How does the forage utilisation during winter of a native grassland pasture affect the subsequent dry matter on offer in spring?

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Abstract

Excessive forage utilisation over winter, resulting in short residual sward heights (SH), may compromise spring production of native *Campos* grasslands. To assess the relationship between end-of-winter SH and subsequent spring dry matter (DM) on offer, an experiment was carried out in 2020 and 2021 to describe forage dynamics for swards clipped at 2, 4, 6, 8 and 10 cm as winter residual SH during five sampling dates throughout spring. Each year, 150 homogeneous plots (0.2 x 0.5 m) were arranged in a complete random block design experiment with six replicates (blocks). In both years, residual end-of-winter SH affected spring forage DM on offer but only had a small effect on net DM accumulation. The magnitude and extent of this response differed between years (interaction year* treatment, $p<0.001$). The main climatic difference between years was less rain in 2021 compared to 2020, yet, there was a greater DM on offer and greater net increase in DM accumulation in 2021. Average minimum temperature was greater in 2021 and may account for these year effects. There was little effect of low residual SH at the end of winter on subsequent spring DM production, but the extra DM within the system, by planning to have a greater SH at the end of winter, provided a buffer to render the whole system more weather-resilient.

Introduction

Native *Campos* grasslands are the main nutrition basis for meat and wool production systems in Uruguay, especially for extensive production (Jaurena et al. 2021). Since these pastures are grazed directly all year round and each season provides different amounts of forage dry matter (DM) productivity, with the lowest productivity observed during winter and the highest typically in spring (Orcasberro et al. 2021), it is difficult to properly manage livestock production considering these differences. Thus, it is common to observe excessive forage utilisation in winter, resulting in short residual sward heights (SH) by the end of this season. This shorter initial spring SH may compromise spring forage production.

Stockpiling native grassland forage from a season with a rapid growth rate (such as autumn) in order to be consumed in a season with very little growth (such as winter, when growth is temperature limited - Forde et al. 1975) is a common practice of certain farmers in the Pampa Biome (Jaurena et al. 2021). Thus, during winter, only animal consumption (demand) and virtually no new forage growth (offer) is expected. The question arises as to whether there is any subsequent impact on spring DM production depending on the pasture remaining at the end of winter. The objective of this study was to determine if forage utilisation (final winter SH) of native pastures affects the subsequent dry matter production in the following spring.

Methods

The trial was carried out at "Glencoe" Research Station (INIA Tacuarembó, Uruguay), with average annual rainfalls of 1200 mm, a subtropical humid climate with no dry season, and mean temperatures of the coldest and warmer months being -3 and 18ºC, respectively (Panario & Bidegain, 1997).

Five hectares of native rangelands were stockpiled during autumn from 28th and 25th March on 2020 and 2021, respectively, being intensely grazed before the accumulation period aiming to remove dead material from the summer. This initial autumn stockpiling period aimed to imitate what some farmers do before winter begins.

After the stockpiling period, at the end of the winter (date 0, on 7th and 14th September in 2020 and 2021, respectively), five SH treatments were applied to 150 plots of 0.5 x 0.2 m, with an initial SH of 10±2 cm, by clipping as follows: 2 cm, 4 cm, 6 cm, 8 cm and 10 cm above ground SH. No cattle grazed the site over the duration of the experiment.

Treatments were arranged as a split plot design with assessment date as the main plot and initial SH as subplot treatments, with six replicates each. The dates and treatments were allotted randomly within its corresponding main plot (date) and subplot (SH). The assessment dates (described in Fig. 1) were fixed beforehand and estimated as the summation of degree days (DD) using a base temperature of 8 °C, every 165 DD after the treatment application (date 0).

Forage DM on offer and SH were analysed using a mixed model approach, while simple linear regressions were applied to calculate growth rates (GR). Weather variables between years were analysed using ANOVA. All statistical analysis was performed using Infostat programme (Di Rienzo et al. 2015).

Additionally, GR were calculated as the average DM of each treatment on the final date minus the initial DM value divided by the number of days between sampling.

The DM and SH lab and field evaluations were conducted following the same methods as Cazzuli et al. (2023). Weather data was collected from an automatic station near the trial area.

Table 1. Weather variables during the pre-trial period (stockpiling during autumn and winter) and during the trial (spring) for both years

Weather variable	**2020**	**2021**	**p-value**
	Period: stockpiling pre-trial (autumn-winter)		
Average maximum temperature (°C)	20.6	14.5	< 0.001
Average minimum temperature (°C)	7.4	13.4	< 0.001
Average temperature (°C)	13.7	13.9	0.68
Average rainfall (mm/day)	8.4	4.6	0.10
	Period: trial (spring)		
Average maximum temperature (°C)	26.0	20.3	< 0.001
Average minimum temperature (°C)	10.7	18.9	< 0.001
Average temperature (°C)	18.4	19.6	0.06
Average rainfall (mm/day)	4.6	0.7	> 0.001

Pre-trial dates: 2020 = 28th March 2020 – 7th September 2020 (163 days); 2021 = 25th March 2021 – 14th September 2021 (173 days).
Trial dates: 2020 = 7th September 2020 – 9th December 2020 (93 days); 2021 = 14th September 2021 – 16th December 2021 (93 days).

Results

There was less rain in 2021 compared to 2020 but only during the trial period, and the minimum overnight temperature in spring was much higher in 2021 (Table 1). There were slightly more frosts during the stockpiling period of 2021 compared to the same period of 2020 (53 and 36 frosts for 2021 and 2020, respectively), and no differences between number of frosts during the trial period (5 frosts for both years).

In both years, residual end-of-winter SH affected spring forage DM on offer, but the magnitude and extent of this response differed between years (interaction year * treatment, $p<0.001$) (Fig. 1).

There was a significant year effect (2021 > 2020, $p<0.05$, Table 2) on net DM GR. Even though GR was not affected by treatment, a trend could be observed for greater GR for 10cm in both years.

Final SH reflected initial SH, although there was a trend for 10cm initial sward height to have higher growth rates (double) than all shorter start SHs.

Fig. 1. Dry matter (DM) on offer on each of the 5 sampling dates of a native *Campos* grassland during spring, evaluating either 2, 4, 6, 8, or 10 cm final winter sward heights, for two years. The dotted lines are the regression of DM on offer over time.

Table 2. Daily dry matter (DM) growth rate and sward height (SH) of a native *Campos* grassland during spring, evaluating either 2, 4, 6, 8, or 10 cm final winter SH treatments, for two years.

Treatment SH	Final SH (cm)				Daily DM Growth Rate (kg/ha/day)	
	2020		2021		2020	2021
	Mean	SE	Mean	SE		
2cm	7.1	0.42	9.0	0.98	2.7	18.2
4cm	9.3	0.42	8.6	0.98	1.0	15.6
6cm	9.5	0.42	11.6	0.98	-1.5	18.2
8cm	11.8	0.42	11.5	0.98	3.0	13.9
10cm	13.3	0.42	14.6	0.98	6.2	29.0

Growth rates were calculated as the average DM of each treatment on the final date minus the initial DM value divided by the number of days between sampling. This is why there is a negative value.

Discussion

Residual sward height at the end of the winter affected spring forage-on-offer in both years but there was no effect on net DM accumulation nor on changes in SH (Fig. 1 and Table 2). High utilisation over winter with a low residual SH will have little effect on subsequent spring DM growth but low forage utilisation (high residual SH) may be used as a forage bank if spring DM production is compromised as illustrated in 2020 here. This has important management implications (Claramunt et al. 2018, Orcasberro et al. 2021).

There was a marked year effect, in agreement with Royo Pallarés et al. (2005) who concluded from their 19-year data on similar pastures that there was great inter-annual variability of forage production. On average, these authors found maximum GR of 25 kg/ha/day (between summer and autumn), and minimum GR of 5.5 kg/ha/day (winter months), the latter being above our spring GR data. The values of DM from 2021 were always greater than those from 2020 despite less rain over the period and no difference in the number of frosts in spring. The one difference was that average minimum temperature in 2021 (18.9C) was greater than 2020 (10.7C) and C4 plants are sensitive to minimum temperature to initiate and promote growth (Forde et al. 1975, Ivory & Whiteman, 1978). *Campos* grasslands have a high proportion of C4 plants and this may account for the differences between years in net DM accumulation and SH. Our DM on offer values are similar to the highly variable estimates of the native *Campos* grasslands during spring (e.g. Claramunt et al. 2018 with 1000 and 1500 kg/ha depending on the year, or Orcasberro et al. 2021 with 4147 kg/ha at 11.6 cm and 2910 kg/ha at 6.8 cm).

When analysing production systems as a whole, the higher the pre-drought herbage allowance and herbage accumulation rate, the lower the risk of a negative impact of a drought on the whole system (Modernel et al. 2019). Thus, having a relatively high end-of-winter SH provides a buffer of forage within the system and may have some advantage in not limiting subsequent DM growth over spring. However, the minimum temperature over spring appears to have a major effect on spring DM growth which requires further research in the heterogenous C3 and C4 plant systems such as these.

Implications

Weather conditions play a very significant role on overall forage on offer, even though their interactions are not always thoroughly understood. Minimum temperature in spring appears to be important in the growth response of Campos grasslands.

Nonetheless, there are some principles that apply if the aim is to optimise overall system productivity. Whilst the low residual end-of-winter SH has little effect on net DM accumulation in spring, there is no buffer DM present.

A higher residual SH would make the system more resilient to management strategies and between year variation in temperature and occurrence of frosts. Alternatively, although not statistically different in this study, further research may be warranted to investigate whether the observed trend of greater growth rates with 10cm is a real effect, as this would have implications for recommended end of winter target sward height to maximise spring forage growth and available dry matter.

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