Research, Society and Development, v. 11, n. 10, e413111032729, 2022
(CC BY 4.0) | ISSN 2525-3409 | DOI: http://dx.doi.org/10.33448/rsd-v11i10.32729

Management of dual-purpose wheat genotypes by rotatinuous stocking

Manejo de genótipos de trigo de duplo propósito pela lotação rotatínua

Manejo de genotipos de trigo de doble propósito mediante siembra rotatínua

Received: 07/09/2022 | Reviewed: 07/26/2022 | Accept: 07/28/2022 | Published: 08/06/2022

Manuele Zeni
ORCID: https://orcid.org/0000-0003-0590-0000
Universidade de Passo Fundo, Brazil
E-mail: 94703@upf.br
Carlos Bondan
ORCID: https://orcid.org/0000-0002-4827-2609
Universidade de Passo Fundo, Brazil
E-mail: cbondan@upf.br
Renato Serena Fontaneli
ORCID: https://orcid.org/0000-0002-1970-4791
Embrapa Trigo, Brazil
E-mail: renato.fontaneli@embrapa.br
Angelica Consoladora Andrade Manfron
ORCID: https://orcid.org/0000-0001-8316-6169
Universidade de Passo Fundo, Brazil
E-mail: 126330@upf.br
Emanuel Dall'Agnol
ORCID: https://orcid.org/0000-0002-7041-2217
Universidade de Passo Fundo, Brazil
E-mail: dallagnolemanuel@gmail.com

Abstract
The objective was to evaluate whether rotatinuous stocking management in dual-purpose wheat genotypes provides greater forage performance compared to the traditional rotational grazing management, which could become an alternative to ryegrass, once this new management strategy has been validated. Three dual-purpose wheat cultivars (BRS Pastoreio, BRS Tarumã and BRS Tarumaxi) and a black oat cultivar (Embrapa 139 Neblina) were used in the experiment, in traditional rotational and rotatinuous stocking. The experiment was carried out in a randomized complete blocks design, with treatments arranged in a 4 x 2 factorial scheme (cultivars x management strategies), with pre and post-harvest heights in traditional rotational management (RT) of 25 and 5 cm, and 25 and 15 in the rotatinuous stocking management (RN). The experiment was carried out at Embrapa Trigo, in Passo Fundo, Rio Grande do Sul state, southern Brazil. Nitrogen was applied after sowing and after cuts, according to the management strategies. Dry matter yield, percentage of leaf blades and forage accumulation per cut and total were evaluated. Wheat cultivars in rotatinuous stocking management showed higher numbers of cuts, greater cycle, percentage of leaves and average rate of forage accumulation, with smaller intervals between cycles. The total forage production showed no difference between the cultivars, however, BRS Tarumaxi was higher in the rotatinuous stocking management. Thus, responses between the genotypes in relation to the management strategies adopted are different.
Keywords: *Triticum aestivum*; Nutritive value; Biomass; Grazing management.

Resumo
Objetivou-se avaliar se o manejo rotatínuo em genótipos de trigo de duplo propósito proporciona maior desempenho forrageiro em relação ao manejo rotativo tradicional, que poderá se tornar uma alternativa com espécies de gramíneas anuais de inverno ao azevém, uma vez validado essa nova estratégia de manejo. Foram utilizados no experimento três cultivares de trigo de duplo propósito (BRS Pastoreio, BRS Tarumã e BRS Tarumaxi) e uma de aveia preta (Embrapa 139 Neblina), em manejo rotativo tradicional e lotação rotatínua. O delineamento experimental em blocos casualizados, com os tratamentos arranjados no esquema fatorial 4 x 2 (cultivares x estratégias de manejo), sendo a altura de pré e pós-corte no manejo rotativo tradicional (RT) de 25 e 5 cm e no manejo lotação rotatínua (RN) 25 e 15 cm, respectivamente. O experimento foi desenvolvido na área experimental da Embrapa Trigo, em Passo Fundo, RS. Após a semeadura, foram realizadas adubações de cobertura e após os cortes, conforme as estratégias de manejo, sendo avaliada a produção, percentagem de lâminas foliares e a taxa de acúmulo de forragem por corte e total. As cultivares de trigo no manejo lotação rotatínua apresentaram maiores números de cortes, dias do ciclo, percentagem de folhas e taxa média de acúmulo de forragem, com menores intervalos de dias entre os ciclos. A produção total de forragem não demonstrou diferença entre os genótipos, no entanto, BRS Tarumaxi foi superior no manejo lotação rotatínua. Assim, respostas entre os genótipos frente às estratégias de manejo adotadas são distintas.
Palavras-chave: *Triticum aestivum*; Valor nutritivo; Biomassa; Manejo de pastejo.

Resumen
El objetivo fue evaluar si el manejo del trigo tradicional de rotación puede convertirse en una alternativa en relación al invierno para el ryegrass rotacional en relación al invierno para el ryegrass, una vez validada una nueva estrategia de manejo. Tres cultivares de trigo de doble propósito (BRS Pastoreio, BRS Tarumã y BRS Tarumaxi) y un cultivar de avena negra (Embrapa 139 Neblina) fueron utilizados en el experimento, en manejo tradicional y siembra rotacional. El diseño experimental fue en bloques al azar, con tratamientos dispuestos en esquema factorial 4 x 2 (cultivares x estrategias de manejo), con alturas pre y poscosecha en el manejo tradicional (RT) de 25 y 5 cm y en el media rotacional (RN) 25 y 15 cm, respectivamente. El experimento fue realizado en el área experimental de Embrapa Trigo, en Passo Fundo, RS. Como estrategias de manejo se realizaron fertilizaciones en cobertura y post cortes, después de la producción se determinó la proporción de hojas y la tasa de acumulación de forraje por corte y total. Al igual que los cultivares de trigo en el manejo, la siembra rotacional presentó mayores cortes, días de ciclo, número de hojas y promedio de tasa de acumulación de forraje, con menores intervalos de días entre ciclos. La producción total de forraje no difirió entre los genotipos, sin embargo, BRS Tarumaxi fue superior en el manejo de siembra rotacional. Así, las respuestas entre los genotipos en relación a las estrategias de elaboración elaboradas son diferentes.
Palabras clave: *Triticum aestivum*; Valor nutricional; Biomasa; Manejo de pastoreo.

1. Introduction

Livestock production in Brazil is mainly pasture-based, essentially due to environmental and economic aspects (Pezzopane et al., 2017). However, some factors related to the inefficiency in animal and forage management, associated with sanitary problems and the limited supply of low-cost, high-quality fodder, decrease the herd production rates to below their potential (Rodrigues et al., 2011).

Grazing management interferes with forage and animal production (Schons et al., 2021). Since tissue removal caused by defoliation modifies vegetation growth and competition, this altered structure determines forage intake and defoliation patterns performed by animals (Carvalho, 2013), and consequently reflects on pasture harvest responses and feed conversion (Schons et al., 2021), therefore, the structural and morphogenic characteristics of the plants suffering these influences, present different results for the cultivars of each species (Barbero et al., 2015).

Traditional grazing management practices do not prioritize animal performance, as they are based on increasing pasture harvest accumulation (Savian et al., 2018), among which is rotational management with resting periods (Marin et al., 2022), alternating the time the animals stay in the area.

Therefore, a new grazing management strategy has been studied, called rotatinuous stocking, which is based on the animal behavioral response to the structure of the pasture, and aims to obtain high levels of forage intake per unit of grazing time, thus, it was developed to identify the ideal heights considering animal behavior (Carvalho, 2013), requiring adequate pasture structures (Fonseca et al., 2012).

Planting small grains species in the winter period can contribute to animal feeding (Silveira et al., 2017) mainly through the use of idle areas (Tonato et al., 2014), and dual-purpose wheat is one of the alternatives (Meinerz et al., 2012).

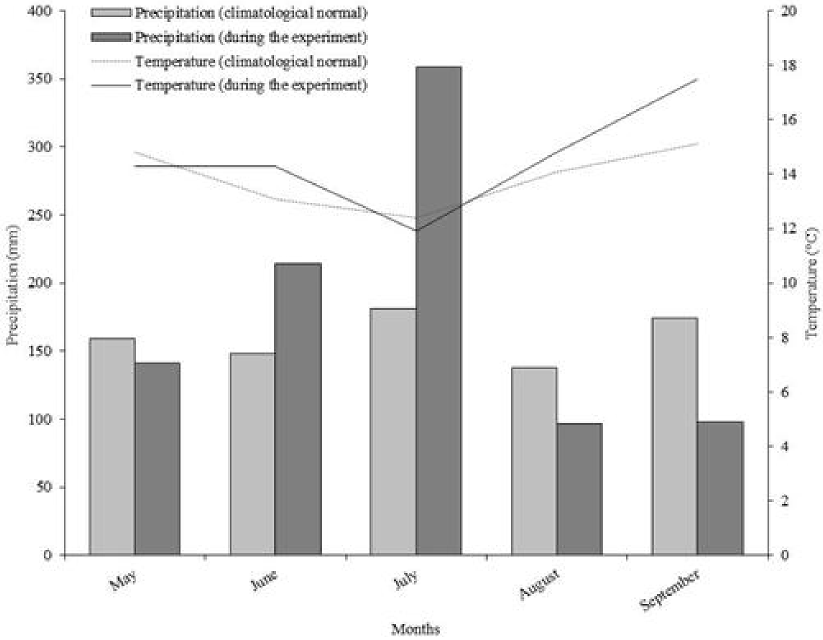
Due to the great importance livestock production systems have, it is necessary to understand the procedures involving grazing ecosystems, in order to provide strategies that improve the production and quality of food provided to humans. For livestock systems to be more productive, competitive and sustainable, knowledge of forage management strategies aimed at understanding the grazing process plays an elementary role (Savian et al., 2020b).

Wheat forage production can fluctuate due to management, being impacted according to the intensity and frequency of defoliation performed, and may respond differently according to each genotype. Thus, the present work has the general objective of evaluating whether rotatinuous grazing management in dual-purpose wheat genotypes provides greater forage performance than traditional rotational management.

2. Methodology

The experiment was conducted in 2020 at Embrapa Trigo, in Passo Fundo, Rio Grande do Sul state. The soil is classified as humic dystrophic Red Latosol (Streck et al., 2008), and the climate as subtropical humid (Cfa), with year-round rain and hot summers (Kuinchtner & Buriol, 2001). The monthly averages of rainfall and temperatures during the experiment period (May to September 2020) and the climatological normal (1981-2010) are represented in Figure 1.

Figure 1 - Temperature and precipitation averages, occurred during the experimental period (May to September 2020) and historical normal.



Source: Data referring to monthly rainfall were obtained from Embrapa Trigo, the climatological normal (1981-2010) were taken from the National Institute of Meteorology (INMET) (2021).

The treatments consisted of three genotypes (BRS Pastoreio, BRS Tarumã and BRS Tarumaxi) of double-purpose wheat (*Triticum aestivum* L.), compared with the black oat (*Avena strigosa* Schreb.) cultivar Embrapa 139 Neblina (control), in traditional rotational management and rotatinuous stocking, consisting of 8 treatments from a 4 x 2 factorial arrangement (cultivars x management strategies), arranged in a randomized block experimental design, with four replications and experimental units with an area of 8 m² (8 lines x 5 m x 0.2 m spacing).

Sowing took place on May 11, 2020, with a seed drill for plots (Semina 1®), at a density of 400 suitable seeds per m² in all treatments. 350 kg ha^{-1} of formulated fertilizer 05-25-25 (N-P_2O_5-K_2O) was applied before sowing, according to soil analysis (Table 1).

Table 1- Physicochemical attributes of the soil at 0-0.10 m depth in the experimental area.

Clay		pH	SMP	P	K	OM	Al	Ca	Mg
(g/dm³)	Text	water	index	(mg/dm³)		(g/dm³)	(mmol$_c$/dm³)		
605	2	6.4	6.4	50.8	331	31	0.0	69.8	33.1

Source: Embrapa Wheat.

The topdressing fertilization applied was the equivalent of 40 kg ha^{-1} of N, performed at the tillering stage, stage 2, according to the Feeks and Large scale (Large, 1954), with supplementation after cuts, in the dose of 30 kg ha^{-1} of N. Weed control was performed by manually.

In the traditional rotational management (RT), which aims to maximize forage use, the management goals were 25 cm in the pre-cut and 5 cm in the post-cut. In the rotatinuous stocking (RN) treatment, pasture management goals proposed by Carvalho (2013) were used, and the lowering should not exceed 40% of the optimal pre-grazing height (Fonseca et al., 2012; Mezzalira et al., 2014), therefore, the pre- and post-cut height were 25 and 15 cm, respectively.

In this experiment, before each cut, the height of the canopy (distance between the soil surface and the average top of the upper leaves) was measured with a ruler to determine the right moment to cut. Each paddock was manually trimmed with a sickle, in order to simulate grazing, being carried out successively in the vegetative stage when the plants reached the targeted height for each treatment (RT and RN). The herbage mass was obtained by cutting 0.6 m² of each paddock. After the samples were collected, the paddocks were trimmed with a mower to the targeted stubble height.

The fresh mass was weighed immediately after cutting and then two samples were taken, one of these samples was used to determine the dry matter content and the other to determine the percentage of leaf blades. The samples were weighed and dried at 60°C until they reached constant weight.

The material collected in the second sample was manually separated into green leaves (leaf blades + sheath) and stem. Each component was placed in properly identified paper bags, the mass was measured and dried, then weighed again, to calculate the percentage of leaf blades. The daily accumulation rate was determined by dividing the forage accumulation by the number of days between one cut and another.

Data were submitted for analysis of variance by the F test and, when significant, the means were compared by the Tukey test for the genotypes and the managements (rotational and rotatinuous stocking) by the 'Student's T' test at 5% probability of error occurrence, using Sisvar (Ferreira, 2011) statistical analysis program. Data were transformed to improve residual normality and homogeneity when needed.

3. Results and Discussion

3.1 Forage production

Sowing occurred on May 11, 2020. The cuts were performed according to each treatment, on different dates (Table 2). It can be observed that: cutting dates, resting periods, total number of cuts, and cycle (days after the emergence of the plants until the date of the last cut) were different between treatments, and presented variations according to each management.

The genotypes have some different characteristics, among them is the precocity of black oat (cv. Embrapa 139 Neblina) cut 58 days after emergence (DAE) on July 14, 2020. The others needed 64 (DAE) for the first cut to be performed (July 20, 2020), six days longer than black oat. A result that indicates the precocity at the beginning of its development cycle (Marques et al., 2014).

Table 2 - Cut dates, total cuts and cycle of wheat and black oat genotypes submitted to rotational management and rotatinuous stocking.

Treatments[1]	Number of cuts						Total	Cycle[4]
	1	2	3	4	5	6		
E (RT)	Jul/14 (58)[2]	Jul/31 (17)[3]	Aug/11 (11)	Sep/10 (30)	-	-	4	116
E (RN)	Jul/14 (58)	Jul/31 (17)	Aug/11 (11)	Sep/10 (30)	-	-	4	116
Pa (RT)	Jul/20 (64)	Jul/31 (11)	Aug/11 (11)	Sep/04 (24)	Sep/15 (11)	-	5	121
Pa (RN)	Jul/20 (64)	Jul/31 (11)	Aug/11 (11)	25/ago (14)	Sep/04 (10)	Sep/15 (11)	6	121
Tx (RT)	Jul/20 (64)	Aug/03 (14)	Sep/10 (38)	-	-	-	3	116
Tx (RN)	Jul/20 (64)	Aug/03 (14)	Aug/11 (8)	25/ago (14)	Sep/10 (10)	Sep/22 (11)	6	128
Ta (RT)	Jul/20 (64)	Aug/03 (14)	Sep/04 (32)	Sep/15 (11)	-	-	3	121
Ta (RN)	Jul/20 (64)	Aug/03 (14)	Aug/11 (8)	Aug/25 (14)	Sep/04 (10)	Sep/15 (11)	6	121

Notes: Conventional sign used: - null numerical value (cutting was not performed due to the plant height being below the values determined in each treatment, together with the ending of the plants cycle).
[1]E: black oat Embrapa 139 Neblina in rotational management (RT); and rotatinuous stocking (RN); Pa: wheat BRS Pastoreio under (RT) and (RN) managements; Tx: BRS Tarumaxi wheat under (RT) and (RN) managements; Ta: BRS Tarumã wheat under (RT) and (RN) managements. [2]DAE (days after emergence) in the first column; [3]DAC (days after cutting) in all columns except the first column. [4]Cycle in days after emergence (05/17/2020) to the date of the last cutting. Source: Authors (2022).

Authors such as Cassol et al. (2011) observed the possibility of starting grazing with animals between 45 and 60 days after emergence in black oat, provided that there is supplementation with nitrogen fertilization in this period. For wheat, it is described by Meinerz et al. (2012) that in later genotypes the cut was performed 72 days after emergence, later than observed in this work.

Resting periods ranged from 8 to 32 days. The largest and smallest intervals between cuts were found in cv. BRS Tarumã in RT and RN managements, respectively. The proportion of forage removed is related to pasture height (Mezzalira et al., 2013), and both the entrance and exit targeted heights must be respected, as plants can be harmed, and intense grazing will cause greater resting periods for recovery and establishment of the new canopy, increasing the interval between cycles (Barbero et al., 2015).

Manfron et al. (2022) required a resting period of 14 days between the first and second cut on wheat and black oat, cutting when plants reached 25 to 30 cm, leaving 7 to 10 cm of stubble height, similarly to what was acquired in the second cut with cv. BRS Tarumã in both managements (RT and RN). In ryegrass (*Lolium multiflorum* Lam.) the interval periods were between 13 and 35 days in RN and RT, respectively (Schons et al., 2021).

When analyzing the total number of cuts made in each treatment, it is noted that black oat tolerated 4 cuts, regardless of the management strategy, while for wheat cultivars, this number ranged from 3 to 6 cuts (BRS Tarumaxi and BRS Tarumã), with distinction according to the management performed. On cv. BRS Pastoreio, these values were 5 and 6, which may have influenced the cycle of the treatments. Schons et al. (2021), working with ryegrass, obtained 4 and 12 cuts in RT and RN stocking, respectively.

Due to sowing been carried out on May 11, 2020, it was necessary from 58 to 64 (DAE) to achieve the targeted cutting height, so it did not allow forage contribution in autumn, with 5 cuts during the winter and 1 in early spring. The peak of production obtained in most of the genotypes happened by the third and fourth cuts, in the winter season. Unlike Manfron et al. (2022), that sowed by broadcast on March 27, 2019, and 49 days after made the first cut in black oat and wheat, and 14 days after the second, summarizing 2 cuts made in the fall.

Therefore, earlier sowing allows for an increase in forage yield and greater vegetative cycle (Ferrazza et al., 2013b). Authors such as Lehmen et al. (2014) indicate the use of cultivars with a long cycle, so that there is a contribution in these critical periods. When compared to early species, these materials have greater tillering (Meinerz et al., 2012). Throughout the cuts, it is expected that there will be availability in forage production without oscillations during the months of development.

The results of forage production (Table 3) demonstrate that in the first evaluation period there was no statistical difference between the genotypes within the rotational management, unlike the rotatinuous stocking management in which there was a significant difference. The highest forage production in the first cut was for black oat in the rotatinous stocking management, with 399 kg ha^{-1} of DM, surpassing the wheat cultivars, which did not differ from each other (P>0.05). There was excessive rainfall in July (359 mm), 50% more than expected by the climatological normal. Kroth et al. (2015) report that excess water can reduce forage accumulation.

Results lower than those found by Manfron et al. (2022) that verified, in the first cut, yields of 1384 and 1237 kg ha^{-1} of DM in black oat and wheat, respectively. This may be related to the weather conditions that occurred in the period of that experiment. Minimum temperature and water regime are directly related to growth and forage accumulation (Araújo Júnior et al., 2021).

Table 3- Forage production per cut (kg ha^{-1} of DM), of wheat and black oat cultivars submitted to rotational management (RT) and rotatinuous stocking (RN).

Genotypes	Number of cuts					
	1		2		3	
	RT	RN	RT	RN	RT	RN
Black oat Embrapa 139	595 Ans	399 Aa	414 Ans	524 Aa	769 Ab	959 Aa
Wheat BRS Pastoreio	463 A	182 Bb	398 A	357 Aab	393 Ac	493 Ab
Wheat BRS Tarumaxi	401 A	183 Bb	510 A	399 Aab	1235 Aab	280 Bbc
Wheat BRS Tarumã	382 A	131 Bb	499 A	265 Bb	1391 Aa	253 Bc
Average (genotypes)	461 A	224 B	455 A	386 A	947 A	496 B
CV (%)	4.7		5.3		4.6	

Notes: Values within a column followed by the same lower case letter or in the same row followed by the same upper case letter are not different (P>0.05) by Tukey test for the genotypes and by the Student's t test (LSD) for the managements (Rotational and Rotatinuous stocking). ns: not significant by the F test (P>0.05). Source: Authors (2022).

When comparing the management strategies within each genotype, no difference was found for black oat (P>0.05), while for the wheat genotypes, rotational management was higher to rotatinuous stocking management for forage production in the first cut. Another relevant aspect according to Pereira et al. (2012) and Tafernaberri et al. (2012) for the choice of forage plants is the amount of leaf production, a component related to the nutritional value and digestibility of the plants. Regarding the percentage of leaf blade (Table 4), all treatments presented 100% in the first two cuts, with no statistical difference, which was expected due to the development stage. Small grains often have a high leaf/stem ratio (L/S) (Meinerz et al., 2011).

Table 4- Leaf blade percentage (%) per cut base on DM yield of wheat and black oat genotypes submitted to rotational management (RT) and rotatinuous stocking (RN).

Genotypes	Number of cuts					
	1		2		3	
	RT	RN	RT	RN	RT	RN
Black oat Embrapa 139	100 ns	100 ns	100 ns	100 ns	72 Ab	63 Bb
Wheat BRS Pastoreio	100	100	100	100	100 Aa	100 Aa
Wheat BRS Tarumaxi	100	100	100	100	59 Bc	100 Aa
Wheat BRS Tarumã	100	100	100	100	66 Bbc	100 Aa
Average (genotypes)	100 A	100 A	100 A	100 A	74 B	91 A
CV (%)	0.0		0.0		1.4	

Notes: Values within a column followed by the same lower case letter or in the same row followed by the same upper case letter are not different (P>0.05) by Tukey test for the genotypes and by the Student's t test (LSD) for the managements (Rotational and Rotatinuous stocking). ns: not significant by the F test (P>0.05). Source: Authors (2022).

For forage production in the second cut (Table 3), there was difference only for the rotatinuous management between genotypes, and cv. BRS Tarumã presented the lowest forage production (265 kg ha^{-1} of DM) while the other genotypes were statistically higher (P<0.05). Manfron et al. (2022) obtained 1303 kg ha^{-1} of DM with the same wheat cultivar in the second cut with traditional management. For the managements within each genotype, there was difference only in this cultivar, with the rotational management having the highest forage production, 499 kg ha^{-1} of DM.

In the third cut (Table 3), cv. BRS Tarumã in rotational management produced 1391 kg ha^{-1} of DM, differently from cv. BRS Pastoreio that produced only 393 kg ha^{-1} of DM in the same management, for the rotatinuous stocking management, black oat was statistically higher to the wheats with 959 kg ha^{-1} of DM. When comparing the managements within the genotypes, for BRS Tarumaxi and BRS Tarumã the rotational management was higher, while the others had no statistical difference.

BRS Pastoreio had 100% of leaf blades in the third cut (Table 4), the genotype with the lowest percentage was BRS Tarumaxi, with 59% in (RT) management, which accounts for a 1.44 L/S ratio, being statistically different (P<0.05). In the rotatinuous stocking management, only the black oat presented values lower than 100% of leaf blades, distinctly from the wheats that in this cut and management presented only leaves.

After the fourth cut (Table 5) some genotypes were not cut anymore, due to the plants not reaching the targeted height for each management strategy, together with the death of part of the canopy resulting from the successive cuts. The first cultivar to end its cycle in rotational management was BRS Tarumaxi, as it has taller plants, and probably the meristems were damaged by the cuts. In this management there was a difference between the genotypes, cv. BRS Tarumã showed lower values than the others. For the rotatinuous management, there was no difference between genotypes. Some factors interfere with the morphophysiological characteristics of forages that are influenced by environmental issues, crop management, and grazing (Alves et al., 2021).

Table 5- Forage production per cut (kg ha^{-1} of DM) of wheat and black oat genotypes submitted to rotational management (RT) and rotatinuous stocking (RN).

Genotypes	Number of cuts					
	4		5		6	
	RT	RN	RT	RN	RT	RN
Black oat Embrapa 139	624 Aa	728 Ans	0 Ab	0 Ac	0 Ans	0 Ac
Wheat BRS Pastoreio	904 Aa	905 A	348 Aa	360 Ab	0 B	470 Ab
Wheat BRS Tarumaxi	0 Bc	681 A	0 Bb	688 Aa	0 B	805 Aa
Wheat BRS Tarumã	323 Bb	668 A	0 Bb	495 Ab	0 B	480 Ab
Average (genotypes)	463 B	746 A	87 B	386 A	0 B	439 A
CV (%)	5.0		5.5		7.1	

Notes: Values within a column followed by the same lower case letter or in the same row followed by the same upper case letter are not different (P>0.05) by Tukey test for the genotypes and by the Student's t test (LSD) for the managements (Rotational and Rotatinuous stocking). ns: not significant by the F test (P>0.05). Source: Authors (2022).

For leaf blades percentage (Table 6) in the fourth cut, both black oat and cv. BRS Pastoreio showed higher values at rotational management, distinctly, in the rotatinuous management, black oat was statistically lower than the other genotypes with 77% (3.36 of L/S ratio). The authors Schons et al. (2021) mention that the proportion of leaves on ryegrass in pre-grazing in the months of June, July and September did not differ between the treatments (RT and RN), however, the treatment (RN) presented higher values in June, with variations throughout the development.

The fifth cut was performed only in cv. BRS Pastoreio at rotational management (Table 5), the other genotypes were cut 3 or 4 times in this management. For the rotatinuous management, the first material to finish the cutting cycles was black oat, the wheats tolerated more than 5 cuts. In this management, the cultivar BRS Tarumaxi was higher to the rest of the materials, presenting 688 kg ha^{-1} of DM of forage production.

In this cut (Table 6), BRS Pastoreio presented 57% of leaf blades (1.34 L/S ratio) in rotational management, therefore, 43% of the cut forage was composed of stems. In the rotatinuous management, the percentage of leaf blades was lower than 100%, and these values ranged from 70 to 79%. The resting period of pastures determines the frequency of defoliation, alters the tillering, the number of leaves and the interception of photosynthetically active radiation (Santana et al., 2017).

Table 6- Leaf blade percentage (%) per cut based on DM yield of wheat and black oat genotypes submitted to rotational management (RT) and rotatinuous stocking (RN).

Genotypes	Number of cuts					
	4		5		6	
	RT	RN	RT	RN	RT	RN
Black oat Embrapa 139	83 Aa	77 Ab	0 Ab	0 Ab	0 Ans	0 Ab
Wheat BRS Pastoreio	68 Ba	100 Aa	57 Ba	70 Aa	0 B	48 Aa
Wheat BRS Tarumaxi	0 Bc	100 Aa	0 Bb	71 Aa	0 B	44 Aa
Wheat BRS Tarumã	49 Bb	100 Aa	0 Bb	79 Aa	0 B	40 Aa
Average (genotypes)	50 B	94 A	14 B	55 A	0 B	33 A
CV (%)	3.3		5.0		13.1	

Notes: Values within a column followed by the same lower case letter or in the same row followed by the same upper case letter are not different (P>0.05) by Tukey test for the genotypes and by the Student's t test (LSD) for the managements (Rotational and Rotatinuous stocking). ns: not significant by the F test (P>0.05). Source: Authors (2022).

In the sixth cut (Table 5), it is noted that no genotype was cut in the rotational management, therefore, the wheat cultivars were cut only in the rotatinuous stocking management, and BRS Tarumaxi was higher to the other wheat genotypes with 805 kg ha^{-1} of DM forage production. Regarding the leaf blades percentage, there was no distinction between wheat cultivars. Grazing methods with lower intensities and defoliation periods cause less impact on forage (Liu & Li, 2010) a fact related to the rotatinuous stocking management that allows a greater number of cycles, due to lower defoliation and grazing intensity.

BRS Tarumaxi presented 44% of leaf blades (0.79 L/S) in the sixth cut in the rotatinuous stocking management, the other wheat genotypes presented lower L/S ratio. The increase of stems interferes with animal performance, causing longer rumination time and resistance to chewing (Moreira et al., 2001).

3.2 Total forage production

Table 7 shows the limit values of significance for factors related to total forage production.

Table 7 - Limit values of the significance level in percentage by the F test and coefficient of variation for the variables: total forage production, total production of leaves and stems (kg ha^{-1} of DM), percentage (%) of leaf blades and stem and daily average rate of total forage accumulation (kg ha^{-1} day^{-1} of DM).

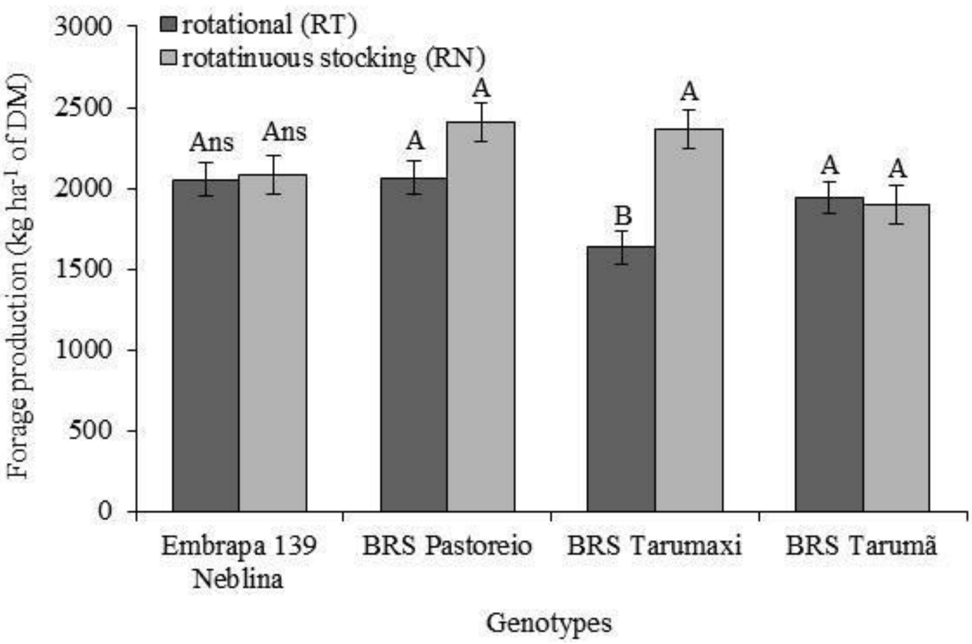
Factors	Total production	Leaf production	Straw production	Leaf blade	Straw percentage	Rate
Genotypes (GE)	0.28 ns	1.40 ns	1.69 ns	5.66 *	4.59 *	0.31 ns
Management (MA)	3.66 ns	6.55 *	0.03 ns	1.51 ns	1.10 ns	2.24 ns
Int. (GE) x (MA)	2.50 ns	2.71 ns	3.39 *	5.21 *	5.23 *	1.56 ns
CV (%)	2.26	2.07	6.26	1.13	8.04	5.47

Note: ns: not significant; *Significant by the F test (P<0.05) of probability. Source: Authors (2022).

For total leaf blade production (Figure 2), no difference was verified (P<0.05) between the genotypes within each management, however, for managements within each genotype, rotatinuous stocking management was higher to the rotational management for BRS Tarumaxi, with 2364 and 1634 kg ha^{-1} of DM, successively. This represents 78 and 76% of the total average percentage of leaf blades, which means 3.18 and 3.51 of L/S, respectively (Figure 4). The combination of ideal height and light forage depletion favors the animals to have access to the upper stratum, where leaves predominate, and consequently, regrowth is accelerated due to the greater foliar residue (Schons et al., 2021).

Values similar to those reported by Meinerz et al. (2012), who performed three cuts on wheat (cv. BRS Tarumã) in traditional management. The L/S ratio ranged from 0.67 to 4.46, with the highest value in the first cut, and a successive reduction in the other cuts. The decrease in the L/S ratio is caused by reserve mobilization, a decrease in leaves number and consequently, an increase in stems (Castagnara et al. 2010). The proportion of pre-grazing stems varies over the months, in ryegrass the authors Schons et al. (2021) describe that in June and July with (RN) stocking the proportion was lower, in contrast with August and September where there was no difference (P>0.05) between the management strategies.

Figure 2 - Total leaf blade production (kg ha^{-1} of DM) of wheat and black oat cultivars submitted to rotational management and rotatinuous stocking.

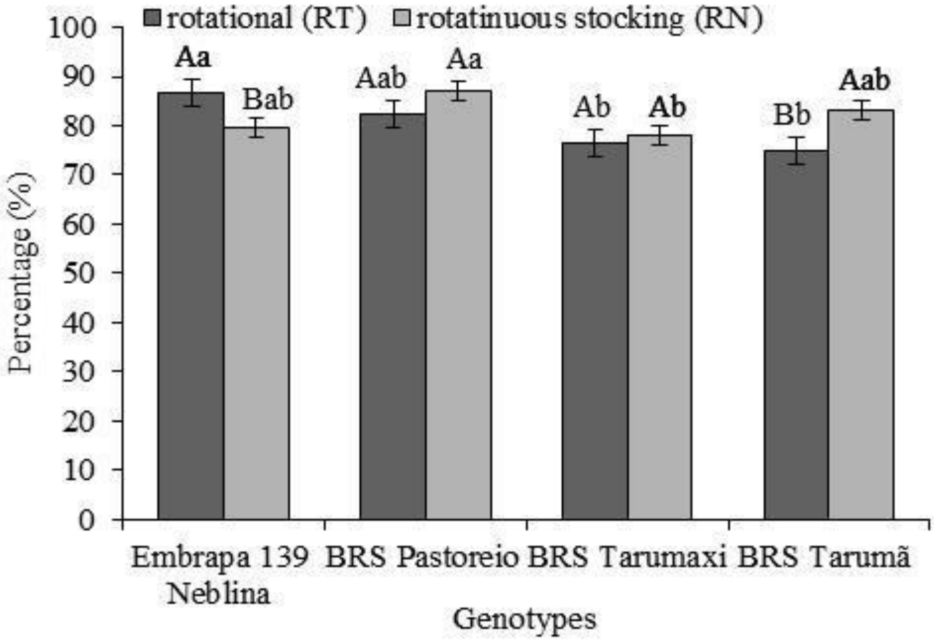


Notes: Means followed by the same uppercase letter comparing managements (Rotational and Rotatinuous stocking), by cultivar, are not different (P>0.05) by Student's t test (LSD). ns: not significant by the F test (P>0.05). Vertical thin bars indicate the standard error of the mean. Source: Authors (2022).

Both managements showed statistical differences between the genotypes, and in the rotational management, black oat showed higher leaf blade values than the others with 87% and a leaf/stem ratio of 5.89. In the rotatinuous management, cv. BRS Pastoreio was 87% higher than the other genotypes, presenting a 6.63 L/S ratio.

In the comparison of genotypes within each management, inverse behaviors were observed (Figure 3). In black oat, the highest leaf blade percentage was in the rotational management with 87% in contrast to 80% at rotatinuous, and an L/S ratio of 5.89 and 3.94, respectively. For cv. BRS Tarumã, the rotatinuous management was higher (83% of leaf blades) and 75% in the rotational, resulting in L/S ratios of 4.83 and 2.95, respectively. Similarly, Savian et al. (2018) obtained a higher L/S ratio in RN management, but for Savian et al. (2020b), the pre-grazing leaf/stem ratio (~2.87) did not differ between treatments (RT and RN).

Figure 3- Total leaf blade average percentage (%) of wheat and black oat cultivars submitted to rotational management and rotatinuous stocking.



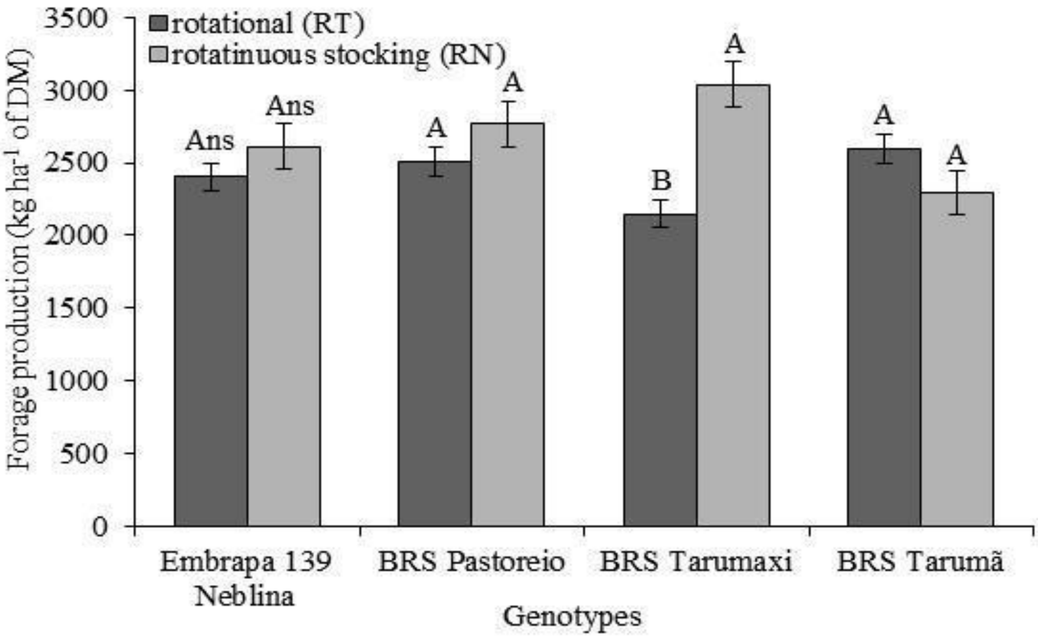
Notes: Means followed by the same uppercase letter, compare managements within each cultivar, and same lowercase letter, between cultivars within each management, are not different (P>0.05) by Tukey's test for genotypes and by Student's t test (LSD) for management (Rotational and Rotatinuous stocking). ns: not significant by the F test (P>0.05). Vertical thin bars indicate the standard error of the mean. Source: Authors (2022).

For the total dry matter production (Figure 4), no difference was observed ($P<0.05$) between the genotypes for both rotational and rotatinuous managements. However, when the managements within each genotype are analyzed, it is noted that the cultivar BRS Tarumaxi was higher in the rotatinuous stocking management, with 3037 kg ha^{-1} of DM and 2146 kg ha^{-1} of DM in rotational stocking, there were no differences for the other treatments.

In black oat, there was no significance between the managements, and the production values were 2610 and 2403 kg ha^{-1} of DM in (RN and RT) managements, respectively. Results below those found by Ferrazza et al. (2013a), in black oat and wheat cv. BRS Tarumã. They verified yields of 4277 and 5981 kg ha^{-1} of DM, respectively, in traditional management (25 cm height and 7 cm waste). Materials that have later production cycles usually present higher forage production (Meinerz et al., 2012).

Differently from De Souza Filho et al. (2019), who observed that forage mass in continuous stocking was inversely proportional to grazing intensity (10, 20, 30 and 40 cm), increasing with forage height (black oat and ryegrass mixture). Schons et al. (2021) with ryegrass in rotatinuous stocking (18 and 11 cm before and after grazing) obtained a total forage production of 8714 kg ha^{-1} of DM, being significantly higher than the rotational stocking (25 and 5 cm before and after grazing), with 6822 kg ha^{-1} of DM.

Figure 4 - Total forage production (kg ha^{-1} of DM) of wheat and black oat cultivars submitted to rotational management and rotatinuous stocking.



Notes: Means followed by the same uppercase letter compare managements (Rotational and Rotatinuous stocking) within each cultivar, are not different (P>0.05) by Student's t test (LSD); ns: not significant by the F test (P>0.05). Vertical thin bars indicate the standard error of the mean. Source: Authors (2022).

In June and July, the precipitation that occurred during the development of the experiment was 69 and 50% higher than the climatological normal (Figure 1). In August and September, rainfall was lower, with 42 and 78% less rain in relation to the climatological normal, only 97 and 98 mm per month, respectively. Climatic conditions impact plants during their development, the decrease or excess in rainfall can reduce the production and nutritional value of pastures (Lee et al., 2013) presenting a challenge to obtaining profitability (Chang-Fung-Martel et al., 2017). These factors may be related to the low forage production observed in this study.

3.3 Average forage accumulation rate

Managing pasture based on canopy height in the tillering rate, by impacting the competition that occurs for light and the mobilization of reserves (Silveira et al., 2010). The daily dry mass accumulation rate of the first cut differed between the two managements (Table 8), and black oat was higher in both rotational and rotatinuous stocking, for the second cut, we noticed that there was no such difference. On cv. BRS Tarumã, when comparing the managements, the rotational was higher, presenting an average accumulation rate of 36 kg ha^{-1} day^{-1} of DM, the other genotypes had no significant differences. Differently from what was described by Meinerz et al. (2012), who verified values of 30 and 32 kg ha^{-1} day^{-1} of DM in wheat and black oat at first cut, respectively.

Table 8 - Average forage accumulation rate (kg ha^{-1} day^{-1} of DM) of the first and second cut of wheat and black oat genotypes submitted to rotational management (RT) and rotatinuous stocking (RN).

Genotypes	First cut		Second cut	
	RT	RN	RT	RT
Black oat Embrapa 139	10 Aa	7 Ba	24 Ans	31 Ans
Wheat BRS Pastoreio	7 Aab	3 Bb	36 A	32 A
Wheat BRS Tarumaxi	6 Ab	3 Bb	36 A	28 A
Wheat BRS Tarumã	6 Ab	2 Bb	36 A	19 B
Average (genotypes)	7 A	4 B	33 A	28 A
CV (%)	12.5		8.9	

Notes: Values within a column followed by the same lower case letter or in the same row followed by the same upper case letter are not different (P>0.05) by Tukey test for the genotypes and by the Student's t test (LSD) for the managements (Rotational and Rotatinuous stocking). ns: not significant by the F test (P>0.05). Source: Authors (2022).

In the third cut (Table 9) black oat is higher in both managements, presenting values of 70 and 87 kg ha^{-1} day^{-1} of DM in the rotational and rotatinuous management, respectively. It is noticed that in the fourth cut the cv. BRS Pastoreio is statistically higher to black oat in rotational management with values of 38 and 21 kg ha^{-1} day^{-1} of DM. Meinerz et al. (2012), verified the forage accumulation rates in black oat and wheat of 61 and 49 kg ha^{-1} day^{-1} of DM, in the third cut, therefore, values lower than those found in this study for black oat.

In the rotatinuous stocking management, the wheat cultivars were higher to black oat. When observing the managements within the genotypes, only the fourth cut showed a statistical difference, and for the wheats in the rotatinuous stocking management, the growth rates were higher.

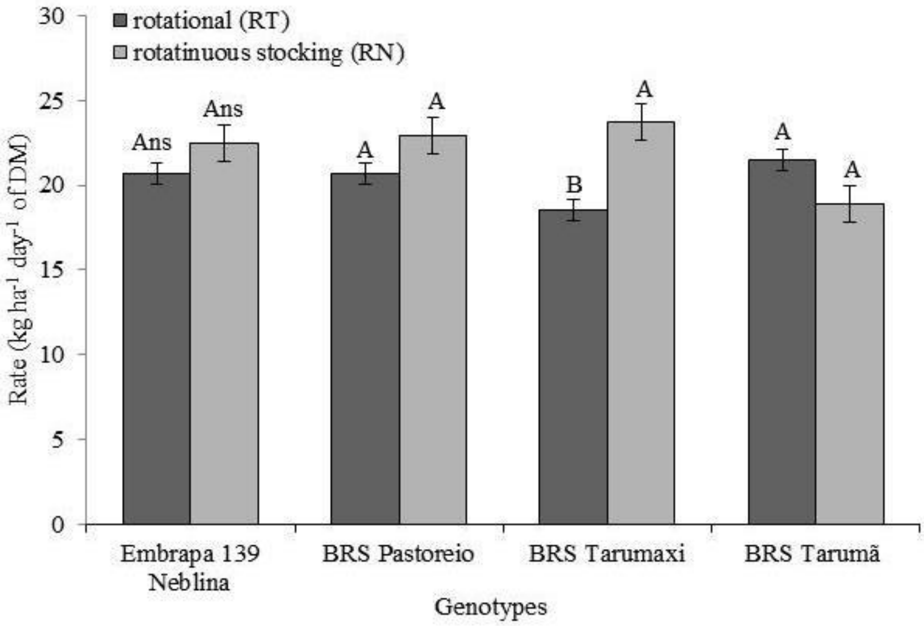
Table 9 - Average forage accumulation rate (kg ha^{-1} day^{-1} of DM) of the third and fourth cuts of wheat and black oat genotypes submitted to rotational management (RT) and rotatinuous stocking (RN).

Genotypes	Third cut		Fourth cut	
	RT	RN	RT	RN
Black oat Embrapa 139	70 Aa	87 Aa	21 Ab	24 Ab
Wheat BRS Pastoreio	36 Ab	45 Ab	38 Ba	65 Aa
Wheat BRS Tarumaxi	32 Ab	35 Ab	0 Bc	43 Aa
Wheat BRS Tarumã	43 Aab	32 Ab	29 Bab	48 Aa
Average (genotypes)	45 A	50 A	22 B	46 A
CV (%)	7.6		8.6	

Notes: Values within a column followed by the same lower case letter or in the same row followed by the same upper case letter are not different (P>0.05) by Tukey test for the genotypes and by the Student's t test (LSD) for the managements (Rotational and Rotatinuous stocking). ns: not significant by the F test (P>0.05). Source: Authors (2022).

For the average total forage accumulation rate (Figure 5), the managements within the genotypes were not significant, but for the managements within each genotype, the cultivar BRS Tarumaxi was higher in rotatinuous stocking, with 24 kg ha^{-1} day^{-1} of DM and 18 kg ha^{-1} day^{-1} of DM in rotational stocking. The greater leaf blade residue amounts along with the L/S ratio may explain the higher average rates of forage accumulation (Meinerz et al., 2012), according to the genotypes and managements used. Intense grazing extends the recovery and reestablishment of the canopy (Barbero et al., 2015). In continuous management, mixtures of black oat and ryegrass at different grazing intensities resulted in the daily forage accumulation rates without differences between treatments (De Souza Filho et al., 2019).

Figure 5 - Average rate of total forage accumulation (kg ha^{-1} day^{-1} of DM) of wheat and black oat genotypes submitted to rotational management and rotatinuous stocking.



Notes: Means followed by the same uppercase letter compare managements (Rotational and Rotatinuous stocking) within each cultivar are not different (P>0.05) by Student's t test (LSD). ns: not significant by the F test (P>0.05). Vertical thin bars indicate the standard error of the mean. Source: Authors (2022).

The choice of appropriate grazing management contributes both to animal production and to the reduction of environmental impacts (De Souza Filho et al., 2019), which is essential in pasture-based systems in order to reduce CH4 intensity and yield on a global scale (Savian et al., 2020a). The rotatinuous stocking strategy is technologically adaptable and conceptually applicable in properties distributed around the world (Savian et al., 2020a), however, to promote the use of this new strategy, the behavioral responses of animals to the pasture structure must be considered (Schons et al., 2021), evaluating different forage species and animal categories.

4. Conclusion

Our study shows that the responses are different among genotypes of the same forage species.

Wheat genotypes in rotatinuos stocking management showed higher numbers of cuts, cycle days, leaves percentage and average rate of forage accumulation, with smaller resting periods between cuts.

The leaf blade production in black oat showed an opposite response to wheat regarding its management, obtaining higher amounts in rotational management.

Throughout the development of the crops, in both strategies there were oscillations in forage production per cut, and forage production peaks are higher in the third and fourth cuts, at the end of winter.

BRS Tarumaxi wheat produced more with rotatinuous stocking.

Finally, we suggest for future work that some factors must be considered for greater adoption of the rotatinuous management strategy in rural properties, among them understanding the responses of each genotype and the nutritive value of the pasture within the management along with the behavioral responses of the animals concerning the structure of the pasture.

Acknowledgments

Author M. Z. gratefully acknowledges the CAPES postgraduate grant from the Ministry of Education, along with Embrapa Trigo and (UPF) for supporting the development of the experiment.

References

Alves, C. P., Cirino Júnior, B., Rocha, A. K. P., Vieira, D. S. M. de M., Eugênio, D. da S., & Leite, M. L. de M. V. (2021). Respostas morfofisiológicas das plantas forrageiras sob manejo de cultivo e pastejo: Uma revisão. *Research, Society and Development,* 10 (6), e10610615405. http://dx.doi.org/10.33448/rsd-v10i6.15405

Araújo Júnior, G. N., Jardim, A. M. da R. F., Silva, M. J, Alves, C. P., Souza, C. A. A., Costa, S. A. T., Cunha, M. V., Simões, A. do N., Silva, J. R. I, Souza, L. S. B., & Silva, T. G. F. (2021). Growth dynamics and accumulation of forage mass of forage cactus clones as affected by meteorological variables and water regime. *European Journal of Agronomy*, 131, 126375. https://doi.org/10.1016/j.eja.2021.126375

Barbero, L. M., Basso, K. C., Igarasi, M. S., Paiva, A. J., & Basso, F. C. (2015). Respostas morfogênicas e estruturais de plantas tropicais submetidas à desfolhação. *Boletim de Indústria Animal*, 72 (4), 321-330. https://doi.org/10.17523/bia.v72n4p321

Carvalho, P. C. de F. (2013) Harry Stobbs Memorial Lecture: Can grazing behavior support innovations in grassland management?. *Tropical Grasslands - Forrajes Tropicales*, 1 (2), 137-155. https://doi.org/10.17138/tgft(1)137-155

Cassol, L. C., Piva, J. T., Soares, A. B., & Assmann, A. L. (2011). Produtividade e composição estrutural de aveia e azevém submetidos a épocas de corte e adubação nitrogenada. *Revista Ceres*, 58 (4), 438-443. https://doi.org/10.1590/S0034-737X2011000400006

Castagnara, D. D., Rádis, A. C., Souza, L. C., Souza, F. H., Neres, M. A., & Mesquita, E. E. (2010). Características estruturais e produtivas da aveia preta comum em cinco idades de rebrote na região Oeste do Paraná. *Cultivando o Saber,* 3 (2), 116-129. https://cultivandosaber.fag.edu.br/index.php/cultivando/article/view/251/173

Chang-Fung-Martel, J., Harrison, M. T., Rawnsley, R., Smith, A. P., & Meinke, H. (2017). O impacto de eventos climáticos extremos em sistemas leiteiros a pasto: uma revisão. *Crop and Pasture Science,* 68 (12), 1158. https://doi.org/10.1071/cp16394

De Souza Filho, W., Nunes, P. A. de A., Barro, R. S., Kunrath, T. R., de Almeida, G. M., Genro, T. C. M., Bayer, C., & Carvalho, P. C. de F. (2019). Mitigation of enteric methane emissions through pasture management in integrated crop-livestock systems: Trade-offs between animal performance and environmental impacts. *Journal of Cleaner Production,* 213, 968-975. https://doi.org/10.1016/j.jclepro.2018.12.245

Ferrazza, J. M., Soares, A. B., Martin, T. N., Assmann, A. L., Migliorini, F., & Nicola, V. (2013a). Dinâmica de produção de forragem de gramíneas anuais de inverno em diferentes épocas de semeadura. *Ciência Rural,* 43 (7), 1174-1181. https://doi.org/10.1590/S0103-84782013005000086

Ferrazza, J. M., Soares, A. B., Martin, T. N., Assmann, A. L., & Nicola, V. (2013b). Produção de forrageiras anuais de inverno em diferentes épocas de semeadura. *Revista Ciência Agronômica*, 44 (2), 379-389, 2013b. https://doi.org/10.1590/S1806-66902013000200022

Ferreira, D. F. (2011). Sisvar: a computer statistical analysis system. *Ciência e Agrotecnologia,* 35, 1039-1042. http://doi.org/10.1590/S1413-70542011000600001

Fonseca, L., Mezzalira, J. C., Bremm, C., Filho, R. S. A., Gonda, H. L., & Carvalho, P. C. de. F. (2012). Management targets for maximising the short-term herbage intake rate of cattle grazing in *Sorghum bicolor*. *Livestock Science*, 145 (1-3), 205-211. https://doi.org/10.1016/j.livsci.2012.02.003

Instituto Nacional de Meteorologia (2021). *Normais Climatológicas do Brasil, 1981-2010*. https://portal.inmet.gov.br/normais

Kroth, B. E., Bonfim-Silva, E. M., Silva, T. J., Koetz, M., & Schlichting, A. F. (2015). Cultivares de *Brachiaria brizantha* sob diferentes disponibilidades hídricas em Neossolo Flúvico. *Revista Brasileira de Engenharia Agrícola e Ambiental*, 19 (5), 464-469. https://doi.org/10.1590/1807-1929/agriambi.v19n5p464-469

Kuinchtner, A., & Buriol, G. A. (2001). Clima do Estado do Rio Grande do Sul segundo a classificação climática de Köppen e Thornthwaite. *Disciplinarum Scientia,* 2, 171-182. https://periodicos.ufn.edu.br/index.php/disciplinarumNT/article/view/1136

Large, E. C. (1954). Growth stage in cereals: illustration of the Feekes scale. *Plant Pathology*, 3, 128-129. http://doi.org/10.1111/j.1365-3059.1954.tb00716.x

Lee, J. M., Clark, A. J., & Roche, J. R. (2013). Climate change effects and adaptation options for temperate pasture based dairy farming systems: a review. *Grass and Forage Science*, 68, 485-503. https://doi.org/10.1111/gfs.12039

Lehmen, R. I., Fontaneli, R. S., Fontaneli, R. S., & Santos, H. P. dos (2014). Rendimento, valor nutritivo e características fermentativas de silagens de cereais de inverno. *Ciência Rural,* 44 (7), 1180-1185. https://doi.org/10.1590/0103-8478cr20130840

Liu, Z. G.; Li, & Z. Q. (2010). Effects of different grazing regimes on the morphological traits of Carex duriuscula on the Inner Mongolia steppe, China. *New Zealand Journal of Agricultural Research*, 53 (1), 5-12. https://doi.org/10.1080/00288231003606047

Manfron, A. C. A., Bondan, C., Fontaneli, R. S., & Zeni, M. (2022). Sobresemeadura de forrageiras na entressafra de grãos no Brasil. *Research, Society and Development,* 11 (5), e10111527914. http://dx.doi.org/10.33448/rsd-v11i5.27914

Marin, L., Quadros, F. L. F. de, Oliveira, L. B. de, Nascimento, P. L. do, Vicari, T., Antonello, L., & Souza, A. N. M. de (2022). Does first and last stocking could "fits" Campos grassland structure to improve beef cattle production?. *Ciência Rural*, 52 (12), e20210531. https://doi.org/10.1590/0103-8478cr20210531

Marques, A. C. R., Krolow, R. H., Rigodanzo, E. L., Basso, L. J., & Botta, R. A., Missio, E. (2014). Desempenho da mistura de aveia preta e azevém em função da adubação orgânica e mineral. *Revista Ceres*, 61 (1), 112-120. https://doi.org/10.1590/S0034-737X2014000100015

Meinerz, G. R., Olivo, C. J., Fontaneli, R. S., Agnolin, C. A., Fontaneli, R. S., Horst, T., Viégas, J., & Bem, C. M. de. (2011). Valor nutritivo da forragem de genótipos de cereais de inverno de duplo propósito. *Revista Brasileira de Zootecnia,* 40 (6), 1173-1180. https://doi.org/10.1590/S1516-35982011000600003

Meinerz, G. R., Olivo, C. J., Fontaneli, R. S., Agnolin, C. A., Horst, T., & Bem, C. M. de (2012). Produtividade de cereais de inverno de duplo propósito na depressão central do Rio Grande do Sul. *Revista Brasileira de Zootecnia,* 41, 873-882. https://doi.org/10.1590/S1516-35982012000400007

Mezzalira, J. C., Carvalho, P. C. de F., Fonseca, L., Bremm, C., Cangiano, C., Gonda, H. L., & La, E. A. (2014). Behavioural mechanisms of intake rate by heifers grazing swards of contrasting structures. *Applied Animal Behaviour Science,* 153, 1-9. https://doi.org/10.1016/j.applanim.2013.12.014

Mezzalira, J. C., Carvalho, P. C. F., Amaral, M. F., Bremm, C., Trindade, J. K., Gonçalves, E. N., Genro, T. C. M., & Silva, R. W. S. M. (2013). Manejo do milheto em pastoreio rotativo para maximizar a taxa de ingestão por vacas leiteiras. *Arquivo Brasileiro de Medicina Veterinária e Zootecnia*, 65 (3), 833-840. https://doi.org/10.1590/S0102-09352013000300032

Moreira, F. B., Cecato, U., Prado, I. N., Wada, F. Y., Rego, F. C. A., & Nascimento, W. G. (2001). Avaliação da aveia preta cv. Iapar 61 submetida a níveis crescentes de nitrogênio em área proveniente de cultura de soja. *Acta Scientiarum*, 23 (4), 815-821. https://doi.org/10.4025/actascianimsci.v23i0.2608

Pereira, E. A., Barros, T., Volkmann, G. K., Battisti, G. K., Silva, J. A. G. da, Simioni, C., & Dall'Agnol, M. (2012). Variabilidade genética de caracteres forrageiros em *Paspalum*. *Pesquisa agropecuária brasileira,* 47 (10), 1533-1540. https://doi.org/10.1590/S0100-204X2012001000017

Pezzopane, J. R. M., Santos, P. M., Evangelista, S. R. M., Bosi, C., Cavalcante, A. C. R., Bettiol, G. M., Miranda Gomide, C. A. de, & Pellegrino, G. Q. (2017). *Panicum maximum* cv. Tanzânia: climate trends and regional pasture production in Brazil. *Grass and Forage Science*, 72 (1), 104-117. https://doi.org/10.1111/gfs.12229

Rodrigues, D. A., Avanza, M. F. B., & Dias, L. G. G. G. (2011). Sobressemeadura de aveia e azevém em pastagens tropicais no inverno. *Revista Científica Eletrônica de Medicina Veterinária*, 9 (16), 1-22. http://faef.revista.inf.br/imagens_arquivos/arquivos_destaque/Xuh4UcEksPD3TLT_2013-6-26-11-14-53.pdf

Santana, S. S., Brito, L. F., Azenha, M. V., Oliveira, A. A., Malheiros, E. B., Ruggieri, A. C., & Reis, R. A. (2017). Canopy characteristics and tillering dynamics of Marandu palisade grass pastures in the rainy-dry transition season. *Grass and Forage Science*, 72 (2), 261-270. https://doi.org/10.1111/gfs.12234

Savian, J. V., Schons, R. M. T., Marchi, D. E., Freitas, T. S., Silva Neto, G. F. da, Mezzalira, J. C., Berndt, A., Bayer, C., & Carvalho, P. C. de F. (2018). Rotatinuous stocking: A grazing management innovation that has high potential to mitigate methane emissions by sheep. *Journal of Cleaner Production*, 186, 602-608. https://doi.org/10.1016/j.jclepro.2018.03.162

Savian, J. V., Schons, R. M. T., de Souza Filho, W., Zubieta, A. S., Kindlein, L., Bindelle, J., Bayer, C., Bremm, C., & Carvalho, P. C. de F. (2020a). "Rotatinuous" stocking is a win-win grazing management strategy that allows high lamb meat production with environmental sustainability: An example of climate-smart livestock production. *Science of The Total Environment*, 753, 141790. https://doi.org/10.1016/j.scitotenv.2020.141790

Savian, J. V., Schons, R. M. T., Mezzalira, J. C., Barth Neto, A., Da Silva Neto, G. F., Benvenutti, M. A., & Carvalho, P. C. de F. (2020b). A comparison of two rotational stocking strategies on the foraging behaviour and herbage intake by grazing sheep. *Animal*, 14 (12), 2503-2510. https://doi.org/10.1017/s1751731120001251

Schons, R. M. T., Laca, E. A., Savian, J. V., Mezzalira, J. C., Schneider, E. A. N, Caetano, L. A. M., Zubieta, A. S., M. A. Benvenutti, M. A., & Carvalho, P. C. F. (2021). 'Rotatinuous' stocking: An innovation in grazing management to foster both herbage and animal production. *Livestock Science*, 245, 104406. https://doi.org/10.1016/j.livsci.2021.104406

Silveira, M. C. T., Nascimento Junior, D., Silva, S. C., Euclides, V. P. B., Montagner, D. B., Sbrissia, A. F., Rodrigues, C. S., Sousa, B. M. L., Pena, K. S., &

Silveira, V. C. P., González, J. A., & Fonseca, E. L. (2017). Land use changes after the period commodities rising price in the Rio Grande do Sul State, Brazil. *Ciência Rural,* 47 (4), 1-7. https://doi.org/10.1590/0103-8478cr20160647

Streck, E. V., Kampf, N., Dalmolin, R. S. D., Klamt, E., Nascimento, P. C. do, Schneider, P., Giasson, E., & Pinto, L. F. S. (2008). *Solos do Rio Grande do Sul.* (2ª.ed. rev. e ampl). Porto Alegre: Emater/RS-Ascar.

Tafernaberri, V. J., Dall'Agnol, M., Montardo, D. P., Pereira, E. A., Peres, É. R., & Leão, M. L. (2012). Avaliação agronômica de linhagens de aveia-branca em duas regiões fisiográficas do Rio Grande do Sul. *Revista Brasileira de Zootecnia,* 41 (1), 41-51. https://doi.org/10.1590/S1516-35982012000100007

Tonato, F., Pedreira, B. C., Pedreira, C. G. S., & Pequeno, D. N. L. (2014). Aveia preta e azevém anual colhidos por interceptação de luz ou intervalo fixo de tempo em sistemas integrados de agricultura e pecuária no Estado de São Paulo. *Ciência Rural,* 44 (1), 104-110. https://doi.org/10.1590/S0103-84782014000100017

Vilela, H. H. (2010). Morphogenetic and structural comparative characterization of tropical forage grass cultivars under free growth. *Scientia Agrícola,* 67 (2), 136-142. https://doi.org/10.1590/S0103-90162010000200002