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Economic Viability of Biochar Use in Aerobic Rice Production in the Brazilian Cerrado

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Introduction

According to Matovic (2011) biochar production and mixing in soil are seen as the best options for atmospheric carbon sequestration, providing simultaneous benefits to soil and opportunities for distributed energy generation. The proximity of biomass source and biochar dispersal greatly reduces the energy and emissions footprint of the whole process. Matovic (2011) showed that there are enough sources available to be converted into biochar and there is enough land available to receive the biochar generated out of different sources.

Biochar is increasingly being recognized by scientists and policy makers for its potential role in carbon sequestration, reducing greenhouse gas emissions, renewable energy, waste mitigation, and as a soil amendment (Kookana et al., 2011). According to the authors, some sources may have unintended consequences, like heavy metals if waste is used.

Galinato et al. (2011) estimated the economic value of biochar application on agricultural cropland for carbon sequestration and its soil amendment properties in winter wheat cultivation in Eastern Whitman County, Washington. According to Galinato et al. (2011) it may be profitable to apply biochar as a soil amendment under some conditions if the biochar market price is low enough and/or a carbon offset market exists.

Considering different sources of biochar and using Marginal Abatement Cost Curves (MACCs), Pratt & Moran (2010) showed that economic feasibility of biochar projects depends on a range of factors including the price of carbon and significant ancillary benefits in terms of agricultural productivity.

Kookana et al. (2011) described some unintended consequences of biochar use. If it is obtained from waste, there may be heavy metal concentration in soil. Thus, in our case in Brazil, we only consider biochar obtained from charcoal residues out of plantation timber.

Brazil produces a significant amount of charcoal out of plantation timber. According to IBGE (2011), in 2009 a total of 3,378,493 metric tons of charcoal were produced out of plantation timber (mainly *Eucaliptus* sp.). In the Middle-West, charcoal production out of plantation timber reached 72,413 tons.

According to ABRAF (2010), for each ton of charcoal produced 0.25 tons of charcoal residues are being generated. Thus, it can be assumed that in the Middle-West region of Brazil in 2009 a total amount of 17,953.25 tons of charcoal residues must have been produced. One possible use of those residues are as soil amendment. Therefore those residues need to be crushed to a granulometry of 2 millimeters, which can be considered as charcoal fine. There are providers of charcoals fine in Minas Gerais state offering it for R$ 250.00/ton plus transportation costs.

The charcoal fine, also considered as biochar, is being tested as a soil amendment to improve soil fertility and in turn increase sustainability of aerobic rice production systems (mainly rainfed). Thus, this study aimed to assess the economic viability of biochar use in aerobic rice production in the Brazilian Cerrado, considering current market conditions (acquisition of biochar, no premium price for produced rice and no carbon offset market for biochar).

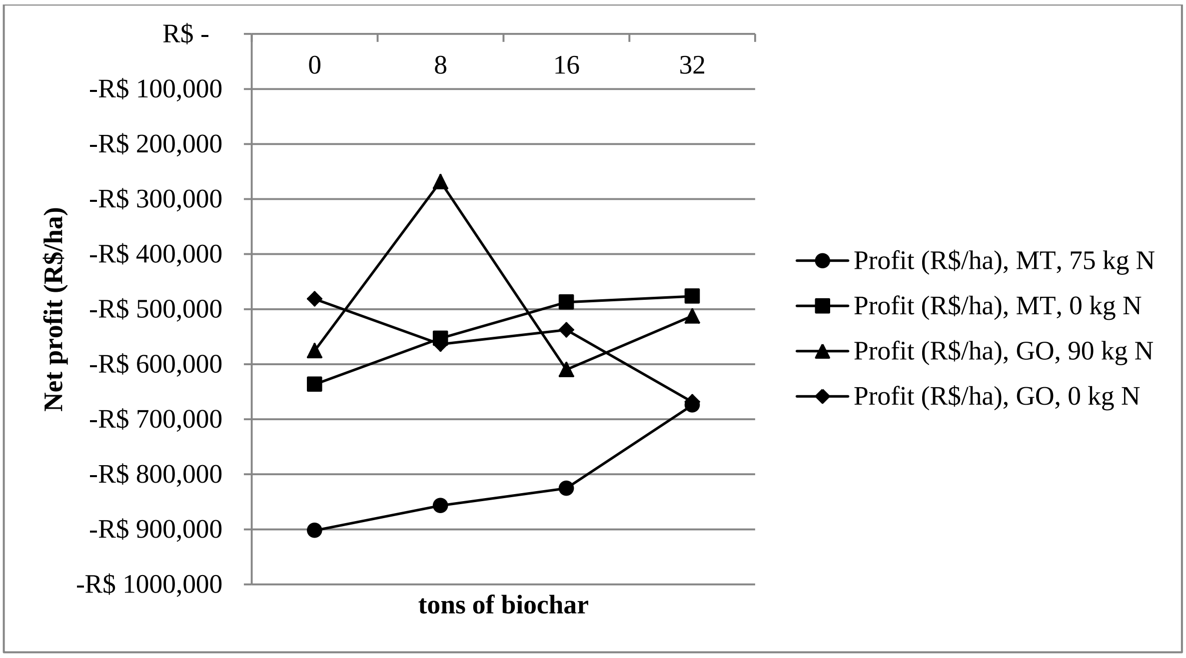
Material and Methods

The study has been carried out with agronomic data from field experiments at two sites: Nova Xavantina (Mato Grosso state, MT) and Santo Antonio de Goiás (Goiás state, GO). At MT site, results were based on three cropping seasons 2008/2009, 2009/2010 and 2010/2011; and at GO site, results were based on two seasons 2009/2010 and 2010/2011. Treatments consisted of a combination of two nitrogen fertiliser levels (0 and 90 kg N/ha in GO; and 0 and 75 kg N/ha in MT) and four levels of biochar (0, 8, 16 and 32 tons/ha). Biochar was obtained from *Eucalyptus* charcoal residues of 2.00 mm particle size. Biochar was incorporated into the soil only once, before the sowing of the first crop. It was done in one single application, in season 2008/2009 in MT and in season 2009/2010 in GO. The cost of obtaining biochar was R$ 310/ton at GO site and R$ 330/ton at MT site. Additionally to acquisition, the costs for distribution and soil incorporation were considered. All other costs of rice production were similar to conventional aerobic rice fields in the region. Production costs considered are mulching, direct seeding, fertilisation, weed control and harvest operations. Revenues were generated by paddy rice yields, considering market price in April of each considered year (R$ 32.30/bag of 60 kg paddy in 2008/2009, R$ 29.00 in 2009/2010 and R$ 27.00 in 2010/2011). Short-term profitability was estimated as revenues – production costs (without biochar). Since biochar use represents an investment, its feasibility was measured using payback period (years) with different levels of rice prices.

Results and Discussion

All considered treatments – with or without biochar - generated negative net profits (Figure 1). However it can be observed from Figure 1, that increasing rates of biochar use – with our without N application - reduced the negative profit at Nova Xavantina (MT) site. In the case of Santo Antonio de Goias (GO) site, no clear trend in net profit with increasing biochar rates could be identified. Without N application profit development was even worsen.

Figure 1. Net profit (R$/ha) of aerobic rice production after biochar application in Santo Antonio de Goias (Goias state) and Nova Xavantina (Mato Grosso state) at different nitrogen and biochar use levels.



Obtaining and applying biochar requires remarkable investments. The investment level goes up to more than R$ 10,000 when using 32 tons per hectare (Table 1). Investment may be reduced due to locally obtained (self-made or acquired) biochar.

Table 1. Costs of biochar application (biochar + application + incorporation)

Investment level*) at different sites	Biochar rates used (tons/ha)			
	0	8	16	32
Santo Antonio de Goias (GO) (R$/ha)	-	R$ 2,712.00	R$ 5,352.00	R$ 10,632.00
Nova Xavantina (MT) (R$/ha)	-	R$ 2,872.00	R$ 5,672.00	R$ 11,272.00

* Investment includes biochar acquisition, distribution and incorporation to the soil.

The payback period of biochar investment showed site specific behavior. In the case of MT site, the investment could not be recovered at any time. In the case of GO site, it would take 3.2 years to fully recover investment wen using 8 tons/ha of biochar + 90 kg N/ha. Using 8 tons/ha without additional nitrogen would raise the payback to 5.4 years. This scenario was only possible at a rice price level of R$ 45/rice bag of 60 kg, which is above current rice price.

Some options that may improve chances of success of biochar in aerobic rice production are:

- If aerobic rice growers are able to obtain biochar at lower costs;
- If farmers receive premium prices for rice grown on biochar treated soils;
- If there is a carbon offset market for biochar.

Like Galinato et al. (2011), we see a situation where at least one change in current market forces is required in order to turn biochar use economically feasible.

Since those situations are hypothetical scenarios, under current market conditions in Brazil, without the internalization of all benefits related to its use, biochar is not yet economically viable for aerobic rice growers in the Middle-West of Brazil.

Conclusions and Outlook

Under market price conditions (acquisition of biochar, no premium price for produced rice and no carbon offset market for biochar), in all treatments, the costs were higher than the revenues. After using a sensitivity test, varying the market prices for a 60 kg bag paddy rice from R$ 30 to R$ 45, only at GO in the cropping season 2009/2010 the results were promising. The most promising economic results were obtained using 90 kg N and 8 tons biochar per hectare. At current market prices for conventional long-grain rice, however, it was not as viable as expected. If aerobic rice yields increase and producer get an additional price for their production (niche markets) or biochar becomes cheaper, then it may become an interesting option under certain conditions.

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