Understanding Plantain (*Plantago lanceolata* L.) responses to defoliation in Uruguay

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Abstract

This trial provided information about the effects of defoliation intensity and frequency on the productivity and plant population of a plantain pasture. Despite the restrictions in plantain management, the focus is to promote its use as specialised pasture for specific purposes. Maximum herbage production was 10.9 t DM/ha/year for a frequent and severely defoliation treatment. Frequency of defoliation affected productivity at different times, mainly in spring (P=0.0013), production being promoted by frequent defoliation intervals (21 days). Plant population was affected by defoliation strategies during the year, being promoted by infrequent and lightly defoliation regimes. Previous results showed that the effects of intense defoliation increased over time, reducing plant size and density. The understanding of plantain response to defoliation regimes will contribute to increased outputs of plantain pastures and extend species persistence, and allow management strategies to be defined according to the production system.

Keywords: defoliation, intensity, frequency, population

Introduction

The potential of plantain as a novel herb for use in pure or mixed pastures was described by Stewart (1996), and reinforced by other reports of its forage value (Golding *et al*. 2008; Corkan 2009). Based on limitations in potential of regrowth or plant persistence, Kuiper & Boss (1992) proposed that plantain is a short-lived forage plant with a half-life of 2 to 3 years. Adequate grazing management can extend plant persistence and productivity of any forage species. While plantain is not commonly used in Uruguay, preliminary reports have demonstrated its potential as an alternative forage species (Barrios 2006). The study of defoliation strategies have been focused on a research program of INIA Uruguay determining the critical effects of winter grazing on plantain productivity and population (Ayala *et al*. 2011). The objective of this trial was to provide additional information about the effect of defoliation intensity and frequency on productivity and plant population changes of plantain pasture. Considering restrictions observed in stand persistence, the focus is to promote plantain use and adjust management strategies for those periods like summer where other temperate forage alternatives decline in production.

Materials and Methods

The experiment was carried out at INIA Treinta y Tres, Uruguay, South America (Latitude 33º 54´ S, Longitude 54º 38´ W) from March 2009 to March 2010, on a 2-year-old plantain 'Ceres Tonic' stand. The soil was a fine, mixed vertic argiudoll (ARS-USDA classification), with a $pH_{(H_2O)}$:5.2 and 5.4, organic carbon (%): 3.9 and 2.1, phosphorus using citric acid extractant (µg P/g): 22.1 and 9.7 in the 0–5 and 5–15 cm depth respectively. The paddock was sown in July 2008 at 5 kg/ha and annually fertilised with 150 kg/ha of N-P-K (18-46-0). An additional 50 kg/ha of N-P-K (46-0-0) was applied in spring each year, and the site was grazed with fattening lambs. A factorial (2 × 2) block design with three replicates was used to evaluate a combination of two defoliation intensities (3 or 10 cm post-grazing residual height, referred as severely (S) or lightly (L) grazed) and two frequencies of defoliation (each 21 or 42 days referred as frequent (F) or infrequent (I) grazing). During winter (June to early September) pasture was not grazed, based on a previous report (Ayala *et al*. 2011) that described critical effects of winter grazing on productivity and population of a 3-year-old plantain stand. The grazing schedule resumed in early September and was followed until March. Plots of 130 m^2 were grazed by sheep during short periods (10–12 hours) to achieve the residual height targets. Determinations included pre- and post-grazing mass (two 20 × 50 cm quadrats/plot were cut, weighed and dried), sward height for grazing control (25 measurements/plot/date) and botanical composition. To determine dry matter concentration, the samples were oven-dried at 60ºC for 48 hours. Plant population density was evaluated in one fixed quadrat/plot (50 × 50 cm each) on 10 March 2009, 15 May 2009, 26 October 2009 and 15 March 2010. The variables were analysed by a repeated measurements model over time using the PROC GLM procedures of the SAS program (SAS 9.2), using the $LSD_{0.05}$ test for means comparisons.

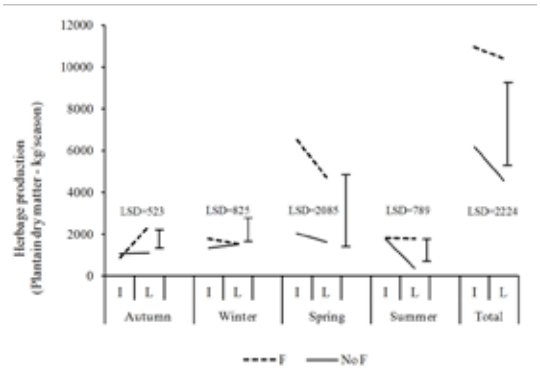

Figure 1. Seasonal and annual plantain herbage production under a combination of two intensities (severe (S) or light (L)) and two frequencies of defoliation (frequent (F) or infrequent (I)).

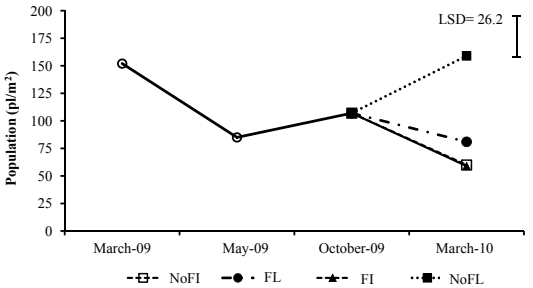

Figure 2. Plantain plant population change under a combination of two intensities (severe (S) or light (L)) and two frequencies of defoliation (frequent (F) or infrequent (I)).

Results and Discussion

During the experimental period rainfall during autumn and winter was lower by 31 and 33% respectively than the 1971–2011 average. In spring and summer rainfall was 47 and 119% higher than the average (360, 338, 256 and 261 mm for autumn, winter, spring and summer respectively). Mean temperature did not differ from 1971–2011 average, being 18.1, 11.1, 16.3 and 22.8°C for autumn, winter, spring and summer respectively.

To verify the intensity of the defoliation treatments, the residual sward height was measured. On average for the whole year, the severely defoliation treatment achieved a residual height that averaged 5.6 ± 2.3 cm and the lightly defoliation treatment averaged 11.2 ± 2.7 cm. During seasons, the residual herbage mass varied between 0.8 to 1.1 and 1.0 to 2.0 t DM/ha for the severely and lightly defoliation treatments, respectively. Plant structure and the proportion of leaf determine the amount of biomass, with height alone not being the best indicator of grazing intensity control in a plantain stand.

Herbage production

Annual production was on average 9.1 t DM/ha, with 88% being plantain. Other components were annual grasses, *Trifolium pratense* and some weeds, with the results reported here only referring to the plantain component. Autumn herbage production was affected by both frequency and intensity, having a significant interaction between frequency and intensity (P=0.0073). The light and frequent defoliation increased herbage production by 141% over the average of other defoliation strategies (Fig. 1). Herbage production measured at the end of winter period was not affected by treatments, achieving on average 1.53 t DM/ha for the whole season. In spring, only the frequency of defoliation affected herbage production significantly (P=0.0013), being 5.6 and 1.8 t DM/ha for 21 and 42 days intervals respectively. In summer, defoliation frequency still affected herbage production (P<0.001), which declined when the light and infrequent defoliation strategy was applied. The annual herbage production was significantly affected by frequency of defoliation (Table 1), with 5.3 and 10.6 t DM/ha being produced for infrequent and frequent defoliation respectively. Maximum annual plantain herbage production reported was 10.9 t DM/ha for the

Table 1. Frequency (Fr) and intensity (In) of defoliation effects probabilities on plantain herbage production.

Parameters	Autumn 2009	Winter 2009	Spring 2009	Summer 2010	Total
Fr	0.0363	0.5458	0.0013	<0.001	0.001
In	0.0054	0.8938	0.2820	0.3050	0.3181
Fr×In	0.0073	0.5542	0.5018	0.4752	0.6196

Table 2. Frequency (Fr) and intensity (In) defoliation effects probabilities on plantain plant population.

Parameters	March 2009	May 2009	October 2009	March 2010
Fr	0.1056	0.5152	0.7009	0.0122
In	0.9924	0.1791	0.8975	0.0013
Fr×In	0.5591	0.8946	0.6104	0.0105

frequent and severely defoliation treatment. Positive effects of frequent defoliation intervals on production were clearly observed in spring, contrasting with infrequent intervals (42 days) where plants maintained a biomass with a high proportion of old leaves. These may be less photosynthetically active and therefore less efficient.

Plant population

Plant population was monitored at the beginning of the experimental period in March 2009, when it was 152 ± 44 plants/m^2. In May 2009, the stand had declined significantly ($P<0.01$) to 85 ± 32 plants/m^2. By October 2009, there were no differences in plant population as a consequence of defoliation regimes, averaging 107 ± 29 plants/m^2. However, by the end of the experimental period in March 2010, there were significant differences as a consequence of frequency, intensity and their interaction between the two (Table 2). The infrequent × light defoliation strategy retained high plant numbers in comparison with the average of the other treatments (159 vs 67 plants/m^2), which did not differ between them (Fig. 2). In fact, a high proportion of new plants were observed in March 2010, probably as a consequence of seedling recruitment. The 42-day interval may have allowed plantain plants to complete the reproductive process, and this appeared to be faster in swards with high residual biomass (10 cm).

In general, the results showed that the annual production of plantain was relatively high for the tested environment, reinforcing the opportunity for it to be included as an alternative for less fertile environments in the east region of Uruguay. Frequent defoliation (each 21 days) significantly increased herbage production, particularly in spring and in total herbage production. A previous report (Ayala *et al*. 2011) showed that winter grazing had critical effects on plantain productivity and plant persistence. Other studies in the northeastern USA, considering only defoliation strategies, concluded that there is little opportunity to improve plantain plant survival (Labreveux *et al*. 2004), winter survival being the main limitation as a consequence of cold weather conditions. In our experiment, this concept was incorporated, and the experiment was rested from grazing during winter, from June to early September. Early spring production did not differ as a consequence of autumn treatments applied, and plant population had not declined. Infrequent defoliation reduced herbage production particularly during spring, probably because plantain plants maintained old and less active leaves during this period. Additionally, it was observed in this and other experiments that old leaves were rejected by sheep, reflecting the impacts of animal behavior on pasture productivity. Plant population at the end of the evaluation was improved by infrequent and lightly defoliation, based on new plant recruitment. Infrequent defoliation intervals combined with lightly grazing during summer can contribute to the ability of plantain to complete all reproductive processes from flowering to seeding, increasing soil seed bank reserves. Based on the reported knowledge of plantain defoliation management, it can be concluded that flexible grazing schemes according to period of the year and productive interest should be recommended. Also, these results give an opportunity to extend productive life of plantain swards based on defoliation strategies.

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