CHILEANJAR
CHILEAN JOURNAL of AGRICULTURAL RESEARCH

SCIENTIFIC NOTE

Predicting green leaf proportion in ungrazed kleingrass (*Panicum coloratum* L.) in the semiarid Pampas Region of Argentina

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Green leaf proportion is an important factor affecting nutritive value, ingestive behavior and forage intake. Determination of green leaf proportion by hand separation of plant samples is time consuming and expensive. The aim of this work was to establish whether a stable relationship exists between the proportion of green leaf blade and total mass of harvestable forage in ungrazed kleingrass (*Panicum coloratum* L.) cv. Verde. The study was carried out during four consecutive growing seasons in an established pasture of kleingrass. During two growing seasons, 90 kg N ha^{-1} was applied. Forage samples were collected at biweekly intervals and separated into leaf blades, stems (inclusive of leaf sheaths), and senescent material. Regression analysis indicated a consistent relationship ($y = 0.70x^{-0.41}$, $R^2 = 0.84$, $P < 0.001$, $n = 180$) between the proportion of green leaf blade and total mass of harvestable forage in ungrazed kleingrass, even under varying environmental conditions of rainfall and N availability. Thus, total harvestable forage might be used to predict the green leaf proportion of kleingrass in contrasting environments, and used as an easy-to-measure indicator of green leaf proportion that would permit a balance of forage quality and quantity in kleingrass.

Key words: Green leaf, leaf:stem ratio, total harvestable forage.

INTRODUCTION

Kleingrass (*Panicum coloratum* L. var. *coloratum*) is a perennial C_4 grass native to Eastern Africa that grows in tropical, subtropical and warm temperate regions. This species was introduced successfully to the semiarid Pampas region of Argentina two decades ago (Petruzzi et al., 2003), showing good adaptation, biomass production and nutritive value (Ferri, 2011). Today, it is a valuable feeding resource for cattle grazing systems as one of the major sources of income in the region (Frasinelli et al., 2002; Guevara et al., 2009). This grass is also used in other grazing livestock systems around the world, as well as for hay (House et al., 2008).

In the semiarid Pampas region, pastures are used for continuous and rotational grazing. In rotational grazing the used model is 7 d of grazing and 35 d of resting. In both grazing systems, it is difficult to balance the nutritional value and biomass quantity, as well as pasture persistence (Fulkerson and Donaghy, 2001). In this context, a plant-related indicator as a criterion for sustainable pasture growth (i.e. persistence and production) and quality is needed.

In grasses the ratio leaf to stem and the proportion of green leaf mass are similar concepts. These relationships describe proportionate differences in the morphological components of plant biomass affecting nutritive value, ingestive behavior and forage intake (Bélanger et al., 2001). The pioneer work of Stobbs (1973) and Chacon and Stobbs (1976) found that, in tropical grasses, the green leaf:stem ratio is an important factor that determines the diet selection and forage intake by cattle. In kleingrass, leaf bulk density (g organic matter m^{-2} cm^{-1}) and leaf:stem ratio were the two variables that affected forage intake the most (Ferri at al., 2011). Although leaf:stem ratio is an important measurement for making grazing-management decisions, determination of this ratio by hand separation of plant samples is time consuming and expensive (Smart et al., 2004).

There is abundant literature describing relationships between plant height and stem mass, aboveground biomass and stem diameter, as well as development rate of shrub and tree plant parts (Jenkins et al., 2003; Basuki et al., 2009; Návar, 2009). However, reports of relationships in herbs and grasses, such as the proportion of green leaf and total harvestable forage, are scarce (Nafus et al., 2009). To our knowledge, studies of this nature have not been conducted to date in kleingrass.

The aim of this work was to establish whether a stable relationship exists between the proportion of green leaf blade and total mass of harvestable forage in ungrazed kleingrass cv. Verde. This relationship would be a rapid and effective method to determine the green leaf proportion in kleingrass pastures, in order to find the balance between forage quantity and quality in warm-season grasses.

MATERIALS AND METHODS

The study was conducted over four growing seasons (2001-2002 to 2004-2005) in a 3.0 ha monophytic

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Received: 6 July 2012.
Accepted: 15 February 2013.
doi:10.4067/S0718-58392013000200017.

pasture of kleingrass (*Panicum coloratum* L.) cv. Verde established during the spring of 1996 at the Experimental Farm of the Facultad de Agronomía, Universidad Nacional de La Pampa (UNLPam), La Pampa (36°46' S; 64°16' W; 210 m a.s.l.), Argentina. The soil was an entic Haplustol, with 2.34% organic matter, 84 mg kg^{-1} extractable P (Bray-Kurtz) and pH 6.3 (in water) in the top 150 mm of soil. The pasture was used exclusively for cutting (i.e. it was not grazed by cattle since its establishment). Prior to the experiment, no herbicides or fertilizers were applied. The plots were prepared by clipping the vegetation to a height of 8 cm above the ground level with a sickle mower and removing the clippings from the paddock in fall of every year. New plots were randomly selected each year so that the harvested plots were unique for each growing season. Rainfall and air temperature data was collected in the meteorological station of the Facultad de Agronomía, UNLPam, and distant 1 km from the study site.

The pasture sampling grid was divided in 30 plots of 1.5 × 3.0 m for the first two growing seasons. The last two growing seasons, due to the fertilization treatment, additional 30 plots were prepared (60 plots in total). Plots were fertilized with 90 kg N ha^{-1} (2003-2004 and 2004-2005) as urea in two applications of 45 kg each (second week of October and third week of December). This treatment was applied in order to test the regression model in two different N conditions. In each plot, 1 m^2 samples were cut at 2 cm above ground. Samples were collected in triplicate every 2 wk during a 140-d period starting at early vegetative stage (early October). Plants were hand-separated into green-leaf blade (L), stem (S; including leaf sheath and inflorescence) and senescent (D) material. Plant parts were oven-dried (55 ºC, 48 h) and weighed to estimate the dry matter (DM) of green leaf, stem, senescent and total mass of harvestable forage per hectare (t DM ha^{-1}). In addition, the proportion of green leaf blade and the total mass of harvestable forage was calculated for further analysis. To analyze the relationship between green leaf proportion and total of harvestable forage, we used a power regression ($y = ax^b$). The statistical analyses were performed using InfoStat (2008).

RESULTS AND DISCUSSION

The total rainfall in each growing season (September-April) from 2001-2002 to 2004-2005 was 777, 471, 378, and 573 mm, respectively, as compared with the long-term mean (25 yr) of 628 mm (Figure 1). Mean air temperature for the growing season 2001-2002 was 1.4 ºC below the long-term mean. The relatively low temperature in this season could be associated with the high rainfall in the season. The wide variation in both variables during the growing seasons allows us to build the model in contrasting environments.

Regression analysis showed a significant relationship between the proportion of green leaf blade and total mass of harvestable forage in undefoliated kleingrass. This relationship was significant ($y = 0.70x^{-0.41}$, $R^2 = 0.84$, $P < 0.001$, Figure 2), still in varying environments (i.e. temperature, water, and N availability). The negative relationship can be explained as a "dilution effect", as a consequence of a greater increment of stem mass than green leaf mass. In this study, we consider the changes in green leaf proportion as a function of the increasing total harvestable forage. Growing season, sampling date and N fertilization affected the green leaf proportion of kleingrass through increasing total harvestable forage. Based on this model, we consider that a significant proportion of the environmental variability could be removed.

In this study, we found a significant relationship between green leaf proportion and total harvestable forage that is stable under contrasting environmental conditions. The forage accumulation, which affects leaf proportion, is a function of the growing condition. Other authors predicted the leaf:stem ratio using either time (i.e. calendar day or accumulated growing degree days) or morphological development (Smart et al., 2001; Moore et al., 2007). These relationships are helpful to predict the chronological age effect on leaf:stem ratio. However, they do not account for the effect of environment. This fact limits the predictive value of these relationships. In our study, we propose to predict the decrease in green leaf proportion as a function of increasing total harvestable forage.

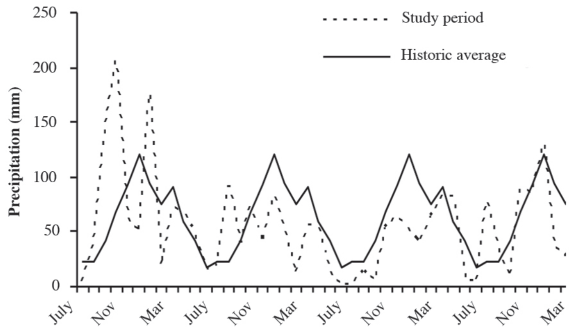

Figure 1. Monthly rainfall (mm) at Santa Rosa, La Pampa, Argentina, from July 2001 to June 2005. Dashed line denotes long-term mean (1975-2000).

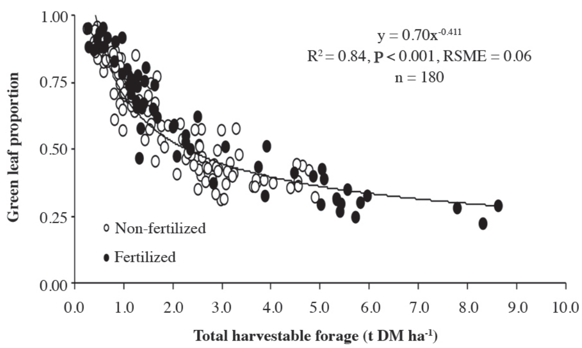

Figure 2. Relationship between green leaf proportion and total harvestable forage. RMSE: root mean squared error.

We found that total harvestable forage could be a suitable indicator to management of sward structure, particularly via grazing frequency. This is a relatively easy-to-measure indicator and provides an effective method to control proportion of green leaf mass. Besides, measurement of total harvestable forage mass as a routine is an essential previous requisite to adjust the stocking density for more efficient feed management (Cangiano and Pece, 2011).

Frequency and defoliation time in kleingrass is important to optimize quality forage, accumulation rate and pasture persistence. In this species, the proportion of green leaf decreases rapidly because of increases in stem DM and senescent material after the spring regrowth (Ferri, 2011). In general, grass leaves have higher nutritive value than stems, and, concomitantly, there is a higher voluntary intake of leaves (Collins and Fritz, 2003). This fact can be explained by the shorter retention time of leaf particles in the rumen in comparison to stems (Poppi et al., 2000). Maturity of plants accompanied by an increase in biomass affects the leaf:stem ratio and the nutritive value (Bélanger et al., 2001). As a consequence, there is a decrease both in the forage intake and the nutritional value. A proper balance between forage quality and quantity would allow controlling the animal response per unit area.

Recent studies of forage intake by grazing ruminants showed that the instantaneous intake rate depends, in part, on the proportion of tissues with high and low nutritional value (e.g., leaf and stems; Boval et al., 2007; Benvenutti et al., 2008; van Langevelde et al., 2008). In this context, total harvestable forage could be used as an easy-to-measure indicator of green leaf proportion that would permit a balance of forage quality and quantity in warm-season grasses.

CONCLUSIONS

Total harvestable forage can be used to predict green leaf proportion of kleingrass in contrasting environments. This ratio has been determined in undefoliated plants, making it useful to define the initial spring defoliation date. Further studies are underway in order to validate these parameters in defoliated plants.

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