ID #32-09

LENGTH AND WIDTH TO ESTIMATE DRY MASS OF PANICUM MAXIMUM CV. TANZÂNIA LEAVES

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Abstract

An analysis of the relationship of leaf length (LL) and leaf width (LW) with leaf dry weight (LDW) in *Panicum maximum* was carried out with the objective of improving estimations of tissue flow in that plant. Data was collected in a mob grazing experiment with 28 days grazing interval sampled the day before grazing in 9 grazing cycles. Regression analysis revealed highly significant effect ($P < 0.001$) of both LL and LW on LDW. A lack of fit test gave strong evidence of non-linear relationship of LDW with LL ($p < 0.05$), fitting the model $LDW = \beta_0 LL^{\beta_1}$, while LW presented a linear relation with LDW. LL was a better predictor of LDW than LW. LL solely or in combination with LW produced equations with high R^2 (0.61 – 0.90 and 0.80 – 0.92, respectively). The power relationship between leaf length and leaf dry weight imply that longer leaves are heavier per unit of length and, therefore the use of a constant to describe dry weight may be misleading when treatments affect leaf size in *Panicum maximum* pastures.

Keywords: Leaf, model, weight, regression, *Panicum maximum*

Introduction

Leaf area index and leaf mass have often been pointed out as important state variables in pastoral systems, affecting on both plant photosynthetic potential (Hay and Walker, 1989) and herbage intake by the grazing animals (Poppi et al, 1981; Flores et al., 1993; Forbes and Colleman, 1993) and are therefore valuable indicators of pasture status. Also methodologies for quantifying tissue flow rely on measurement of leaf elongation and length of senescent part of the tissue. Calculations usually assume constant dry weight per unit of length (usually mm) in order to estimate tissue mass flow rates (Grant et al., 1983). This paper aims to analyze the relationship between size measurements (length and width) and the dry weight of *Panicum maximum* cv. Tanzânia leaves in order to improve estimations of leaf mass and tissue flow in those plants.

Material and Methods

Data was collected from a mob grazing experiment carried out in Piracicaba, SP, Brazil, 22^{o}42’30” S, 47^{o}38’30” W, from October 1995 to October 1996 (Santos, 1997). The experiment was conceived in a factorial design with three grazing intervals (28, 38 and 48 days) and two cultivars Tanzania and Mombaça with 7 replications. All treatments received 400 kg of nitrogen as urea in 5 applications during the experimental period and were grazed to a residual dry mass averaging 1900 kg.ha^{-1}. Only data collected for Tanzania under 28 days grazing interval were analyzed. Ten representative tillers were taken from each plot the day before grazing, totaling 70 tillers per evaluation date. Leaf length (LL) was measured from ligulae to the leaf tip in the fully grown leaves and from the ligulae of the last expanded leaf to the leaf tip in the growing leaves. Leaf width (LW) was measured at the widest place of the leaf. Leaves were detached from stem and weighted fresh. Leaf dry weight (LDW) was calculated by multiplying fresh weight by the average whole sample dry matter (65^{o}C until constant weight).

A total of 1098 observations in 9 dates of measurement (09/02/9 6, 13/03/96, 11/04/96, 14/05/96, 08/06/96, 30/06/96, 31/07/96, 29/08/96, 25/09/96) were included in the analysis. Data was categorized into 6 independent groups (three seasons: summer, autumn and winter; and two leaf types: elongating and fully grown leaves). A test of lack of fit was applied to a simple linear model to verify non-linear trends (Drapper, 1981).

Results and Discussion

Length and width were highly significant (P< 0.001) both in simple and multiple regression analysis models (Table 1). Lack of fit was significant in the simple linear model (LDW = $\beta_0 + \beta_1$ LL; $p < 0.05$) in all datasets except for expanded leaves in summer, indicating a non-linear relationship between those variables. An exploratory analysis showed a power relation described by the equation $LDW = \beta_0 LL^{\beta_1}$ was adequate whenever lack of fit was detected (Figure 1; Table 1).

LL was a better predictor than LW, with the first producing equations with higher R^2 and lower RSD (Table 1). In the multiple linear regression model ($\log LDW = \beta_0 + \beta_1 \log LL + \beta_2 LW$) both measurements were significant and presented R^2 varying between 0.80 and 0.92 and RSD between 0.026 and 0.106). The relationships were found to be stable both throughout the year and between leaf types (completely expanded and emerging). Using just one equation for all data had R^2 close to the highest found in the respective model (Table 1).

The results showed the power parameter of the nonlinear equations between LL and LDW to vary between 1.33 and 1.91. A power relation of 2 would be expected between LL and LDW if they presented allometric growth (admitting constant specific leaf area). This result highlights the predominance of elongation in leaf area development. Figure 1 shows separately the relationship between LDW and LL and LW in winter. It can be noticed that while leaf length varied at the proportion of 10 times, leaf width changed less that half that amount. The same trend was found in all periods. Regarding the assumption of specific leaf weight , previous work of Wilson (1976) has found this index to increase with leaf size. The magnitude of those changes seems, however, to be smaller than the variation of the length/width ratio. The results suggest that the use of a constant to describe weight per unit of leaf length (LDW/LL) would not be adequate for estimating mass of those leaves, since longer leaves are heavier per unit of length. Use of an average would not generate error if the samples have exactly the same range and distribution of LL, though errors may be potentially large otherwise, particularly when treatments have effect on leaf size. The assumption of constant LDW/LL may also be misleading when modeling leaf growth during pasture regrowth, where obviously leaves are shorter at the beginning of the period. The statistics for regression equations indicate that those relations may be successfully used to estimate individual leaf mass and consequently leaf tissue dynamics in *Panicum maximum* cv. Tanzânia pastures and should be preferred in detriment to constant LDW/LL ratio.

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Table1 - Regression analysis statistics for prediction of leaf dry weight from leaf length and width

Model	Season	Leaf Type	Parameters			Statistics		
			β_0	β_1	β_2	Adj R2	RSD	Observations
$LDW = \beta_0 LL^{\beta}{}_1$	Summer	FG[1]	0.0027	1,328	-	0,61	0.149	207
		E[2]	0.0002	1,870	-	0,85	0.094	149
	Autumn	FG	0.0006	1,638	-	0,85	0.061	275
		E	0.0002	1,649	-	0,79	0.049	136
	Winter	FG	0.0013	1,417	-	0,82	0.050	207
		E	0.0002	1,914	-	0,90	0.030	124
	All		0.0002	1.649	-	0.85	0.087	1098
$LDW = \beta_0 + \beta_1 LW$	Summer	FG	-0,260	0,337	-	0,52	0,164	207
		E	-0,304	0,327	-	0,34	0,196	149
	Autumn	FG	-0,243	0,254	-	0,70	0,090	275
		E	-0,183	0,200	-	0,62	0,065	136
	Winter	FG	-0,216	0,261	-	0,61	0,074	207
		E	-0,121	0,185	-	0,61	0,059	124
	All		-0.340	0.329		0.63	0.137	1098
$\text{Log } LDW = \beta_0 + \beta_1 LW + \beta_2 \log LL$	Summer	FG	-5,886	0,981	0,504	0,80	0.106	207
		E	-7,721	1,467	0,409	0,92	0.068	124
	Autumn	FG	-6,845	1,199	0,487	0,91	0.047	275
		E	-6,895	1,162	0,516	0,87	0.038	136
	Winter	FG	-6,395	1,058	0,604	0,89	0.039	207
		E	-7,310	1,415	0,330	0,92	0.026	124
	All		-6.876	1.224	0.475	0.91	0.067	1098

LDW = leaf dry weight (g), LL = leaf length (cm) and LW is leaf width (cm).[1]E = Elongating leaves, [2]FG = Fully expanded leaves

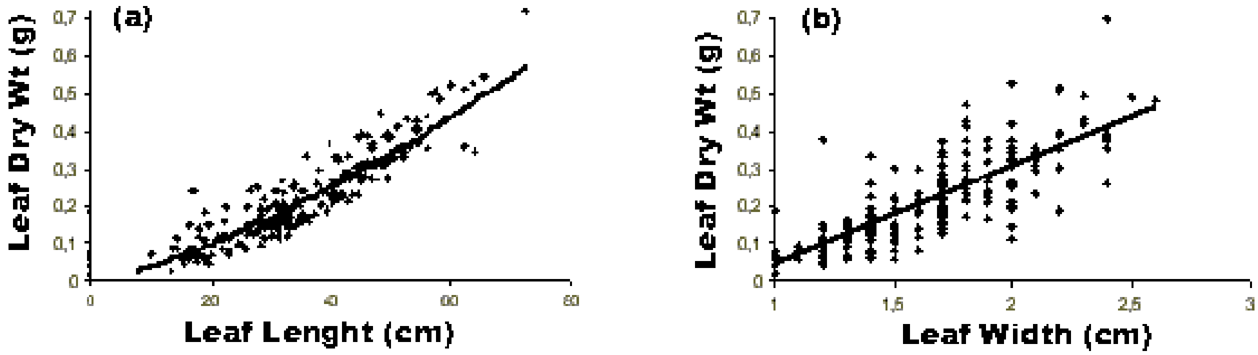

Figure 1 - Individual observations and regression line for (a) the power relation between leaf length and leaf mass and (b) the linear relation between leaf width and leaf dry weight.