How Does N Fertilization or Forage Legumes Affect Forage and Animal Production?

B. G. C. Homem
EMBRAPA, Brazil

I. B. G. Lima
Federal University of Lavras, Brazil

P. P. Spasiani
Federal University of Lavras, Brazil

José C. B. Dubeux Jr.
University of Florida

R. M. Boddey
EMBRAPA, Brazil

See next page for additional authors

The XXIV International Grassland Congress / XI International Rangeland Congress (Sustainable Use of Grassland and Rangeland Resources for Improved Livelihoods) takes place virtually from October 25 through October 29, 2021.

Proceedings edited by the National Organizing Committee of 2021 IGC/IRC Congress

Published by the Kenya Agricultural and Livestock Research Organization

Presenter Information

B. G. C. Homem, I. B. G. Lima, P. P. Spasiani, José C. B. Dubeux Jr., R. M. Boddey, and D. R. Casagrande

Sub-Theme 4: Wildlife, Tourism and Multi-Facets of Rangeland/Grassland

Biodiversity and ecosystem services of rangelands/grasslands

Concurrent session: Forage legume ecosystem services in sustainable livestock systems

How does N fertilization or forage legumes affect forage and animal production?

Homem, B.G.C.[*]; Lima, I.B.G.[**]; Spasiani, P.P.[**]; Dubeux Jr., J.C.B.[†]; Boddey, R.M.[*]; Casagrande, D.R.[**]
[*]Embrapa Agrobiologia, Seropedica, Brazil; [**]Federal University of Lavras, Lavras, Brazil; [†]University of Florida, North Florida Research and Education Center, Marianna, USA.

Key words: *Arachis pintoi*; beef cattle; *Brachiaria*; warm-season legume

Abstract
Livestock grazing in tropical climates is characterized by low productivity. Forage and animal production can be improved by applying nitrogen (N) fertiliser or using forage legumes. This 2.5-yr study assessed the canopy structure and productivity of beef cattle grazing either a mixed pasture of *Brachiaria brizantha* cv. Marandu (palisadegrass) and *Arachis pintoi* (forage peanut) cv. BRS Mandobi or a Marandu palisade grass monoculture with or without N fertilisation. The experiment was carried out in Southeast Brazil, where the canopy structure (herbage mass) and animal productivity (stocking rate and liveweight gain per ha) were compared for three types of pastures: 1) mixed pasture of Marandu palisade grass and forage peanut **(GRASS+LEGUME)**; 2) a monoculture of Marandu palisadegrass fertilised with 150 kg N/ha/year **(GRASS+N)**; and 3) monoculture of Marandu palisadegrass without N application **(GRASS)**, under continuous stocking. A minimum of two Nellore heifers and additional put-and-takes were used to keep canopy height at 20-25 cm. A randomized complete block design was used with four replicates; seasons were considered repeated measurements over time. Herbage mass was greater in the GRASS+N pasture ($P < 0.001$); however, in the last three seasons (Spring II, Summer III, and Fall III), there was no difference to GRASS+LEGUME pasture. In the GRASS+LEGUME pasture, there was an increase of legume mass (1.260 to 2.565 kg/ha) and botanical composition (23.6 to 39.1% of legume in forage mass) throughout the study. The stocking rate ($P < 0.001$) and liveweight gain per ha ($P < 0.001$) were greater in GRASS+N, without difference among GRASS+LEGUME and GRASS pastures in the first seven seasons. In the last three seasons, with an increase of legume proportion, stocking rate and liveweight were intermediate for GRASS+LEGUME pasture. Legume increased herbage mass and animal productivity in the long term. Immediate responses were achieved with N fertilization.

Introduction
Brazilian beef production is of great global importance as Brazil has the largest commercial herd of cattle in the world (USDA 2019). In Brazil, most grass-beef operations rely on pastures of the *Brachiaria* genus. Recently, nitrogen (N) fertiliser application is becoming a more common practice, which may result in increases in forage and animal productivity of tropical regions (Delevatti et al. 2019). However, its use may be limited by costs and distribution logistics, since the beef industry is based on extensive operations. An attractive alternative would be the establishment of a mixed grass-legume pasture. Legumes can establish symbioses with rizhobia, which induce the formation of root nodules with the capacity of biological fixation of atmospheric N, which, in turn, will increase the forage and animal productivity. Therefore, the aim of this study was to investigate canopy structure and animal productivity responses of mixed pasture of Marandu palisadegrass and forage peanut compared to Marandu palisadegrass in monoculture, whether or not fertilised with N.

Methods and Study Site
The study was carried out on the Experimental Farm of the Federal University of Lavras, Brazil (21°14′S, 44°58′W; 918 m above sea level). The soil in the area is a Ferralsol (WRB/FAO classification) with clayey texture. The treatments encompassed three pastures types, namely: 1) Marandu palisadegrass and forage peanut mixed pasture without N fertiliser application **(GRASS+LEGUME)**; 2) Marandu palisadegrass monoculture fertilised with 150 kg N/ha/year **(GRASS+N)**; and 3) Marandu palisadegrass monoculture

without N fertiliser application **(GRASS)**. The whole experimental area was seeded with Marandu palisadegrass at a rate of 6.0 kg/ha of pure live seeds. The 12-ha experimental area was limed (2500 kg dolomitic lime/ha) 60 d before grass seeding, and 52 kg of P/ha and 41 kg of K/ha were applied during grass seeding. The whole experimental area was divided into four paddocks with three hectares each (blocks). Afterwards, the blocks were divided into three paddocks where pasture types were randomly allocated. The GRASS+N, GRASS+LEGUME and GRASS paddock sizes were 0.7, 1.0 and 1.3 ha, respectively. The GRASS+LEGUME paddocks were seeded with forage peanut into a previously established Marandu palisadegrass pasture with a seeding rate of 10 kg/ha of pure live seeds.

From December 2016 to July 2019, ten seasons were evaluated over time. Continuous stocking with a variable stocking rate was used to maintain the canopy height between 20 and 25 cm. Two Nellore heifers (234 ± 36 kg of BW and 12 ± 1.3 months of age) were used as tester animals in each paddock. When it was necessary to adjust the canopy height, put-and-take animals were added. Water and commercial mineral supplementation were supplied *ad libitum.* Average canopy height was measured weekly using a sward stick (Barthram 1985) at 100 random points per paddock. Annually, in the spring (between November and December), all paddocks were fertilised by applying 22 kg/ha of P and 41 kg/ha of K. In the GRASS+N, the N fertiliser application was divided into three applications per year (50 kg N/ha each in November, January, March), all applied as urea.

Herbage mass was sampled by harvesting six frames at ground level, measuring 1 x 0.5 m, per paddock, at points with average canopy height, once every 30 days. The fresh material was weighed and subsamples were taken for manual separation of botanical components. Forage samples were oven-dried at 55 ºC for 72 h to a constant weight. Grass mass (kg/ha) was considered as leaf + stem without dead material and the legume mass (kg/ha) included leaf plus stem mass. Herbage mass was considered the sum of grass and legume mass, according to each treatment.

Cattle were weighed in the morning, every 28 d throughout each season, without food or water restriction. The values obtained in each weighing were submitted to individual analyses of regression per season ($y = ax + b$). In this equation, the individual initial weight in each season was the intercept, and the average daily gain (ADG) was the slope. The stocking rate [AU/ha; (AU: animal unit was considered a bovine weighing 500 kg; Allen et al. 2011)] was measured for each season by the sum of weights of all animals present in each paddock divided by the area of the paddock. The liveweight gain per ha was calculated by multiplying the ADG by stocking rate.

All variables were averaged per experimental unit before analysis, for each season. The experimental design was randomized complete blocks with three treatments (pasture type; GRASS+N, GRASS, and GRASS+LEGUME), four replications, and repeated measurements over time (seasons of the year). Data were analysed by fitting mixed models, using the MIXED procedure as SAS. The effects of pasture type, seasons, and their interactions were considered fixed and the effect of block as a random effect. The averages were estimated using the LSMEANS statement, and comparisons were made using Fisher's protected least significant difference (LSD) test at 10% probability.

Results

Herbage mass

There was an interaction between pasture type and seasons for herbage mass ($P < 0.001$; Figure 1). In the summer, there was no difference between pasture types (an average of 4625 kg/ha). Herbage mass was greatest in the GRASS+N pasture from fall up to winter II. In the last three seasons (spring II, summer III, and fall III), GRASS+N and GRASS+LEGUME pastures had the greatest herbage mass. In the GRASS+LEGUME pasture, there was an increase of legume mass (from 1260 to 2565 kg/ha) and botanical composition (from 23.6 up 39.1% of legume in forage mass) throughout the experiment period.

Animal productivity

There was an interaction between pasture type and seasons for the stocking rate ($P < 0.001$; Figure 2). In the summer, there was no difference between pasture types (an average of 3.74 AU/ha). Stocking rate was greatest in the GRASS+N pasture from fall to fall III. However, in the last three seasons (spring II, summer III, and fall III), the values of stock rate for GRASS+LEGUME pasture were intermediate and greater than GRASS pasture. There was an interaction between pasture type and seasons for the liveweight gain per ha ($P < 0.001$; Figure 3). The greatest liveweight per ha was obtained for GRASS+N pasture in summer, fall, winter, summer II, fall II, spring II, summer III. In spring and winter II, there was no difference between pasture types (averages of 86.1 and 5.1 kg/ha/season, respectively). In fall III, GRASS+N and GRASS+LEGUME pasture had the greatest liveweight gain per ha. (215 and 180 kg/ha/season vs. 99 kg/ha/season in GRASS pasture).

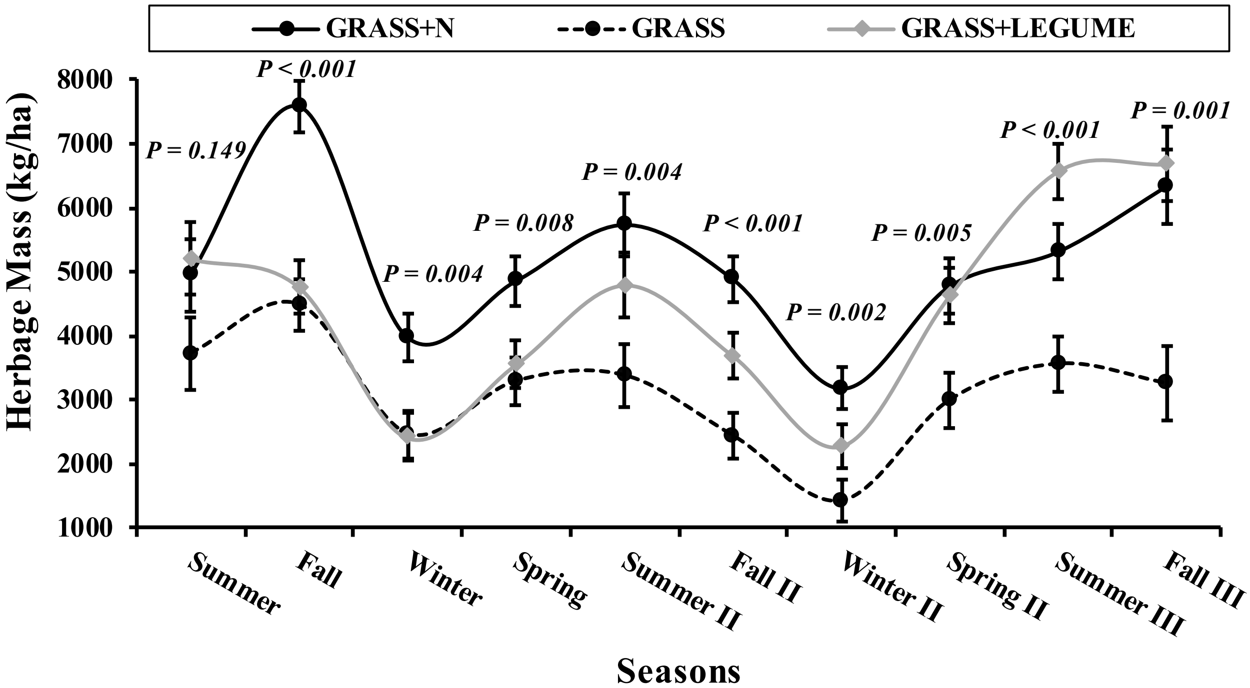

Figure 1. Herbage mass of Maranud palisadegrass pastures with or without N application, and mixed with forage peanut during the seasons of the experimental period. Error bars represent ± standard errors of the means.

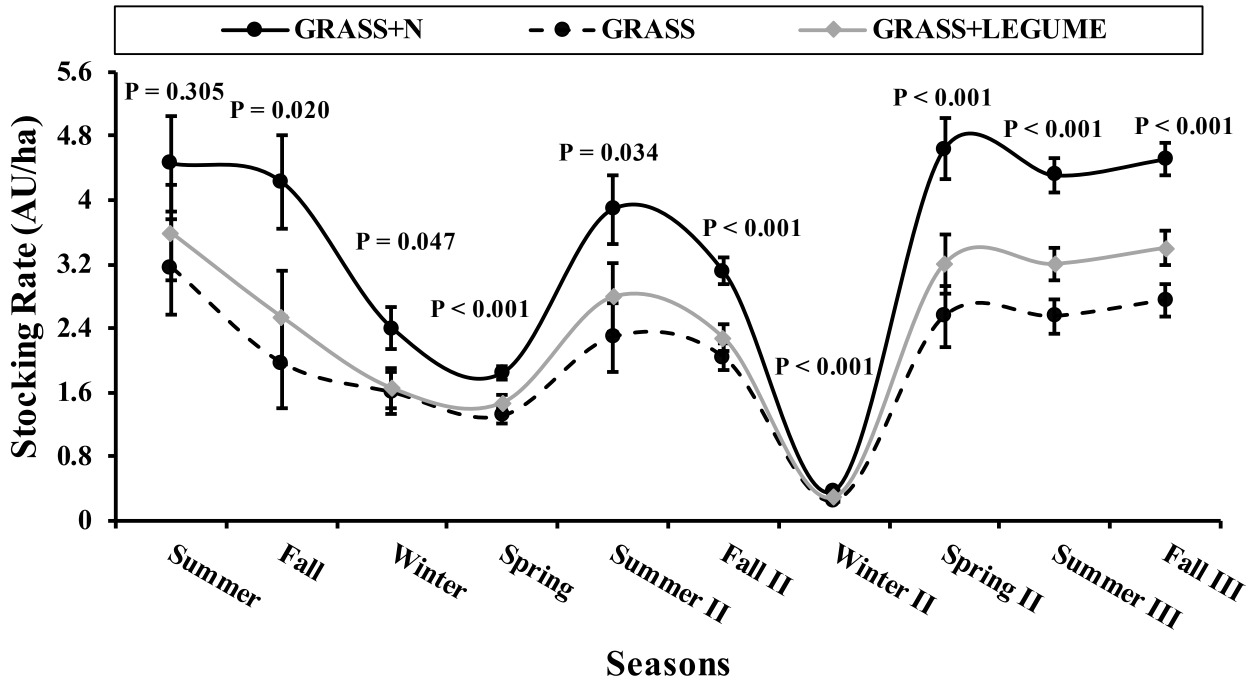

Figure 2. Stocking rate of Marandu palisadegrass pastures with or without N application, and mixed with forage peanut during the seasons of the experimental period. Error bars represent ± standard errors of the means.

Discussion

Herbage mass of the GRASS+N pasture increased, ranging from 51 to 84% more forage compared to GRASS pasture. Application of N has an impact on tiller population density due to faster generation of new leaves from several axillary buds, which may result in the appearance of new tillers, and having a positive impact on herbage mass (Lafarge 2006). In the GRASS+LEGUME, the increase of the herbage mass occurred of a lenient way. Forage peanut has been reported to be generally slower to establish in comparison to grasses (Tamele et al. 2018). Furthermore, the transference of the atmospheric N fixed to the systems is likely to be slower, depending on the biological process of mineralization (i.e., litter decomposition) or transfer from livestock excreta.

Nitrogen input increased the stocking rate and liveweight gain per ha; however, the effect of forage peanut occurred at the end of the study. On average, N application or the presence of the legume led to an increase in stocking rate of 72.4% and 25.3%, respectively, compared with the GRASS pasture. Provided that the canopies had been managed under similar canopy height target, greater forage accumulation for N application or the presence of the legume resulted in increases in the stocking rate and liveweight gain per ha. In Brazil, the increase in productivity of livestock production on pasture in a sustainable manner becomes a necessity. Nitrogen application is the fastest and easiest way to produce more meat in smaller areas. However, mixed pastures have direct benefits to farmers, with a reduction of the cost of maintenance N application and an increase in productivity relative to GRASS pasture.

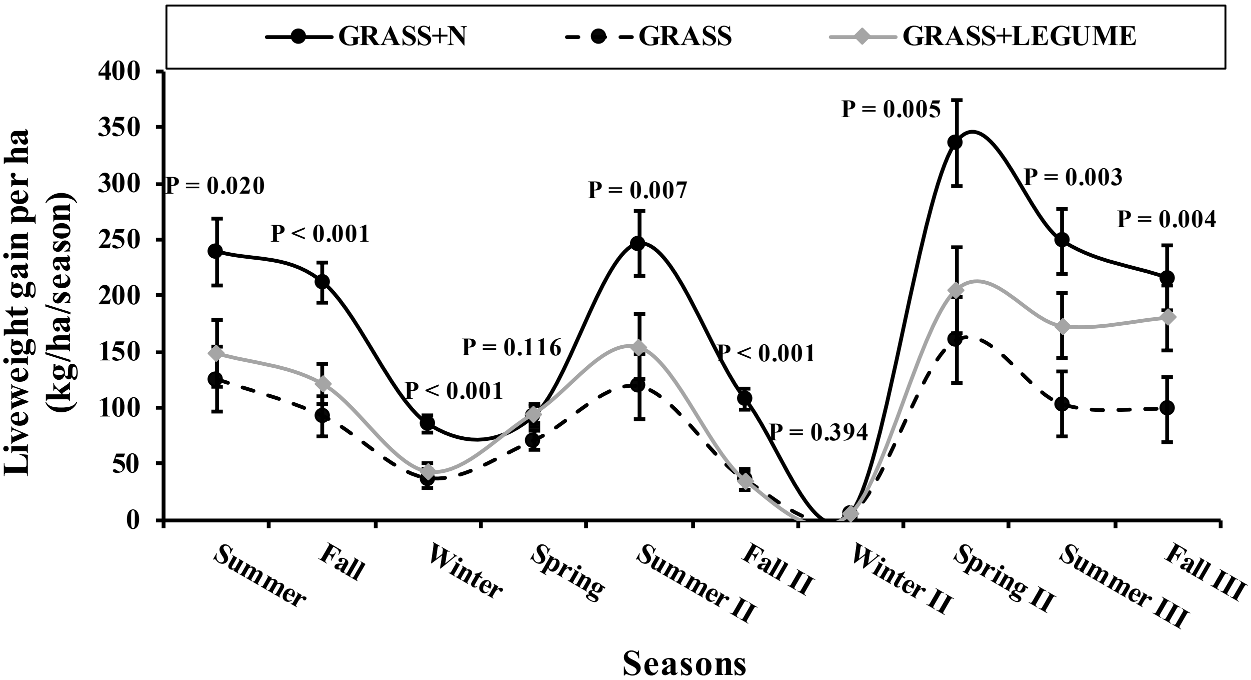

Figure 3. Liveweight gain per ha of Marandu palisadegrass pastures with or without N application, and mixed with forage peanut during the seasons of the experimental period. Error bars represent ± standard errors of the means.

Acknowledgements

The work was funded by the FAPEMIG, CNPq, CAPES, and INCT-CA.

References

Barthram, G. T. (1985). Experimental techniques: the HFRO sward stick. In: M. M. Alcock, editor, *Biennial report of the hill farming research organization.* Hill Farming Research Organization, Midlothian, p. 29–30.

Delevatti, L. M., Cardoso, A. S., Barbero, R. P., Leite, R. G., Romanzini, E. P., Ruggieri, A. C., and Reis, R. A. (2019). Effect of nitrogen application rate on yield, forage quality, and animal performance in a tropical pasture. *Sci. Rep.*, 9, 7596.

Lafarge, M. (2006). Reproductive tillers in cut tall fescue swards: differences according to sward age and fertilizer nitrogen application, and relationships with the local dynamics of the sward. *Grass Forage Sci.*, 61, 182-191.

Tamele, O. H., Lopes de Sá, O. A. A., Bernardes, T. F., Lara, M. A. S., and Casagrande, D. R. (2018). Optimal defoliation management of brachiaria grass–forage peanut for balanced pasture establishment. *Grass Forage Sci.*, 73, 522-531.

USDA - United States Department of Agriculture. (2019). *Brazil once again becomes the world's largest beef exporter.* Retrieved from: https://www.ers.usda.gov/amber-waves/2019/july/brazil-once-again-becomes-the-world-s-largest-beef-exporter/