Improving nutrient efficiency use through conversion to organic farming, Madagascar

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About the authors

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Description: Family production systems in Madagascar

Today, a great number of family production systems in Madagascar are organic, as farmers no longer have the financial capacity to buy mineral or chemical inputs (e.g. fertilizers, herbicides, fungicides).

In the region of the Malagasy highlands (1200-1550 m.a.s.l.) the climate is characterized by warm and rainy summers from November to April (average rainfall of 1300 mm and temperature of 19.2 °C) and cool and dry winters from May to October (188 mm and 15.0 °C). Agriculture is mainly practiced on smallholder farms with mixed crop-livestock systems. Paddy rice is the most important crop for food consumption and for sales. A range of upland crops and natural vegetation are also

present on the convex hill slopes, known locally as *tanety*. Livestock production is dominated by small herds with less than five heads, ranging from low-productive native *Zebu* cattle to intensive dairy based on European pure-bred cattle (Norwegian Red and Holstein).

In 2009, the economic crisis in Madagascar and disruption of the dairy sector led to a decrease in milk prices from an average of 0.31 USD to about 0.05 USD per litre in a few weeks. As a result, smallholder farms were forced to decrease dairy production to reduce costs (by not using concentrate supplementation and/or selling animals) until prices recovered sufficiently after a few months. In this situation, farmers needed to search for alternative inputs to remain profitable. This study demonstrates one solution, transforming the farming system from conventional inputs to a greater use of organic inputs to enhance the efficiency of nutrient use while reducing input costs.

Finding alternatives to synthetic inputs

The farm of Mr Jules Ranaivo provides a case study that illustrates a successful conversion to alternative inputs. Mr Jules mainly grows rice in irrigated lowlands, some maize and fodder plants in the *tanety* and in the lowlands during the off-season. Rice is mainly for home consumption (about 80 percent of production) and the rest is sold at the local market. Straw is conserved to feed cattle. Elephant grass is the main forage source for cattle during the wet season. The association of oat and ryegrass occupies 40 percent of the surface of lowlands in off-season and is fully intended to supply dairy cattle. Stems and tubers of fodder radish are used for feeding dairy cattle during the hunger gap.

The 20 ha farm is home to 25 ruminants, 10 pigs and 50 chickens. When the farm was established in 1989 it only had two dairy cows. The livestock on the farm are made up of *Zebu* breed (*Bos*; *Bos primigenius indicus*) and dairy cows (*Bos*; *Bos primigenius taurus*), as well as monogastric pigs (*Sus*; *Sus scrofa*) and chickens (*Gallus*; *Gallus gallus*).

The situation before 2009

Before 2009, Mr. Jules used considerable amounts of mineral fertilizers (urea and NPK) to fertilize his crops. Paddy rice and milk were the two main farm products produced for household consumption and income. Livestock activities provided the largest part of farm income and the relative importance of milk sales in total farm income was particularly high (around 75 percent). The second most important income-generating activity was pig farming. The food self-sufficiency ratio was about 90 percent. This farm had high values for all productivity indicators, food self-sufficiency and agricultural gross margins, but also high N losses to the environment and dependence on external inputs (concentrate feeds and mineral fertilizers). This farm is an example of the diversity of crop-livestock farming systems according to a typology of farms based on cropping, breeding and manure management practices. It is almost unique in terms of the large number of animals and cropping area.

Impacts of the economic crisis in 2009

A critical point of vulnerability for the farm was the high dependence on external inputs (mineral fertilizers and concentrate feeds) needed to maintain crop and animal production. The economic crisis in 2009 caused a dramatic reduction of the income from milk production and increase of raw

material prices for animal feeding (e.g. corn, soybean meal). This was an unsustainable situation and almost led to financial bankruptcy.

In addition, the price increase of oil and mineral fertilizers since 2008 has had a significant impact on the amounts of mineral fertilizers used. Soil fertility began to decline due to the export of nutrients via crops and to losses from leaching and erosion, which were not compensated by the addition of fertilizer input. This resulted in a dramatic reduction of agricultural productivity. In response, Mr Jules began using organic fertilizers from his herd with the long-term goal of restoring field, in order to ensure his own food security.

Improving sustainability of livestock management

To help cope with the increase in input prices, FIFAMANOR and CIRAD launched a research project to identify farming methods linked to the efficiency of nutrient conservation on mixed crop and livestock farms. The research was supported by surveys and on-farm monitoring operations and by characterization of the chemical composition of biomass by near-infrared spectroscopy.

These tools have been used to assess on-farm nitrogen flows and study the impact of farming practices on the fertilizer value of manure and nutritive value of silage, including on Mr Jules farm. Encouraged by the initial results observed on the farm, Mr Jules implemented all the management practices considered essential to maintain fertilizer quality of manure and to improve the nutritional quality of maize silage. The improvements proposed and implemented by Mr Jules involved changes in the schedule and in the nature of agricultural practices (e.g. maize harvesting stage), small investments in infrastructure (protective roof for manure) and in ensilage technology (chopping size, degree of compaction, and closing/opening the silo).

Dairy cattle, in permanent stalling, are now fed with forages produced on the farm. Previously, dairy cows in production were fed with purchased concentrate feed. Milk production (230 litres per day on average) was almost completely transformed on the farm for the commercialization of cheese, butter and cream. The by-products of the processing of milk (whey) are distributed to pigs. *Zebus* graze on communal lands (*tanety*) and stay in the barn at night. In addition to pasture, they receive rice straw and also brewers grain when the animals are doing work. The farm is also breeding *Large White* pigs and has a pigsty. Their diet was based on the purchase of concentrate feed mainly composed of corn and rice bran and on the whey from cheese production on the farm. Backyard poultry are intended for on-farm consumption. Their diet is based on corn and rice purchased or produced on the farm. Nitrogen balances, N use efficiency and productivity and profitability indicators have been used to measure the impacts of strategy and practices used.

Other features of changing practices: Reduction of fertilizer use leading to improved N efficiency

Improving manure management in the barn, during manure storage and at manure spreading has led to a reduction in N losses to the environment. The N content of conserved manure was around 2.5 percent (on a dry-matter basis) compared to 0.9 percent before the implementation of manure management practices.

The improvement of silage quality, in addition to better management of other forage resources on the farm, has allowed Mr Jules to feed his ruminant herd almost exclusively on fresh and conserved forages.

Although milk production has decreased significantly (110 litres per day on average), it is sufficient to maintain a comfortable cash position for the family. Mr Jules says that now he is more interested in the manure production potential of his dairy cows than in their milk production alone. His objective is to maintain or even improve soil fertility and consequently the yield on the farm as a whole, rather than solely milk performance of his dairy herd.

The first measurements of rain-fed rice productivity on the farm using improved manure showed that grain production increased by 24 percent and straw rice production increased by 22 percent, compared to conventional organic fertilization.

Measures to improve manure management included paving the floor of stables, adding rice straw to litter, storing manure in pits, adding pig or poultry slurry and reducing storage times. These practices boost the nitrogen value of manure. Improving maize silage techniques showed that maize harvest time increased from 90 to 100 days of the cycle, with dry-matter content between 30 and 35 percent. Hermetic seal and rainproof storage were some of the main techniques for preserving silage quality.

Organic certification is not an explicit goal at the moment, but Mr Jules is interested in it and there is the potential for this system to be certified. Mr Jules only uses antibiotics very rarely to treat mastitis in his dairy cows. Mr Jules also uses two vaccines (anti-coal and anti-bicharcoli) that are required by the Malagasy government for cattle. Mr Jules only occasionally uses pest control. Mr Jules uses brewer grains to feed cattle, but only during peak of lactation and when the availability of forage is very low.

Innovations must be socially and culturally appropriate

In Madagascar, the availability of technical and economic innovations alone does not guarantee their widespread adoption amongst the farming community. It is also important to consider a societal point of view. For example, some ethnic groups do not use pig manure to fertilize crops despite it being a rich and balanced fertilizer due to cultural and religious reasons. It was observed that the adoption of technical innovations required time for debating and learning. The improvement of farm technical and economic results is important, even decisive, but innovations must always respect farmers' social practices.

Lessons learnt

The next step at the farm could be introduction of a direct sowing mulch-based cropping system, which may lead to reduction of N losses via runoff and erosion at field scale, and improve soil N balance at farm scale. In addition, introduction of legumes in rotations will also improve nutrient dynamics in soils and recovery of crops.

The biomass produced on the farm (crop residues and natural vegetation), which were previously put aside or burnt, are now used to restore soil fertility, supplement mineral supplies and produce feed and forage resources for animals. The results of this case study indicate that a set of manure management practices impact positively the degree of crop-livestock integration and the global farm N efficiency, decreasing total system N losses.

These practices coupled with feed quality improvement (silage) showed good opportunities for better economic performance, farmer's livelihood and self-sufficiency, and environmental sustainability (decreased N losses and increase of soil N stock capacity). These improvements also helped to reduce farmers' reliance on external inputs, the prices of which greatly depend on market volatility. The conversion from external inputs to a greater use of organic inputs has therefore, helped to improve the economic resilience of the farm. Moreover, reducing mineral fertilizer use helps to improve the environmental efficiency of agricultural activities (reduction of greenhouse gas emissions and fossil fuel consumption) while reducing concentrate feed use helps to increase the amount of food for human consumption.