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Production and nutritional value of wheat and triticale cultivars in different harvest times in the Minas Gerais semiarid

Produção e valor nutricional de cultivares de trigo e triticale em diferentes épocas de colheita no semiárido mineiro

Emanuell Medeiros Vieira[1]*; Carlos Juliano Brant Albuquerque[2]; João Paulo Sampaio Rigueira[3]; Virgílio Mesquita Gomes[3]; Maurício Antônio de Oliveira Coelho[4]; Vicente Ribeiro Rocha Júnior[3]; Flávio Pinto Monção[3]; Isadora Alves Santana[5]; Fernanda Ferreira da Hora[5]; Maria Letícia Rodrigues Gomes[6]

Highlights

It is possible to produce wheat and triticale as forage in the semiarid region.
Different wheat and triticale cultivars were compared for yield.
Triticale cultivars are more productive than wheat.

Abstract

The objective of the present study was to evaluate the productive performance and nutritional value of forage of wheat and triticale cultivars at different harvest times in the semiarid region of Minas Gerais. Eight wheat cultivars and two triticale cultivars harvested at three stages of plant development were evaluated: Rubberization, grain at the stage of soft mass and harvest maturation. The experimental design adopted was a randomized block in a factorial scheme 10 × 3, with three replicates, 10 cultivars and 3 developmental stages for plant collection. The main agronomic characteristics and nutritional value were evaluated of forage of the cultivars under study. The study demonstrated the potential of wheat and triticale cultivation for forage in the semiarid region of Minas Gerais. The mean dry matter yield of wheat cultivars was 5.90 t

[1] Discente do Curso de Doutorado do Programa de Pós-Graduação em Produção Vegetal, Universidade Federal de Minas Gerais, UFMG, Institute of Agricultural Sciences, Montes Claros, MG, Brazil. E-mail: emanuell.medeiros.vieira@gmail.com
[2] Prof., UFMG, Montes Claros, MG, Brazil. E-mail: carlosjuliano@ufmg.br
[3] Profs., Universidade Estadual de Montes Claros, UNIMONTES, Janaúba, MG, Brazil. E-mail: joao.rigueira@unimontes.br; virgilio.gomes@unimontes.br; vicente.rocha@unimontes.br; moncaomoncao@yahoo.com.br
[4] Researcher, Empresa de Pesquisa Agropecuária de Minas Gerais, EPAMIG, Patos de Minas, MG, Brazil. E-mail: macoelho62@gmail.com
[5] M.e, UNIMONTES, Janaúba, MG, Brazil. E-mail: doramoa6@gmail.com; fernandaferreirazootec@gmail.com
[6] Discente do Curso de Mestrado do Programa de Pós-Graduação em Ciência Animal, Universidade Federal do Vale do São Francisco, UNIVASF, Petrolina, PE, Brazil. E-mail: lelive90@gmail.com
* Author for correspondence

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ha^{-1}, 7.85 t ha^{-1} and 7.98 t ha^{-1} and triticale 6.47 t ha^{-1}, 9.97 t ha^{-1} and 10.5 t ha^{-1} for the rubber harvesting stages, grain at the stage of soft mass and harvest maturation, respectively. For the average crude protein content, the wheat cultivars showed 15.07%, 9.13%, 10.60% and the triticale cultivars showed 14.4%, 9.31% and 10.05% for the harvest stages of rubber formation, grain at the stage of soft mass and harvest maturation, respectively. When evaluating the average levels of total digestible nutrients, the wheat and triticale cultivars showed an average of 48.90% and 48.67% in the rubber harvesting stage and 42.68% and 49.60% in the grain in the mass stage suave and 44.43% and 42.90% at harvest maturation. The highest yield of digestible dry matter was observed with the cultivars harvested at the grain stage at the soft mass stage. Triticale IPR 111 and Wheat IPR PANATY had greater productive potential and better nutritional quality for use as forage.
Key words: Bromatology. Winter cereals. *Triticum aestivum L.*. X. *Triticosecale Wittmack.*

Resumo

Objetivou-se com o presente estudo avaliar o desempenho produtivo e valor nutricional da forragem de cultivares de trigo e triticale em diferentes épocas de colheita no semiárido Mineiro. Foram avaliados oito cultivares de trigo e duas cultivares de triticale colhidas em três estádios de desenvolvimento das plantas: no Emborrachamento, grão no estádio de massa macia e maturação de colheita. O delineamento experimental adotado foi em blocos ao acaso em esquema fatorial 10×3, com três repetições sendo 10 cultivares e 3 estádios de desenvolvimento para colheita das plantas. Foram avaliadas as principais características agronômicas e o valor nutricional da forragem das cultivares em estudo. A pesquisa demonstrou o potencial do cultivo do trigo e triticale para forragem no semiárido de Minas Gerais. A produtividade média de matéria seca das cultivares de trigo foi de 5,90 t ha^{-1}, 7,85 t ha^{-1} e 7,98 t ha^{-1} e triticale 6,47 t ha^{-1}, 9,97 t ha^{-1} e 10,5 t ha^{-1} para os estádios de colheita de emborrachamento, grão no estádio de massa macia e maturação de colheita respectivamente. Para os teores médios de proteína bruta as cultivares de trigo apresentaram 15,07%, 9,13%, 10,60% e as cultivares de triticale 14,4%, 9,31% e 10,05% para os estádios de colheita de emborrachamento, grão no estádio de massa macia e maturação de colheita respectivamente. Ao se avaliar os teores médios de nutrientes digestíveis totais as cultivares de trigo e triticale apresentaram média de 48,90% e 48,67% no estádio de colheita de emborrachamento, 42,68% e 49,60% no grão no estádio de massa macia e 44,43% e 42,90% na maturação de colheita. A maior produtividade de matéria seca digestível foi observada com as cultivares colhidas no estádio de grão no estádio de massa macia. O Triticale IPR 111 e o Trigo IPR PANATY tiveram maior potencial produtivo e melhor qualidade nutricional para uso como forragem.
Palavras-chave*:* Bromatologia. Cereais de inverno. *Triticum aestivum L.*. X. *Triticosecale Wittmack.*

Introduction

The northern region of the state of Minas Gerais is characterized by an arid climate, with rainfall concentrated in a few months of the year, opening a margin for long periods of drought. In this region, cattle ranching has a strong influence on the local economy. Irrigation projects stimulated by governmental actions made corn monoculture feasible for silage production. The use of wheat and triticale in succession to summer

crops can optimize the use of irrigated land and the use of existing irrigation systems in the properties. In addition, crop rotation can reduce the incidence of diseases, weeds, and pests and promote improvements in soil physicochemical and biological conditions (Santos et al., 2019).

Wheat and triticale are annual winter grasses that can be used for the production of quality forage for animal feed by grazing or in conserved forms of hay or silage and subsequently in the regrowth to produce grains (Empresa Brasileira de Pesquisa Agropecuária [EMBRAPA], 2012).

The nutritional value of these crops is directly linked to their phenological stage of development. In the early stages of stem growth and elongation, there is a higher concentration of nutrients due to the greater participation of leaves in the forage; however, there is a lower production of dry matter at this stage. At the grain stage at the soft mass stage, there is an increase in starch in the forage formation caused by grain maturation and in the forage. harvest maturation of these crops, the dry matter yield per area increases, and there is still a higher concentration of starch deposited in the mature grains (Wrobel et al., 2018). For this reason, during the vegetative development stages, the nutritional value of wheat and triticale must be estimated so that management can occur, seeking to reach the maximum productive potential in the shortest time to harvest, avoiding expenditure on production inputs and achieving high productivity and good nutritional value.

It is important to note that the viability of wheat and triticale as forage in the semiarid region is incipient or nonexistent in Brazil. In studies conducted in the semiarid region of Minas Gerais involving irrigated wheat, grain yields were reported to range from 2.9 to 5.6 t ha^{-1} in four years of evaluation (Fronza, Souza, & Resende, 1998). These yields were higher than those in the study conducted in the semiarid region of the municipality of Montes Claros. In this case, the authors showed productivity of up to 2.5 t ha^{-1} (Rezende et al., 2020).

The wheat and triticale cultivars were expected to adapt to the different harvest seasons, maintaining or increasing their productive potential and nutritional quality. Thus, the present study aimed to evaluate the productive performance and nutritional value of forage in wheat (Triticum aestivum) and triticale (X. Triticosecale Wittmack) cultivars at different harvest times in Janaúba, MG.

Materials and Methods

The experiment was conducted under field conditions in an irrigated area located in the Gorutuba perimeter at the Experimental Farm of the State University of Montes Claros (UNIMONTES) - Janaúba Campus, from April to August 2019. The municipality of Janaúba is located in the northern region of Brazil. de Minas Gerais, Brazil, its geographic coordinates are 15 ° 48 '32' 'latitude and 43 ° 28 19' 3 '' longitude, at an altitude of 516 m.

The soil of the area is classified as a dystrophic Red Latosol with epieutrophic character in the surface layer with clayey texture (EMBRAPA, 2018). The chemical characteristics of this soil, in samples taken in the 0-20 cm layers, are: pH in H_2O 6.1; OM 2.6 dag kg^{-1}; P, K and Na in Mehlich 1 of 3.8; 120, and 0.1 mg dm^{-3}, respectively; Ca, Mg and Al extracted in KCl 1mol L^{-1} with values of 4.7; 1.9 and 0.0 cmolc dm^{-3}, respectively; and H+Al with 2.9 cmol and dm^{-3}; T = 9.9 cmolc.dm^{-3}; V = 70%.

The region has a predominantly Aw-type climate, tropical savanna, with a defined dry season in winter (Alvares, Stape, Sentelhas, Moraes Gonçalves,& Sparovek, 2013). The main climatic conditions are observed during the experiment (Figure 1). The temperatures reported at the time of cultivation were acceptable for wheat and triticale production in the semiarid region. The water limitation observed in the experimental period was overcome with irrigation

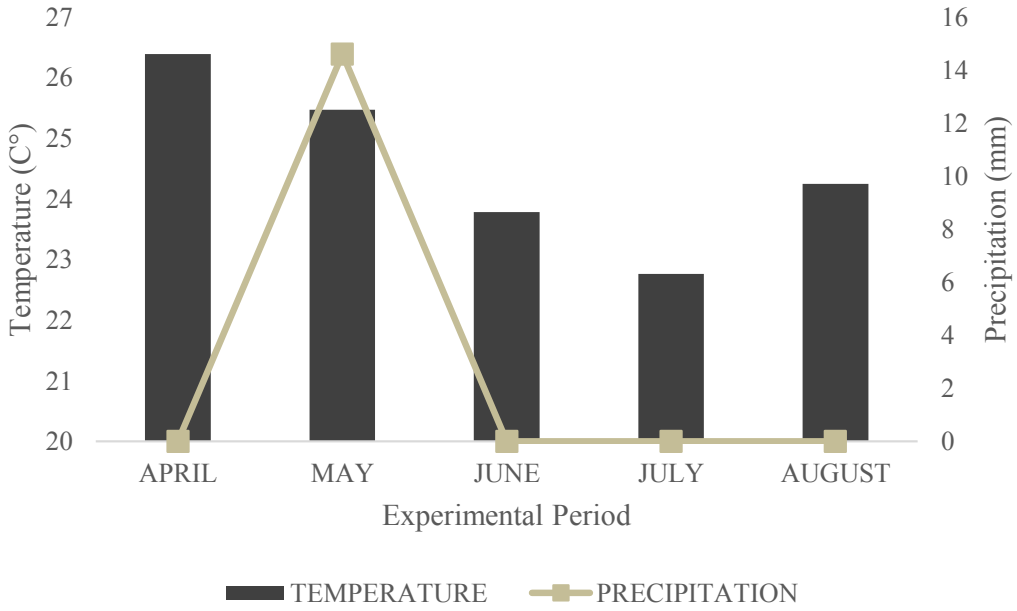

Figure 1. Average temperature and precipitation per decendium, during the period of wheat and triticale cultivation, in Janaúba – MG. Planting: 04/24/2019, First harvest: 06/19/2019, Second harvest: 07/26/2019, Third harvest: 08/09/2019.
Adapted from Instituto Nacional de Metereologia [INMET] (2020).

Genetic materials provided by the Brazilian Agricultural Research Corporation (Empresa Brasileira de Pesquisa Agropecuária - EMBRAPA) and the Agronomic Institute of Paraná (Instituto Agronômico do Paraná - IAPAR) were used. Eight wheat cultivars were used: BRS 264, BRS 394, BRS 404, IPR 144, IPR 85, IPR PANATY, IPR POTYPORÃ, IPR TAQUARI, and two triticale cultivars: IPR 111 and IPR AIMORÉ.

Samples were harvested at three stages of plant development: in rubberization, grains at the stage of soft mass and harvest maturation, following the Feekes scale, modified by Large (1954). Thus, the experimental design adopted was a randomized block design with three replicates in a 10 × 3 factorial scheme, with 10 cultivars and 3 harvest seasons characterized by the stages of grain maturation, thus comprising 30 treatments. Each plot had 5 rows of cultivation 12 meters in length, spaced at 0.20 m. The three central lines were considered useful for the collection and analysis of plants, disregarding the two lateral lines as borders.

In the preparation of the soil, harrowing was performed for uniformity. Sowing was performed manually after making juices at a spacing of 0.20 m with the aid of a tractor cultivator on April 24, 2019. The planting density was 350 seeds per m^2.

Soil fertilization was performed according to the recommendations of the Technical Manual for wheat and triticale (Franco & Evangelista, 2018), using 0.4 t ha^{-1} of the formulation 04- 30-10 at sowing and 0.2 t ha^{-1} of potassium chloride and 0.2 t ha^{-1} of urea as topdressing at 30 days after sowing.

The crop was irrigated by a conventional sprinkler with a 2-day irrigation schedule, maintaining the soil at its field capacity. The agronomic evaluations performed were the number of days from sowing to harvest (days), plant height (m) and dry matter yield (t ha^{-1}).

To determine the number of days to harvest, the plants were analyzed daily after stem elongation, and when the plants were at the determined stages, they were collected. The height of the plants was obtained by measuring twenty plants from their base to the apex of the ears, disregarding the edges, with the aid of a tape measure graduated in centimeters at the time of harvest in each stage, and then measured by the average height of the twenty plants. The dry matter yield at each stage was obtained by collecting, weighing and drying plants of known area harvested at three random locations in the plots and subsequently estimated per hectare by the average of the three collection sites.

To evaluate the nutritional value of the cultivars under study, chemical-bromatological analyses of the foods were performed, determining the levels of dry matter (INCT-CA G-001/1 and G-003/1), crude protein (INCT-CA N -001/1), neutral detergent fiber (INCT-CA F-001/1), lignin (INCT-CA F-007/1), indigestible neutral detergent fiber (INCT-CA F-008/1), carbohydrates nonfibrous and total digestible nutrients, following the recommendations described by Detmann et al. (2012).

The *in vitro* digestibility of dry matter and neutral detergent fiber was determined according to the methodology described by Tilley and Terry (1963). The technique was modified according to Detmann et al. (2012) using the *Tecnal*® *in vitro* incubator (TE-150) and nonwoven fabric (TNT -100 g/m^2) to prepare the incubation bag (7.5 x 7.5 cm), according to Casali, Detmann and Valadares (2009). The production of digestible dry matter was obtained by multiplying the values of dry matter production (t ha^{-1}) by the digestibility of the dry matter of each cultivar.

The results of the agronomic and chemical-bromatological evaluations were subjected to analysis of variance, and the means were compared by the Scott-Knott test (1974) at 5% significance for comparison of the means. The analysis of variance and the means test were performed using SISVAR software (Ferreira, 2020).

Results and Discussion

When evaluating the variable number of days to harvest, also called" "cycle", a significant effect was found for the developmental stage. The average harvest days of the different wheat and triticale cultivars were 49.35, 95.54 and 109.50 days for the rubber stages, grains at the stage of soft mass and harvest maturation, respectively.

When evaluating the variable plant height, a significant difference was observed between species and cultivars. Comparing the species and cultivars, it can be seen that Triticale IPR 111 had the largest size at 0.69 m. The remaining wheat cultivars had heights of 0.44, 0.40, 0.42, 0.60, 0.47, 0.56, 0.46, and 0.48 meters for cultivars BRS 394, BRS 264, BRS 404, IPR POTYPORÃ, IPR 144, IPR PANATY, IPR85 and IPR TAQUARI, respectively, and 0.51 m for the triticale cultivar IPR AIMORÉ. Plant height is an agronomic indicator of natural and dry matter yield. Lehmen, Fontaneli, Fontaneli and Santos (2014), when working with winter cereals, observed a mean of 0.79 and 0.83 m for plant height in the wheat cultivars BRS Tarumã and BRS UMBU. In the same study, the EMBRAPA 53 BRS Minotauro triticale cultivars had plant heights of 1.03 and 1.05 m, respectively.

For the production of digestible dry matter, significant differences were observed for the effects of developmental stages, wheat cultivars and triticale and interactions x stages of wheat and triticale cultivars (Table 1). Within the rubber stage, the best results were obtained in the triticale cultivar IPR 111 and in the wheat cultivars IPR 144 and IPR PANATY. No grain at the stage of soft mass of the wheat cultivars BRS 264 and BRS 394 and triticale IPR 111 showed the best results, whereas triticale IPR 111 and IPR PANATY wheat stood out from the others during grain maturation. Observing each cultivar within the stages shows that most of the cultivars under study showed better results. of grain at the stage of soft mass, with the exception of the wheat cultivar IPR 85. The wheat cultivars BRS 404, IPR 144, IPR PANATY and IPR TAQUERI showed no difference between the three stages under study.

When evaluating the dry matter yield, there were significant differences in the effect of developmental stages, wheat cultivars and triticale and interactions between harvest stage x wheat and triticale cultivars (Table 2).

The IPR 144, IPR PANATY and IPR POTYPORÃ wheat cultivars showed no differences in dry matter yield between stages. The other cultivars showed higher yields at the grain maturation stage, except for BRS 394 wheat, which had higher yields of grain at the stage of soft mass.

Within the stages, the triticale cultivar IPR 111 and wheat cultivars IPR 144, IPR PANATY and IPR POTYPORÃ had higher productivity. For the grain at the stage of soft mass, the cultivars BRS 264, BRS 394, IPR 111 and IPR AIMORÉ stood out from the others, and for harvesting during grain maturation, triticale IPR 111 showed higher dry matter yield among the cultivars under study.

According to Wrobel et al. (2018), the mean dry matter yield of the cultivar BRS UMBU under the effect of nitrogen fertilization on the cover at two levels (0.088 t ha^{-1} and 0.148 t ha^{-1}) was 9.79 t ha^{-1}. In another study with the same cultivar Carletto, Leão Neumann and Horst (2020) reported values of 10.92 t ha^{-1}.

Table 1
Average results of digestible dry matter production (t ha^{-1}) of wheat and triticale cultivars at different stages of development. Janaúba - MG, 2021

Cultivars	Stages		
	Rubberization	Grain at the stage of soft mass	Harvest maturation
Triticale IPR 111	2,47 Ba	3,58 Aa	3,42 Aa
Wheat BRS 394	1,55 Cb	3,44 Aa	2,13 Bc
Wheat BRS 264	1,57 Bb	3,02 Aa	2,63 Ab
Wheat BRS 404	1,61 Ab	2,11 Ac	2,04 Ac
Wheat IPR POTYPORÃ	2,01 Bb	2,66 Ab	2,08 Bc
Triticale IPR AIMORÉ	1,57 Cb	2,83 Ab	2,19 Bc
Wheat IPR 144	2,59 Aa	2,58 Ab	2,30 Ac
Wheat IPR PANATY	2,44 Aa	2,83 Ab	3,05 Aa
Wheat IPR 85	1,64 Bb	2,09 Bc	2,59 Ab
Wheat IPR TAQUARI	1,82 Ab	2,39 Ac	2,22 Ac
SEM	0,13	0,16	0,15
P-value	Cultivars	0,01	
	Stages	0,01	
	Cultivars x Stages	0,01	

Means followed by the same uppercase letter horizontally within each cultivar and means with the same lowercase letter vertically within each period belong to the same cluster, according to the Scott-Knott test at 5% probability.

Table 2
Yield of dry matter (t ha^{-1}) of wheat and triticale cultivars at different stages of development. Janaúba - MG, 2021

Cultivars	Stages		
	Rubberization	Grain at the stage of soft mass	Harvest maturation
Triticale IPR 111	8,28 Ca	10,26 Ba	12,60 Aa
Wheat BRS 394	4,66 Cb	10,15 Aa	7,87 Bc
Wheat BRS 264	4,55 Bb	9,04 Aa	7,81 Ac
Wheat BRS 404	4,66 Bb	6,30 Ab	6,65 Ac
Wheat IPR POTYPORÃ	8,16 Aa	7,81 Ab	7,93 Ac
Triticale IPR AIMORÉ	4,66 Bb	9,68 Aa	8,40 Ab
Wheat IPR 144	7,00 Aa	7,58 Ab	7,93 Ac
Wheat IPR PANATY	7,93 Aa	8,28 Ab	9,68 Ab
Wheat IPR 85	5,13 Bb	6,53 Bb	8,75 Ab
Wheat IPR TAQUARI	5,13 Bb	7,11 Ab	7,23 Ac
SEM	0,51	0,46	0,53
P-value	Cultivars	0,01	
	Stages	0,01	
	Cultivars x Stages	0,01	

Means followed by the same uppercase letter horizontally within each cultivar and means with the same lowercase letter vertically within each period belong to the same cluster, according to the Scott-Knott test at 5% probability.

Mancipe-Muñoz et al. (2021), when evaluating the productivity and nutritional value of 25 wheat cultivars from different countries, reported dry matter yields between 1.00 t ha^{-1} and 19.00 t ha^{-1}.

For the crude protein (CP) content, significant differences were observed in the developmental stages, cultivars and stage x cultivar interactions (Table 3). The highest crude protein content was observed at the grain rubber stage, with the exception of the triticale cultivars IPR 111 and wheat IPR POTYPORÃ and IPR PANATY, which showed no differences in CP between the developmental stages. The triticale cultivars IPR 111 and wheat IPR POTYPORÃ and IPR PANATY showed lower values of crude protein in rubber. With the grains at the stage of soft mass and harvest maturation, no difference was observed in the CP content of the wheat and triticale cultivars.

Table 3
Mean crude protein content (%) of wheat and triticale cultivars at different developmental stages. Janaúba - MG, 2021

Cultivars	Stages		
	Rubberization	Grain at the stage of soft mass	Harvest maturation
Triticale IPR 111	12,09 Ab	9,84 Aa	11,83 Aa
Wheat BRS 394	15,99 Aa	9,23 Ba	11,78 Ba
Wheat BRS 264	15,05 Aa	9,52 Ba	10,21 Ba
Wheat BRS 404	18,12 Aa	8,70 Ba	11,09 Ba
Wheat IPR POTYPORÃ	11,75 Ab	9,18 Aa	9,64 Aa
Triticale IPR AIMORÉ	16,71 Aa	8,79 Ba	8,28 Ba
Wheat IPR 144	16,75 Aa	9,02 Ca	12,19 Ba
Wheat IPR PANATY	10,78 Ab	8,77 Aa	9,64 Aa
Wheat IPR 85	15,73 Aa	9,11 Ba	9,75 Ba
Wheat IPR TAQUARI	16,40 Aa	9,53 Ba	10,52 Ba
SEM	0,88	0,89	0,91
P-value	Cultivars	0,01	
	Stages	0,01	
	Cultivars x Stages	0,01	

Means followed by the same uppercase letter horizontally within each cultivar and means with the same lowercase letter vertically within each period belong to the same cluster, according to the Scott-Knott test at 5% probability.

In an experiment with four wheat cultivars (BRS FIGUEIRA, BRS UMBU, BRS GUATAMBU and BRS TARUMÃ), five doses of nitrogen in fertilization (0, 0.045; 0.090; 0.135; and 0.180 t ha^{-1}) and different cutting management systems were observed. averages of 26.57% and 21.98% for the crude protein content with one and two cuts, respectively (Hastenpflug, Martin, Ziech, Simionatto, & Castagnino, 2011). Conversely, Wrobel et al. (2018) found a mean crude protein content of 6.96% in silage with grain in the soft mass. To analyze the effect of the cutting regime on the production and nutritional value of wheat cv. BRS Umbu for forage, Carletto et al. (2020) observed crude protein contents of 21.08% with one cut and 19.79% with two counts at 57 days after planting. Corroborating the results of the present study, there seems to be a trend in the reduction of CP contents with later harvests. It is possible that the increase in senescent leaves, stems and stem components contributed to this. According to Mancipe-Muñoz et al. (2021), when evaluating different wheat cultivars from different countries, crude protein levels ranging from 14.2% to 23.9% of dry matter were observed in these cultivars. Bartmeyer et al. (2011), while to evaluate the grain yield of the BRS 176 dual-purpose wheat cultivar and the cattle weight gain as a function of grazing periods, observed crude protein contents of 33.02%, 24.19%, 17.60% and 13.16% at 50, 65, 80 and 90 days, respectively, after plant emergence.

When analyzing the lignin content, significant differences were observed for the effects of developmental stages, cultivars and stage x cultivar interactions (Table 4). A similar behavior was observed for wheat cultivars BRS 264, IPR POTYPORÃ, IPR 144, IPR TAQUARI and triticale IPR AIMORÉ in lignin levels between harvest stages. At the rubber stage, the highest lignin content was observed in wheat cultivars BRS 394 and IPR PANATY. In the grain at the stage of soft mass, the wheat and triticale cultivars were similar, whereas in the harvest maturation of the grains, the BRS 404 wheat had the highest lignin content. Studies involving the evaluation of lignin content in wheat and triticale are not common in the literature. In one of the few studies, Meinerz et al. (2011) observed a lignin content of 4.26% for the triticale BRS 148 cultivar. In the same study, the authors observed lignin contents of 5.19%, 4.90%, 4.93% and 4.17% for the wheat cultivars BRS 277, BRS Guatambu, BRS Tarumã and BRS Umbu, respectively.

Table 4
Average lignin contents (%) of wheat and triticale cultivars at different developmental stages. Janaúba - MG, 2021

Cultivars	Stages		
	Rubberization	Grain at the stage of soft mass	Harvest maturation
Triticale IPR 111	2,75 Cc	6,90 Ba	13,83 Ab
Wheat BRS 394	12,91 Aa	7,90 Ba	9,05 Bc
Wheat BRS 264	10,72 Ab	7,42 Aa	7,14 Ac
Wheat BRS 404	9,13 Bb	6,78 Ba	21,82 Aa
Wheat IPR POTYPORÃ	7,95 Ab	6,97 Aa	9,05 Ac
Triticale IPR AIMORÉ	9,05 Ab	6,95 Aa	9,05 Ac
Wheat IPR 144	10,89 Ab	8,74 Aa	6,90 Ac
Wheat IPR PANATY	14,58 Aa	6,88 Ba	6,42 Bc
Wheat IPR 85	9,13 Ab	8,32 Aa	4,13 Bc
Wheat IPR TAQUARI	9,05 Ab	6,62 Aa	6,84 Ac
SEM	1,32	1,33	1,36
P-value	Cultivars	0,01	
	Stages	0,01	
	Cultivars x Stages	0,01	

Means followed by the same uppercase letter horizontally within each cultivar and means with the same lowercase letter vertically within each period belong to the same cluster, according to the Scott-Knott test at 5% probability.

When evaluating the total digestible nutrients (TDN), significant differences were observed for the effects of developmental stages and interactions x stages of wheat and triticale cultivars (Table 5). The highest levels of TDN for most of the cultivars were obtained in the rubberization stages and of grain at the stage of soft mass. The exception was the wheat cultivars BRS 394 and BRS 264. When comparing the cultivars within each developmental stage, it was observed that in the rubber and grain at the stage of soft mass, the TDN was similar for all tested materials. To harvest maturation of the grains, higher concentrations were found in the wheat cultivars BRS 394, BRS 264 and IPR PANATY. Hastenpflug et al. (2011), in a study evaluating wheat cultivars with increasing doses of nitrogen in fertilization and different cutting managements, observed TDN contents of 69.11%, 67.91%, 72, 49% and 67.31% for the cultivars BRS FIGUEIRA, BRS UMBU, BRS GUATAMBU and BRS TARUMÃ, respectively, in the first cut; in the second cut, the values observed for the same cultivars were 68.22%, 68.59%, 70.78% and 72.92%. Mancipe-Muñoz et al. (2021), in a study using 25 wheat cultivars to evaluate the yield and nutritional value of these cultivars from different countries, reported TDN contents ranging from 56.4% to 65.1% dry matter.

Table 5
Average levels of total digestible nutrients (TDN) of wheat and triticale cultivars at different stages of development. Janaúba - MG, 2021

Cultivars	Stages		
	Rubberization	Grain at the stage of soft mass	Harvest maturation
Triticale IPR 111	50,24 Aa	49,25 Aa	42,30 Bb
Wheat BRS 394	47,15 Aa	47,25 Aa	48,50 Aa
Wheat BRS 264	50,32 Aa	48,13 Aa	46,08 Aa
Wheat BRS 404	49,29 Aa	49,59 Aa	44,40 Bb
Wheat IPR POTYPORÃ	47,78 Aa	48,73 Aa	43,03 Bb
Triticale IPR AIMORÉ	47,10 Aa	49,96 Aa	43,51 Bb
Wheat IPR 144	47,78 Aa	47,46 Aa	42,56 Bb
Wheat IPR PANATY	50,63 Aa	51,13 Aa	45,91 Ba
Wheat IPR 85	48,73 Aa	47,41 Aa	42,52 Bb
Wheat IPR TAQUARI	49,54 Aa	49,24 Aa	41,77 Bb
SEM	1,24	1,26	1,28
P-value	Cultivars	0,01	
	Stages	0,01	
	Cultivars x Stages	0,01	

Means followed by the same uppercase letter horizontally within each cultivar and means with the same lowercase letter vertically within each period belong to the same cluster, according to the Scott-Knott test at 5% probability.

For the in vitro digestibility of NDF, significant differences were observed for the effects of developmental stages, wheat and triticale cultivars, and stage x wheat and triticale cultivar interactions (Table 6). When evaluating the wheat and triticale cultivars between the developmental stages, most of the best results were obtained in the rubber and grain at the stage of soft mass. Interestingly, the IPR 144 and IPR PANATY wheat cultivars showed no differences between the three developmental stages. In turn, within each stage of development, in rubber, the lowest in vitro digestibility of dry matter was observed in wheat cultivars IPR POTYMORÃ and IPR PANATY. For the grain at the stage of soft mass and harvest maturation of the grains, no differences were observed in the in vitro digestibility of NDF among the cultivars under study. In a study evaluating the nutritional value of green elephant grass harvested at different regrowth ages, Martins et al. (2020) found NDF digestibilities of 71.40%, 57.78% and 57.19% for cutting ages of 56, 84 and 112 days, respectively.

For indigestible NDF, significant differences were observed for the effects of developmental stages, wheat and triticale cultivars, and stage x wheat and triticale cultivar interactions (Table 7). When evaluating the indigestible NDF between the developmental stages, no difference was found between the three developmental stages for the triticale cultivars IPR 111 and IPR AIMORÉ and for the wheat cultivars BRS 394, BRS 264, IPR

POTYPORÃ, IPR 144 and IPR 85. Within each stage, there were no differences in indigestible NDF between the cultivars studied in the rubber treatment. In turn, grain at the stage of soft mass, the cultivars BRS 404 and IPR TAQUARI presented the highest levels of indigestible NDF, and for harvest maturation of the grains, higher concentrations of indigestible NDF were observed in the wheat cultivars BRS 394, IPR 144, IPR PANATY and IPR 85. In an experiment to analyze the nutritional value of elephant grass obtained at different cutting ages, a linear increase was observed for the concentration of indigestible NDF with increasing cutting age. Values of 20.64%, 21.33%, 20.37%, 29.07%, 30.75% and 34.64% were observed for cut-off ages of 30, 45, 60, 75, 90, and 105 days, respectively (R. H. de A. M. Costa, Cabral, Bhering, & Abreu, 2008). According to K. A. de P. Costa et al. (2007), the proportion of lignin and cellulose and other indigestible fractions increases, decreasing the digestibility of forage plants.

Table 6
Average results of the *in vitro* digestibility of NDF (NDFID) of wheat and triticale cultivars at different developmental stages. Janaúba - MG, 2021

Cultivars	Stages		
	Rubberization	Grain at the stage of soft mass	Harvest maturation
Triticale IPR 111	46,64 Aa	45,30 Aa	35,21 Ba
Wheat BRS 394	54,01 Aa	43,14 Ba	34,86 Ba
Wheat BRS 264	49,46 Aa	44,63 Aa	31,97 Ba
Wheat BRS 404	50,34 Aa	46,56 Aa	36,21 Ba
Wheat IPR POTYPORÃ	28,34 Bc	43,26 Aa	31,84 Ba
Triticale IPR AIMORÉ	46,85 Aa	44,18 Aa	34,71 Ba
Wheat IPR 144	47,10 Aa	44,20 Aa	40,79 Aa
Wheat IPR PANATY	39,05 Ab	42,39 Aa	39,25 Aa
Wheat IPR 85	46,11 Aa	46,12 Aa	34,26 Ba
Wheat IPR TAQUARI	53,17 Aa	44,53 Ba	43,94 Ba
SEM	2,93	2,97	3,04
P-value	Cultivars	0,01	
	Stages	0,01	
	Cultivars x Stages	0,01	

Means followed by the same uppercase letter horizontally within each cultivar and means with the same lowercase letter vertically within each period belong to the same cluster, according to the Scott-Knott test at 5% probability.

Table 7
Mean results for indigestible NDF (iNDF) of wheat and triticale cultivars at different stages of development. Janaúba - MG, 2021

Cultivars	Stages		
	Rubberization	Grain at the stage of soft mass	Harvest maturation
Triticale IPR 111	29,11 Aa	25,37 Ab	23,53 Ab
Wheat BRS 394	21,25 Aa	25,63 Ab	28,29 Aa
Wheat BRS 264	30,27 Aa	28,34 Ab	24,79 Ab
Wheat BRS 404	27,91 Ba	37,07 Aa	21,99 Bb
Wheat IPR POTYPORÃ	23,21 Aa	25,43 Ab	24,80 Ab
Triticale IPR AIMORÉ	24,51 Aa	23,74 Ab	23,56 Ab
Wheat IPR 144	26,28 Aa	30,03 Ab	35,21 Aa
Wheat IPR PANATY	18,66 Ba	28,10 Ab	29,23 Aa
Wheat IPR 85	27,40 Aa	28,51 Ab	32,25 Aa
Wheat IPR TAQUARI	28,88 Ba	36,46 Aa	23,37 Bb
SEM	2,62	2,65	2,71
P-value	Cultivars	0,01	
	Stages	0,01	
	Cultivars x Stages	0,01	

Means followed by the same uppercase letter horizontally within each cultivar and means with the same lowercase letter vertically within each period belong to the same cluster, according to the Scott-Knott test at 5% probability.

Conclusion

The best yield of digestible dry matter was observed with the wheat and triticale cultivars harvested as grains at the stage of soft mass. Triticale IPR 111 and IPR PANATY wheat have the highest production potential of dry matter with the best nutritional quality. It is possible to produce wheat and triticale as forage in semiarid animal feed. Depending on the cultivar and harvest stage, the dry matter yield reached 12.60 t ha^{-1}, 18.12% protein and 56.53% in vitro dry matter digestibility.

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