Tropical Grass Growth Functions Modeling by Using Nonlinear Mixed Models

A. Hernández Garay
Colegio de Postgraduados, México

H. Vaquera Huerta
Colegio de Postgraduados, México

M. Calzada Marín
Colegio de Postgraduados, México

E. Ortega Jiménez
Colegio de Postgraduados, México

J. F. Enríquez Quiroz
INIFAP, Mexico

The 22nd International Grassland Congress (Revitalising Grasslands to Sustain Our Communities) took place in Sydney, Australia from September 15 through September 19, 2013.

Proceedings Editors: David L. Michalk, Geoffrey D. Millar, Warwick B. Badgery, and Kim M. Broadfoot

Publisher: New South Wales Department of Primary Industry, Kite St., Orange New South Wales, Australia

Tropical grass growth functions modeling by using nonlinear mixed models

A Hernández Garay [A], H Vaquera Huerta [A], M Calzada Marín [A], E Ortega Jiménez [A] and J F Enríquez Quiroz [B]

[A] Colegio de Postgraduados, México. www.colpos.mx
[B] INIFAP, Mexico, www.inifap.gob.mx.
Contact email: hernan@colpos.mx

Keywords: Tropical grasslands, *Pennisetum* sp, growth function, non linear models.

Introduction

Nonlinear Growth curves are used for modeling plant physiological variables. These models are preferable because the polynomial coefficients of the equations have a biological significance. The response variables of the curves occurs commonly with repeated measurements over time and measurements are on different environments. The traditional statistical analysis does not include a repeated measures approach, which can lead to improper estimation of the error terms. It is important to study the growth of tropical grass (Da Silva and Carvalho 2005).

Methods

A experiment was conducted at the experimental site "Papaloapan" of the National Institute for Agriculture, Forestry, Livestock (INIFAP), located in Isla, Veracruz, Mexico (18°06'N and 95°31'W) and at an altitude of 65 *mosl*. The climate is hot and subhumid, with rainy summer and an average rainfall of 1,000 mm, the average temperature is 25.7°C (Enriquez and Romero 1999).

The experiment was established on July 2011 and the assessments were made from 24 August to January 23, 2012. It was established in plots (5 x16 meters), with three repetitions. Evaluation was made at different stages of growth (30, 60, 75, 90, 105, 120, 135, 150, 165 and 180 days after planting [DAP]). The morphological components of the grass (leaf, stem and dead material) were measured over time.

We used nonlinear models by NLMIXED procedures in SAS, and by using Bayesian approach with WINBUGS software for estimating the growth curve. We use a multiple nonlinear growth function to model; it is assumed that the response variable follows a multivariate normal distribution. A comparison of biologically relevant coefficients and the estimated standard error, and measures of adjustment are obtained. The results show a clear advantage of nonlinear mixed models over linear mixed. The proposed model for the response variable (y) is a hierarchical normal distribution with mean $\mu(t)$ and variance σ^2 where:

$$\mu(t) = \frac{a}{1 + be^{-ct}} + \varepsilon \qquad (1)$$

The elements of the mean $\mu(t)$: *a*, *b*, *c* are parameters , t is the time variable, and $\varepsilon \sim n(0, \sigma_\varepsilon^2)$

Results

The estimated growth curve parameters are presented in Table 1, the growth dynamics of total plant mass, morphological components (leaf, stem) and sward height are shown in Figure 1. Overall, total plant mass, and leaf and stem increased slowly during days 0-60, after which rate of growth accelerated from day 61 to day 150 and then decreased almost to zero as growth was counteracted by increase in dead material.

Conclusion

The non linear mixed logistic model gives a good fit for a tropical forage *Pennisetum* spp. cv. Maralfalfa growth, in each of the growth components. This curve suggests that the best time to harvest this grass is at 150 days (where right inflection point of derivative of estimate of equation (1) is obtained) if total dry matter is the aim.

Table 1. Estimated parameters of growth curves for cumulative herbage mass (kg DM/ha), cumulative leaf mass (kg DM/ha), cumulative stem mass (kg DM/ha) and sward height (cm) of *Pennisetum* sp. cv. Maralfalfa.

	Total herbage mass		Leaf mass		Stem mass		Sward height	
Parameter	Estimate	Standard Error	Estimate	Standard Error	Estimate	Standard Error	Estimate	Standard Error
a	37.2552	2.8047	7.4043	0.7344	25.9946	1.7894	2.4227	0.06972
b	336.01	383.7	33.9985	28.0675	852.21	1182.94	12.7706	4.7777
c	5.2302	1.1168	3.7793	1.0138	6.029	1.3138	4.369	0.636
R^2	0.95		0.94		0.95		0.99	
AIC	195.0		110.0		175.1		-3.6	
CME	30.9621		1.8837		15.9621		0.0414	

Note: AIC=Aiakaike Information Criterion , MSE=Mean Square Error

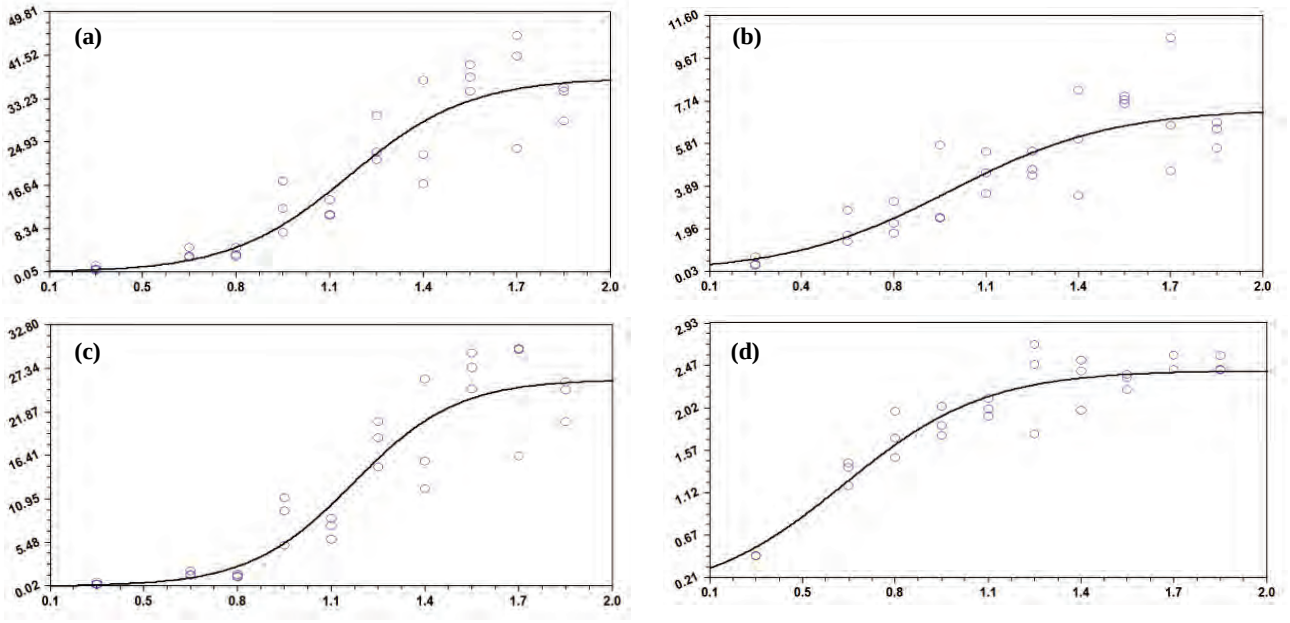

Figure 1. Growth curves for the variables: (a) total cumulative herbage mass (kg DM/ha) x 1000; (b) cumulative leaf mass (kg DM/ha) x 1000; (c) cumulative stem mass (kg DM ha/) x 1000; and (d) sward height (cm) x 100. The horizontal axis is time in days x 100.

References

Enríquez-Quiroz JF, Romero-Mora J (1999). Tasa de crecimiento estacional a diferentes edades de rebrote de 16 ecotipos de *Brachiaria spp*. en Isla, Veracruz. *Agrociencia* **33**, 141-148.

Da Silva SC, Carvalho PC de F (2005). Foraging behavior and herbage intake in the favourable tropics/sub-tropics. *XX International Grassland Congress* 'Grassland a Global Resource'. University College. Dublin, Ireland. pp. 81-95.

SAS. SAS User´s Guide: Statistics (version 9.3.). Cary NC, USA: SAS Inst. Inc. 2011.