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Effect of nitrogen fertilization and cutting age on yield of tropical forage plants

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This work aimed to assess the yield of five forage species subjected to nitrogen (N) levels at three different cutting ages. The experiment was carried out in the city of Santa Tereza do Oeste, at IAPAR's (Agronomic Institute of Paraná) experimental field, by applying a randomized complete block design in a factorial scheme 5×4×3, with five species: common black oat (*Avena strigosa* Schreb cv. Common), IPR 61 oat (*Avena strigosa* Schreb cv. IPR 61), Triticale Tpolo 981(*Xtriticosecale wittmack)*, IPR 126 White oat (*Avena sativa* cv. IPR 126) and ryegrass (*Lolium multiflorum* Lam.); N levels were (0, 30, 60 and 120 kg ha^{-1}); cutting ages were 66, 95 and 116 days after emergence (DAE), with three replications. Dry matter (DM) productivity was assessed in kg ha^{-1} by cut and total. The common black oat proved to be different from the other forage plants in DM yield, accumulating less quantities of it due to its cycle. The application of nitrogen fertilization to the coverage linearly influenced the ryegrass at 66 DAE and all other species at 116 DAE in a positive manner. Nitrogen did not influence the total accumulation of dry matter of both common black oat and Triticale Tpolo 981.

Key words: *Avena sativa* L., *Triticosecale wittmack*, *Lolium multiflorum* Lam, nitrogen, cuts.

INTRODUCTION

The quality and quantity of dry matter to be produced by winter forage plants are determined, among other factors, by the handling to which they are subjected in the production stage, such as irrigation, fertilization, as well as cutting height and frequency (Alvim and Coser, 2000). Tropical pastures are the most practical and economical means of food for the Brazilian livestock. It is constituted as the base for dairy and beef cattle feeding in most rural properties (Vitor et al., 2009). The factor that most influences the productivity of pastures is fertilization, according to Malavolta (1980). Wilkins et al. (2000), stated that N is the most limiting nutrient for plant growth.

Nitrogen is fundamentally important in the production process of pastures, for is an essential component of organic compounds such as amino acids and proteins, nucleic acids, hormones and chlorophyll (Lavres and Monteiro, 2003). Nelson et al. (1977) stated that nitrogen fertilization and evaluation periods on the tiller population are some of the main determinants of biomass production. Moreira et al. (2001) obtained results around 150 kg N ha^{-1}, in terms of yield and forage quality for oat cultivar IPR 61 subjected to increasing levels of nitrogen with higher concentrations of cell wall (ADF and NDF) and lower crude protein in the second cut at 119 days

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Table 1. Chemical attributes of an oxisol before the establishment of the experiment.

Layer (cm)	pH ($CaCl_2$)	C (g dm^{-3})	P (mg dm^{-3})	Al	H+Al	Ca+Mg	K	S	CTC	V (%)
				--------------------cmol/cdm^{-3}------------------						
0 - 10	4.70	9.35	16.3	0.25	8.35	6.60	0.58	7.18	15.53	46.23
10 - 30	4.50	7.79	3.9	0.95	9.70	3.60	0.38	3.98	13.68	29.09

C-carbono, P-phosphorus, Al-aluminum, H+Al-Hydrogen + aluminum, Ca+Mg-calcium + magnesium, K- potassium, S- sum of bases, CTC- cation exchange capacity, V- %base saturation.

compared to the first cut at 89 days.

Various cuts in forage species cause plant defoliation and stress. According to Bortolinii et al. (2004), depending on the timing and intensity of defoliation, forage yield will be affected in a greater or lesser degree, because the ability to forage regrowth. Defoliation intensity is related to the time it will take the forage to rearrange itself in the field, what which depends on the proportion of removed tissue and photosynthetic capacity of the remaining plant leaves (Confortin et al., 2010). Among the activities that alter plant development, cutting management can potentially define the growth and productivity of pastures (Skonieski et al., 2011). However, when the pasture is not managed, the excessive regrowth damages the root system (Donaghy and Fulkerson, 2002).

Demétrio et al. (2012) in a research on common black oat, IPR 61, IPR 126, FAPA 2 and FUNDACEP FAPA 43, found increased forage production with the management of three cuts at the vegetative stage, however, in order to cover the soil the best cultivar performance was up to two cuts at the vegetative stage, or a single cut during flowering. Thus, this experiment aimed to assess the dry matter production of five forage species subjected to nitrogen doses at different cutting ages.

MATERIALS AND METHODS

The experiment was conducted under field conditions during the growing season of 2011, in an agricultural area located at IAPAR's (Agronomic Institute of Paraná) experimental station in the municipality of Santa Tereza do Oeste - PR, located at the following geographic coordinates: longitude W 53° 29'37'', latitude S 24° 50'42'', and altitude of 607 m. The climate in the region is classified as subtropical humid, according to the classification of Köeppen, with average annual rainfall of 1840 mm (IAPAR, 2011). The soil is classified as oxisol, with clayey texture (Embrapa, 2006). The results of the chemical analysis of the soil before the establishment of the experiment are shown in Table 1.

The experiment was performed by employing the randomized design randomized complete block design in a 5×4×3 factorial scheme with five forage species: Common *Avena strigosa* Schreb *cv.* Common, *A. strigosa* Schreb cv. IAPAR 61, *Avena sativa* cv. IPR 126, *Lolium multiflorum* Lam., × *Triticosecale wittmack*), four doses of nitrogen (zero, 30, 60 and 120 kg ha^{-1}) and three cutting ages (at 66, 95 and 116 DAS), with three replications, summing up to 60 experimental units, each one being 5 m long by 1.2 m wide, with 4 m^2 of area sample.

Soil preparation consisted of scarification, followed by harrowing. The entire experimental area was fertilized according to soil analysis with 250 kg ha^{-1} of the NPK 08-18-18 formula at the time of sowing and phosphogypsum ($CaSO_4 2H_2O$) with 26% calcium and 15% of S. Coverage fertilization was performed 15 days after seed emergence as urea with 46% of N. The area in which the experiment was carried out was previously occupied by soybean (*Glycinemax*) in summer and by forage species for crop rotation during winter for the formation of vegetal coverage. Sowing was performed on 29/04/2011 with emergence 10 days after sowing. The area remained under constant management to ensure pasture establishment.

The cuts were performed manually at about 5 to 7 cm above ground level, with the aid of a 0.25 m^2 board randomly thrown at the plots with two samples per parcel. Then the plants were collected in paper bags and taken to the laboratory to be weighted and dried in an oven with forced air ventilation, where they remained for 72 h at 65°C to constant weight. After this period the plants were removed from the oven and weighed. Then their amount of dry matter (DM) per hectare was calculated.

Data were subjected to analysis of variance and regression. Means comparison was performed by using Tukey's test at 1 and 5% significance. For the quantitative factor, the models were chosen based on the probability of the regression coefficients, using the t test at 1 and 5% probability, with the use of statistical package Assistat® version 7.5 beta (Silva and Azevedo, 2002).

RESULTS AND DISCUSSION

Table 2 shows F values obtained in the analysis of variance for DM data for the species, with different doses and cutting ages. One can observe the significance of treatments and interaction between forage species × cutting ages, and levels of nitrogen × cutting ages. There were significant effects ($p < 0.01$) between forages in dry matter production (DM). Nitrogen fertilization of the coverage significantly influenced ($p < 0.01$) DM yield per ha. In the analysis of variance no significance was detected for the interactions forages × nitrogen fertilization, and nitrogen fertilization × cutting ages ($p> 0.05$).

DM production was not affected by nitrogen fertilization in the first cut (66 DAE) for the following species: common oat, IPR 61 and Triticale Tpolo 981 (Figure 1A, B and C), not significantly adjusting to linear or quadratic regression. Species IPR 61 presented decreasing linear behavior in relation to the accumulation of DM in the first cut (Figure 1D). Nitrogen fertilization did not increase DM yield in the first cut, possibly due to low rainfall, what may have influenced the incorporation of fertilizers in the soil.

Several studies unanimously indicate the efficiency of

Table 2. F values and coefficient of variation (CV) obtained for the evaluations of analysis of variance of forage dry matter (kg ha^{-1}) for different factors and interactions. Santa Teresa doOeste-PR, 2011.

Causes of variation	DM (Kg ha^{-1})
Forages (A)	27.06**
Doses N (B)	12.97**
Cuts (C)	95.27**
A × B	$0.7065^{n.s.}$
A × C	27.78**
B × C	3.1942**
A × B × C	$1.1400^{n.s.}$
C.V. (%)	15.94

** Significant at 1%, * significant at 5%, n.s.: non-significant.

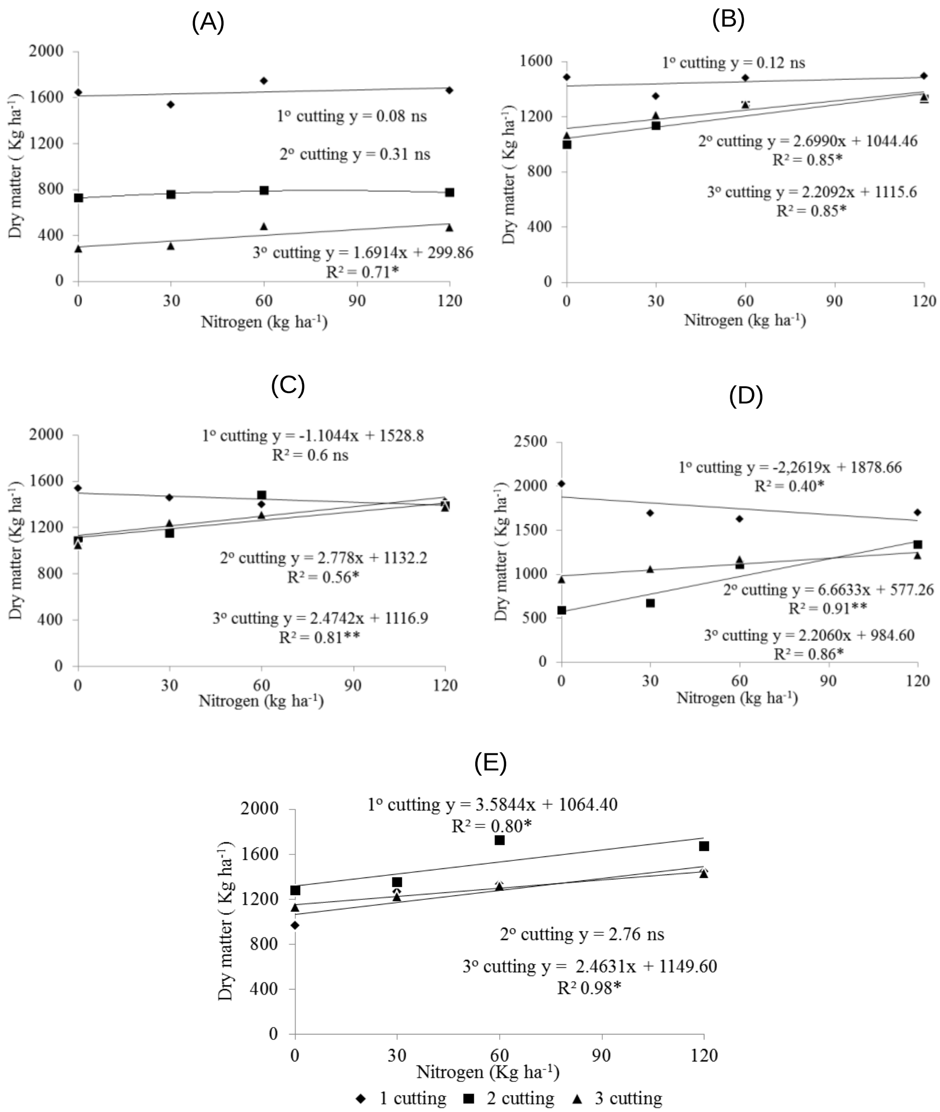

Figure 1. Variation of dry matter (kg ha^{-1}) in dosages of nitrogen (kg ha^{-1}) for the cultivation of common black oat (A), IPR 61 oat (B), Triticale Tpolo 981 (C), IPR 61 oat (D) and ryegrass (E); ** = significant at 1% probability; * = significant at 5% probability; ns = non-significant at 5% probability.

nitrogen fertilization on yield and dry matter accumulation in forage species, but Guideli et al. (2000) when using nitrogen fertilization on millet crops verified total dry matter production of 2571, 2802, 2722 and 3103 kg ha^{-1} to 0; 75, 150 and 225 kg $ha^{-1}$of N respectively. Simili et al. (2008) found values of 2713.7, 2680.2 and 3009.7 kg ha^{-1} for 100, 200 and 300 kg of N, respectively for sorghum-sudan, noting no significant increase in DM production in response to nitrogen fertilization in both cases. Results different contrary to nitrogen fertilization are also described by Goes et al. (2012) and Casagrande and Fornasieri et al. (2002) on corn, showing no effect of fertilization on crop yield, a fact that, according to the authors, may be related to soil moisture, plant genetics and dose used, as well as the availability of organic matter in the soil.

Nitrogen fertilization linearly influenced in DM an increasing way only at the third cutof the common oat species (Figure 1A), with a maximum DM accumulation at 66 DAE in the first cut with 1744 kg ha^{-1}. Such results were superior to those found by Fão et al. (2006) who observed a production of 1.024 kg ha^{-1} in Cruz Alta (RS) with the application of 200 kg ha^{-1} of the formula 5-20-20 at planting and 20 kg of N at tillering with cutting at 74 days. The common oat had lower forage production, which corroborates the studies by Demetrius et al. (2012) who found lower dry matter accumulation and do not recommend the species for soil coverage for not adding enough straw. The IPR 126 oat (Figure 1B) was influenced only in the second and third cuts by nitrogen fertilization, with 1000, 1133.6, 1283, 1328 kg ha^{-1} of DM to doses of 0, 30.60 and 120 kg of N ha^{-1}, respectively in the second cut and 1066.6, 1217, 1293.33 and 1349.33 kg ha^{-1} of DM for doses of 0, 30, 60 and 120 kg of N ha^{-1}, respectively in the third cut, linearly expressing nitrogen fertilization in an increasing way. Demétrio et al. (2012) obtained for IPR 126 oat a production of 907, 1644 and 1692 kg ha^{-1} of dry matter in three cuts with an average production of 2121 kg ha^{-1}. These values were lower than those obtained in this experiment.

Species Triticale Tpolo 981 and IPR 61 (Figure 1C and D), according to the regression equation, did not show DM increase when doses were increased from 0 to 120 kg ha^{-1} at the first cut at 66 DAE. But when the cut management was performed at 95 and 116 DAE, one could notice an increasing linear accumulation of DM for both species. Moreira et al. (2001) found similar results with increasing linear effect of nitrogen fertilization with the raise ($P < 0.10$) in dry matter production in the second cut at 119 days, with 1.280, 2.277, 2.081 and 2.910 kg ha^{-1} for 0, 50, 100 and 200 kg of N ha^{-1}, respectively. Mota et al. (2010) when studying nitrogen doses and irrigation plates on pioneer grass, found positive linear correlation to the combination of factors. Costa et al. (2009) also found a linear effect of nitrogen on dry matter production of cultivars *Brachiariabrizantha* (Marandu, Xaraés and MG-4).

In the third cut at 116 DAE, there was an increase in dry matter production, according to the maximum level of nitrogen applied to all five species, not showing the dose of maximum technical efficiency (MTE). Moreira et al. (2001) found maximum values of dry matter according to the quadratic regression for the first cut at 89 days of 128 kg of N ha^{-1}. Silva et al. (2009) observed a quadratic response with the application of increasing doses of nitrogen on the number of leaves per tiller in two *Brachiaria* species in pots containing a 157 mg/dm^{-3} rate. According to Novo and Camargo (2002), tropical grasses may respond linearly to nitrogen fertilization up to the level of 800 kg of N. ha^{-1}.

Species Triticale Tpolo 981 and ryegrass, unlike oat species, accumulated DM at the second cut at 95 DAE. Fão et al. (2006) found a production of 1. 271 kg ha^{-1} DM at 84 days for IAPAR 61 oat. Sá et al. (2006) when working with common oat, IAPAR 61, IPR 126, FAPA 2 and FUNDACEP FAPA 43 obtained, respectively, 1.251, 1.095, 1.040, 921 and 818 of DM, at the second cut. Floss et al. (2007) with cuts at every 14 days in *Avena sativa* L. cv. UPF 7 reported that at 42 DAE, the forage yield was 1. 905 kg ha^{-1} of DM. The differences in the response of each cultivar are due to the ability of plants to produce new tillers after cutting (Bortolini et al., 2004).

Cedeño et al. (2003) in the south of Minas Gerais working with three forage species (Tifton 68, Tifton 85 and Coast cross), highlight the influence of the cut in forage production. For local conditions the Cedeño et al. (2003) found out that the best cutting age occurs between 35 and 48 days for grasses. Fão et al. (2006) evaluated oat cultivars in Cruz Alta (RS), with the application of 200 kg ha^{-1} of the formula 5-20-20 at planting and 20 kg of N at tillering with cut at 74 days after emergency emergence for the cultivar common black oat, and at 87 days for IAPAR 61, IPR 126, FAPA 2 and FUNDACEP FAPA 43, respectively, 1.024, 1.271, 1.265, 1.671 and 1.649 kg ha^{-1} of dry matter. The total production of dry matter - TDM - (summing up all three cuts) was 2658; 2635,33; 3079,3 and 3027,6 kg ha^{-1} for the common black oat, 3550,3; 3698,3; 4054,6; 4173,6 for IPR 126 oat, 3679,6; 3853,6; 4195,6; 4187,6; for triticale Tpolo 981, 3564; 3425,6; 3909,6; 4250,3 kg ha^{-1} for IPR 61 oat; and 33803847; 4377,3 and 4547,33 kg ha^{-1} and for the ryegrass, at levels of 0, 30, and 120 Kg ha^{-1} of N, respectively (Figure 2).

Moreira et al. (2001) observed TDM, with two cuts (at 89 and 119 days) for cultivar IPR 61 283, 4691, 4993 and 5471 kg ha^{-1} to levels 0, 50, 100 and 200 kg of N ha^{-1}. Species common oat and triticale Tpolo 981 showed no significant linear increase in relation to nitrogen in all three cuts. One can notice in Figure 2 that in relation to the accumulated production of forage in the three cuts, the common black oat accumulated less quantity of DM, which is in accordance with what was found by Demétrio et al. (2012), who highlight the material's precocity. In the same study, Demétrio et al. (2012) observed higher

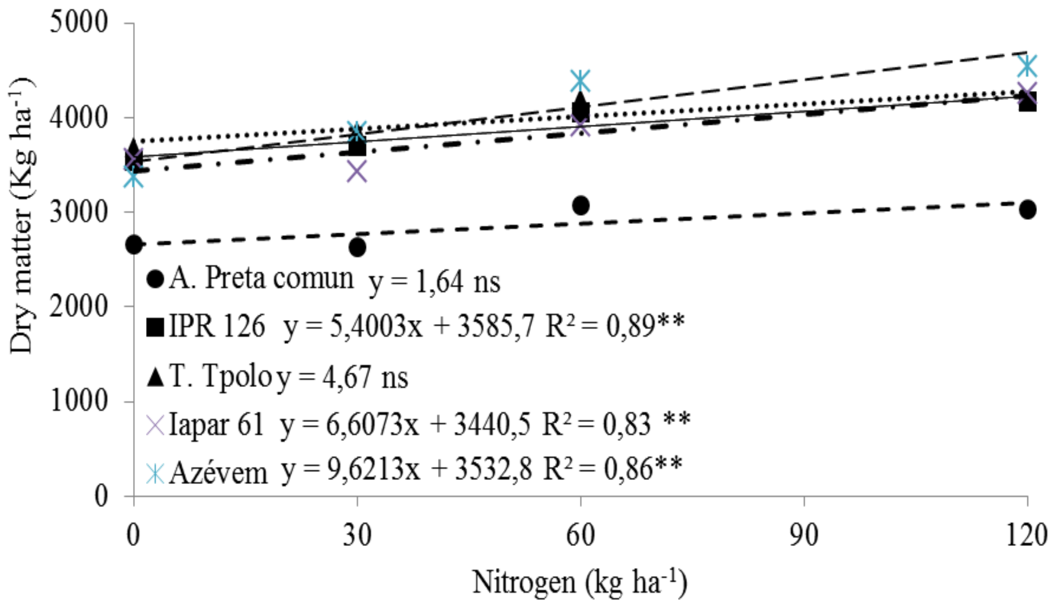

Figure 2. Total dry matter variation - TDM (kg ha^{-1}) in dosages of Nitrogen (kg ha^{-1}) for the culture of common black oat, IPR 61 oat, Triticale Tpolo 981, IPR 61 and Ryegrass. ** = significant at 1% probability; * = significant at 5% probability; ns = non-significant at 5% probability.

accumulated yield for cultivar FAPA 2, which has medium-long cycle and, according to Primavesi et al. (2006), is 46% more productive than those with precocious cycle.

Matzenbacher (2001) observed the production of 12.970 kg ha^{-1} of dry matter for cultivar FAPA 2 with cut at flowering. Sá et al. (2012) for cultivars IAPAR 61 and IA-96101-B (lineage of the current IPR 126) with cuts at flowering in Londrina (PR), achieved the production of 13.670, 12.329 and 8.314 kg ha^{-1} of DM, respectively. Primavesi et al. (2006) evaluated oat cultivars in São Carlos (SP), fertilized with 250 kg ha^{-1} of formula 10-30-10 and 20 kg ha^{-1} of N as coverage at tillering, and obtained for cultivars common black oat, IAPAR 61, IPR 126, FAPA 2 and FUNDACEP FAPA 43, at 41, 37, 41, 39 and 48 days after emergence (DAE), forage production of 724, 989, 1.176, 1.170 and 1.433 kg ha^{-1} of dry matter, respectively. Cecato et al. (1998) using levels of 90 kg of N ha^{-1}in common black oat cv IAPAR 61, achieved production of 4.205 kg of DM ha^{-1}in irrigated areas.

Conclusion

It can be concluded that nitrogen fertilization influenced the yield of DM in a positive linear way only at the third cut in all species studied in this work. The common oat differentiated itself from other forage species for its DM yield, accumulating smaller amounts because of its cycle, expressing itself in a negative linear form in relation to nitrogen fertilization. Nitrogen did not affect the total accumulation of dry matter (TDM) of species common oat and triticale Tpolo 981.

REFERENCES

Alvim MJ, Coser AC (2000). Aveia e azevém anual: recursos forrageiros para a época da seca. In: Carvalho, M. M.; Alvim, M. J. (Eds.). Pastagens para gado de leite em regiões de influência de mata atlântica. Brasília, DF: Embrapa. pp. 83-107.

Bortolini PC, Sandini I, Carvalho PCF, Moraes A (2004). Cereais de inverno submetidos ao corte no sistema de duplo propósito. Revista Brasileira de Zootecnia, Viçosa. 33(1):45-50.

Casagrande JRR, Fornasieri FD (2002). Adubação nitrogenada na cultura do milho safrinha. Pesquisa Agropecuária Brasileira, Brasília, 37(1):33-40.

Cecato U, Sarti LL, Sakaguti ES, Damasceno JC, Rezende R, Santos GT (1998). Avaliação de cultivares e linhagens de aveia (*Avenna* spp.) ActaScientiarum An. l Sci. Maringá. 20(3):347-354.

Cedeño JAG, Rocha GP, Pinto JC, Gomide JA (2003). Efeito da idade de corte na performance de três forrageiras do gênero *Cynodon*. Ciência Agrotecnica, Lavras. 27(2):462-470.

Confortin ACC, RochaMG, Quadros FLF, Glienke CL, Rossi GE, Moraes AB (2010). Structural and morphogenicalcharacteristics of black oats and Italian ryegrass on pasture submitted to two grazing intensities. RevistaBrasileira de Zootecnia, Viçosa. 39(11):2357-2365.

Demétrio JV, Costa ACT, Oliveira PSR (2012). Produção de biomassa de cultivares de aveia sob diferentes manejos de corte. Pesquisa Agropecuária Trop. 42(2):198-205.

Donaghy DJ, Fulkerson WJ (2002). The impact of defoliation frequency and nitrogen fertilizer application in spring on summer survival of perennial ryegrass under grazing in subtropical Aust. Grass. Forage Sci. Oxford 57(4):351-359.

Embrapa-Empresa Brasileira de Pesquisa Agropecuária (2006). Serviço Nacional de Levantamento e Conservação de Solos. Sistema brasileiro de classificação de solos. 2nd ed. Rio de Janeiro: Embrapa Solos, P. 306.

Fão VM, Boss R, Lima AS de (2006). Ensaio nacional de aveias forrageiras. Cruz Alta, RS, 2005. In: XXVI REUNIÃO DA COMISSÃO BRASILEIRA DE PESQUISA DE AVEIA, 2006, Guarapuava, PR. Anais, pp. 141-143.

Ferolla FS, Vásquez HM, Silva JFC, Viana AP, Domingues FN, Aguiar RS (2007). Produção de matéria seca, composição da massa de forragem e relação lâmina foliar/caule + bainha de aveia-preta e triticale nos sistemas de corte e de pastejo. Revista Brasileira de Zootecnia 36(5):1512-1517.

Floss EL, Palhano AL, Soares Filho CV, Premazzi LM (2007). Crescimento, produtividade, caracterização e composição química da aveia Branca. Acta Scientiarum An. Sci. Maringá. 29(1):1-7.

Goes RJ, Rodrigues RAF, Arf O, vilela RG (2012). Nitrogênio em cobertura para o milho (*Zea mays* L.) em sistema plantio direto na safrinha. Revista Brasileira de Milho e Sorgo. 11(2):169-177.

Guideli C, Favoretto V, Malheiros EB (2000). Produção e qualidade do Milheto semeado em duas épocase adubado com nitrogênio. Pesquisa Agropecuária Brasileira, Brasília. 35:10.

IAPAR - Instituto Agronômico do Paraná (2011). Médias históricas em estações doIAPAR.Disponívelem:<http://www.iapar.br/arquivos/Image/monitoramento/Medias_Historicas/Cascav-el.html>. Acesso em: 10 set. 2012.

Lavres JJ, Monteiro FA (2003). Perfilhamento, área foliar e sistema radicular do capim-Mombaça submetido a combinações de doses de nitrogênio e potássio. Revista Brasileira de Zootecnia, Viçosa, 32(5):1068-1075.

Malavolta E (1980). Elementos de nutrição de plantas. Piracicaba: Agronômica Ceres. P. 251.

Matzenbacher RG (2001). Ensaio com aveias brancas de duplo propósito na FUNDACEP, Cruz Alta, RS em 2000. In: Reunião da Comissão Brasileira de Pesquisa de Aveia, 21, 2001, Lages. Anais. Lages: CBPA, pp. 178-183.

Moreira FB,Cecato U, Prado IN,Wada FY, Rego FCA, Nascimento WG (2001). Avaliação de aveia preta cv Iapar 61 submetida a níveis crescentes de nitrogênio em área proveniente de cultura de soja. Acta Scientiarum Animal Science, Maringá. 23(4):815-821.

Mota VJG, Reis ST, Sales ECJ, Rocha Júnior VR, Oliveira FG,Walker SF, Martins C E,Cóser AC (2010). Lâminas de irrigação e doses de nitrogênio em pastagem de capim-elefante no período seco do ano no norte de Minas Gerais. Revista Brasileira de Zootecnia, Viçosa. 39(6):1191-1199.

Nelson CJ, Asay KH, Sleper DA (1977). Mechanisms of canopy development of tall fescue genotypes. Crop Sci. 17:449-452.

Novo ALM, Carmargo AC de (2002). Manejo intensivo de pastagens. São Paulo: Instituto Fernando Costa. Curso à Distância em Bovinocultura Leiteira. Módulo III: Manejo de Pastagens.

Primavesi AC, Primavesi O, Corrêa LA, Silva AG, Cantarella H (2006). Nutrientes na fitomassa de capim marandu em função de fontes e doses de nitrogênio. Revista Ciência e Agrotecnologia. 30(3):562-568.

Sá JPG, Oliveira JC de, Aragão AA de (2006). Ensaio nacional de aveia forrageira, em Londrina, PR, 2005. In: XXI Reunião da Comissão Brasileira de pesquisa de aveia, 2006, Guarapuava, PR. Anais, pp. 144-145.

Sá JPG, Oliveira JC de, Aragão AA de (2012).Ensaio regional de aveias de cobertura em Londrina-PR., 2000. In. XXI Reunião da Comissão Brasileira de pesquisa de aveia, 2001, Lajes – SC. Anais.., 2001. pp. 225-226.

Silva CCF, Bonomo P, Pires AJV, Maranhão CMA, Pâtes NMS, Santos LC (2009). Características morfogênicas e estruturais de duas espécies de braquiária adubadas com diferentes doses de nitrogênio. Revista Brasileira de Zootecnia, Viçosa. 38(4):657-661.

Silva FAS, Azevedo CAV (2002). Versão do programa computacional Assistat para o sistema operacional Windows. Revista Brasileira de Produtos Agroindustriais 4(1):71-78.

Simili FF, Reis RA, Furlan BN, Paz CCP, Lima MLP, Bellingieri PA (2008). Resposta do híbrido de sorgo-sudão à adubação nitrogenada e potássica: composição química e digestibilidade *in vitro* da matéria orgânica. Ciência e Agrotecnol. 32(2):474-480.

Skonieski FR, Vargas L, Bermudes RF, Nörnberg JL, Ziech MF, Costa OAD, Meinerz GR (2011). Composição botânica e estrutural e valor nutricional de pastagens de azevém consorciadas. Revista Brasileira de Zootecnia, Viçosa. 40(3):550-556.

Vitor CMT, Fonseca DM, Coser AC (2009). Produção de matéria seca e valor nutritivo de pastagem de capim-elefante sob irrigação e adubação nitrogenada. Revista Brasileira de Zootecnia. 38(3):435-442.

Wilkins PW, Allen DK, Mytton LR (2000). Differences in the nitrogen use efficiency of perennial ryegrass varieties under simulated rotational grazing and their effects on nitrogen recovery and herbage nitrogen content. Grass. Forage. Sci. Oxford 55(1):69-76.