Evaluation of Vegetation Indices at Pasture-Based Systems for Dairy Cattle using Remote Sensing Data

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Introduction

Milk is among the six most important products of Brazilian agriculture, ahead of processed coffee and rice. Brazilian production of milk tripled between 1970 and 2006 (IBGE, 2016), and the country is currently the sixth largest producer in the world and growing at an annual rate of 4%, which is higher than that of the other top producing countries. The availability of forage, both in quantity and quality, is essential for the animals' production to reach maximum potential, and directly influences animal productivity, area productivity, overall productivity, breeding potential and herd health (Carvalho et. al, 2016). Focusing on this line of reasoning and on gathering economical and environmental sustainability, researchers have been evaluating the introduction of new forage types and management techniques that drive the industry to higher productivity without the need for expanding the areas used. Our objective in this study was to evaluate the effect of two dairy-cattle production systems on the Normalized Difference Vegetation Index (NDVI) of the pasture, obtained from a temporal series of Landsat images. The greenness displayed in the NDVI values may be correlated with plant production to indicate a stronger or weaker production, as well as to act as an indicator for different types of management of livestock systems (Alvarenga et al., 2015). On its turn, the pastures' biomass production may be correlated with potential for carbon storage in the soil (Oliveira, 2015).

Material and Methods

The study area is located within the *Mata Atlântica* biome (Brazilian Atlantic Forest), with average annual precipitation of 1,362 mm, average annual temperature of 21.5 ºC and humid subtropical climate. The experimental design featured the following dairy-cattle production systems: (A) irrigated with intensive management and high stocking rate (INTIRRI_AL) and degraded pasture with continuous grazing and low stocking rate (EXTDEGR_BL) (Figure 1). The two systems are described in Table 1.

Table 1. Description of the pasture-based dairy-cattle production systems.

Production system	Stocking rate	Pasture management	Grass	N dose (kg ha^{-1})
INTIRRI_AL	high	Rotation	*Panicum maximum*	>100
EXTDEGR_BL	low	extensive/continuous	*Brachiaria decumbens*	0

The NDVI values were extracted from OLI/Landsat-8 images using the method described by Conceição et al. (2015). The temporal data consisted of 30 cloud-free images taken from April 2013 to August 2015. The NDVI values of each production system were grouped based on season under 'dry season 2013', 'rainy season 2013/2014', 'dry season 2014', 'rainy season 2014/2015', and 'dry season 2015'. The Kruskal-Wallis ANOVA statistical analysis was applied in order to discriminate each production system for each described period.

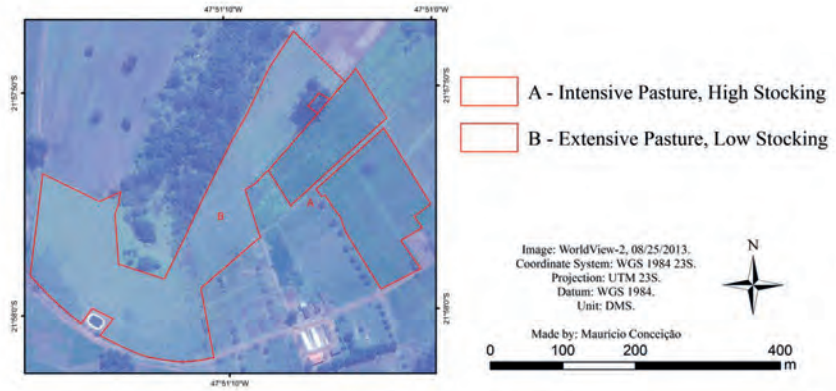

Figure 1. Experimental design with the beef cattle production systems at the study area.

Results and Conclusions

Figure 2 shows average NDVI values in each experimental area for each OLI/Landsat-8 image.

As expected, the intensive management, high stocking rate system showed the highest NDVI values, with a global average of 0.74 (Table 2). The extensive degraded pasture with low stocking rate system showed average NDVI values 8% lower (0.68), reaching up to 12% in the dry season of 2014.

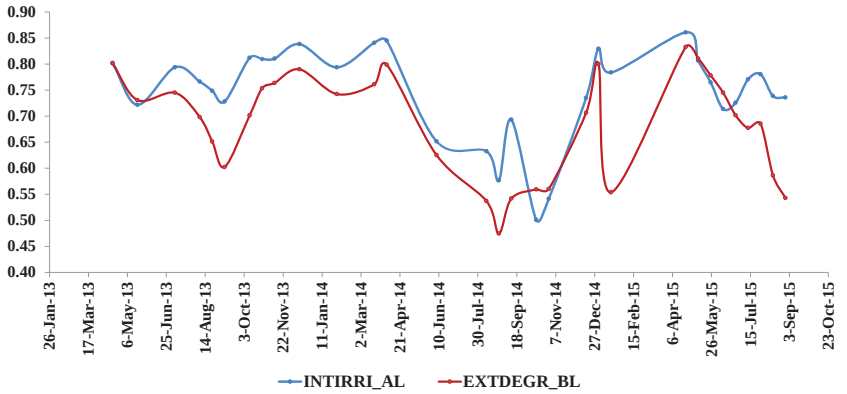

Figure 2. Livestock production systems' NDVI values from April 2013 to August 2015.

Production systems	DRY SEASON 2013 (6)*	RAINY SEASON 2013/2014 (6)*	DRY SEASON 2014 (5)*	DRY SEASON 2014 (5)*	DRY SEASON 2015 (9)*	AVERAGE 2013-2015 (30)*
INTIRRI_AL	0.76[a]	0.82[a]	0.68[a]	0.68[a]	0.76[a]	**0.74**
EXTDEGR_BL	0.70[b]	0.75[b]	0.59[b]	0.64[b]	0.70[b]	**0.68**

*Number of Landsat images. **Averages with different letters showed difference between production systems ($p<0.05$).

The best performance of the intensive system is due to the grass species chosen, which is more productive under favorable conditions of minimum air temperature and availability of water in the soil (Table 1) despite the higher animal load and the consequent higher biomass consumption (Muller et al., 2002). Vegetation indices show good potential for use in the monitoring of pasture greenness. Well-managed pastures favor carbon accumulation in the soil and contribute to mitigate the concentration of greenhouse gases in the atmosphere.

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