The Effect of Tree Densities on the Biomass of *Leucaena leucocephala* and *Chloris gayana* Using a Nelder Fan Design

Anibal Nahuel Alejandro Pachas
The University of Queensland, Australia

H. Max Shelton
The University of Queensland, Australia

Christopher J. Lambrides
The University of Queensland, Australia

Scott A. Dalzell
Santos GLNG Project, Australia

G. John Murtagh
LanSci Management Pty Ltd, Australia

The 23rd International Grassland Congress (Sustainable use of Grassland Resources for Forage Production, Biodiversity and Environmental Protection) took place in New Delhi, India from November 20 through November 24, 2015.
Proceedings Editors: M. M. Roy, D. R. Malaviya, V. K. Yadav, Tejveer Singh, R. P. Sah, D. Vijay, and A. Radhakrishna
Published by Range Management Society of India

Paper ID: 710
Theme 2. Grassland production and utilization
Sub-theme 2.6. Interdependence of grassland and arable lands for sustainable cereal, forage and livestock production

The effect of tree densities on the biomass of *Leucaena leucocephala* and *Chloris gayana* using a Nelder fan design

Anibal Nahuel Alejandro Pachas[1]*, H. Max. Shelton[1], Christopher J. Lambrides[1], Scott A. Dalzell[2], G. John Murtagh[3]
[1]The University of Queensland, Brisbane, Australia
[2]Santos GLNG Project, Brisbane, Australia
[3]LanSci Management Pty Ltd, Labrador, Australia
*Corresponding author e-mail: a.pachas@uq.edu.au

Keywords: Agroforestry, Competition, Rhodes grass, Yield

Introduction

Leucaena leucocephala-grass pastures are widely used for ruminant feeding in tropical and subtropical regions. In Australia, over 200,000 ha of leucaena grass pasture have been planted with more plantings expected as it is recognized as the most productive, profitable and sustainable feeding system (Shelton and Dalzell, 2007). Planting densities and planting configurations for the leucaena component vary, ranging from single or double leucaena hedgerows 3 to 12 m apart (Radrizzani *et al*., 2010). There is little information about how tree/grass planting configurations and resulting inter- and intraspecific competition affect above and below-ground interactions. We hypothesise that individual leucaena tree biomass will be inversely related to leucaena tree density, with greatest competition at low density, while medium to high leucaena densities will reduce grass biomass production.

Materials and Methods

The experiment was conducted at the Gatton Research Farm (27.54°S, 152.34°E) of the University of Queensland, Australia. The soil was a deep (3 m) black/brown Haplustoll. The climate is subtropical, with an average rainfall of 798 mm per annum and average maximum and minimum temperatures of 31.6 and 19.3°C in the hottest month (January) and 20.7 and 6.2°C in the coolest month (July) (Bureau of Meteorology, 2015).

Leucaena leucocephala (Leucaena) (Lam.) de Wit ssp. *glabrata* (Rose) Zarate cv. Tarramba was planted using a Nelder fan design (Nelder, 1962) on 27th November 2013. Twelve concentric rings of trees with radii of 0.6, 0.9, 1.3, 1.9, 2.8, 4.0, 5.9, 8.5, 12.3, 17.9, 25.9 and 37.6 m were planted. Each ring contained 16 trees planted equi-distant around the circumference, giving a range of tree densities: 100, 210, 442, 928, 1,951, 4,100, 8,618, 18,112, 38,065 and 80,000 trees/ha. *Chloris gayana* (Rhodes grass) (Kunth.) cv. Finecut was sown in March 2014 in two quarters of the Nelder fan. The total area occupied by the experiment was 0.47 ha.

Measurements: Above ground biomass was harvested 3 times over 231 and 252 day growth periods for Rhodes grass and leucaena respectively during 2014 and 2015. For each leucaena density, total biomass of 8 trees was measured (4 with Rhodes grass and 4 without grass). The leucaena was harvested to a height of 100 cm. The basal diameter of several stems/tree was measured with callipers and total biomass estimated using a robust regression relationship between biomass (g DM/stem) and cross sectional area of the cut stem (cm^2). For each harvest, a calibration equation was prepared based on the measurements of 25-45 stems. Regression coefficients (R^2) of 0.91, 0.99 and 0.99 corresponded to harvests on 10/10/14, 9/12/14 and 21/01/15 respectively. The above-ground biomass of Rhodes grass was estimated using BOTANAL sampling procedures (Tothill *et al*., 1978). Regression calibration equations linking biomass to visual yield score had R^2 values of 0.92, 0.97 and 0.99 for harvests on 7/10/14, 19/11/14 and 20/01/15 respectively.

Data analysis: Scatters plots of accumulated leucaena above-ground biomass (kg DM/tree and kg DM/ha) and Rhodes grass biomass were made against leucaena density (leucaena trees/ha). Following the methodology of Ritchie (1997), tree density was log transformed and the data subjected to non-linear and linear regression. The statistical software used was Minitab (version 16.2.4, MiniTab Inc, State Collage, PA) and SigmaPlot (version 12, Systat, San Jose, CA).

Results and Discussion

As anticipated, leucaena tree density strongly influenced individual tree biomass (kg DM/tree) and total leucaena biomass (kg DM/ha) ($p<0.001$). Individual leucaena tree yield was negatively related to the log of tree density ($R^2 = 0.99$). Maximum biomass (8 kg DM/tree) was reached at 100 trees/ha without grass competition, and was reduced by 62 % with grass competition (Fig. 1). The individual biomass of leucaena trees was reduced with increasing density due to intraspecific competition reaching 0.2 kg DM/tree at 38,065 and 80,000 trees/ha. There was no effect of Rhodes grass competition on leucaena biomass at tree densities above 10,000 trees/ha due to poor vigour of the grass sward.

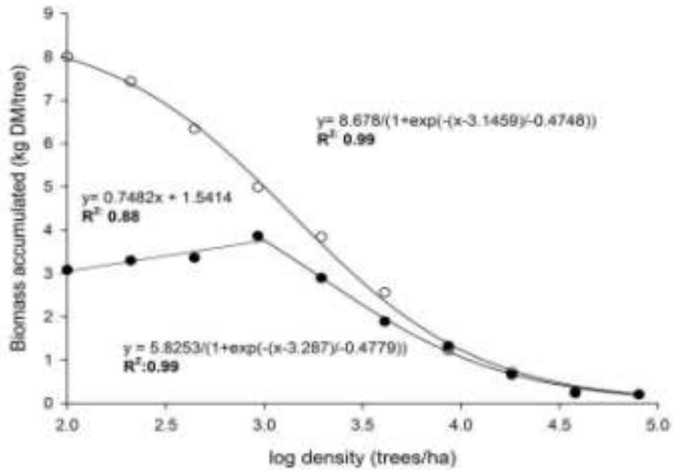

Fig. 1: Relationship between the individual cumulative tree biomass (kg DM/tree) over a 252 day period and log of leucaena tree density (trees/ha).

Accordingly, total biomass/ha of leucaena was positively related to the log of leucaena density (R^2 = 0.97) regardless of grass competition, reaching 16,540 kg DM/ha at the highest leucaena density of 80,000 trees/ha (Figure 2). In contrast, the yield of Rhodes grass was linearly and inversely correlated with the log of tree density (R^2 = 0.97). There was no grass growth at densities ≥11,120 trees/ha. At low tree densities, the reduced leucaena yield due to grass competition had a minor impact on total yield. The grass component constituted 97% (10,050 kg DM/ha), 50% (4,952 kg DM/ha) and 5% (609 kg DM/ha) of total biomass at tree densities of 100, 1578 and 8618 trees/ha respectively (Fig. 2).

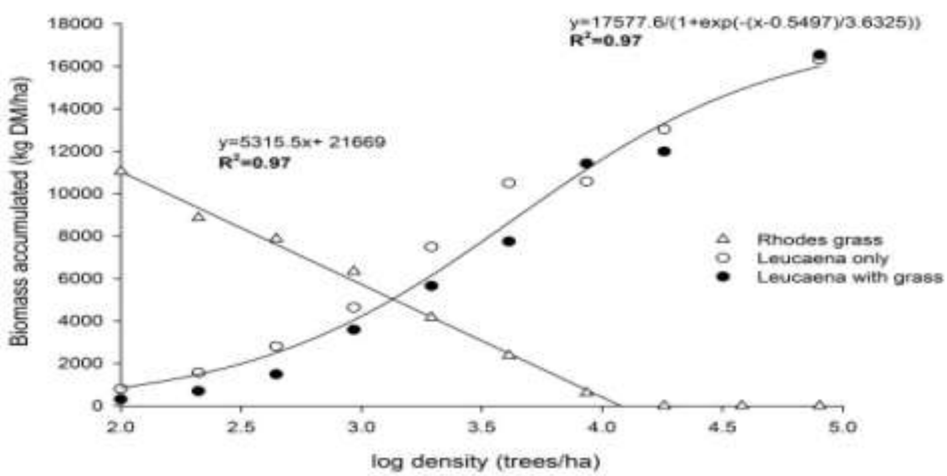

Fig. 2: Relationship between cumulative biomass (kg DM/ha) of Rhodes grass (231 days) and leucaena (252 days) and the log of leucaena tree density (trees/ha).

Conclusion

Leucaena and Rhodes grass can be successfully grown together to provide both high quantity and high quality forage for animal production. The relative yield contributions of the two components will be determined by the density of leucaena trees given equidistant planting configurations. The Nelder fan design was a useful approach to evaluate the effect leucaena density on intra-tree and inter-specific competition between leucaena and Rhodes grass. However, the outcome of competition may be different depending upon the planting configuration of tree and grass species. Configurations of leucaena trees comprising close tree spacing within leucaena hedgerows combined with wide alleys between rows will enhance the light interception by the inter-row grass. Further studies focusing on below-ground competition such as root architecture and patterns of water uptake are ongoing to provide a better understanding of leucaena-grass systems.

References

Nelder, J. A. 1962. New kind of systematic designs for spacing experiments. *Biometrics* 18: 283-309.

Radrizziani, A., S. A. Dalzell, O. Kravchuk and H. M. Shelton. 2010. A grazier survey of the long-term productivity of leucaena (*Leucaena leucocephala*)-grass pastures in Queensland. *Animal Production Science* 50: 105 - 113.

Ritchie, G. A. 1997. Evidence for red: far red signaling and photomorphogenic growth response in Douglas-fir (*Pseudotsuga menziesii*) seedlings. *Tree Physiology* 17: 161-168.

Shelton, M. H, Dalzell S. A. 2007. Production, economic and environmental benefits of leucaena pastures. *Tropical Grasslands* 41: 174 - 190.

Tothill, J. C., J. N. G. Hargreaves and R. M. Jones. 1978. Botanal - a comprehensive sampling and computing procedure for estimating pasture yield and composition. 1. Field Sampling. Trop. Agron. Tech. Mem. No. 8. CSIRO Aust. Div. Tropical Crops and Pastures, St Lucia, Queensland.

Acknowledgement

This research was supported and funded by Santos GLNG project and Meat & Livestock Australia Donor Company. The author A. N. A. Pachas gratefully acknowledges the PhD scholarship from the National Institute of Agricultural Technology (INTA).