Estimation and comparison of benefits due to feeding hay and silage during the dry season on commercial dual-purpose cattle production systems in Honduras and Costa Rica

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Abstract

Smallholders with dual-purpose cattle production systems in most Central America experience a shortage of forages during the dry season (4-8 month. As a result, substantially lower milk production and weight gain occurs. Dual-purpose operations seeking to maximize milk and beef production in the dry season can produce and feed hay or silage to their livestock.

The increase in milk and beef production due to feeding hay or silage during the dry season on commercial dual-purpose cattle productions systems, the production costs of making silage or hay and the benefits as a result of feeding silage or hay are estimated and compared in Honduras and Costa Rica.

Due to feeding silage or hay, farmers in Honduras and Costa Rica have increased milk production during the dry season. The costs of feeding hay are lower in both countries, although farmers feed a higher amount (kg

DM/cow/day) than silage.

Feeding silage or hay to milking cows is profitable in both countries. The income-cost ratio and the net benefit ($/cow/day) due to feeding these feedstuffs are positive. Farmers with milking cows in Honduras realise a higher income-cost ratio and net benefit due to feeding silage and hay than farmers in Costa Rica.

Likewise, beef cows or young livestock supplemented with these feeding alternatives don't loose weight during the dry season. In Honduras as well in Costa Rica, it is profitable to feed silage or hay to beef cows or young livestock.

Currently, no silage and a small hay market exist in Honduras. Possibly, these will develop due to an increasing demand for these profitable feedstuffs. In Costa Rica thanks to the efforts of agricultural organisations, a hay market of different qualities is developing.

Key words: benefit, cost, dry season, feed shortage, hay, silage

Introduction

Livestock production in Central America

Most livestock production in Central America takes place on farms using the dual-purpose (meat and milk) cattle production system. Producers on these farms obtain a daily cash flow from the sale of milk and in addition, a profit from the sale of beef in the form of weaned calves (FAO-IMMG 2001). The productivity of these farms is characterized by low reproductive rates, high mortality, low weight gain, advanced age of animals at market weights and low output. This low productivity is due to the low quality and seasonal shortages of feeds, mineral imbalances, diseases and parasites, environmental stress and lack of selection for genetic improvement (FAO-IMMG 2001). Livestock holders in Central America keep a mix of Zebu, Criollo, and European breeds (Ortega et al 2004). The feeding strategies include native pasture and crop-residue grazing, rice straw, silage, cut-and-carry forages and purchased inputs (Fujisaka et al 2005).

Due to population growth, urbanization and resumption of economic growth in the 1990s in Central America the demand for meat and milk is expected to double in the next two decades (Bruinsma 2003). During the 1990s, milk production in Central America grew at an annual rate of 4.6%. But even with this high growth rate, the region imports dairy products to satisfy high demand. Imports are growing at an annual rate of 13%, increasing from 20% of the national demand in 1990 to almost 28% in 1996. About 85% of the region's milk comes from farms with dual-purpose cattle (Holmann and Lascano 2004).

Although the demand for dairy products is growing faster than supply, a majority of poor livestock producers have difficulties participating in this expanding market. Smallholders with dual-purpose cattle in much of Central America experience a shortage of forages during the dry season (4-8 month). In some cases water is also scarce. As a result, substantially lower milk production occurs in the dry season since fewer cows are milked and cows have lower milk yield. In addition, dry season feed scarcity also limits herd size and weight gains of animals (Fujisaka et al 2004). Dual-purpose

operations seeking to maximize milk production in the dry season can provide more concentrates, allocate a greater proportion of scarce resources or produce cut-and-carry forages or forage maize/ sorghum. Those able to produce surplus feed in the wet season for dry season use can also turn to alternative components such as preparation of hay and silage (Fujisaka et al 2004). However, the use of silage and hay varies significantly and in general, adoption is low.

Conserved feedstuffs

Forage, crop residues and by-products are usually consumed fresh by domestic animals. However, it is possible to conserve them for use during future periods of feed shortages. Conservation can be achieved by drying (hay), artificial drying (meal) and addition of acids or fermentation (silage; Mannetje 2000). In the case of dual-purpose cattle systems, conserved feeds are usually first fed to lactating cattle to maintain or increase milk yields. In exceptional occasions (when silage or hay is in excess) it is fed to other animal categories either to increase beef production or to maintain body weight and condition.

Hay

Hay is dried forage, containing less than 15 % water. Fresh forage is harvested and dried as quickly as possible. Drying can be done naturally (exposure to the sun on the ground aerating the forage regularly by turning it over) or artificially by active circulation of air (Livestock and environment toolbox 2005). Hay can be made from improved grasses, legumes, or from a combination of both. During the growing period, weeds and plagues can be controlled and fertilizers can be used (Morales et al 2003). Before making hay, the pasture is not grazed for some weeks. The quantity and quality of hay depend on the resting period before harvesting the pasture.

Silage

Silage is forage, crop residue or agricultural and industrial by-product preserved by acids, either added or produced by natural fermentation. Fresh forage is harvested or crop residues and by-products are collected; the material may be chopped or conditioned; additives may be added; and it is then stored in the absence of air so that anaerobic bacteria, present on the forage or added, can rapidly convert the water-soluble carbohydrates into lactic acids and to a lesser extent to acetic acid. Due to the production of these acids, the pH of the ensiled material becomes low (around 4), spoilage micro-organisms are inhibited and the material can be preserved for as long as it remains in airtight storage. The quality of the ensiled product depends on the feeding value of the material ensiled, the harvesting and ensiling technique and on the fermentation products present: the types of acid and the amount of ammonia (Mannetje 2000).

Objectives

The objectives of this study are (a) to estimate and compare the increase in milk and beef production due to feeding hay and silage during the dry season, (b) to estimate and compare the production costs of making silage and hay, and (c) to estimate and compare the net benefits as a result of feeding silage and hay.

Results from this study are expected to contribute to a better understanding of the opportunities of feeding hay and silage on dual-purpose cattle production systems and can be used to promote its use.

Material and Methods

In Honduras thirteen farmers were personally interviewed: seven farmers who produced silage and six farmers who produced hay. All surveyed farms were located in Yoro and its surroundings, a region with a prolonged dry period. In Costa Rica nine farmers were interviewed: seven who produced silage and two who produced hay.Two farmers were selected in the Esparza-Puntarenas region and seven farmers in the Nicoya Peninsula, both regions on the Pacific Coast with a prolonged dry season. No formal sampling procedure was employed because the interviews were targetted intentionally to users of hay and silage to elicit their views regarding the benefits of suplementing conserved feedstuffs. It is not intended to make a scientific comparison of the countries and methods, but rather to present a review of findings as observed in practice.

In addition, the Asociación de Productores Agroindustriales de Bagaces (APAIB), which is an association of small producers who do not own cattle, but who produce hay under irrigation to sell to other farmers, was visited. Extension specialists from DICTA in Honduras and from CORFOGA in Costa Rica led the interviews to facilitate the acquisition of information. The interviews took place during April and May of 2005 at the end of the dry season.

Farmers were asked general, closed questions about their land use, labour use, livestock, milk and beef production, market and input prices, and supplements used to feed the herd. They were also asked specific questions related to the production, use, and benefits of feeding silage or hay. In addition, producers were asked two open questions, one about the way silage or hay was made and one about the advantages and disadvantages of feeding hay or silage to the herd. The acquired data was put into an Excel spreadsheet and analysed.

Results and Discussion

General farm information

The interviewed farmers were asked general questions about land and labour use and also a livestock inventory was made. This general farm information is given in Table 1.

Table 1. General farm information

	Honduras (n=13)	Costa Rica (n=9)
Total area, ha	85.9	74.8
Improved grasses, ha	33.4	20.7
Native grasses, ha	2.8	39.3

Average number of animals per farm	112	76
Amount of animals per hectare	2.5	1.9
Year producer has been feeding silage or hay	5	8

Table 2a contains information of farms which produce silage,

Table 2a. General farm information of farms which produce silage

	Honduras (n=7)	Costa Rica (n=7)
Land use, ha		
Total area	*72.2*	*76.1*
Improved grasses	28.7	22.3
Native grasses	5.3	35.8
Cut-and-carry	0.9	1.6
Perennial crops	0.1	0
Annual crops	4.7	0.9
Forest	30.5	15.5
Other use	2	0
Labour use		
Family labour (fte)	1.6	1.1
Hired labour (fte)	5	2
Fte/hectare	0.2	0.1
Value of wage ($/day)	2.57	8.47
Livestock, #		
Cows	32	38
Other livestock	57	30
Animals/ha	2.7	2.0

Fte = Full time employee equivalent

and Table 2b about farms which produce hay.

Table 2b. General farm information of farms which produce hay

	Honduras (n=6)	Costa Rica (n=2)
Land use, ha		
Total area	*102.1*	*70*
Improved grasses	38.9	15
Native grasses	0	51.5
Cut-and-carry	1.5	0.5
Perennial crops	0	0
Annual crops	15.3	0
Forest	45.2	3

Other use	1.2	0
Labour use		
Family labour, fte	1.6	2
Hired labour, fte	6	3
Fte/hectare	0.2	0.1
Value of wage, $/day	2.57	8.47
Livestock, #		
Cows	44	53
Other livestock	94	50
Animals/ha	2.1	1.5

Fte = Full time employee equivalent

Survey results demonstrated that the average farm size of all interviewed farmers in Honduras and Costa Rica was 86 and 75 hectares, respectively (Table 1). The average herd size per farm was 112 and 76 animals, respectively and the average stocking rate was 2.5 animals/ha and 1.9, respectively. Compared with national averages, farms in this study were larger. According to national statistics, in Honduras a livestock farm on average has 15 ha and 20 animals. In Costa Rica these numbers are 40 and 37, respectively. The mean number of animals per hectare, according to national statistics, is 1.3 in Honduras and 0.9 in Costa Rica. The difference between the national averages and the interviewed farms partly could be explained by the fact that in this study only commercial farms were interviewed. In Honduras, more than half of the herd is concentrated in the 5% of the farms larger than 50 hectares. In Costa Rica the majority of the herd is kept in 24% of the farms larger than 40 hectares (Pérez 2004). These farms, in contrast to most of the smaller farms, keep animals on a commercial basis, and belonged therefore to the target group of this study. An earlier examination in Honduras and Nicaragua revealed that only medium to large farms produce silage and that the major part of the improved grasses (of which hay is made) was grown on larger farms (Fujisaka et al 2005). Because this study was dealing with the use of hay and silage, mainly medium and large farms were part of the target group.

On average, interviewed farms in Honduras had 33 ha of improved grasses and farms in Costa Rica 21 ha. Furthermore, the average amount of land with native grasses was about 3 ha and 39 ha, respectively (Table 1). These data indicated that the use of improved grass at the expense of the use of native grass was higher in Honduras.

For making silage, farmers used cut-and-carry forages and annual crops. As can be seen in Table 2a, silage-using farmers in Honduras had almost 1 ha of cut-and-carry forages allocated to silage production, while farmers in Costa Rica had on average 1.6 ha. However, in Costa Rica not all cut-and-carry forages were made into silage. Table 4a shows that 43% of the silage-using farmers in Costa Rica fed fresh sugar cane to their animals. The amount of annual crops (ie., maize, sorghum) planted by silage-using farmers in Honduras was higher than the amount planted by farmers in Costa Rica (i.e. 4.7 ha vs. 0.9 ha). This could be explained by the fact that farmers in Honduras allocated more land to make silage (see Table 3a).

Table 3a. General information about silage

	Honduras (n=7)	Costa Rica (n=7)
Used forage, % of farms		
Silage made of corn	42.9	71.4
Silage made of (corn and) Cratylia	14.2	28.6
Silage made of corn and other forages	42.9	0
Used type of silo, % of farms		
Little bag silage	0	14.3
Monton silage	14.3	85.7
Bunker silage	85.7	0
Amount of land allocated to produce silage, ha	3.9	1.1
Yield, mt/ha	23.9	16
Yield as DM, mt/ha	8.4	5.6
Size of silo, m^3	134.1	24.3*
Construction costs, $/$m^3$	19.08	0
Waste, %	4.5	2.7
Duration of silage in store, months	6	3
Years producers have been feeding silage	6	7
Producers in neighbourhood using silage, %	16.3	6.3

**n = 6*

General information about the use of hay and silage

Farmers were asked general questions about silage and hay. A description about the procedures of making the different types of silage and making hay is given in Schoonhoven et al (2005).

In Yoro in Honduras the dry season lasts about 7 months (O'Brien et al 2004), while in Nicoya and Esparza-Puntarenas in Costa Rica the dry season lasts 5 months (Go visit Costa Rica 2005). Farmers in Yoro had to deal with a longer dry season and therefore, the use of conserved feedstuffs was desired for a longer period. Hence, as can be seen in Table 3a, farmers in this part of Honduras compared with farmers in Costa Rica, allocated more land to make silage (i.e. 3.9 ha vs. 1.1 ha) and fed it for a longer period (i.e. 6 mo vs. 3 mo). Likewise, Table 3b shows that farmers in Honduras compared with farmers in Costa Rica, allocated more land to produce hay (i.e. 6.4 ha vs. 3.5 ha) and fed this for a longer period (i.e. 6 mo vs. 5 mo).

Table 3b. General information about hay

	Honduras (n=6)	Costa Rica (n=2)
Used forage, % of farms		
Hay made of improved grass	66.7	100
Hay made of (improved grass and) corn	33.3	0

Amount of land allocated to produce hay, ha	6.4	3.5
Yield, mt/ha	8.2	10.5
Yield as DM, mt/ha	7.2	9.2
Size of storing facility, m^3	298*	480
Construction costs of storage facility, $/$m^2$	15.62	25.89
Resting period before harvesting hay, days	37*	90
Duration of hay in store, months	6	5
Price of hay, $/mt	46.55*	93.96
Years producer has been feeding hay	5	10
Producers in neighbourhood using hay, %	2.0	20

**n = 5*

Table 3a shows that in Honduras the yield of silage was higher than in Costa Rica (i.e. 24 mt/ha vs. 16 mt/ha). This could be explained by the use of a combination of maize and sugarcane and/or sorghum by 43% of farmers in Honduras. A study executed in Honduras and Nicaragua revealed that sugarcane had a yield 80 mt/ha, while maize had 33 mt/ha (Fujisaka et al 2005). Sorghum had a yield of 45-50 mt/ha (Jiménez and Rojas 2002). Table 3b shows that in Costa Rica the yield of hay was higher than in Honduras (i.e. 10.5 mt/ha vs. 8.2 mt/ha). In Costa Rica and Honduras, on average, the resting period before harvesting the pasture was 90 and 37 days, respectively. The longer resting period in Costa Rica resulted in a higher yield.

As seen in Tables 3a, 3b and Table 1, both silage and hay were introduced earlier in Costa Rica than in Honduras. This could be explained by the fact that Costa Rica is an economical and social more developed country (UNDP 2001a y 2001b). As countries become more developed, farmers no longer are satisfied with labour-intensive chores like the cutting of grasses every day, irrespective of the climatic conditions and look for alternatives to obtain, store and utilize feed in a more convenient way (Mannetje 2000). Producing silage or hay offers a solution, which requires technology knowledge and an investment of capital (Mannetje 2000). In Costa Rica, producers have more resources and efforts are made by the government and agricultural organisations to provide technical support and information concerning on-farm technologies such as improved forages (Morales et al 2003; Morales 2001).

The results of this study seemed to indicate that in Honduras the adoption rate of silage was higher than of hay, while in Costa Rica the adoption rate of hay was higher. In Honduras, the interviewed farmers mentioned that 16% of the farms in their vicinity utilised silage and 6% utilised hay, while this percentages in Costa Rica were 2% and 20%, respectively (see Tables 3a and 3b). As can be seen in Table 3a, farmers in Honduras chose to construct an expensive and durable type of silo; 86 % of farmers used bunker silo compared to 14% who used a monton silo. Contrarily, 86% of farmers in Costa Rica used a monton silo. On the other hand, farmers in Costa Rica constructed larger and more expensive stores to stockpile their hay than farmers in Honduras despite the fact that farmers in Costa Rica produced less of it.

A higher adoption rate of silage in Honduras could be explained by the facts that the costs of

producing it were lower compared to the costs of producing hay (i.e. $16/mt vs. $20/mt, respectively, see Tables 5a and 5b) and that the yield as dry matter (DM) (i.e. 8.4 mt/ha) was higher than the yield of hay as DM (i.e. 7.2 mt/ha), as Tables 3a and 3b show. On the other hand, a higher adoption rate of hay in Costa Rica is supported by the facts that the production cost was lower than of silage (i.e. $39/mt vs. $46/mt, respectively) and that the yield as DM (mt/ha) was higher than the yield of silage as DM (i.e. 9.2 mt/ha vs. 5.6 mt/ha).

Production of milk and beef in relation to offered feed supplements during the dry season

Tables 4a and 4b describe the amount and types of supplements fed during the dry season on silage and hay-using farms, respectively. Also the milk and beef production on these farms are given.

As seen in Tables 7a or 7b farmers in Costa Rica were paid less per litre of milk than farmers in Honduras ($0.24/lt vs. $0.29/lt). The price of concentrates in both countries was $0.24/kg; this implied that a kilogram of concentrate was relatively more expensive in Costa Rica. As Tables 5a and 5b show, the costs of producing both silage (i.e. $46/mt vs. $16/mt) and hay (i.e. $39/mt vs. $20/mt) were higher in Costa Rica. These data explained the lower quantities of concentrates, silage and hay fed in Costa Rica, compared with Honduras (see Tables 4a and 4b).

About half of the farms in Costa Rica planted sugarcane to partly replace the use of concentrates. A previous study in Honduras and Nicaragua showed that the costs of sugarcane ($26/mt DM) were lower compared with the costs of hay ($30/mt DM) and silage ($68/mt DM, Fujisaka et al 2005). Moreover, as can be seen in Tables 4a and 4b farmers in Costa Rica fed less kg DM per cow per day during the dry season (i.e. 3.7 kg/cow/day vs. 9.3 kg/cow/day). This lower amount of DM in the dry season in Costa Rica resulted in a lower milk yield per cow per day compared with Honduras (i.e. 3.8 lt/cow/day and 7.3 lt/cow/day, respectively).

Due to feeding silage or hay, producers increased their milk production during the dry season. Farmers in Costa Rica fed lower quantities of silage (i.e. 7.6 kg/cow/day vs. 11.8 kg/cow/day in Honduras) which resulted in a lower increase in milk production (i.e. 2.1 lt/cow/day vs. 3.2 lt/cow/day in Honduras). Likewise, farmers in Costa Rica also fed lower amounts of hay (i.e. 5 kg/cow/day vs. 7.1 kg/cow/day in Honduras), which also resulted in a lower increase in milk production (i.e. 1.5 lt/cow/day vs. 4 lt/cow/day in Honduras).

In Honduras, milk production during the dry season with the use of silage or hay was higher than milk production during the rainy season (see Tables 4a and 4b). This could either mean that (a) the quality of the feed ration containing silage and/or hay during the dry season was better than the fodder which was used during the rainy season; or (b) that the increase in milk production was not only due to feeding silage or hay, but also to the increased proportion of concentrates in the feed ration.

Table 4a and 4b also show that hay-using farmers in Honduras fed more hay than the silage-using farmers fed silage (i.e. 6.2 kg DM vs. 4.1 kg DM). The total amount of supplemented feed during the dry season (kg DM) fed by hay-using farmers was also higher. This resulted in a higher milk

production during the dry season (i.e. 8.4 lt/cow/day vs. 6.9 lt/cow/day) and a higher increase in milk production due to hay (4 lt/cow/day vs. 3.2 lt/cow/day) on hay-using farms.

Table 4a. Offered feed supplements during the dry season and production of milk and beef on silage-using farms

	Honduras (n=7)	Costa Rica (n=7)
Silage fed during dry season, kg/cow/day	11.8	7.6
Silage as DM fed during dry season, kg/cow/day	4.1	2.7
Concentrate fed during dry season, kg/cow/day	2.6	0.1
Dry matter fed during dry season, kg/cow/day	6.4	3.5
Other fodder fed during dry seaso,n(% of farms		
Sugarcane	0	42.9
Concentrates	28.6	14.3
Concentrates and hay	57.1	0
Milk		
Milk production dry season, lt/cow/day	6.9	3.7*
Cows milked in dry season, %	57	46.7*
Milk production rainy season, lt/cow/day	7.6	4.9*
Cows milked in rainy season, %	69.8	54.5*
Milk production (dry season) without silage, lt/cow/day	6.3	1.5*
Milk production (dry season) with silage, lt/cow/day	9.5	3.6*
Increase in milk production due to silage, lt/cow/day	3.2	2.1*
Increase in milk production due to silage, %	34.6	66.8*
Price concentrates:milkprice dry season-ratio	0.84	1.01
Beef		
Weight gain (dry season) without silage, kg/head/day		-0.75**
Weight gain (dry season) with silage, kg/head/day		0
Price concentrates:meatprice-ratio cow	0.21	0.27
Price concentrates:meatprice-ratio calf	0.2	0.26

**n = 5; **n = 2*

Table 4b. Offered feed supplements during the dry season and production of milk and beef on hay-using farms

	Honduras (n=6)	Costa Rica (n=2)
Hay fed during dry season, kg/cow/day	7.1*	5
Hay as DM fed during dry season, kg/cow/day	6.2*	4.4
Hay fed during dry season, kg/calf/day	1.7*	
Concentrate fed during dry season, kg/cow/day	2.9*	0

Concentrate fed during dry season, kg/calf/day	0.7*	
Dry matter fed during dry season, kg/cow/day	11.3*	4.4
Dry matter fed during dry season, kg/calf/day	2.1*	
Other fodder fed during dry season, % of farms		
Concentrates	33.3	0
Concentrates and silage	66.6	0
Others	0	100
Milk		
Milk production dry season, lt/cow/day	8.4*	4.5**
Cows milked in dry season, %	63.5*	55.6**
Milk production rainy season, lt/cow/day	11*	5.5**
Cows milked in rainy season, %	75.1*	55.6**
Milk production (dry season) without hay, lt/cow/day	7.3*	3**
Milk production (dry season) with hay, lt/cow/day	11.3*	4.5**
Increase in milk production due to hay, lt/cow/day	4*	1.5**
Increase in milk production due to hay, %	34.4*	31.8**
Price concentrates:milkprice dry season-ratio	0.84	1.01
Beef		
Weight gain (dry season) without hay, kg/head/day	-0.2*	-0.5**
Weight gain (dry season) with hay, kg/head/day	0	0
Price concentrates:meatprice-ratio cow	0.21	0.27
Price concentrates:meatprice-ratio calf	0.2	0.26

**n = 3; **n = 1*

In Costa Rica, hay-using farmers fed also more hay than silage-using farm fed silage (4.4 kg DM and 2.7 kg DM, respectively). The total amount of supplemented feed during the dry season (kg DM) fed by hay-using farmers was also higher than the total amount fed by silage-using farmers. The milk yield during the dry season was therefore higher on hay-using farms than of silage-using farms (i.e. 4.5 lt/cow/day vs. 3.7 lt/cow/day, respectively).

In Costa Rica, the increase in milk yield was higher on silage-using farms than on hay-using farms (i. e. 2.1 lt/cow/day and 1.5 lt/cow/day, respectively). This could be explained by the fact that farms which fed silage without this feedstuff produced very few or no milk. In low-yielding production systems higher increases in milk production (in relation to the amount of fed supplements) can be achieved than in systems were a higher production is realised (Holmann et al 2003), therefore it was possible that, the low-yielding farms which fed a lower amount of silage [as DM (kg/cow/day)], realised a higher increase in milk production than the farm with a higher production, which fed a higher amount of silage.

On two farms in Costa Rica, silage was just fed to beef cows which were not milked. The same was done with hay on one farm. As seen in Tables 3a and 3b, beef cows didn't loose weight during the

dry season due to this supplementation. In Honduras, three farmers fed hay to their young livestock. Due to this strategy, the animals maintained their body weight during the dry period. Beef cows not supplemented with either hay or silage generally loosed more weight per head than young livestock. It was not useful to compare beef production between and within countries because; (a) the results were based on just one, two or three farms, thus, due to this low sample size the outcomes probably were not reliable, (b) no numbers about beef production by silage-producing farms in Honduras were known, and (c) the beef producing farmers in Honduras had young livestock, while the beef producing farmers in Costa Rica had mature beef cows.

Costs of hay and silage

Tables 5a and 5b contain the costs of silage and hay. The costs of making silage were subdivided in labour costs (costs for clearing and preparing the land, applying fertilizer, planting, controlling weed and harvesting), machinery costs, and other costs (ie., herbicide, seed, fertilizer, additives, and plastic). The costs of making hay were subdivided in labour costs (although labour costs most of the time were included in the rental costs of machinery), machinery, and other costs (ie., fertilizer).

Table 5a. Costs of silage

	Honduras (n=7)	Costa Rica (n=7)
Costs of making silage		
Labour costs, $/mt	6.32	23.57
Machinery costs, $/mt	3.73	7.82
Other costs, $/mt	6.43	14.24
Total costs, $/mt	16.48	45.63
Total costs as DM, $/mt	47.08	130.37
Costs of feeding silage, $/head/day	0.21	0.33
Costs of feeding silage, $/farm/year	511.56	565.19

Table 5b. Costs of hay

	Honduras (n=6)	Costa Rica (n=2)
Costs of making hay		
Labour costs, $/mt	13.67*	NA
Machinery costs, $/mt	13.05	34.6
Other costs, $/mt	5.01	4.37
Total costs, $/mt	20.34	38.94
Total costs as DM, $/mt	23.11	44.25
Costs of feeding hay, $/cow/day	0.19**	0.19
Costs of feeding hay, $/calf/day	0.03**	
Costs of feeding hay, $/farm/year; cows	447.69**	990.65
Costs of feeding hay, $/farm/year; calfs	61.99**	

**n = 1; **n = 3; NA = Not Available. Labour costs are included in the rental cost of machinery*

Silage

Table 5a shows the costs of making silage in Honduras and Cost Rica (i.e. $16/mt and $46/mt, respectively).

The production costs of silage was significantly lower in Honduras than in Costa Rica, mainly explained by the lower labour cost. The higher labour costs in Costa Rica were due to more expensive labour (the salary of a worker was $8.47/day, compared with $2.57/day in Honduras, see Tables 2a or 2b) and an higher amount of labour per hectare (i.e. 32 man-days/ha vs.18 man-days/ha in Honduras, see Table 6a).

Table 6a. Costs of making silage

	Honduras (n=7)	**Costa Rica (n=7)**
Labour costs, $/mt	***6.32***	***23.57***
Total days/hectare	*18.4*	*32.4*
Clearing, days/ha	2.2	20**
Clearing, $/mt	0.92*	14.12**
Land preparation, days/ha	1.49	
Land preparation, $/mt	0.55	
Application of fertilizer, days/ha	1.2***	
Application of fertilizer, $/mt	0.44***	
Planting,days/ha	1.9	7.2***
Planting, $/mt	0.66	4.14***
Weed control, days/ha	3.43**	1.65****
Weed control, $/mt	1.24**	0.92****
Cutting, transferring, chopping, filling, days/ha	11.21	17.14
Cutting, transferring, chopping, filling, $/mt	3.67	13.70
Machinery costs, $/mt	***3.73***	***7.82***
Tractor rent, $/mt	1.98	7.09***
Cutter rent, $/mt	1.75	3.04*
Other costs, $/m	***6.43***	***14.24***
Herbicide, $/lt	13.32**	5.08***
Herbicide, lt/ha	6.20**	1.45***
Herbicide, $/mt	1.83**	0.48***
Seed, $/kg	1.34	2.8***
Seed, kg/ha	19.1	23.6***
Seed, $/mt	1.12	4.72***

Fertilizer, $/kg	0.32***	0.37***
Fertilizer, kg/ha	225.8***	385.9***
Fertilizer, $/mt	3.40***	9.87***
Additives, $/mt	5.29*****	2.70*****
Plastic, $/mt	0.55	1.09***
Construction costs, #/mt	0.36***	

**n = 4; **n = 3; ***n = 6; ****n = 2*

In Costa Rica more labour was involved in land clearing (i.e. 20 man-days/ha vs. 2 man-days/ha in Honduras, see Table 6a). This could be explained by the fact that three smallholders produced silage for the first time, and therefore had to clear the land thoroughly. In Costa Rica also more labour was allocated to planting (i.e. 7 man-days/ha vs. 2 in Honduras, see Table 6a) because of the higher amounts of seed used. In addition, in Costa Rica more labour was engaged in harvesting, transporting and filling the silo, although the yield (mt/ha) was lower compared with Honduras (i.e. 16 mt/ha and 24 mt/ha, respectively, see Table 3a).

Machinery costs were also lower in Honduras than in Costa Rica. This was because the rental costs of a tractor or cutter were lower and because of the use of oxen instead of tractors by about half of the farmers in Honduras.

Furthermore, as seen in Table 6a, silage-using farmers in Costa Rica used more expensive management practices than farmers in Honduras: (a) almost every interviewed farmer in Costa Rica used herbicides, while in Honduras just about half of farmers applied it, (b) farmers in Costa Rica applied more seed (24 kg/ha vs. 19 kg/ha) and (c) farmers in Costa Rica used higher amounts of fertilizers per hectare (386 kg/ha vs. 226 kg/ha in Honduras).

In addition, the yield (mt/ha) of silage was lower in Costa Rica (see Table 3a). Therefore, the costs, which were independent of the quantity of silage (like costs of cleaning the land) were more expensive than in Honduras.

Hay

Table 6b shows the costs of making hay in Honduras and Costa Rica ($20/mt and 39/mt, respectively). The higher cost of producing hay in Costa Rica was due to the high machinery costs. The rent of machinery for baling (with labour costs included) was more expensive in this country. Two farmers in Honduras did not bale the hay, but stored it as a heap, which was a cheaper option than baling.

Table 6b. Costs of making hay

	Honduras (n=6)	**Costa Rica (n=2)**
Labour costs,($/mt	13.67*	
Machinery costs, $/mt	13.05	34.58
Other costs, $/m)	*6.01***	*4.37*

Fertilizer, $/kg	0.28***	0.37*
Fertilizer, kg/ha	146.98***	69*
Fertilizer, $/mt	5.12**	2.82*
Costs of building, $/mt	1.11***	2.96

**n = 1; **n = 5; ***n = 4*

Comparing the costs of silage and hay, it appeared that in the case of hay the machinery costs were much higher. This was because labour costs were (in almost all cases) included in the rental costs of machinery. On the other hand, other costs were lower for hay production. This could be explained by the use of improved pastures. Farmers didn't need to buy seed and didn't use herbicides, which were necessary for silage.

Comparing Tables 5a and 5b revealed that in Honduras the cost of producing silage was higher than the cost of producing hay (i.e. $47/mt DM vs. $23/mt DM). The feeding costs were lower when hay was fed (i.e. $0.19/cow/day vs. $0.21/cow/day), although the amount fed was higher (i.e. 6.2 kg DM/ cow/day vs. 4.1 kg DM/cow/day, see Table 4a and 4b). In Costa Rica, as seen in Tables 5a and 5b, the cost of producing hay was lower than the cost of producing silage (i.e. $44/mt DM vs. $130/mt DM). The feeding costs were lower when hay was fed (i.e. $0.19/cow/day vs. $0.33/cow/day), although the amount fed was higher (i.e. 4.4 kg DM/cow/day vs. 2.7 kg DM/cow/day, see Table 4a and 4b). Thus, these data demonstrated that, both in Honduras and Costa Rica, feeding hay was cheaper than feeding silage.

Benefits from feeding hay and silage

Based on the increased milk production or the maintained body weight and the prices of milk or beef, the net income and net benefit due to feeding hay and silage were calculated. In Tables 7a and 7b these benefits are given.

As described before, due to higher amounts of silage fed in Honduras, farmers obtained a higher increase in milk yield. Additionally, profits from milk were higher in Honduras due to higher milk prices (i.e. $0.29/lt vs. $0.24/lt in Costa Rica). Therefore, as shown in Table 7a, the net income due to feeding silage was higher in Honduras than in Costa Rica (i.e. $0.93/cow/day vs. $0.52/cow/day).

Table 7a. Benefits from feeding silage

	Honduras (n=7)	**Costa Rica (n=7)**
Milk		
Price of milk in dry season, $/lt	0.29	0.24
Income from milk without silage, $/cow/day	1.83	0.36*
Income from milk with silage, $/cow/day	2.76	0.88*
Net income due to feeding silage, $/cow/day	0.93	0.52*
Net income due to feeding silage, $/farm/year	3318.30	725.93*
Income:cost-ratio	6.1	1.6

Net benefit due to feeding silage, $/cow/day	0.72	0.20*
Net benefit due to feeding silage, $/farm/year	2806.74	512.03*
Beef		
Price of cow meat, $/kg	1.14•	0.9••
Price of calf meat, $/kg	1.2•	0.94••
Income loss due to not feeding silage, $/head/day		-0.68**
Net income due to feeding silage, $/head/day		0.68**
Net income due to feeding silage, $/farm/year		1485**
Benefit:cost-ratio		2
Net benefit due to feeding silage, $/head/day		0.45**
Net benefit due to feeding silage, $/farm/year		1052.07**

**n = 5, **n = 2*

•Source: announcement J.C. Ordoñez, DICTA, may 2005

••Source: Corfoga, Corporacion Ganadera, february/march 2005

The same was true for hay (Table 7b).

Table 7b. Benefits from feeding hay

	Honduras (n=6)	**Costa Rica (n=2)**
Milk		
Price of milk in the dry season, $/lt	0.29	0.24
Income from milk without hay, $/cow/day	2.06**	0.75*
Income from milk with hay, $/cow/day	3.22**	1.10*
Net income due to feeding hay, $/cow/day	1.16**	0.35*
Net income due to feeding hay, $/farm/year	7684.80**	945*
Income:cost-ratio	9.1**	1.9*
Net benefit due to feeding hay, $/cow/day	0.97**	0.17*
Net benefit due to feeding hay, $/farm/year	6884.90**	419.85*
Beef		
Price of cow meat, $/kg	1.14•	0.9••
Price of calf meat, $/kg,)	1.2•	0.94••
Income loss due to not feeding hay, $/head/day	-0.28**	-0.45*
Net income due to feeding hay, $/head/day	0.28**	0.45*
Net income due to feeding hay, $/farm/year	1220.40**	3240*
Benefit:cost-ratio	16.59	2.2*
Net benefit due to feeding hay, $/head/day	0.25**	0.24*
Net benefit due to feeding hay, $/farm/year	1158.41**	1751.76*

**n = 1; **n = 3*

•Source: announcement J.C. Ordoñez, DICTA, may 2005

••Source: Corfoga, Corporacion Ganadera, february/march 2005

Farmers in Honduras fed more hay and therefore, obtained a higher increase in milk yield (see Table 4b). Consequently, the net income due to feeding hay was also higher in Honduras than in Costa Rica (i.e. $1.16/cow/day vs. $0.35/cow/day), although it has to be mentioned that the net income due to feeding hay in Costa Rica was based on just one farmer, therefore, this number was may not be representative.

Farmers in Honduras fed more hay to their milking cows than farmers fed silage. Therefore, farmers realised a higher increase in milk yield and, as Tables 7a and 7b show, a higher income due to feeding hay (i.e. $1.16/cow/day vs. $0.93/cow/day). In Costa Rica the silage-using farms achieved higher increases in milk yield than the hay-using farmer, which resulted in a higher income (i.e. $0.52/cow/day and $0.32/cow/day, respectively).

As Table 7a shows, the income-cost ratio of feeding silage [net income ($/cow/day) divided by total costs ($/cow/day)] of farms with milking cows was positive in both countries; 6.1 and 1.6 respectively. Also the net benefit due to feeding silage [net income ($/cow/day) minus costs ($/cow/day)] of farms with milking cows was positive in both countries; $0.72/cow/day and 0.20/cow/day, respectively. This indicated that feeding silage to milking cows was profitable in both countries. In Honduras, the lower production cost and the higher net income explained the higher income-cost ratio and net benefit on farms with milking cows compared with Costa Rica. In addition, due to the higher amount of milking cows fed during more months, the net annual benefit due to silage was much higher in Honduras than in Costa Rica ($2,807/farm/year and $512/farm/year, respectively). This same scenario was true for the case of hay in both countries (Table 7b)

Comparing Tables 7a and 7b revealed that in Honduras the income-cost ratio of hay was higher than of silage (i.e. 9.1 vs. 6.1). Also the net benefit due to feeding hay was higher (i.e. $0.97/cow/day vs. $0.72/cow/day). Therefore, the annual net benefit from feeding hay (i.e. $6,885/farm/year) was higher than from silage (i.e. $2,807/farm/year) and appeared therefore to be more profitable. Thus, the low adoption rate of the use of hay in Honduras, as described before (2% vs. 16% of silage, Table 3a), seemed not logical.

A comparison within Costa Rica revealed that the income-cost ratio of hay was higher than of silage (i.e. 1.9 and 1.6, respectively), although the net benefit due to feeding silage was higher (i.e. $0.20/cow/day vs. $0.17/cow/day) due to the fact that the interviewed silage-using farms in Costa Rica were all low-milk yielding farms, while the hay-using farmer realised a higher milk production. Because silage-using farmers fed this feedstuff to more cows, their net benefit ($/farm/year) was higher than the net benefit ($/farm/year) of hay-using farmers ($512 and $420/farm/year, respectively). Again, it has to be mentioned that the net benefit due to feeding hay in Costa Rica was based on just one farmer; therefore, this number may not be representative.

In the case of beef production, in Honduras, the net income and net benefit due to feeding hay were $0.28/calf/day and $0.25/calf/day. The income-cost ratio was 16.6. In Costa Rica the net income and net benefit due to feeding silage were $0.68/cow/day and $0.38/cow/day and due to feeding hay were $0.45/cow/day and $0.24/cow/day. The income-cost ratio was 2 in the case of silage and 2.2 in the case of hay. These results indicate that feeding silage in Honduras and hay or silage in Costa Rica to young and mature non-milking animals was profitable.

Market potential

Hay

All interviewed farmers in Honduras and Costa Rica suspected that other producers were willing to buy the surplus of hay. Except for one farmer in Honduras, all farmers knew the selling price. On average, this was more than twice the price of producing it; $47/mt in Honduras and $94/mt in Costa Rica. This indicates that farmers were aware of the market value or their hay. In Costa Rica, actually, the two interviewed farmers sold hay to neighbours.

In Honduras, the adoption rate of hay was low. However, the income-cost ratio and net benefit due to feeding hay was higher than silage, which possibly will bring along a increased demand, higher adoption rate and the development of a market. However, at this moment, just informal sales on very small scale occurred.

In Costa Rica, the adoption rate of hay, compared with silage, was high. Since many years, bales of hay mostly from rice straw or from "Transvala"grass (ie., *Digitaria decumbens*) had been marketed. In most cases, the demand, and not the quality and price, played an important role.

The ministry of Agriculture and Livestock of Costa Rica developed, in cooperation with agriculture organisations, a program to stimulate the production and sale of high quality hay, which is executed at the moment of writing this report (Morales et al 2003). Possibly, due to this program, the hay market will expand in Costa Rica. Currently, the development of a national market for hay is also part of a project of the Instituto Nacional de Innovación y Transferencia de Tecnología Agropecuaria (INTA). The development of this market is based on auctions, where hay with different prices, which reflect different qualities, is auctioned and sold to the higher bidder (Morales 2001). In April 2005, the Asociación de Productores Agroindustriales de Bagaces (APAIB) held the first auction in Costa Rica, where six farmers sold hay (between 150 and 250 bales per farmer). The hay was classified in three different qualities with prices ranging from $0.11/kg for the highest quality (i.e. 9% CP and 55% DIVMS) to $0.08/kg for the lowest quality (i.e. 4% CP and 35% DIVMS). The APAIB intends to have another auction in February 2006, with 5 different types of qualities and corresponding prices and with a higher amount of hay (APAIB 2005).

Silage

All farmers in Honduras and Costa Rica assumed they could sell an excess of silage to other producers. However, farmers didn't have a surplus and therefore didn't sell it. Most of the silage-producing farmers didn't know the selling price. It appeared that neither in Honduras nor in Costa Rica existed a market for silage. This was possibly due to the fact that it is cumbersome to transport, which makes it difficult to market (Mannetje 2000).

In Honduras the adoption rate of silage was higher than hay. However, the income-costs ratio and net benefits due to feeding hay were higher. This meant that the use of hay was more profitable. Therefore, the adoption rate and demand for hay may increase in the future at the expense of silage.

In Costa Rica, although the use of silage was profitable, its adoption rate was low. Opposite to the efforts which are made to develop a market for hay (see next paragraphs), no attempts are made to develop a market for silage.

Conclusions and Recommendations

- These results clearly demonstrated that due to feeding hay or silage, farmers in both countries increased milk production during the dry season. Because farmers in Honduras fed higher quantities of silage and hay they obtained higher increases in milk yields than farmers in Costa Rica. In both countries, farmers fed a higher amount (kg DM/cow/day) of hay than of silage. Nevertheless, the costs of feeding it were in both countries lower than the costs of feeding silage.
- The results presented in this study indicated that feeding hay or silage to milking cows was profitable in both countries. The income-cost ratio and the net benefit ($/cow/day) were positive but farmers in Honduras realised a higher income-cost ratio and net benefit due to feeding silage and hay than farmers in Costa Rica. This could be explained by (a) lower production costs, mainly due to lower labour and machinery costs in Honduras, and (b) a higher net income, due to a higher milk price ($/lt) and higher increase in milk production in Honduras.
- In Honduras, hay-using farmers, because they fed higher amounts, realized a higher increase in milk production than silage-using farmers. Also the income-cost ratio and net benefit due to feeding hay were higher.
- In Costa Rica, the increase in milk production was higher on silage-using farms. This resulted in a higher net benefit due to feeding silage although the income-cost ratio was higher in the case hay was fed. Because the increase in milk production due to silage was based on farmers who produced no or few milk during the dry season and because the increase in milk production due to hay was based on just one farmer who had a higher milk production, this number has to be re-evaluated with a higher number of interviewed farmers.
- This study also revealed that beef cows or young livestock supplemented with either hay or silage didn't loose weight during the dry season. The income-cost ratio and net benefit due to feeding silage and hay to beef cows or young livestock were positive in both countries. This also demonstrated that feeding silage or hay to beef cows or young livestock was profitable in both countries. Because of the low number of interviewed farmers who fed hay or silage to beef cows or young livestock, no comparison between and within countries with regard to beef production was made. In a following study, more farmers have to be interviewed about the effect of feeding hay or silage to the different livestock categories.
- In Honduras, no market existed for silage and the hay market was small. Because the use of silage was profitable and the adoption rate was high, a demand for, and therefore a market potential of silage can be expected but needs to be transported in a convenient way. Although the adoption rate of hay was low, its use was very profitable, which possibly brings along an increased demand for hay and a development of a market. Agricultural organisations, like DICTA have to increase efforts to develop a national market for silage as well as for hay based on quality and related prices.
- In Costa Rica, no market for silage existed. Probably, the partly developed market for hay

will further evolve, due to the fact that its use appeared to be profitable and highly adapted and thanks to the efforts of agricultural organisations like APAIB.
- It is suggested to re-evaluate the results of this study with a larger sample of farmers. In subsequent studies, more attention has to be paid to the benefits of feeding silage or hay to beef cows or young livestock.

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