Tropentag 2014, Prague, Czech Republic
September 17-19, 2014

Conference on International Research on Food Security, Natural Resource Management and Rural Development
organised by the Czech University of Life Sciences Prague

An Agro-silvo-pastoral Production System in Brazil

Mariana Pereira[a], Davi José Bungenstab[b], Roberto Giolo de Almeida[b], Horst-Jürgen Schwartz[c]

a Universidade Federal de Mato Grosso do Sul, Avenida Senador Filinto Muller, 2443, Vila Ipiranga, CEP: 79070-900, Campo Grande, MS, Brasil. Email maripereirazoo@gmail.com
b Embrapa Gado de Corte, Avenida Rádio Maia, 830, Zona Rural, CEP 79106-550, Campo Grande, MS, Brasil.
c Humboldt University of Berlin, Asternplatz 2a, 12203 Berlin, Germany

Introduction

Extensive beef production with cattle grazing exclusively on sown pastures and cultivation of soy beans, maize and sugar cane are the main agricultural activities in Central-Brazil. The country has 249 million hectares used as agricultural land. From that, 174 million ha are used for cattle grazing, being 122 million ha on seeded pastures. Stocking rates on the typical signal grass (*Brachiaria* ssp.) sown pastures range from 0.4 to 1.0 Animal Units per hectare [AU/ha]. Live weight gains for growing beef cattle are estimated between 70 and 90 kg/head/year. Using improved management, total annual live weight gain could potentially reach up to 400 kg per hectare. Therefore, developing and testing management strategies for sustainable use of land already cleared for agriculture is very important.

The Brazilian Agricultural Research Corporation – EMBRAPA, at its Beef Cattle Centre in Campo Grande-MS, leads technology research for beef cattle husbandry in Brazil. Special focus is given to analyzing interactions among animals, pasture and environment, in order to develop management strategies for improving production sustainability. One technology that has shown excellent results is the integrated crop-livestock-forestry system (ICLF), also called agro-silvo-pastoral systems (ASPS). In Brazil, because of fast growth rates of certain tree species, a full cycle can be accomplished in seven years or even less. Such systems are intended to set the most appropriate combinations of species and cultivars, tree densities and stocking rates, as well as cultivation techniques for local conditions. To investigate details of ICLF systems component's interaction, a 12 years experiment was implemented in 2008 in an area of 18 ha, combining *Brachiaria* sown pasture with *Eucalyptus* trees (227 and 357 trees per ha) using soybeans cultivation every four years to recover pastures.

Material and Methods

The ICLF experiment is being carried out at the Brazilian Agricultural Research Corporation-EMBRAPA, located in Campo Grande-MS, Brazil, (20º27'S; 54º37'W; 530m altitude). The local bimodal climate has average temperatures over 25°C in hot-rainy months and 20°C in colder dry-months. Annual rainfall ranges from 1500 to 2000 mm, having 70 to 80% of the precipitation between November and March.

The experiment is testing two major variables, tree density and grazing height, resulting in four major treatments with two repetitions each. Trees of *Eucalyptus urophila x E. grandis*- clone H13 were planted in single rows, with 2 m between trees and 14 or 22 m between rows, resulting in

357 and 227 trees per ha. Grazing height of Piatã grass (*Brachiaria brizantha* CV. Piatã) was aimed to be kept with average sward heights of 30 and 45 cm under both tree densities.

The ICLF system was implemented on 18 ha degraded traditional signal grass pasture with low yield potential and strong presence of weeds, in a situation typical for Central-Brazil. Figure 01 illustrates the experimental cultivation scheme, representing one of several possible combinations of components in ICLF systems in Central-Brazil.

Cultivation scheme for the first 6 years of the experiment (completed)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2008	Degraded pasture					1	1	1	1	1	2	2
2009	3 2	3 2	3 2	3 2	4	4	4	4	4	4	5	5
2010	5	5	5	5 7	6	6	6	6	6	6	6	6
2011	6	6	6	6	6	6	6 7	6	6	6	6	6
2012	6	6	6	6	6	6	6 7	6	6	6	2	2
2013	2	2	2	2	5	5	5	5	5	6	6	6

Cultivation scheme for the second 6 years of the experiment (projected)

2014	6	6	6	6	6	6	6	6	6	6	6	6
2015	6	6	6	6	6	6	6 8	6 8	6	6	2	2
2016	2	2	2	2	5	5	5	5	5	6	6	6
2017	6	6	6	6	6	6	6	6	6	6	6	6
2018	6	6	6	6	6	6	6	6	6	6	6	6
2019	9	9	New cycle starting after clear cut and tillage									

Legend

(1) Clearing, tillage, liming, fertiliser application (2) Soybean cultivation (3) Planting and nursing of Eucalyptus over soybean (4) Sorghum cultivation over Brachiaria (5) Brachiaria establishment for pasture use (6) Grazing with cattle (7) Repeated pruning of Eucalyptus (8) First Eucalyptus cut, every second tree (9) Final cut of all Eucalyptus

Figure 1: Cultivation scheme of the integrated agro-silvo-pastoral System experiment at Embrapa Beef Cattle in Campo Grande-MS, Brazil.

In the experiment, commonly used techniques for pasture reclamation in the region are tested. From May to October 2008 the area was prepared using heavy and light tillage, as well as fertilizers and lime application, especially aiming to increase pH and to improve phosphor availability for the crop. In November 2008, soybeans cultivar BRS 255 RR was seeded with 0.45 m between rows and 30 seeds/m within the rows. Crop management was carried out following well established practices for the region (EMBRAPA, 2006). In January 2009 Eucalyptus seedlings were hand planted in the strips left on the soy field for this purpose. After the soybean harvest, using zero tillage, Piatã grass was seeded mixed with sorghum for hay production, since animals could not be introduced in the system yet, avoiding damages on juvenile trees. In April 2010 tree branches up to 2 m were pruned. In May 2010, when trees reached over 70 mm diameter at breast height (DBH), animals were introduced in the system. Another soy crop phase followed from November 2012 to April 2013.

Considering one of the trial's main goals of studying grazing behavior with two sward heights under an ICLF system, the pasture was kept under continuous grazing with variable stocking

rates. Forage availability and total animal live weight gains were measured. Trees reached 12.44 m height in February and 15.16 m in August 2011. In July 2011 second tree pruning was carried out up to 4.0 m above ground. Also in July 2011, Nellore heifers, aged 11 months, were introduced into the system with initial average weight of 158 kg. Animals had water and dry minerals constantly available. Stocking rates were calculated based on weight of the heifers allocated to each paddock; animals were weighted every 30 days until July 2012. Grass availability and nutritional quality as well as shading intensity in given points of the plots were also assessed. The tree component was first evaluated when 36 months old for the features: height, DBH, wood volume per tree and per area and estimated carbon storage.

Following the cultivation scheme, in December 2012, after liming and fertilization, soybeans (cultivar BRS 318 RR) were again introduced using zero tillage to reduce costs of pasture renovation as intended in integrated crop-livestock systems. Crop management was carried out as before. Soybeans yields were also recorded.

Results and Discussion

The initial soybean harvest was carried out in the first third of April 2009, with an average yield of 2100 kg/ha for the whole experiment, with no difference among the plots as the different ICLF treatments had not been established yet. In the second soybean cycle, in the season 2012⁄2013, average yields for both systems were different, with 2035 kg/ha for the 357 trees/ha system and 2270 kg/ha for the 227 trees/ha treatment. Considering that the average yield for Mato Grosso do Sul State in the same season was 2556 kg/ha, the latter can be considered a good result, as the major goal of soybeans cultivation was to reduce pasture renovation costs.

Regarding forage production, in the first dry season of the grazing phase, *Brachiaria brizantha* cv. BRS Piatã total dry matter yield was similar for both treatments, averaging 4.249 kg/ha. In the case of this experiment it is important to notice that in this phase, Eucalyptus trees were in average already 7.9 m high. Animal performance in this season, considering a grazing period of 80 days, averaged also for the whole experiment 654 g/day, reaching a total live weight gain of 127 kg/ha, with an stocking rate equivalent to 1.5 AU/ha. For this period of the year, expected animal response in a similar pasture under a traditional system should be live weight maintenance or even weight loss.

In the second grazing period, from November 2010 to May 2011, encompassing the rainy season and its transition to the dry period, when trees were in average 12.44 m high, both, forage and animal performance showed differences between systems. As expected, in the system with higher tree density total dry matter yield of Piatã grass dropped to 2.403 kg/ha and in the system with less trees, total dry matter grass yield was 2.710 kg/ha. This reduction naturally reflected on animal performance. Average daily live weight gains were 0.69 kg/ha/day and 0.73 kg/ha/day for high and low tree density systems respectively. Average stocking rates were 1.8 and 1.7 UA/ha for both systems respectively, which are still far superior to the estimated national average of 0.8 to 1 UA/ha for traditional systems. In the third grazing year, when evaluations lasted for 303 days, forage yields and consequently animal performance were superior for the system with lower tree density. Total dry matter yield was 4781 kg/ha for the 227 trees/ha and 3441 kg/ha for the 357 trees/ha treatments. In the same period, live weight gains and stocking rates in the system with 227 trees/ha were 1.51 kg/day/ha and 1.3 AU/ha and in the system with 357 trees/ha were 1.10 kg/day/ha and 0.9 AU/ha.

The tree component was evaluated when trees were 36 months old. Results showed that in this preliminary evaluation, plant density did not influence individual tree performance. No difference was found for plant height, DBH and timber volume. Average height was 17.92 m, DBH of 16.25 cm and average individual timber yield volume was 0.18 m^3 per tree. Average tree height for commercial Eucalyptus plantations planted in 3x2 m settings at 36 months is in average 16.24 m

for Brazil, knowing that for Eucalyptus, growth in height is little affected by plant densities, except in extreme cases. Commercial DBH for the 3x2m setting is usually 11.33 cm and individual timber yields range around 0.0688 m³ per tree, while under larger spacing, as 12 x 2.5 m, average individual timber yields are 0.1444 m³. Naturally, timber yields per area were strongly influenced by plant densities. The higher tree density setting resulted in an equivalent to 70.42 m³ per hectare while the treatment with 22 m between tree rows yielded 38.83 m³ per hectare. Commercial Eucalyptus plantations with 3x2 m settings yielded 107.85 m³ timber per hectare due to higher tree densities. Consequently, the higher the number of trees per area, the higher is carbon fixation and the system's potential to mitigate GHG emissions, compensating emissions from the system itself, especially from cattle. For the 357 trees/ha treatment, carbon fixation just on sawlog wood was 20.09 t C/ha. For the 227 trees/ha carbon fixation on wood was 11.07 t C/ha. These figures show that both systems were able to compensate far more than GHG emissions generated by the cattle reared in the system.

Conclusions and Outlook

The integrated crop-livestock-forestry system tested at Embrapa Beef Cattle, as a rule, showed results similar or even superior to regional traditional cattle ranching systems from Central-Brazil. When considering the crop and livestock components of the integrated system, one realizes that their performance is higher under lower tree densities, remaining the task to define the optimal arrangement for each situation, especially regarding forest products market.

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