Evaluating agricultural systems based on mulch technology: a case study

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Abstract
In this paper we evaluate the effects of introducing mulch technology, a mechanised chopping of the follow vegetation in farm family units in the eastern Amazon region of Brazil. The proposed approach includes social research, experimental design and thematic model to calculate economic performance indicators and technical efficiency scores. Efficiency scores were determined using Data Envelopment Analysis (DEA) models in order to compare agricultural systems applying mulch technology to those using slash-and-burn agriculture. The economic viability of mulch technology demands the reduction of the hour/machine cost, as well as the increase of the family monetary benefit, by intensifying land use with vegetables such as maxixe, sweet pepper and eggplant in the temporary production systems.

1. Introduction
Starting from results of agronomic research, SHIFT Project Fallow (\textit{Capoeira or Dense Forest}), involving Embrapa Brazilian Agricultural Research Corporation, Federal University of Pará, University of Bonn and University of Göttingen, proposed the introduction of mulch technology or grinding fallow, in order to analyze the productive process of family farms units that use the fallow system. The system cultivated with mulch technology consists on a method of preparing the soil without using fire, associated to grinding and fallow.

Considering the income to be of great importance for the family work having an influence on decision process of family units, whose preference for certain technology depends upon approaches that assure its reproductive efficiency, Freitas (2004) conducted a study on the impacts caused by the introduction of mulch technology in the productive process of family units of Eastern Amazon. The research purpose was to identify the private benefits and socioeconomic impacts obtained to the family units that use agricultural systems cultivated with mulch technology. On this purpose, it was accomplished an experimental essay that involved 24 family units from a town called Cumarú, belonging to the Municipal District of Igarapé-Açú, in the state of Pará, Brazil. The survey was performed during two annual cycles of production, between August, 2000 and July, 2002.

2. Methodological aspects
As mentioned above the survey (ex-post type) was conducted, involving 24 families from Cumarú town. Several local meetings were accomplished to reach the general objectives of the research, which were used for the formation of the groups previously mentioned. The choice to belong to this or that group was entirely decided according to each family’s opinion. It was decided that the family, which was taken part in the grinding group, could also use “fire” in another plot of the fallow or out of it.

In the first annual cycle of production, between August (2000) to July (2001), two observation groups were formed: a group of 13 family units, that used agricultural systems cultivated with slash and burn, combining mulch technology system; another group involved 11 family units, that used agricultural systems exclusively with slash and burn technology. In the second cycle, between August (2001) and July (2002), all family units had used agricultural systems with slash and burn technology. In the comparative analysis of the economic performance of cultivated areas using mulch technology in relation to the areas cultivated with slash and burn technology, were considered the parameters of average profitability for equivalent worker, average income for cultivated hectare and average income per worked day.

Data Envelopment Analysis (DEA) approach was chosen in order to evaluate the relative technical efficiency between family units that adopted agricultural systems cultivated through mulch technology and the ones that applied slash and burn technology. We considered DEA models with variable returns of scale (Banker et al., 1984). The purpose of it was to compare the technical efficiency in the short period of the agricultural systems cultivated with mulch technology in reference to the agricultural systems cultivated with slash and burn technology. DEA is an optimization method that generalizes single-input/single-output technical efficiency measure to the multiple-input/multiple-output case by constructing the relative efficiency scores as the ratio of the single virtual output to the single virtual input. It is a methodology directed to frontiers: instead of trying to fit a regression plane through the center of the data as in statistical regression, for example, one “floats” a piecewise linear surface to rest on top of the observations. It uses linear programming problems to calculate the relative technical efficiency.

3. Results

3.1. Economic performance

3.1.1. Comparative analysis of the net income for grown hectare

In the 1st annual cycle of production, it was observed that, the average net income per grown hectare in the agricultural systems with mulch technology had a lower performance compared to the agricultural systems with slash and burn system. The vegetables and permanent crops provided the best income in both technical systems. The income per hectare was negative for temporary crops in the agricultural systems using mulch technology (cassava, corn and bean).

The net income per hectare of maxixe’s crop in the agricultural systems cultivated using mulch technology had much higher performance compared to the one on slash and burn technology. Analyzing maracujá’s (passion fruit) case, the net income per hectare of this crop in the agricultural systems grown using mulch technology is statistically similar to the one of agricultural systems that applied slash and burn technology.

3.1.2. Comparative analysis of average income per worked day

The comparison of the net average income per worked day indicates that the observed value in the agricultural systems grown through mulch technology had a lower performance compared to the one with slash and burn technology. The analysis for each crop shows that in the agricultural systems grown by means of mulch technology the net average income per worked day in the temporary cultivation was smaller than in the systems with slash and burn technology.

Therefore, areas with temporary and permanent crops, the income per worked day were much higher for the systems that applied slash and burn technology rather than mulch
technology. On the other hand, in areas of vegetables, the net average income per worked day was the same for both technologies.

For the areas cultivated with mulch technology, the smallest net average income per worked day was found out in the corn’s crop and the largest one on the maxixe’s crop. Regarding to beans and passion fruit’s crops both technical systems provided the same net average income per worked day. On the other hand, the slash and burn technology provided better results for the cassava crop.

An explanation for the excellent performance of maxixe’s crop in both technologies lies behind the duration of the cycle for its production, which is shorter (at most sixty days). Therefore, as the interval of occupation for the cultivated areas has short duration, the costs of preparation of those areas can be divided into a sequence of crops for a same annual cycle of production. In that sense, it is understood that the cultivation of maxixe using mulch technology can be promising.

3.1.3. Comparative analysis of average profitability for a family work

The average profitability for equivalent worker evaluates the average remuneration earned by each worker from family unit in a production cycle and it is one of the main indicators of this work to analyze the economic acting of the agricultural systems cultivated with mulch comparatively (in a total of 13 cultivated areas) to the systems cultivated by means of slash and burn technology (42 areas).

The total profitability for equivalent worker occupied in the agricultural systems cultivated through slash and burn technology went extremely higher compared to the agricultural systems cultivated with mulch technology.

The temporary crops in the systems cultivated with mulch technology produced the smallest average profitability for equivalent worker; the highest average profitability was the one of the cultivation of vegetables. In the slash and burn technology, the highest average profitability for equivalent worker was provided by the permanent crops. The passion fruit’s crops using slash and burn technology, showing much higher value compared to mulch technology obtained the highest average profitability for equivalent worker.

These results were consistent with the field observations, which showed that the amplification of the crops areas of passion fruit cultivated in the agricultural systems with slash and burn constitute productive strategies for those family units, in order to intensify the use of soil and work. However, it is worth to remember that in the initial stage of growth, the permanent crops (such as passion fruit) had lower profitability or even negative. However, to reach the maturity, these crops participate with the highest portion of the value of the average profitability for equivalent worker.

To the average profitability be compared by equivalent worker by production cycle (34 in the 1st cycle, 13 cultivated with mulch system and 21 with slash and burn; and 21 areas in the 2nd cycle, all with slash and burn), independently to the agricultural system prepared to the adopted soil, it was verified that the value of the 2nd production cycle went higher than the 1st cycle. In the evaluation for crop type was noticed that the permanent crops provided the highest average profitability for equivalent worker in both production cycles, and the average profitability of the family work were compared in the vegetables’ cultivation.

3.2. Technical efficiency

DEA BCC was applied to 42 cultivated areas (42 Decision Making Units - DMUs) in the two production cycles; 38 areas cultivated in the agricultural systems with slash and burn technology and only 4 areas cultivated in the agricultural systems with mulch technology. At this analysis, 55 areas were originally considered, 13 areas that presented negative results were discarded. As inputs were considered cultivated area and worked days; the net income is the output.
Isolated analyses were made for the permanent and temporary crops, as well as an analysis considering the resources and the global results in the three types of crops. We also tested models for the situations of current net income, intermediate and ideal (considering scenario with grinding costs about 6 times smaller than the current ones).

It was observed that the technical efficiency for the family units that adopted agricultural systems with mulch technology fluctuated between 20% and 100%. For the family units that adopted agricultural systems with slash and burn technology, the value of the technical efficiency varied from 10% to 100%. We still verified that the type of adopted crop system had a strong influence in the productive efficiency for the family units, so that the adoption of productive systems with passion fruit cultivation provided larger efficiency levels in both technical systems. On the other hand, the corn cultivation had a negative influence on the value of the technical efficiency. Additionally, the family units that adopted agricultural systems cultivated with slash and burn technology were more efficient than the family units that adopted agricultural systems cultivated with mulch technology.

Although the family units that used the system and cultivation through mulch technology obtained, on the average, smaller technical efficiency (18.3%) than those with slash and burn technology (57.2%), the evaluation with ideal values of net income was close to the average values of efficiency (48.9% and 55.6% for mulch and slash and burn technology, respectively), which shows that in the long run, the system with mulch technology can provide higher values of technical efficiency, compared to the slash and burn technology.

Considering the values of technical efficiency in the two costs scenarios, current and ideal, it was verified that increases the chances of adoption of the mulch technology for the farming family units, with the reduction of the costs, since the levels of technical efficiency can become higher than the ones calculated for the family units that adopted agricultural systems cultivated by means of slash and burn technology.

4. Conclusions

The data of this survey suggests that agricultural systems cultivated with slash and burn technology follows different productive strategies for using of soil and work.

The economic performance indicators used in this paper showed lower values for the agricultural systems cultivated with mulch technology when compared with the systems using slash and burn technology. This means that, in the short run, the introduction of mulch technology decreases the profitability for equivalent worker.

In relation to the technical efficiency, we verified smaller values equally for the productive processes with mulch technology. The inclusion of environmental variables in the efficiency measures can result in a scenario very different from the one described here, since the mulch technology can be considered “cleaner” in relation to the slash and burn technology. Adding value to the products generated in the systems cultivated with mulch can also reach the environmental certification, as they can provide environmental services to the society as well.

5. References
