Tiller dynamics of ryegrass managed under two stocking rates

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ABSTRACT. This study investigated the tiller dynamics of Italian ryegrass (Lolium multiflorum Lam) under low and high stocking rates. These rates were determined by heifers exclusively on pasture or grazing and supplemented with oats and corn grain. The experimental design was completely randomized with repeated measurements over time, with two stocking rates, three and six replications of area for low and high stocking rates, respectively. The appearance rate (1.0 tillers tiller-1 m-2), survival rate (0.8 tillers tiller-1 m-2), population stability index (1.6) and site occupation (0.3) were similar for high and low stocking rates. The tiller density was similar for different stocking rates. The first generation of tillers was 56% of the tiller population at end of the ryegrass cycle. The increase by 22.5% in the stocking rate derived from the use of supplements for grazing heifers did not alter the tiller dynamics of ryegrass.

Keywords: population stability index, site occupation, tiller survival, tiller appearance rate.

Introduction

The persistence of forage grasses is related to the ongoing appearance of tillers from axillary buds in the sheath of each leaf blade in older stems. Studies on demographic patterns of tillering have enabled significant improvements in the productivity of grazing systems through fine-tuning of management (MATTHEW et al., 2000).

The manipulation of defoliation by adjustments and combinations of frequency and intensity of grazing can generate different responses in accumulation and nutritive value of forage produced, promoting variations in leaf area from changes in demographic patterns of tillering (DIFANTE et al., 2008). Tillerling is a genetically determined trait. Environmental growth factors such as rainfall, temperature, light and nutrient availability combined with the strategies of defoliation can alter the tiller turnover in the canopy (MATTHEW et al., 2000).

The supplementation of grazing animals allows an increase the stocking rate by 20% (PÖTTER et al., 2010). Changes in stocking rate directly influence the intensity and frequency of defoliation of forages, which may modify the dynamics of tillering, mainly due to changes in the quantity and quality of light that reaches the base of the tiller. Leaf blades near the soil of plants with improved quality of incident solar radiation, activate their dormant buds (ZANINI et al., 2012), positively influencing tillering (ZANINE, 2005).

Considering the importance for livestock production systems in southern Brazil, Italian ryegrass (Lolium multiflorum Lam.) is the most studied temperate species, with studies in several research areas (ROMAN et al., 2007;
and 2,000 kg DM ha\(^{-1}\). The stocking rate was adjusted for maintaining the forage mass between 1,500 kg DM ha\(^{-1}\) every Monday to Saturday, at 14 hours. The stocking rate was adjusted according to Heringer and Carvalho (2002). Evaluation periods comprised the dates from 7/9 to 7/30; 7/31 to 8/28; 8/29 to 9/26 and 9/27 to 10/17. Experimental animals were Angus heifers, with initial age and weight of eight months and 168.6 ± 5 kg, respectively. Three test animals were used for each experimental unit.

**Material and methods**

This experiment was developed from July to November 2012, in the Department of Animal Sciences, Federal University of Santa Maria, in the Central Depression of Rio Grande do Sul State. The climate is humid subtropical, according to the Köppen classification. The soil is classified as paleudalf (EMBRAPA, 2006). Data of soil chemical analysis of the experimental area were: pH-H\(_2\)O: 5.8; % clay: 18 m/v; K: 85.6 mg dm\(^{-3}\); % OM: 2.7 m/v; Al: 0.07 cmol dm\(^{-3}\); Ca: 5.3 cmol dm\(^{-3}\); P: 15.8 mg dm\(^{-3}\); Mg: 2.6 cmol dm\(^{-3}\); CEC pH 7: 8.2.

The experimental area was 7.2 hectares divided into nine paddocks. Italian ryegrass (Lolium multiflorum Lam.) pasture was planted on May 2012. The fertilization consisted of applying 200 kg ha\(^{-1}\) NPK (05-20-20). As topdressing, urea (56.5 kg nitrogen) was applied in two applications (6/21 and 7/14/2012).

Italian ryegrass tiller dynamics was evaluated with two stocking rates: low – beef heifers exclusively on ryegrass pasture, and high – beef heifers on ryegrass pasture plus 0.93% body weight (BW) of corn grain (9.9% crude protein, CP, 91.4% dry matter, DM, 5.6% mineral matter, MM, and 21.7% neutral detergent fiber, NDF), or oats grain (13.8% CP, 91.5% DM, 9.7% MM and 31.1% NDF) as supplement. Supplements were given from 8/28 to 9/26 and 9/27 to 10/17. Experimental animals were Angus heifers, with initial age and weight of eight months and 168.6 ± 5 kg, respectively. Three test animals were used for each experimental unit.

Forage mass (kg DM ha\(^{-1}\)) was determined by visual estimation with double sampling. The stocking rate (kg BW ha\(^{-1}\)) was calculated by summing the average weight of test animals, with the average weight of each regulator animal multiplied by the number of days in which it remained in the paddock, divided by the number of days of the experimental period.

In order to evaluate the tiller population dynamics, three PVC rings (10 cm diameter 0.0078 m\(^2\)) were fixed to the ground of each experimental unit. The first generation of tillers was marked before starting the first evaluation period (7/2/2012), when all ryegrass tillers in the area were marked with plastic wires of a single color. At the end of the first evaluation period (7/30/2012), living tillers marked in the first generation were counted again and the new generation of tillers was marked with plastic wires of a different color. New generations of tillers were marked until the final period of use of ryegrass, and the tillers belonging to all generations marked were always recounted at each new evaluation. With the sum of the number of tillers belonging to each generation, it was possible to calculate the tiller density (tillers m\(^{-2}\)).

The tiller appearance rate (TAR; tillers tiller\(^{-1}\) m\(^{-2}\) or %), in each experimental period was obtained from counting the new tillers developed between two successive evaluations. The survival rate (ST; tillers tiller\(^{-1}\) m\(^{-2}\) or %) of each generation of tillers was estimated by the difference between the population existing in the period and the population existing in the prior period. The stability index (SI) of the tiller population was calculated by the equation:

\[
SI = ST \times (1 + TAR)
\]

Occupation of sites (OS) was calculated using the following equation: \[OS = (TAR/100)/(28 \times LAR \times \text{average temperature})\].

Length of leaf blades, number of green leaf blades and leaf appearance rate (LAR; degree-days) were determined with 40 tillers marked per experimental unit, randomly selected. Twice a week, leaf blades of tillers were measured, in cm, to calculate the length of leaf blades. For obtaining the number of green leaf blades per tiller, we counted the mean number of expanding leaves, expanded leaves and senescent leaves, disregarding leaf blades in which the senescence had exceeded 50%. The leaf appearance rate was determined by linear regression between the number of blades produced and the thermal sum of the period. Thermal sum was calculated by summing daily average temperatures for the period minus five degrees,
which is considered the base temperature of growth of ryegrass. The experimental design was completely randomized with repeated measures over time, two stocking rates, with three and six replicates of area for low and high stocking rates, respectively. All variables were normally distributed. To compare stocking rates, the variables were evaluated considering the fixed effect of stocking rate, evaluation periods and their interactions and the random effects of the residue and nested paddocks in stocking rates, using the MIXED procedure of SAS 8.2. The structure selection test was run using the Bayesian information criterion (LITTELL et al., 1998) to determine the model that best fits the data. When differences were detected, the mean values between stocking rates and evaluation periods were compared using the lsmeans procedure. The interaction of stocking rates with evaluation periods was broken down when significant at 5% probability. The variables were also subjected to Pearson correlation analysis.

Results and discussion

Meteorological data for July, September and October showed that the average temperature (17.4°C) is similar to historical averages, while for August, the temperature was 23.9% higher than the historical average (15.3°C). The average rainfall for July and August was 72.4 mm, 1.97 times lower than the historical average for the same period. The months of September and October were the rainiest with 21.4 and 49.3% above historical averages, 139.5 and 114.3 mm, respectively.

In the high stocking rate, the use of corn grain or oats grain as supplement for heifers on ryegrass pasture resulted in a stocking rate of 1434.6 kg BW ha⁻¹, an increase (p < 0.05) of 22.5% in relation to the low stocking rate obtained exclusively on pasture (1111.8 kg BW ha⁻¹). The increased stocking rate obtained exclusively on pasture (1111.8 kg BW ha⁻¹). The increased density of animals increases the stocking rate obtained exclusively on pasture (1111.8 kg BW ha⁻¹). The increased density of animals increases the stocking rate 22.5% higher, resulting from the use of supplements, had not (p > 0.05) influenced the tiller appearance rate (1.0 ± 0.05 tillers tiller⁻¹ m⁻²), population stability index (0.8 ± 0.03 tillers tiller⁻¹ m⁻²), and occupation of sites (0.3 ± 0.001). The similar structure of canopy in the high and low stocking rates provided a similar light intensity reaching the base of the canopy, keeping unchanged the condition of competition for light, thus justifying the data obtained.

In the last evaluation period, at the reproductive stage of ryegrass, the tiller appearance rate was 0.8 tillers tiller⁻¹ m⁻² (Table 1), 28.9% lower (p < 0.05) than in the other periods (1.1 tillers tiller⁻¹ m⁻²). This rate was positively related to the number of green leaf blades (p = 0.0007; r = 0.56). As each leaf blade has a phytomer, which when photostimulated may originate a new tiller (MATTEW et al., 2000), the reduction in the tiller appearance rate is justified by the alteration in the number of green leaf blades, from 4.4 in the three initial periods of pasture use to 3.6 in the fourth period (p < 0.05; Table 1).

<table>
<thead>
<tr>
<th>Items</th>
<th>Evaluation periods</th>
<th>p*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>7/9 to 7/30</td>
<td>7/31 to 8/28</td>
</tr>
<tr>
<td>Tiller appearance rate¹</td>
<td>1.2a</td>
<td>1.2a</td>
</tr>
<tr>
<td>Tiller survival rate¹</td>
<td>0.9a</td>
<td>0.9a</td>
</tr>
<tr>
<td>Population stability index</td>
<td>1.9a</td>
<td>1.9a</td>
</tr>
<tr>
<td>Site occupation</td>
<td>0.4a</td>
<td>0.3b</td>
</tr>
<tr>
<td>Number of green leaf blades</td>
<td>4.4a</td>
<td>4.3a</td>
</tr>
<tr>
<td>Leaf blade length</td>
<td>19.1a</td>
<td>15.0b</td>
</tr>
<tr>
<td>Leaf appearance rate²</td>
<td>0.009a</td>
<td>0.007b</td>
</tr>
</tbody>
</table>

Mean values followed by different letters in the row are significantly different by lsmeans at 5%, *probability between evaluation periods, †tillers tiller⁻¹ m⁻², ‡cm, †degree-day.
The tillers showed a survival 22% lower (p < 0.05; Table 1), in the third and fourth evaluation periods, compared with the other periods (0.7 tillers tiller⁻¹ m⁻² x 0.9 tillers tiller⁻¹ m⁻²). The tiller survival rate was positively related to the length of leaf blades (p = 0.0003; r = 0.58), which averaged 11.6 cm in the third and fourth periods, 39.3% lower (Table 1; p < 0.05) than the first period (19.1 cm) and 22.7% lower (Table 1; p < 0.05) than the second period (15.0 cm). In this case, as the blades were smaller there was an increased probability of removal of the apical meristem by grazing heifers, which explain the results for tiller survival.

The site occupation in the meristematic zones was altered (p < 0.05) by the evaluation periods. In the first period, the occupation was 0.4, 25% higher than in the other periods, whose was 0.3, on average (Table 1). This highest value can be attributed to the higher number of potential buds due to the 22% higher leaf appearance in the first period (Table 1).

Values of the appearance and survival rates combined resulted in significant variations (p < 0.05) in the population stability index of Italian ryegrass plants, which was 1.4, 31.6% lower (p < 0.05) in the last two periods of evaluation, which was 1.9 (Table 1). In these periods, even at the pre-flowering stage of ryegrass, the tiller appearance exceeded mortality, allowing the maintenance of values of the population stability index above one (Table 1), which indicates an upward trend in the tiller population (BAHAMANI et al., 2003). This trend points out that even at the end of the cycle, ryegrass is able to maintain stable the population of tillers. According to Barth Neto et al. (2013), this indicates the appropriate pasture management during the phenological cycle.

On the basis of the tiller population pattern (Figure 1), the stability was kept by a continuous tillering along the pasture use. This enabled the canopy to support a similar population density (p > 0.05) along the growth stage of ryegrass (6,170 ± 311 tillers m⁻²). Moreover, the continuous tillering promotes a high turnover rate of tissues, contributing to the maintenance of young plants in the pasture (SBRISSIA et al., 2010).

Analyzing separately the density for each tiller generation (Figure 1), the first generation has greater longevity (p < 0.05), with 56% of total of tillers in October. In this way, a proper management during the establishment of the pasture is essential for a successful system of animal production on pasture.

Young tillers have a higher photosynthetic capacity, high rates of appearance and expansion of leaf blades, accounting for canopies with a greater number of green leaves, and hence high quality forage (BARBOSA et al., 2012). Therewith, management strategies to be prioritized should be those allowing the constant appearance of new generations of tillers along the pasture use, even if these generations represent smaller proportions in the total number of tillers (p < 0.005; Figure 1).

**Figure 1.** Demographic pattern and sum of ryegrass tillers in the period July-October 2012. Generation of tillers and evaluation date: G1 – 7/2/2012; G2 – 7/27/2012; G3 – 8/24/2012; G4 – 9/19/2012 and G5 – 10/16/2012.

**Conclusion**

The increase of 22.5% in the stocking rate resulting from the supplementation of for grazing heifers has no effect on the tillering dynamics of ryegrass. The tiller appearance rate is lower in the reproductive stage, while the number of sites occupied by tillers is higher at the beginning of their occupation. Tillers survive for a shorter time after approaching the reproductive stage. Proper management allows the stabilization of the ryegrass population throughout its phenological cycle. The first generation of tillers contributes 56% at the end of the cycle, emphasizing the management practices at the beginning of use of this forage.

**References**


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