Integrated Crop/Livestock Production Systems for Kyusei Nature Farming in Brazil

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Abstract
This paper reports on the development of an integrated system of crop and livestock production in Brazil based on Kyusei Nature Farming. Experiments began in 1984 in which animal feeds and Effective Microorganisms (EM) were major inputs. Some important features of this uniquely integrated system include a) use of animal manures for crop production instead of chemical fertilizers, b) use of EM4 rather than pesticides, antibiotics and hormones, c) addition of poultry manure to cattle and hog rations, and d) addition of cattle and hog manure to cattle rations.

Introduction

The goal of the Kyusei Nature Farming is to produce high quality and safe food, of both vegetable and animal origin, by means of ecologically-sound EM technology. The use of EM in crop production and in animal husbandry has been increasing worldwide with very promising results (Lynch, 1996; Guim, 1994). Through EM technology it is now possible to integrate two separate agriculture activities, i.e., crop production and animal husbandry into a more effective and sustainable system. This integrated system based on Kyusei Nature Farming began in Brazil in 1994.

Kyusei Nature Farming requires good quality organic amendments for crop production such as Bokashi (fermented organic fertilizer) which consists of rice bran, soybean meal, fish meal and other materials that are available. Since most of these are commonly used feeds for domestic animals, it is probably more economical to feed them to livestock and use their manure for crop production purposes. Another advantage of the integrated system is that environmental pollution is essentially nonexistent because all animal wastes are recycled on the farm where they are produced.

In the integrated system, it is recommended that several types of livestock, i.e., ruminants and non-ruminants, be kept to increase feed conversion efficiency. Carbohydrates and proteins not digested by one kind of animal are fed to another, making up a part of their ration.

This paper reports various aspects of the integrated system of Kyusei Nature Farming at the lpeúna and Atibaia farms, both in the State of Sao Paulo, Brazil.

Integrated Crop and Livestock Production for Kyusei Nature Farming

Nutrient Cycling

A major advantage of the integrated system of crop and livestock production for Kyusei Nature Farming is that the nutrients from the wastes of both enterprises can be recycled efficiently on the farm. Figure 1 shows two different models of nutrient cycling for integrated production systems at the lpeúna and Atibaia farms. In both cases, purchased livestock feed is the main source of nutrients and, together with EM4 and EM5, constitute the major farm inputs.

In the lpeúna farm model (Figure 1) chicken manure is used in the swine ration. Cattle rations are also formulated with a certain amount of chicken manure and hog manure. Since EM4 is applied to the waste materials for odor control, and to the drinking water, it is unlikely that pathogenic problems will arise from using these manures as feeds. Cattle manure and liquid hog manure are also major sources of organic fertilizers for upland crops and hay.

In the model adopted for the Atibaia farm (Figure 1) about one-half of the area is low and suited for fish ponds. Manure is not used in the livestock rations. Chicken manure and solid swine manure are applied to vegetable fields and orchards; whereas, the treated liquid swine manure is used to fertilize the fish ponds.

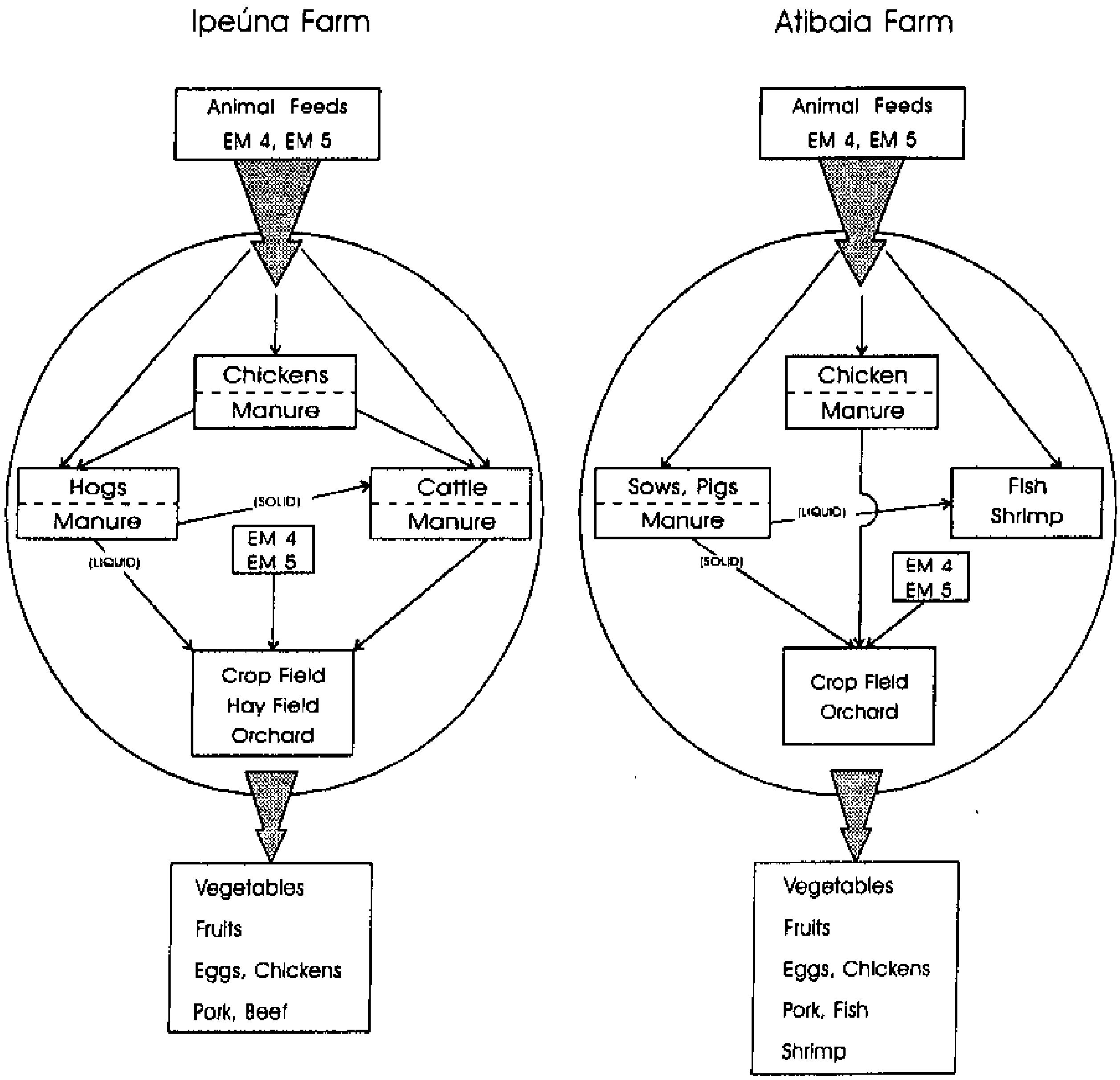

Figure 1. Tow Farm Models for Recycling Nutrients in Integrated Crop/Livestock Production Systems for Kyusei Nature Farming in Brazil.

Table 1. Amount of Livestock Feed Purchased by the Atibaia Farm in 1994.

Feed purchased	Amount (kg)
Corn	34,450
Soybean meal	32,950
Wheat bran	12,210
Rice bran	18,060
Bone meal	7,949
Oyster shell meal	13,600
Fish meal	1,200
Total	120,419

Since the primary source of plant nutrients in the integrated system of Kyusei Nature Farming is the purchased livestock feeds, it is important to know their nutrient content. The total amount of livestock feeds purchased by the Atibaia farm in 1994 is reported in Table 1. Approximately 120,000 kg of feeds were consumed in one year. The total amount of macro nutrients (N-P-K) contained in this amount of feed is presented in Table 2. According to Kiehl (1985), livestock assimilate only 25, 20, and 15 percent, respectively, of the total nitrogen, phosphorous, and potassium in the feed. The remaining nutrients not assimilated by animals are excreted as manure.

As shown in Table 2, the chemical fertilizer equivalent of 3,627 kg of nitrogen in manure is equal to 8,636 kg of urea; 1,962 kg of phosphorous is equal to 22,445 kg of ordinary superphosphate; and 901 kg of potassium is equal to 1,809 kg of potassium chloride. Some of the nutrients, especially nitrogen, are immobilized in humus and not immediately available to plants. Nevertheless, a reasonably adequate flow of plant nutrients enters the farm as livestock feeds in the integrated system of Kyusei Nature Farming. The manure obtained from livestock grown with EM technology in Kyusei Nature Fanning is quite different from that of conventional animal husbandry, with respect to its quality and safety. The former is now called EM-manure to distinguish it from the latter.

Table 2. Amount of Plant Nutrients in Livestock Feed Purchased by the Atibaia Farm in 1994; Nutrient Content of Livestock Manure Produced; and Total Manure Expressed as Fertilizer Equivalents.

Plant nutrient	Feeds (kg)	Manure (kg)	Chemical fertilizer equivalent (kg)
N	4,836	3,627	8,636 (urea)
P	2,452	1,962	22,445 (superphosphate)
K	1,060	901	1,809 (KCl)

Composition of nutrients in feeds taken from EMBRAPA and Morrison (1951).
Nutrient in feeds not assimilated by animals: N = 75%, P = 80% and K = 85% (Kiem, 1985).
Chemical fertilizer equivalent: the amount of N-P-K in manure expressed in terms of chemical fertilizers.

Table 3. Daily Production of Solid Manure per Animal According to Kiehl (1985) Compared with Data Recorded at the lpeúna Farm.

Animal	(kg animal^{-1} day^{-1})	
	Kiehl (1985)	Ipeúna Farm
Chickens	-	0.23
Hogs	2.46	2.00
Cattle	26.00	20.00

The lpeúna Farm data includes the average of both young and adult animals.

Livestock Populations

It is more economical to keep several kinds of livestock, i.e., ruminants and non-ruminants, in the farm enterprise because undigested feeds can be recycled among them. Such diversity of the livestock component often depends on the landscape of each farm. For example, the lpeúna farm is located on a slope and there are no lowlands. Thus, poultry-swine-beef cattle is a workable combination. On the other hand, the Atibaia farm has one-half of its area on upland and the other half on lowland which is suited for fish ponds. Consequently, the most appropriate livestock enterprise is poultry-swine-fish and/or shrimp.

The number of livestock should be adjusted to the amount of manure that is needed for crop production. This, of course, is based on the daily production of solid manure per animal as shown in Table 3. We have found that to provide adequate manure to fertilize one cultivated hectare at the lpeúna farm we must maintain 6 beef cattle, 14 hogs and 833 chickens in a combination enterprise of poultry-swine-beef cattle.

The ideal number of livestock for the combination of poultry-swine-fish and/or shrimp at the Atibaia farm has not yet been determined. First, we must know what volume of liquid hog manure is needed to fertilize one hectare of the fish pond. Besides, there is a plan to use kenki manure (i.e., anaerobically-fermented swine manure), to feed freshwater fish and shrimp.

Livestock Rations

Poultrymen and cattlemen are most interested in formulating their rations to include poultry litter which has a high nutritional value, especially for ruminants. According to Vilela (1983), when poultry litter comprises about 25 percent of the livestock ration improved results are obtained.

Composition of Rations for Laying Hens, Swine and Beef Cattle

The integrated system of Kyusei Nature Farming at the lpeúna farm is shown in Tables 4, 5 and 6, respectively. Ground corn constitutes approximately 60 percent of the rations for chickens and hogs. Chicken manure makes up about 17 percent of the hog ration, and beef cattle are fed with 30 kg of Napier grass, 3 kg of poultry litter and 5 kg of solid hog manure per animal per day.

Poultry litter for the rations of swine and cattle is collected from the chicken house after 6 months of accumulation. EM4 is sprayed monthly over the bedding material (rice husks) which becomes mixed with chicken droppings. Thus, by the time of removal, the litter is well-fermented and ready to incorporate into swine and cattle rations. Solid swine manure is separated from the liquid effluent and the washings of pig pens and wallows. The combined washings go into sedimentation boxes and the liquid manure is collected in treatment tanks. The solid swine manure may then be added to cattle rations; partially dried to make kenki manure for fish; or used as organic fertilizer.

Table 4. Composition of Fermented Feed and Ration for Laying Hens in the Integrated Poultry-Swine-Beef Cattle Production Systems at the lpeúna Farm.

Components	Fermented feed (%)	Hen Ration (%)
Corn (ground)	25.0	60.3
Soybean meal	15.0	21.2
Rice bran	40.0	-
Wheat bran	15.0	-
Fish meal	2.5	2.1
Bone meal	2.5	7.0
Limestone (ground)	-	7.0
Vitanin mix	-	0.1
Mineral mix	-	0.1
Salt (NaCl)	-	0.2
Fermented feed	-	2.0

Fermented feed was formulated with EM4 and molasses both diluted with water at 1:100 for a total moisture content of 20%, Fermented feed was added to the laying hen ration at 2.0% of the total weight. While we designate this product as fermented feed it could also be referred to as EM-Bokashi, a fermented organic fertilizer and soil microbial inoculant that is widely used in nature farming systems.

Table 5. Ration Composition for Swine (Young Pigs and Adult Hogs) in the Integrated Poultry-Swine-Beef Cattle Production System at the Atibaia Farm.

Components	Pig Ration (%)	Hog Ration (%)
Corn (ground)	53.2	63.0
Rice bran	17.2	-
Soybean meal	17.8	18.8
Hen litter	10.8	16.9
Limestone (ground)	0.8	0.6
Salt (NaCl)	0.3	0.7

Table 6. Ration Composition for Beef Cattle in the Integrated Poultry-Swine-Beef Cattle Production System at the Atibaia Farm.

Components	Beef cattle ration (kg animal^{-1} day^{-1})
Nepier grass	30
Hen litter	3
Hog manure (solid)	5
Mineral mixture	Free choice
Salt (NaCl)	Free choice

The average weight per animal was 400 kg.

Table 7. Effect of Bokashi, Animal Manures and Effective Microorganisms (EM) on Dry Matter Yield of Lettuce.

Treatments	EM applied	Dry matter yield (g)
Control	no	65
EM bokashi (3 Mg ha^{-1})	yes	118
EM manure1	yes	184
Cattle (40 Mg ha^{-1})		
Hog (20 m^3 ha^{-1})		
EM manure2	yes	225
Cattle (80 Mg ha^{-1})		
Hog (40 m^3 ha^{-1})		
LSD		33

Cattle manure was in a semi-solid state while hog manure was in a liquid state.
Lettuce was grown on 1 x 5 m plots.

EM-Bokashi and EM-Manure as Organic Fertilizers

A field experiment was conducted to evaluate the efficiency of EM-manure compared with EM-Bokashi for crop production. Beef cattle manure together with liquid hog manure was used as EM-manure.

Treatments:

1. Control (untreated)
2. EM-Bokashi, 3 Mg ha^{-1}
3. Beef cattle manure, 40 Mg ha^{-1} + liquid hog manure, 20 m^3 ha^{-1}
4. Beef cattle manure, 80 Mg ha^{-1} + liquid hog manure, 40 m^3 ha^{-1}

Replicates: 6
Plot size: 1 x 5 m
Crop: lettuce (*Lactuca sativa* cv. Elisa)
Date of transplant: January 24, 1995
Date of harvest: February 27, 1995

All treatments received 3 Mg ha^{-1} of finely ground limestone and 30 liters ha^{-1} of EM4. All six replicates of the same treatment were grouped in one block. The reason is that the experimental site was located on a slope and there was a risk of contamination with liquid manure and nitrate among treatments if a randomized block design was adopted. Lettuce plants were harvested from two center rows with 12 plants in each for a total of 24 plants.

The results of this experiment are shown in Table 7. Soil fertility at the experimental site was very low which explains why the lettuce yield for the control treatment (no EM and no organic fertilizer) was also low. The application of 3 Mg ha^{-1} of EM-Bokashi resulted in lettuce yields that were almost double that of the control, but well below the estimated yield potential. The quantity of EM-Bokashi applied in this experiment is what we usually recommend to farmers; thus, the results verify the soil's very low fertility status. Lettuce yields for the EM-manure (cattle manure + liquid hog manure) treatments were significantly higher than for EM-Bokashi. Earlier studies have shown that 3 Mg ha^{-1} of EM-Bokashi is equivalent to 40 Mg ha^{-1} of EM-cattle manure + 20 m^3 ha^{-1} of EM-liquid hog manure. However, in this experiment 3 Mg ha^{-1} of EM-Bokashi was not sufficient to produce an acceptable lettuce yield in a low fertility soil. The highest lettuce yield was obtained for the treatment with 80 Mg ha^{-1} of EM-cattle manure + 40 m^3 ha^{-1} of EM-liquid hog manure.

An economic assessment of these input costs is of considerable interest to farmers. The cost of EM-Bokashi is $444.00 USD Mg^{-1}, and that of cattle manure is $5.55 USD Mg^{-1}. The cost of 80 Mg ha^{-1} of EM-manure is $444.00 USD which is exactly the same as 1 Mg of EM-Bokashi. Therefore, to obtain the same lettuce yield using these inputs, the cost of EM-Bokashi is three-fold higher than EM-manure. EM-liquid hog manure is not taken into account simply because it is not sold. Consequently, in this integrated system of Kyusei Nature Farming, EM-manure and EM-liquid manure are vital to our net returns.

Conclusions

In the integrated system of Kyusei Nature Farming the on-farm production and use of organic fertilizers for crop production are indispensable; also, the loss of plant nutrients from the sale of farm products is adequately compensated from the purchase of animal feeds. At this time, it was not possible to do a complete economic analysis of the integrated system, but the available data indicate that the cost of production is lower compared with most conventional systems using chemical fertilizers and pesticides. The integrated system greatly reduces the probability of environmental pollution. In fact, no such pollution problems have been detected so far. Nevertheless, a regular analysis of subsoil, groundwater (wells), and fish ponds will be conducted to assess nitrate levels and the presence of pathogenic microorganisms.

This integrated system of Kyusei Nature Fanning has been in operation for little more than a year. During the transition period, the original plan was modified and new ideas were introduced, This process of refinement will continue for awhile. Results thus far strongly indicate that the association of crop production with animal husbandry in Kyusei Nature Farming is very promising and should provide high quality and safe foods for human consumption.

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