Integrated Farming Systems in the Andean Foothills of Colombia (Preliminary Results)

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Abstract
This paper describes changes in farming systems in a community in the Andean foothills of Colombia dictated by altered circumstances and opportunities. The circumstances were the declining supply of water to the community due to deforestation provoked by extension of cattle grazing. The opportunities were: (I) the use of multi-purpose trees (for feed, fuel and soil fertility enhancement); (ii) high yielding biomass crops (sugar cane) providing feed and soil improvement; (iii) recycling of household waste water and livestock manure to produce fuel (biogas) and fertilizer (the effluent); (iv) use of earthworms to convert livestock manure into protein for chickens and organic fertilizer; (v) associated (multi-strata) cropping of horticultural plants with multi-purpose trees to increase biomass yield and enhance biodiversity; and (vi) simplification of the feeding system (giving whole sugar cane stalk and tree leaves to pigs during pregnancy).

Interim results are given showing effects on biomass yield and on soil fertility.

KEY WORDS: Livestock, integration, feed, tree, sugarcane, recycling, biogas, soil fertility

Background

This paper describes some of the results from the introduction of integrated farming systems in a small community (municipalities of La Union and El Dovio) located in the Andean foothills, 1,700m above sea level, in the north of the Cauca Valley in Colombia. The rainfall is 1,400mm and mean temperatures range from 24°C during the day to 14°C at night. The terrain is sloping (>25°) and mean daily hours of sunshine are 2.7.

Most of the farm families are of peasant (campesino) origin and own less than 15ha. Traditionally the region was dedicated to monocultural coffee with some fruit trees and vegetables.

The farming systems are now highly diversified as will be described in this paper. Income is derived almost exclusively from farm activities.

The first modifications to the traditional system were made in 1987 on the basis of recommendations by advisers of the Federation of Coffee Producers to introduce cattle in order to promote diversification of the traditional coffee monoculture. Faced with the problem of inadequate feed supply, help was sought from the Fondo DRI (Fund for Integrated Rural Development) which in turn approached CIPAV for advice as to appropriate forage crops that could be grown. CIPAV's first recommendations were:

1. Reintroduction of pigs and partial confinement of the cattle to provide manure for a biodigester to supply biogas as alternative to firewood (to decrease pressure on the remaining forest area) and organic fertiliser as alternative to purchased chemicals.
2. To establish sugar cane and forage trees (Chachafruto = *Erythrina edulis* and nacedero = *Trichanthera gigantea*) as feed sources for cattle and pigs through fractionation of the sugar cane into juice (for the pigs) and residual pressed cane stalk and the cane tops for the cattle. The "chachafruto" was chosen as a protein supplement for the cattle and "nacedero" for the pigs on the basis of CIPAV's experience with these trees in similar ecosystems.
3. Preparation of syrup from cane juice using an "earth" oven in the ground.

4. On-farm manufacture of multi-nutritional blocks using the "scums" from syrup manufacture as binder.
5. Installation of a low cost tubular polyethylene biodigester.
6. Purchase of soya bean meal to complement "nacedero" and the cane juice for the pigs.
7. Establishment of earthworm culture to provide protein (for poultry) and organic fertilizer for vegetables and coffee.

The Present Strategy: the Objectives

The introduction of high yielding forage crops (sugar cane and trees) had increased the offer level of feed for the livestock making it possible to diversify further the areas previously in pasture. This diversification was introduced gradually beginning in 1992 with the aim of:

1. Responding to environmental pressures to conserve the water resources, to improve soil fertility, to control erosion, and to increase biodiversity.
2. Integrating more closely crop and animal activities so as to optimize the recycling of nutrients and water.
3. Reducing the energy and economic costs of farm activities.

The following procedures were introduced:

Protecting the Water Source and Increasing the Efficiency of Water Use

The area dedicated to the protection of the water source had decreased because of the extension of pasture. The watershed had to supply the needs of the community of 12 families and the severe deforestation in the region had led to conflicts over the supply of water. The fenced (to prevent cattle grazing) watershed area was extended to facilitate natural regeneration of trees and shrubs. More trees, of multi-purpose use (eg: Bamboo), were planted in this area. Banks of multi-purpose forage trees were introduced to provide the joint function of protection and source of feed, replacing natural pasture which is highly susceptible to erosion in areas with slopes exceeding 30°.

The water originating from household and general farm activities was decontaminated by using it as the diluent for the manure put into the biodigesters and by passing the resulting effluent from the digester along a series of canals for sedimentation of residual solids and growth of water plants.

Increasing Plant Biodiversity

More multi-purpose trees were planted in areas previously dedicated to pasture with the aim of improving soil fertility, controlling erosion, providing feed for the livestock and eventually for construction purposes and sale as timber. Horticultural crops (Zapallo - Cucurbita maxima), fruit trees and shrub forages (Ramie - Boehmeria nivea and mulberry - Morus alba) were introduced into areas previously dedicated to a single specie. Areas of pasture were set aside for natural regeneration of shrubs and trees. The intensification of the recycling process included the growing of different water plants (water hyacinth, azolla and duckweed).

Increasing Animal Biodiversity

Pigs, poultry and fish were added to the farming system complementing the cattle that had been introduced previously.

Improving Soil Fertility

New plantings of forage trees were done as associations ("chachafruto" with "nacedero") not as single species. Areas previously in pasture were allowed to regenerate naturally. The recycling of crop and livestock wastes was intensified. Increasing amounts of leaf litter and fibrous residues became available for direct (in situ) return to the soil or for processing by earth worms.

Simplifying Farm Work

The system of fractionating sugar cane for the pigs was suspended and replaced by direct feeding of the whole sugar cane stalk to breeder pigs in free-range pasture. This had been facilitated by expansion and change of emphasis of the pig enterprise to concentrate on reproduction and sale of weaners rather than fattening. Fully grown pigs are able to chew up to 15-20 kg of cane stalk daily extracting the juice and "spitting" out the fibre. The "chewed" fibre and the pig excreta were allowed to mix naturally and later used as substrate for the earth worms.

Increasing Animal Feed Supply
This came about through the replacement of pasture by multi-purpose trees and the introduction of horticultural and forage crops into areas previously managed as monocultures (eg: the coffee and the protein banks). The increased efficiency of the recycling process was achieved by introducing water plants which in turn became sources of feed for the pigs and poultry.

Increasing the Self Reliance and Participation in Farm Activities of All Family Members
The diversification of the farming system, and the simplification of certain of the sub-systems, increased the labour demand. At the same time it created opportunities for increased participation by women and children in productive (income-generating) activities. The parallel reduction in labour demand in the nearby towns has been an important factor facilitating this process. Traditional coffee farming is highly demanding of labour but in specific seasons coinciding with the harvest of the beans. Labour was traditionally "imported" into the region to satisfy this "transient" need. In contrast, diversified farming offers steady year-round employment for all family members.

The Preliminary Results
An evaluation of inputs and outputs of this farming system on the farm belonging to Tiberio Giraldo in 1993 was made by Espinel (1994). It is not yet possible to assess the effect of the changes described in this paper as these are still in the introductory stage. Results of the recent evaluation of four of the sub-systems are summarized in Tables 1-4.

The data in Table 1 show the high yields of biomass obtained from sugar cane and associations of the two principal multi-purpose trees planted in the farm. The total areas planted with these crops are: sugar cane 2.1 ha and forage trees 0.7 ha.

Table 1: Mean annual yield of fresh biomass from plots planted with associations of trees (*Trichanthera gigantea* and *Erythrina edulis*) (sample areas was 3,500m^2) or sugar cane (sample area 1,248m^2). Data converted to hectares.

	Trichanthera gigantea/ Erythrina edulis	Sugar cane
Fresh foliage, mt/ha	81.9	104 (88.4+15.6)*
Dead leaves, mt/ha	13.0	14
Total biomass, mt/ha	94.9	118
Stem cuttings, No/ha	40,000	
Fractionation of sugar cane stalk, % fresh basis:		
Juice (for pigs)	45	
Syrup (family)	10	
Residual pressed cane stalk	45	

*Cane stalk + tops

Table 2: Yield of fresh biomass after 6 months regrowth from plots (3x2m) planted with associations of trees (*Trichanthera gigantea, Erythrina edulis* and *Morus alba*), perennial herbaceous species (*Boehmeria nivea*) and food crops (Maize, beans and pumpkin)*

	Plot 1	Plot 2	Plot 3	Plot 4
Fresh forage, kg/100m^2				
T. gigantea	450	350	380	467
E. edulis	17	50	33	140
M. alba	38	-	33	-
*B. nivea***	-	463	-	450
Weeds	66	-	50	-
Maize, beans, pumpkins*				
Total (6 months)	571	863	496	1057
Annual yield, mt/ha***	114	173	99	211

*Not yet harvested **Mean for two harvests (2 month intervals) projected to 6 months
*** Projection to one year assuming similar yields in second 6 month period

The data in Table 2 indicate that it is highly beneficial, at least in terms of total production of biomass, to associate with the "chachafruto" and "nacedero" other horticultural and forage crops. The impact at the level of the livestock has still to be measured.

The fertility of the soil is one of the most important indicators of the sustainability of a farming system. Conventional ways of measuring soil fertility in chemical, physical and biological parameters are time consuming and expensive and require access to sophisticated laboratory equipment. The biological test of soil fertility (by measuring the growth over 20 days of maize planted in samples of soil from the test areas) is simple, inexpensive and quick. It gives no indication of the factors responsible for improvement or decline of soil fertility but it is an extremely useful tool for monitoring the effects of interventions in the farming system. The results from applying this technique in samples of soil taken from the principal sub-systems described in this paper are presented in Table 3.

The order in which the different sub-systems are placed can mostly be predicted on the basis of the importance of return of organic matter and of N-fixation by leguminous species. The poor rating of the "forest" sub-system indicates that the process of soil formation in tropical forests is a slow process and emphasizes the fragile and transitory nature of tropical soils; and that the maintenance and improvement of soil fertility in tropical ecosystems requires constant attention to the basic principles of soil conservation especially the role of organic matter. It is equally apparent that there need be no conflict between biomass yield and sustainability if the appropriate ecosystems are identified and promoted (eg: sugar cane and multi-purpose trees versus pasture).

The soil "bio-test" is also a useful way of showing farmers how particular crops and cropping systems influence soil fertility and provides a basis for adding an "environmental" element into traditional ways of economic assessment of farming systems.

The data in Table 4 are the production parameters for the pig herd since feeding began with whole sugar cane.

Table 3: Biological test of fertility (growth of maize plants in 21 days) of soil taken from cropping areas (0-25cm depth) (3 samples taken from each "crop" area with 4 repetitions from each sample)

	Height, cm	No of leaves
Red soil	5.56	2.35
Forest*	6.33	2.62
Pasture	6.40	2.78
Sugar cane	7.03	2.73
T gigantea	7.92	3.02
E edulis + *T gigantea*	8.49	2.91
Worm compost	9.12	3.20
SE	+/-0.28	+/-0.15
Prob	0.001	0.009

*Replanted on eroded red soil

Table 4: Pig production parameters in Cipres Farm (Oct 95- Sep 96)

Breeding performance:	
Total number of services	29
Number repeat services	4
Percent repeat services	14
Farrowing performance:	
Number of farrowings	21
Average pigs born alive per litter	10.1
Average birth weight, kg	1.2
Farrowing interval, days	176
Weaning performance:	
Number of litters weaned	19
Pig weaned per litter	8.2
Pre-weaning mortality	20.4
Average weaning weight, kg	7.3
Average age at weaning, days	51.3

Table 4. (Continued).

Population:	
Average female inventory	12
Feeding of sows:	
Feed per sow, kg/day (fresh basis)	
Sugar cane stalks	10
Soybeans	0.4
Foliage	2
By-products	0.3

Reference

Espinel, R. 1994. Sociedad y economia de campesinos cafeteros de la cordillera Occidental en el Norte del Valle del Cauca. Factores que inciden el la construccion de Sistemas Agrarios. Tesis de grado en Maestra en Desarrollo Sostenible de sistemas Agrarios. Universidad Javeriana-IMCA-CIPAV