Phyllochron and leaf lifespan of four C_4 forage grasses cultivated in a silvopastoral system

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Introduction

Silvopastoral systems are emerging as an option for more sustainable land use. However, the challenge is to optimize pasture production and thedetermine suitable management by understanding the growth and development of forages under trees canopy (Palma *et al.* 2007). In the silvopastoral system, trees change the environment that forages grow, and can influence the development of plants and, consequently, the sward dynamics. For instance, the light quantity (*i.e.* photon flux density) and quality (*e.g.* changes in red: far-red ratios) can vary as a result of the tree canopy (Beaudet *et al.* 2011).

Phyllochron and leaf lifespan are morphogenetic processes that control growth and development of plants in a specific environment. These processes determine leaf area index and so the light interception by the sward (Lemaire and Chapman, 1996). These two characteristics can be used as tools for pasture management, and also are influenced by management practices, like nitrogen fertilization. However, there are few studies that evaluated these characteristics for forages cultivated under tree canopy (Paciullo *et al.* 2008), particularly when using the light interception (LI) as a criteria for cutting frequency. Under full sun, rotational stocking using 95% canopy LI has been recommended to use C4 species to their fullest potential and optimize ruminant weight gains on pasture (Silva and Carvalho, 2003).

The aim of our work was to determine both the shading (five-year-old plantation of Eucalyptus dunni) and nitrogen availability effect on phyllochron and leaf lifespan of four C4 forage grasses species in a sub-tropical region, managed using the 95% light interception criteria to determine cutting frequency.

Material and Methods

The study was based on four perennial C_4 grasses (*Cynodon spp*. hybrid Tifton 85 (Cs), *Hemarthria altissima* cv. Florida (Ha), *Megathirsus maximus* cv. Aruana (Mm) and *Urochloa brizantha* cv. Marandu (Ub)) that are widely used in Brazilian livestock, and also have been recommended (*e.g.* Soares *et al*. 2009) for use in silvopastoral systems (SS). The experimental site was located at the Agronomic Institute of Paraná, Ponta Grossa-PR (25°07'22''S; 50°03'01''W).

The species were planted in pure stands in 2010 (4.5 m² in unshaded vs. 100 m² in a shaded area with 155 trees of *Eucalyptus dunnii* per ha). Trees were planted in 2007 according to a double row arrangement using 3 m between plants within rows and 4 m between rows, spaced 20 m apart (3 x 4 x 20 m). Treatments were arranged in a split-split plot experimental design, with three replicates. Shaded (*i.e.* an emulated SS) vs. unshaded conditions were the main plots, species were the subplots and two contrasting N levels, zero and 300 kg N/ha/year, (N0 and N300), were assigned to sub-subplots. The photon flux density was reduced on average by 34 ± 8.57% in the shade area compared with the unshaded. Forages were cut when the light interception of the swards reached 95%. It was simulated rotational defoliation by mechanical cutting. Temperat-ure was measured every five minutes. In the shaded area, temperature was calculated using three thermometers placed between the lines of trees. Phyllochron and leaf lifespan were evaluated in 25 and 10 tillers per plot for shade and unshaded areas, respectively, in the end of spring/2011 during 20 days, every 3-5 days. Phyllochron was calculated as the inverse of the rate of leaf appearance per tiller (linear regression between number of leaves appeared and thermal-time in degree-days ºCd). The number of green mature leaves (GML) per tiller were counted and the leaf life span was estimated by multiplying the number of GML per tiller by the phyllochron. Statistical analyses were performed using R software (http://www.r-project.org/, R Develop-ment Core Team, 2013). The data were subjected to Analysis of Variance (ANOVA, aov procedure) and Tukey test for mean comparison.

Results and Discussion

Phyllochron was lower for species growing in the unshaded condition (94.3 ± 36.23 ºCd) compared to the

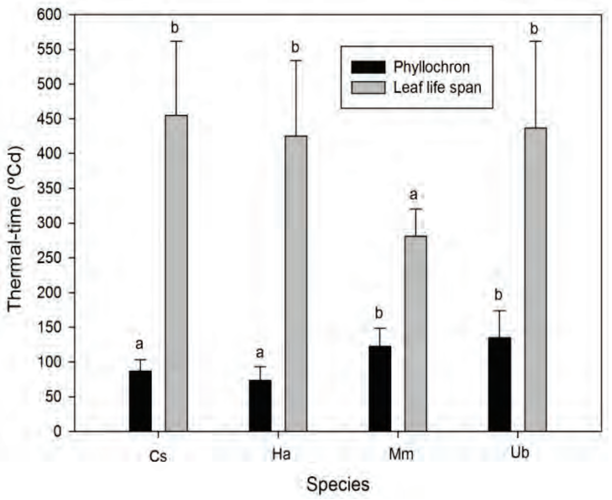

Figure 1. Phyllochron and leaf lifespan of four C_4 species (*Cynodon spp.* hybrid Tifton 85 (Cs), *Hemarthria altissima* cv. Florida (Ha), *Megathirsus maximus* cv. Aruana (Mm) and *Urochloa brizantha* cv. Marandu (Ub)). Letters correspond to significant differences between species for phyllochron and leaf life span (*P*<0.05). Bars indicate the standard deviation.

system with trees (114.7 ± 33.87 ºCd). Therefore, shade reduced the rate of plants development. This result differs from Paciullo *et al.* (2008), which did not observed changes in the phyllochron of *Brachiaria decumbens* Stapf cultivated under *Eucalyptus grandis* canopy at 50% of shade. The nitrogen fertilization reduced the phyllochron (114.9 ± 39.93 for N0 and 94.0 ± 29.22 for N300). Nitrogen is well known in the literature to accelerate plant growth and development (Paiva *et al*. 2012). Further, significant differences were observed between species for the phyllochron (Fig. 1). Species with lower phyllochron, *i.e.* higher growing rate, showed higher number of green mature leaves (*P*<0.0001). However, no significant interactions were observed (*P*>0.056) for phyllochron.

Only the species factor was significant for leaf lifespan. For instance, *Megathirsus maximus* cv. Aruana had the shortest leaf lifespan when comparing with the others species (Fig. 1). The mean daily temperature during the experimental period was 21ºC, ranging from 12 to 32ºC. From these means and leaf lifespan values, the cutting frequency (days) was estimated for both conditions. Therefore, an interval around 32 days between cuts could be used in practical conditions. Despite the same leaf lifespan and, consequently, a similar cutting frequency, the lower rate of development for species growing in shading condition could affect the level of 95% light interception used as cutting frequency.

Conclusions

Grass plants growing under tree canopy had higher phyllochron than plants growing under full light. Nitrogen fertilization also reduced the phyllochron. Leaf lifespan showed differences only between species and was not affected by shading or nitrogen levels.

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