better fit to the linear regression model with the application of nitrogen levels. This behavior was expected, since as in wheat the number of flowers per spikelet and spikelets per spike depends on nutritional and environmental factors (Aude et al., 1994).

Nitrogen fertilization improves maintenance of higher leaf area in plants, contributing to improvement in yield components of wheat and it becomes important because green leaf area represents the active photosynthetic tissue, providing greater partitioning of assimilates in the grain filling (Silva et al., 2006).

Decreases observed in grains productivity may be related to the plant ability to recover after defoliation due

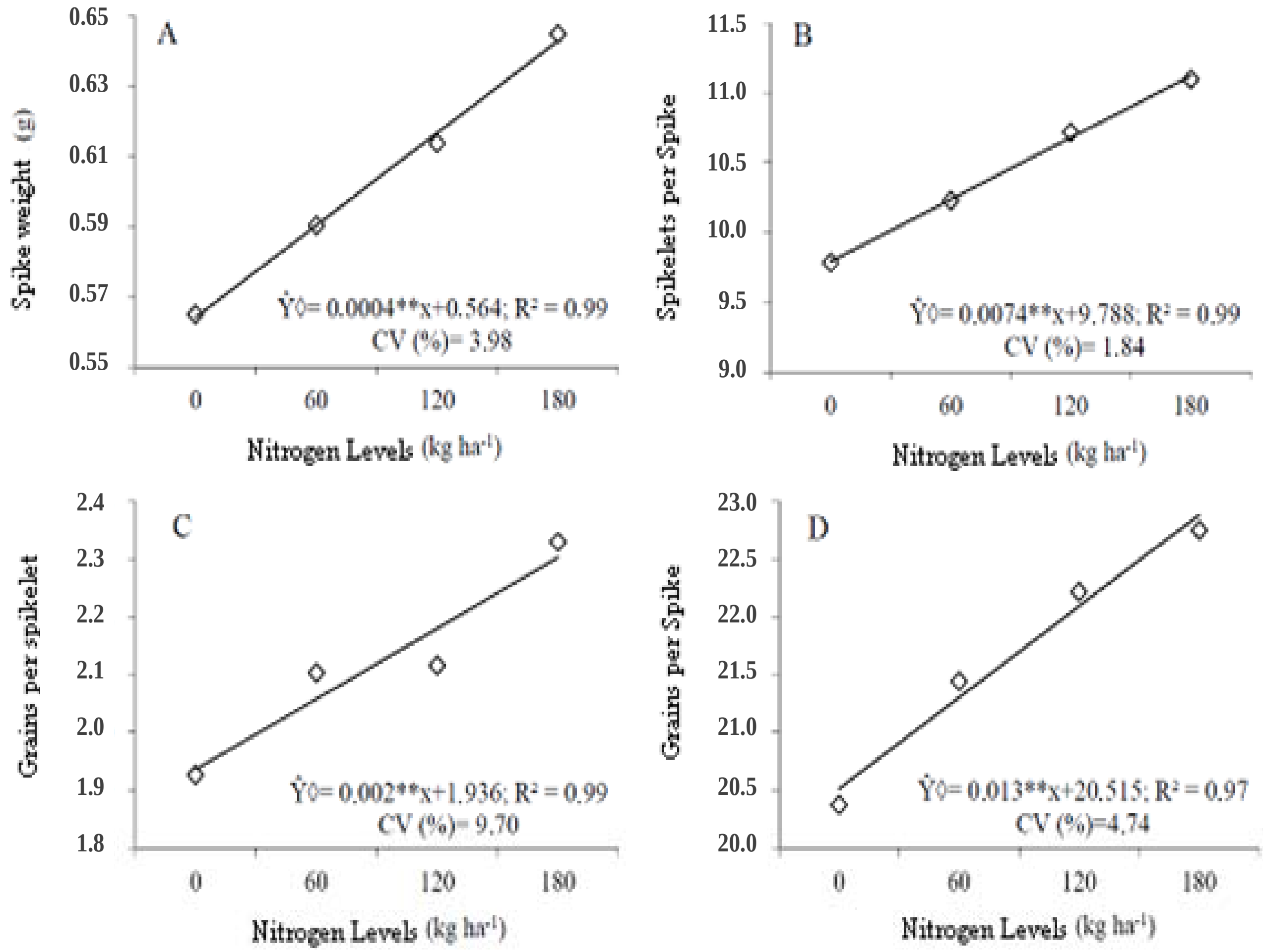

Figure 3. Grains yield components of dual purpose wheat BRS Tarumã under increasing levels of nitrogen. **Significant at 1% of probability by t test. CV (%): Coefficient of variation.

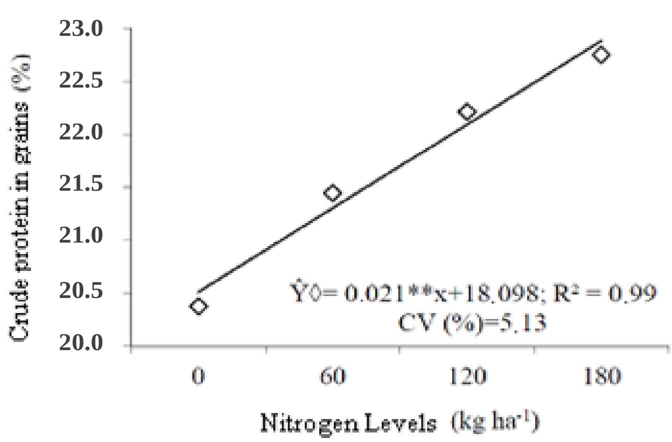

Figure 4. Crude protein content in grains of dual purpose wheat BRS Tarumã under increasing levels of nitrogen. ** Significant at 1% of probability by t test. CV (%): Coefficient of variation.

to the reduction in the rate of the whole plant photosynthesis (Parsons et al., 1988). Bortolini et al. (2004) studied the wheat BR 35 and also observed a reduction in grains production with increasing number of cutting to the forage harvest.

When the cutting handlings were compared, significant differences between treatments were found. The spikes weight and grains number per spikelet were higher in uncut handling compared to the others, while the spikes number was reduced with the increase in the cutting number. The number of grains per spikelet was higher in uncut handling, and lower in the handling of two cuttings, however both them did not differ from the handling with just one cutting (Table 2).

The damage observed on grains yield components when wheat was submitted to cuttings are due to the apical meristem removal. According to Hendrickson et al. (2005), when the apical meristem of plants is removed by cutting, the appearance of side tiller is induced and plants produce smaller spikes, with less grains or no grains. Hastenpflug et al. (2011) observed a reduction in spikes weight, number of spikelets per spike and number of

Table 1. Treatments, number of cuttings and handling of nitrogen fertilization in surface.

Treatments	Number of cuttings	Nitrogen fertilization in surface (kg ha^{-1})		
		Tillering (27 DAS)	After 1st cutting (65 DAS)	After 2nd cutting (96 DAS)
1	0	0	0	0
2	0	60	0	0
3	0	120	0	0
4	0	180	0	0
5	1	0	0	0
6	1	30	30	0
7	1	60	60	0
8	1	90	90	0
9	2	0	0	0
10	2	20	20	20
11	2	40	40	40
12	2	60	60	60

Table 2. Grains yield components and productivity of dual purpose wheat BRS Tarumã under different cutting handlings.

Cuttings	Productivity (kg ha^{-1})	MMG (g)	PE (g)	E/E	G/Es	G/Ep	PB (%)
0	1000^{a}	33.37^{ns}	0.63^{a}	10.77^{a}	2.25^{a}	22.29^{a}	20.14^{b}
1	881^{b}	32.90	0.60^{b}	10.51^{b}	2.04^{b}	21.61^{ab}	20.47^{b}
2	668^{c}	32.51	0.58^{b}	10.08^{c}	2.06^{b}	21.20^{b}	21.75^{a}
CV (%)	6.52	3.28	3.98	1.84	9.70	4.74	5.13

^{ns} Not significant. Means followed by different letters in the column differ by Tukey test (5%). MMG: 1000 grains mass; PE: spike weight; E/E: number of spikelets per spike; G/Es: number of grains per spikelet; G/Ep: number of grains per spike; PB: crude protein content in grains.

grains per spikelet with an increase in cutting number on wheat BRS Tarumã.

Forage productivity and chemical composition

The crude protein content in grains increased linearly with the application of nitrogen levels (Figure 4), and when the cutting handlings were compared, an increase in protein content was observed as the cutting number increased (Table 2). It was expected that nitrogen fertilization would raise the crude protein content of wheat grains due to higher nutrient availability in the soil, which led to greater absorption, metabolism and synthesis of amino acids and proteins by fertilized plants.

The increase of crude protein content in the grains as the number of cuttings increased can be related to the reduction in grains production (Figure 2A), providing a higher crude protein content in the grains mass produced.

A higher crude protein content in grains is a positive aspect because it increases the nutritional value of grains for both human consumption and animal feed. This inverse relationship between productivity and protein content in grains is explained by the higher energy waste which plant needs to form proteins, what can compromise the accumulation of carbohydrates in the grains (Sangoi et al., 2007).

There was effect of the factors interaction for the productivity of green and dry matter (Figure 5). When the handlings were compared the use of two cuttings provided productivity of green and dry matter (sum of two cuttings) higher than only one cutting (Figure 5A and 5B). This higher total forage productivity when wheat was subjected to two cuttings was due to the stimulation of tillering promoted by the cutting and to dry matter productivity in the second growth period between the first and second cutting.

About nitrogen fertilization, in both handlings a linear increase in green and dry matter productivity in response to increased levels of nitrogen was observed (Figure 5).

Bortolini et al. (2004) studied dual purpose cereals and also observed higher dry matter productivity when using two cuttings. The dry matter productivity obtained for only one cutting is similar to those observed by Fontaneli et al. (2007) who studied cultivars of dual purpose wheat.

When comparing the first and second cuttings within the two cuttings handling, there was an interaction of

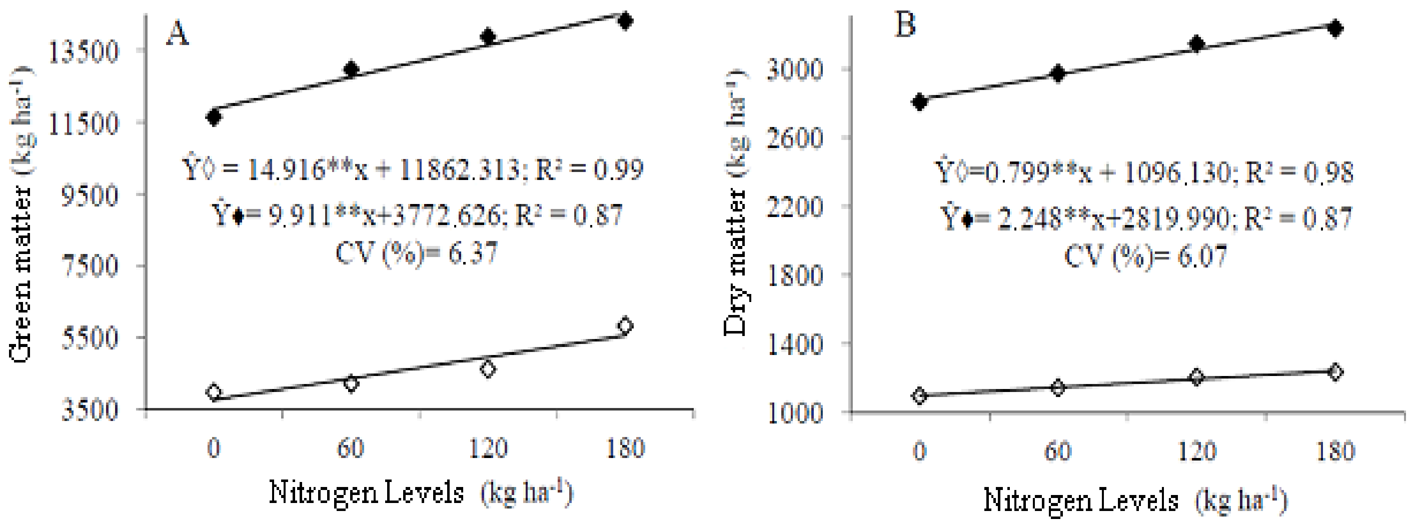

Figure 5. Total productivity of green (A) and dry matter (B) of dual purpose wheat BRS Tarumã under increasing levels of nitrogen and subjected to one (◊) or two (♦) cuttings, and average values (□). (**;* significant at 1 and 5% of probability by t test, respectively).

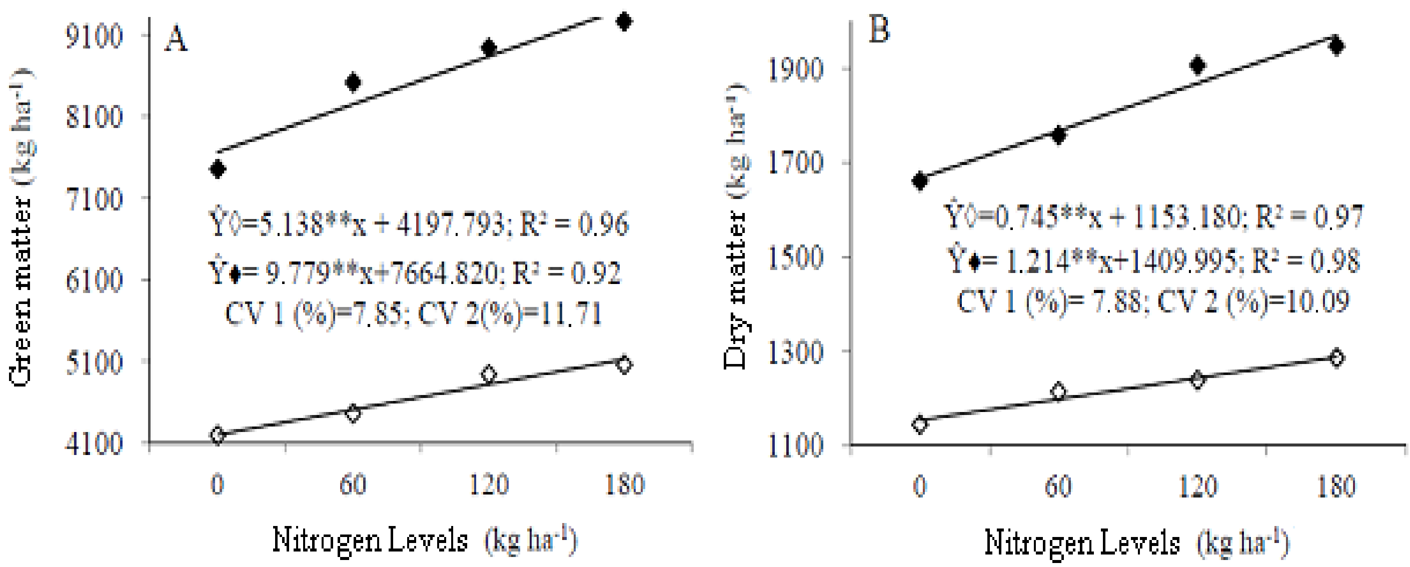

Figure 6. Productivity of green (A) and dry matter (B) of dual purpose wheat under increasing levels of nitrogen at the first (◊) and second (♦) cuttings. (**;* significant at 1 and 5% of probability by t test, respectively).

factors, with higher productivity of green and dry matter in the first cut compared to the second (Figure 6A and 6B). Bortolini et al. (2004) also observed a reduction in productivity of dry matter from the first to the second cutting when they studied dual purpose cereals subjected to one or two cuttings. In the case of nitrogen fertilization, either in the first or the second cutting, a linear increase in the productivity of green and dry matter with increasing levels of nitrogen was observed.

About the chemical composition, there was no significant difference among one or two cuttings in wheat for concentrations of NDF and ADF, which showed a linear decrease with the nitrogen increase (Figure 7A and 7B). The decrease in NDF and ADF contents, according to Grise et al. (2001), can be attributed to the higher participation of leaves over the stems in the forage once the leaves have a higher nutritional value.

Hemicellulose and lignin concentrations were altered by the interaction of factors, but both also showed a linear decrease in response to increased nitrogen levels (Figure 7C and 7D), with reduction in forage produced by wheat subjected to only one cutting.

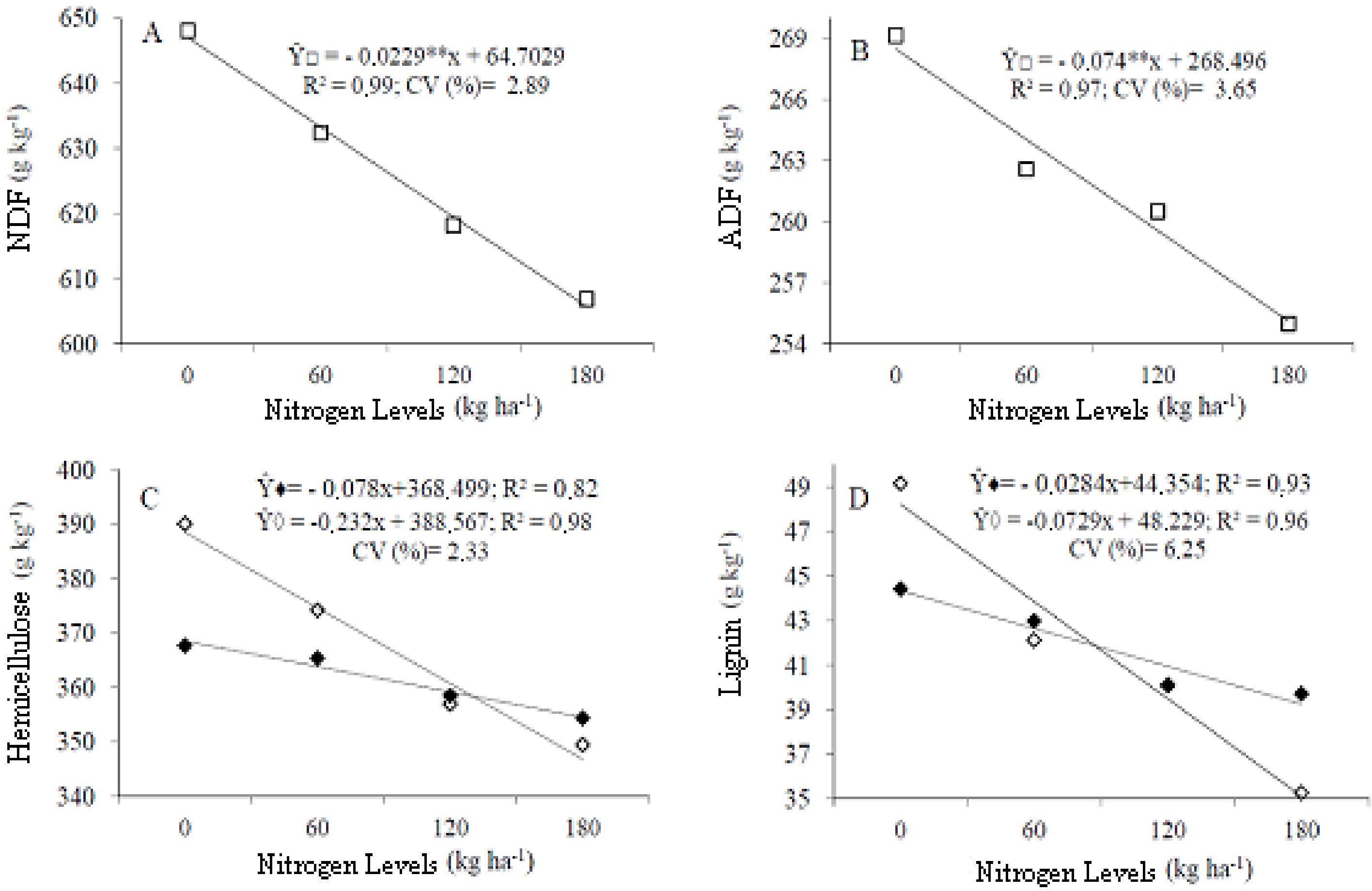

Figure 7. Fibrous components in the forage produced by dual purpose wheat BRS Tarumã under increasing levels of nitrogen and subjected to one (◊) or two (♦) cuttings, and average values (□). (**;*significant at 1and 5% of probability by t test, respectively).

About the crude protein contents, there was effect of factors interaction, however in both handlings with one or two cuttings the values increased in response to nitrogen levels (Figure 8A). The NDF adhered protein however was only affected by nitrogen levels and showed a linear decrease with the nitrogen levels increase (Figure 9B).

Though the Food and Drug Administration (FDA) adhered protein was affected by the interaction of factors, it was higher in the forage obtained by applying just one cutting to wheat. Both with the use of one or two cuttings a linear decrease was observed at concentrations of PIDA with increasing levels of nitrogen applied (Figure 8C).

After studying the chemical composition of forage produced by wheat subjected to two cuttings, in the first and second cuttings there was an interaction of factors for concentrations of NDF, ADF, hemicellulose and lignin (Figure 9). At first cutting the NDF was reduced with the nitrogen application, however in the second cutting the data fitted to a quadratic regression model and the NDF concentration increased up to 69 kg ha^{-1}, with subsequent decrease (Figure 9A). NDF values are within the recommended range (550 to 600 g kg^{-1}) for ruminants feeding (Mertens, 1994).

Concentrations of ADF and hemicellulose decreased in the first cutting, but increased in the second cutting in response to nitrogen levels applied (Figure 9B and 9C). Meinerz et al. (2011) also observed increase in FDA contents from the first to the second cutting in wheat BRS Tarumã. Fontanelli et al. (2007) studied dual purpose cereals and found NDF and ADF contents similar to those observed in this study. As the hemicellulose is NDF component (van Soest et al., 1991), its decrease with the nitrogen increasing levels in the first cutting and increasing in the second cutting is consistent.

At first cutting the lignin concentration decreased with nitrogen levels, however in the second cutting the data had no adjustment to the regression models studied (Figure 9D). Lignin is one of three compounds that bind to form the fiber fraction of forages and is considered the main limiting factor for digestibility (van Soest et al., 1994). In crude protein concentration there was significant effect of the factors interaction with higher crude protein content in the first cutting in relation to the

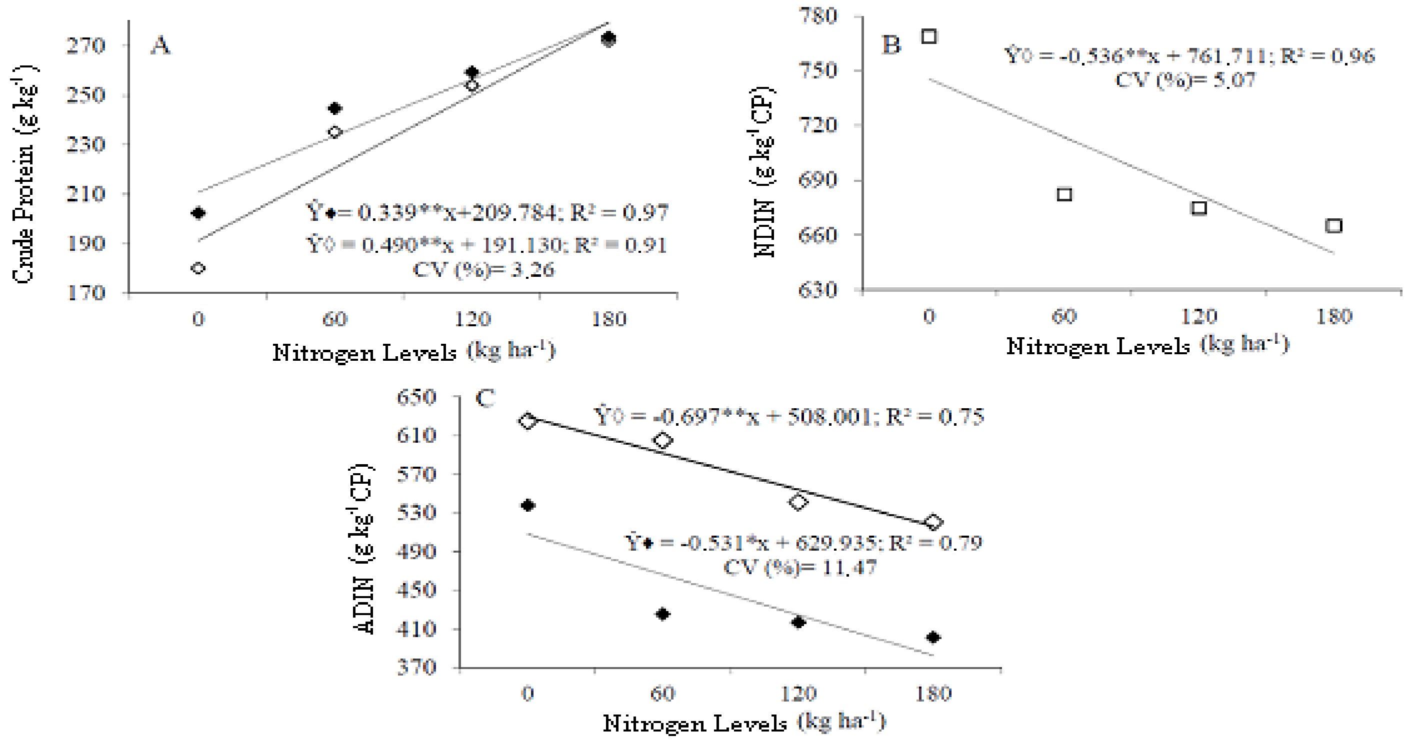

Figure 8. Chemical composition of dual purpose wheat under increasing levels of nitrogen and subjected to one (◊) or two (♦) cuttings and average values (□). (**;*significant at 1and 5% of probability by t test, respectively).

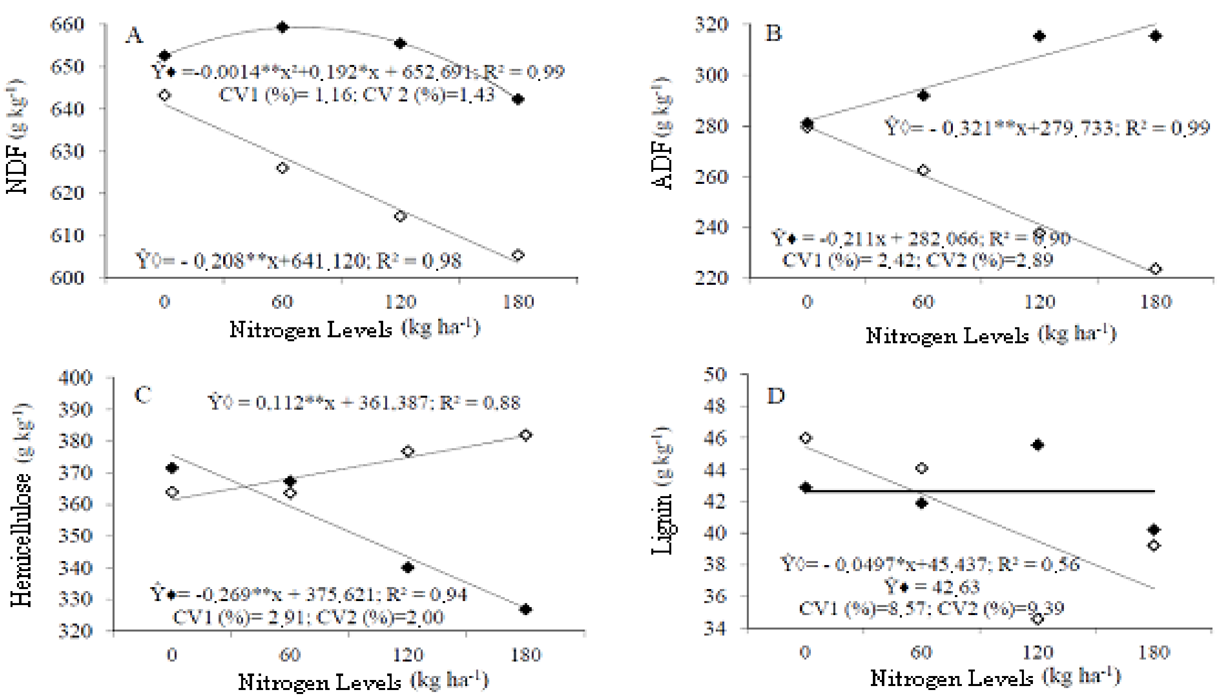

Figure 9. Fibrous components in the forage produced by dual purpose wheat BRS Tarumã under increasing levels of nitrogen and subjected at first (◊) or second (♦) cuttings, or for average values (□). (**;*;ns significant at 1 and 5% of probability or not significant by t test, respectively).

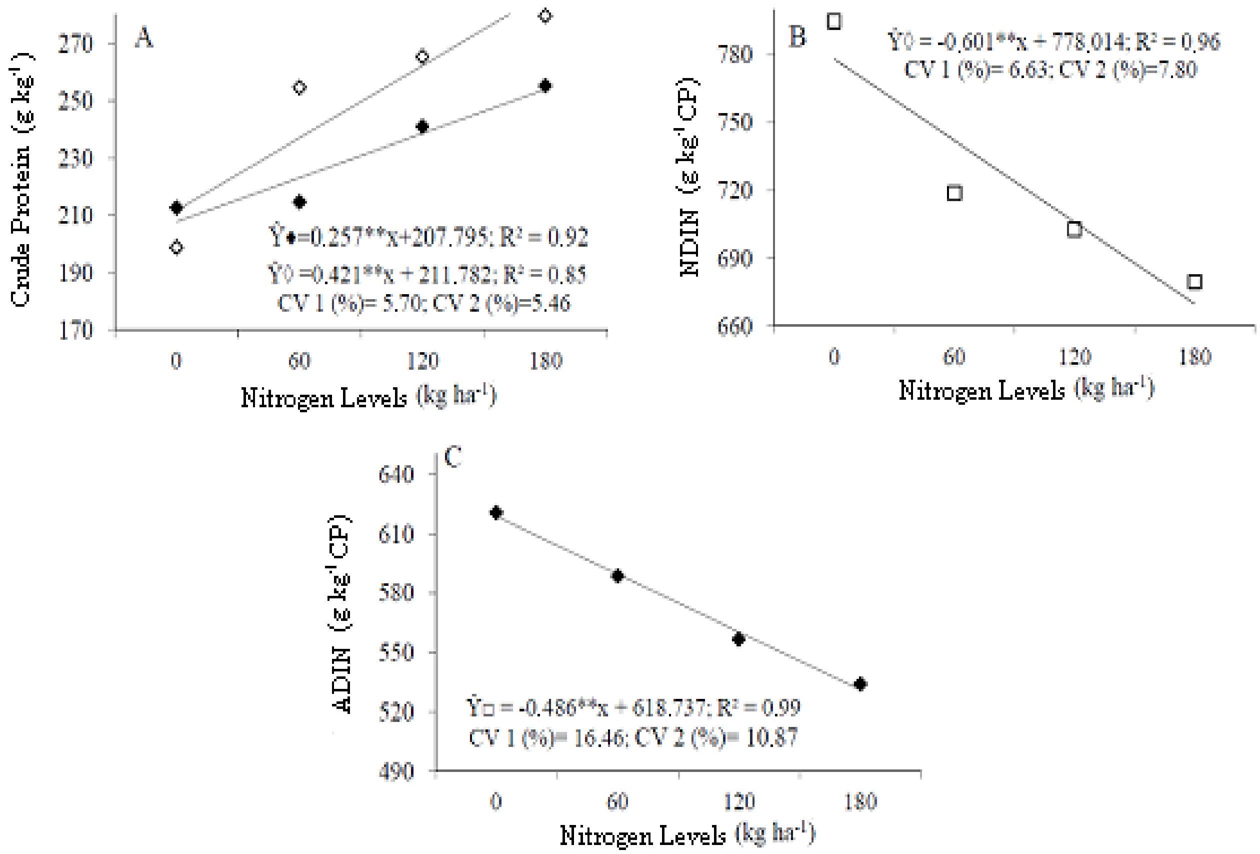

Figure 10. Proteic components in the forage produced by dual purpose wheat BRS Tarumã under increasing levels of nitrogen and subjected to one (◊) or two (♦) cuttings, and average values (□). (**;* significant at 1 and 5% of probability by t test, respectively).

second cutting. As for nitrogen levels, either in the first or the second cutting a linear increase was observed with increasing levels (Figure 10A).

The NDIP levels did not follow the behavior observed for crude protein, and were similar in both cuttings, with linear decrease as nitrogen levels increased (Figure 10B). That is, the increasing protein concentration in dry matter of forage produced by dual purpose wheat did not increase the NDF adhered protein. For the PIDA (ADF adhered crude protein) similar behavior was observed with significance only of nitrogen levels and linear reduction in PIDA contents with increasing levels (Figure 10C).

Quantification of CP associated with NDF is important in studies of forages due to the relationships that this fraction has with nutrients digestibility and intake (Aguiar et al., 2006). Crude protein cannot be considered a homogeneous nutritional fraction because if so can lead to distortions in estimates of apparent digestible fraction from the chemical composition of feed produced in tropical conditions (Detman et al., 2008). According to Silva et al. (2006), the NDIP may be present naturally in plants or can be considered an estimate of heat damage.

Conclusion

The dual purpose wheat BRS Tarumã is responsive to nitrogen fertilization in relation to increasing doses of surface application once its productivity and grains yield components increased by this handling.

The usage of one or two cuttings reduces the productivity and affects the yield of production components, but the use of cuttings increased crude protein content in the grains.

The adoption of two cuttings for production of forage wheat Tarumã BRS provides greater dry matter production without harming the nutritional value of forage produced.

When submitted to two cuttings for the production of forage, the wheat Tarumã BRS provides higher forage production in the second cutting when compared to the first, however with lower nutritional value.

Conflict of Interest

The authors have not declared any conflict of interests.

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