

Constraints, feeding strategies and opportunities to improve productivity and income in milk production systems in Olancho, Honduras

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Abstract

Forages are most important for feeding cattle in Central America; however, the adoption of forage options is still limited. This paper develops an approach to prioritise forage options according to efficiency scales, using Olancho in Honduras as a case study.

Farm management characteristics and their effects on resource use efficiency were assessed for 76 farms, classified into a sequence from very low to top performers using net income per cow from milk in the dry season as the indicator of resource use efficiency. Chances for and constraints to the adoption of forage options were derived for specific contexts.

Both nutritional conditions on farm and the genetic potential of the herd were critical in determining the performance level of the farm. Purchased supplements were the most important cost driver in the dry season. Farmers rated as either very low or low performers did not benefit adequately from their herd owing to inadequate feeding, with only a small amount of high quality farm-produced feed, and low genetic potential of their herds. Medium performers placed more emphasis on feed produced on-farm. Positive examples showed that improvement of the forage component was an important step to better resource use efficiency.

Possible options for improving productivity, especially in very low and low producing herds, are discussed.

Introduction

During the last 30 years, meat and milk consumption in developing countries has grown 3 times faster than in developed countries. Projections to 2020 foresee annual growth in demand for meat of 3% and for milk of 2.9% in developing countries (Delgado 2005). An increase in productivity in the livestock sector through enhanced resource use (e.g. labour, capital, land and animals) can significantly increase incomes of farmers (Kristjanson *et al.* 2007) and create employment for the rural poor (Carpentier *et al.* 2000). IFAD (2007) stated that 51% of the rural population in Honduras was considered poor in 1993. The World Bank (2008) indicated that "agricultural growth has lessened rural poverty and, with it, nationwide disparities."

At the same time, the intensification of livestock systems, in the form of increased production per animal unit, would provide an opportunity to prevent land degradation by overgrazing and deforestation (Peters *et al.* 2001; van der Zijpp 2003).

Between 2001 and 2003, milk production in Honduras lagged 14% behind milk consumption (FAO 2005). The Honduran livestock sector has yet to take advantage of this favourable local market context. The land use survey of the National Statistics Institute (INE 2001a) indicated that nearly 50%, or 1 833 722 ha, of agricultural land in Honduras was under permanent pastures. The department of Olancho accounted for 20% of them. Of the agricultural land in Olancho, 24% was under improved pastures and 37% under natural pastures. The share of natural pastures in Olancho exceeded the country average by 14%. Olancho had the highest total number of milking cows in Honduras (167 107 head), of which 45% were milked in the dry season and 63.2% in the wet season. Average daily milk production per cow was 3.5 litres in the dry season and 4.3 litres in the wet season, so that total dry season milk

production of Olancho was 41.5% lower than in the wet season (INE 2001b).

The low milk productivity of Central American cattle systems is related to a range of factors, including the low genetic potential of the commonly used dual-purpose cattle (*i.e.*, cattle for beef and milk production) and the low quality and quantity of feed resources during the dry season. Naturalised and natural pastures (*e.g.* *Hyperthemia rufa*) usually dry out and lose nutritive value a few weeks after the beginning of the 4- to 8-month dry season (Fujisaka *et al.* 2005). While crop residues of maize and beans are important feed sources, availability is variable and quality is often low. In consequence, Central America's milk production drops sharply during the dry season and is about 40% lower than in the rainy season, when feed resources from green pasture are abundant (Argel 1999; Holmann 2001).

More intensive cattle management through optimising use of forages could help reduce the degradation of natural resources and lead to increased incomes for both smallholders and larger cattle farmers. One option for farm intensification is the use of improved tropical forage grasses and legumes, as cattle farmers largely depend on grazing of naturalised and badly maintained improved pastures as a feed resource. Planted forages could help maintain the natural resource base and reduce the farmers' dependency on external inputs (Peters and Lascano 2003). A key aspect of livestock system intensification is the correct application of forage technologies. The potential benefit of forages for cattle farms has been stressed in various publications (Humphreys 1994; Peters *et al.* 2001; Holmann *et al.* 2004a; Argel 2006; Argel *et al.* 2006).

The objective of this paper was to identify constraints and opportunities in milk production systems in Olancho, Honduras. Management and farm characteristics and their effects on resource use efficiency were assessed to prioritise forage options for individual efficiency scales.

Specific objectives of the paper were to: a) classify farms according to a sequence of resource use efficiency in dry season milk production; b) analyse and explain resource use efficiency according to farm management characteristics; and c) identify bottlenecks to and chances for the adoption of forage technologies for specific contexts.

The strategies farmers follow were analysed first for their economic efficiency and an assess-

ment of the economic and social efficiency of the production process was made. It was hypothesised that low or inefficient resource use in the dry season was related to an increased use of purchased supplements. Milk production systems and underlying strategies of farmers were analysed and compared on the basis of their cost efficiencies to derive appropriate solutions for intensification.

Materials and methods

Questionnaire, databank and data collection

The data used for this paper were collected by means of a comprehensive socio-economic questionnaire, which covered all parts of the farming system (*e.g.* family members, education levels, employment, land use inventory, perennial and annual crops, pastures, cut-and-carry forages, forage cultivation, forage conservation, beef production, milk production, poultry and off-farm work). This enabled the investigating team to take into account the diverse structures of farms and the different feeding strategies. Prior to developing the questionnaire, a contextual analysis was carried out to define areas of the farming systems, which had to be included in the data collection. The questionnaire and database structure were adapted from existing material (Lentjes 2003; Holmann *et al.* 2004b). The focus was on dry season problems and on the definition of farm and family income-generating activities. After a pre-testing phase, the questionnaire was revised on the basis of the field results and the database was constructed.

Participants in the study were typical livestock farmers in Olancho and were split into 2 sub-samples, each with distinct sampling procedures.

Sub-sample A. To assess the economic conditions of the **representative livestock holder (typical farms)**, a random sample of 69 farms was sampled from 5 sub-study areas, which represented the most important agricultural zones of Olancho. Farms were selected as follows: Without knowing the farms in the area, the team selected the route to follow for the day and interviewed farmers in every third household, provided that they had cattle. After consulting local experts and maps, zones were chosen to represent as much area as possible of Olancho, where the prolonged dry season was experienced. Gradients between the

study areas represented elevation and ecological change, as well as a distance gradient from the departmental capital. The largest distance between sampled farms was 91 km. The municipalities covered were Juticalpa and San Francisco de Becera in the valley of Guayape river (22 farms sampled), San Francisco de La Paz at the foot of the mountain (23 farms), Gualaco on the top of the mountain (7 farms) and San Esteban with 2 ranching zones descending the mountain (9 and 8 farms).

Sub-sample B. With the help of local extension staff, 13 farms, referred to in the text as **advanced farms**, were identified as having adopted more improved forage options than the rest of the population. In this study, the advanced farm did not exclusively mean “success story” in the sense of a positive deviance in Biggs (2008). Advanced farms were not necessarily in optimal condition. While adoption of forage technology was seen as necessary for cattle farms to improve resource use efficiency, this was not the sole technology required for integrated development of a farm to achieve complete success. Very large farms were excluded, as the availability of financial resources in these cases was not comparable with the typical Honduran farm as assessed in sub-sample A.

The survey team consisted of 2 technicians from DICTA (Dirección de Ciencia y Tecnología Agropecuaria), the Honduran national agricultural research institute, and 2 CIAT staff members (a research assistant and the first author). The survey was conducted between July and December 2005.

Post data collection activities were designed to: assist farmers in improving forage use; maintain contact with the farmers; validate the data; and discuss some of the results with them. After the initial analyses, discussion meetings were arranged with those farmers that could be met, while others were contacted by telephone. Final indicators were calculated after validation.

Data were checked for outliers in terms of the family income in US\$ per year, when stratified according to herd size classes. In 6 cases, family income was considered to be not representative of average values, so the number of farms was reduced from 82 (interviewed) to 76 (analysed) farms.

Assessment of herd characteristics, costs and income calculations

The questionnaire included a section, which grouped the herd into categories (cows in milk, dry cows, heifers, fattening bulls, breeding bulls, oxen and calves) and allocated an average value per animal for each category. Farmers estimated the genetic composition of their herds, dividing them into the following genetic categories: pure Brahman, 75% Brahman-25% European (Holstein, Brown Swiss or Jersey), 50% Brahman-50% European, 25% Brahman-75% European and pure European.

Net income figures for the whole livestock system (milk and beef) and for all farming activities (annual and perennial crops, milk and beef) were calculated, deducting all costs from the revenue, and presented in US\$ per year and per hectare. Production costs included all purchased and non-purchased inputs, plus costs for renting machinery and services. Farm work of family members was valued at the wage rate paid for the external labour force assessed for each farm. Working on other farms with this salary would be the alternative for the farmers.

Specific net income figures included the revenue minus costs from specific activities. Net farm income included all crops, livestock products and sold forages. Net income from milk production included revenue minus costs from milk production only. In the case of net income from livestock, milk and beef in all forms were considered. As families normally used a part of their products for home consumption, farm income included products sold (cash income) and the opportunity cost of products consumed (in-kind income).

For the partial analysis of the milk production system, several indicators were based on a period of one month per cow in milk during distinct seasons. These indicators were net income and revenue from milk for the dry and the wet seasons. Costs for the dry and wet seasons were broken down in detail.

Production costs for milk in the dry season included the following variables: cost of purchased supplements, production cost of forage grown for the dry season, e.g. silage and hay, cost of cut-and-carry forage production, salaries for workers, opportunity cost of family labour for dry season milk production and cost of veterinary services and medicines.

For the wet season, milk production costs included: purchased supplements, cut-and-carry forage production, weeding of pastures, fertilisation of pastures, salaries for workers, opportunity cost of family labour and veterinary services and medicines.

Assessment of resource use efficiency

Resource use efficiency of milk production was measured by the indicator 'net income from milk per cow per month of the dry season'. This performance indicator was used to compare farms, irrespective of size, management practice and decision-making, including both advanced farms and typical farms.

Based on this analysis, the following performance classifications were derived:

- Very low performers (24 farmers): cost of milk production exceeded the revenue;
- Low performers (13 farmers): positive net returns below the median;
- Medium performers (23 farmers): net returns between the median and the 80% level; and
- Top performers (16 farmers): net returns in the top 20%.

Methods applied for the comparative analysis between groups of farms included descriptive statistics (means, standard deviations, frequencies), linear regression models and non-parametric tests (Mann-Whitney test).

Results

Characterisation of production and income status

Differences in both gross and net incomes between the resource use performance groups were highly significant ($P < 0.01$) (Table 1) in both wet and dry seasons. Income increased progressively from the very low to the top performance group. Since sampling was across climatic zones, relationships between milk production and farmer information on the length of the dry season were examined. This and other parameters, which one could hypothesise caused differences between performance groups, *e.g.* the age of the farmer or his years of experience in milk production, were tested but no significant correlations were found.

Irrespective of the season, income of very low performers failed to cover the expenses for milk production, although losses were smaller in the wet season. In both seasons, this group had the highest production costs. The wet season losses were mostly a consequence of the inclusion of the opportunity cost of the family labour force in the net income calculation, *i.e.*, as if the family members were hired. Low and medium performers had lowest production costs in both seasons. While gross income per cow of low performers in the dry season was about 78% of the wet season gross income, net income in the dry season was only 30% of the wet season net income. Gross income of top performers was highest in the dry season, and despite high production costs, this group had higher net income in the dry than the wet season.

Table 1. Gross and net income from milk production per cow for different performance groups in the dry and wet seasons.

		Very low (n = 24)	Low (n = 13)	Medium (n = 23)	Top (n = 16)
Gross income in dry season (US\$/cow/month)	Mean	12.16d ¹	21.19c	28.42b	54.84a
	SD	13.47	9.22	9.14	40.47
Net income in dry season (US\$/cow/month)	Mean	-15.63d	5.62c	14.29b	32.49a
	SD	22.90	3.09	3.15	13.20
Gross income in wet season (US\$/cow/month)	Mean	23.49c	26.94bc	27.49ab	38.54a
	SD	12.55	12.24	8.46	19.77
Net income in wet season (US\$/cow/month)	Mean	-1.83c	18.41b	18.16b	27.90a
	SD	24.26	7.64	9.45	14.59

¹ Within rows, means followed by different letters differ ($P < 0.05$).

Representation of herd sizes in performance groups

The advanced farms were kept separate, irrespective of their herd size. Amongst the typical farms, there were no consistent performance patterns across herd sizes (Figure 1). More than 60% of the very low performers were small farms, but small farms fell in all groups, with 12.5% in the top performing group. Medium size farms were well represented at all performance levels. Large and extra large farms were concentrated at the medium and low performance levels, with about 23% of the low performers being extra large farms. While advanced farms appeared in all performance categories that were profitable, 75% of the top performers were either medium size farms or advanced farms.

Performance level and value per cow

Farmers usually estimated the commercial value per cow using a rule of thumb by which they added 1000 Lempira (52 US\$) to the slaughter value of a cow for each litre of milk produced per day. From a joint analysis of all farmers sampled, cows of very low performers had a lower commercial value than those of top performers ($P < 0.05$) (Table 2).

Genetic composition of the herds varied between performance groups, with the percentage of European genes in the herds increasing from very low to top performers (Table 3). Genetic differences did not result in significant differences of mean values per milking cow between low, medium and top performers.

Land use efficiency, and dry – wet season dairy herd characteristics

In the dry season, very low performers had proportionately fewer cows in milk (36%) than the other groups (60–65%) ($P < 0.01$) (Table 4). The majority of the very low performers were small farmers (62.5%), of which many ceased milk production in the dry season. Percentage of cows in milk rose markedly in the wet season in the very low performing group, so that all groups had a similar percentage (59–64%) in milk at this time. Very low performers had a lower percentage of their farms under improved pasture than the other groups, relying on naturalised pastures (Table 4).

The efficiencies of the livestock system (net income from livestock) and the combined crop and livestock systems (net farm income) per unit of land are summarised in Table 5. Yearly net income from livestock per ha of pasture

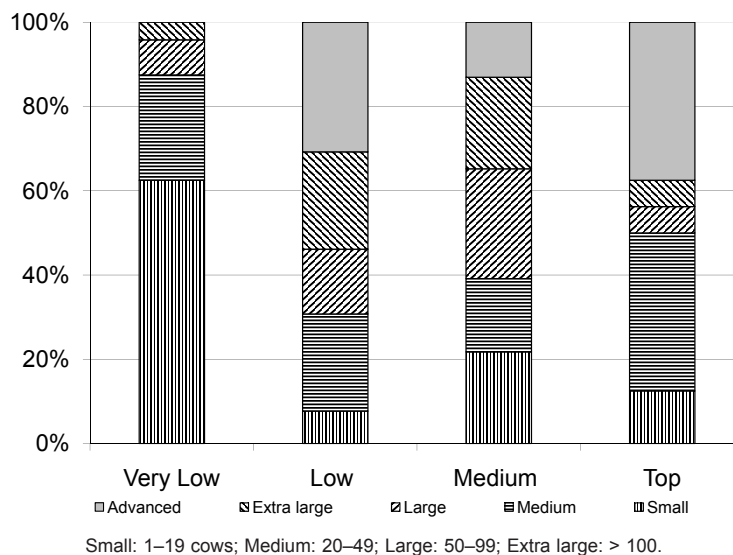


Figure 1. Herd size distribution within different performance groups, Olancho.

Table 2. Mean market value of milking cows for different performance groups.

		Very low (n = 24)	Low (n = 13)	Medium (n = 23)	Top (n = 16)
Value of milking cow (US\$)	Mean	482.46b ¹	562.75ab	565.22ab	723.68a
	SD	117.86	249.78	253.52	314.91

¹ Within rows, means followed by different letters differ (P<0.05).

Table 3. Genetic composition of dairy herds in different performance groups.

Category of farms	Genetic composition	Proportion of herd %
Very low performers	100% Brahman	4.5
	75% Brahman - 25% European	75.8
	50% Brahman - 50% European	19.7
Low performers	75% Brahman - 25% European	66.7
	50% Brahman - 50% European	25.0
	25% Brahman - 75% European	8.3
Medium performers	100% Brahman	8.7
	75% Brahman - 25% European	45.9
	50% Brahman - 50% European	28.0
	25% Brahman - 75% European	15.2
	100% European	2.2
Top performers	75% Brahman - 25% European	39.6
	50% Brahman - 50% European	43.5
	25% Brahman - 75% European	16.9

Table 4. Production conditions of farms in different performance groups.

		Very low (n = 24)	Low (n = 13)	Medium (n = 23)	Top (n = 16)
Improved pastures (% of area)	Mean	46.8b ¹	62.7ab	74.7a	61.8ab
Cows in milk in dry season (% of cows)	Mean	35.7b	65.0a	60.4a	61.5a
Cows in milk in wet season (% of cows)	Mean	61.2	58.6	63.9	62.4

¹ Within rows, means followed by different letters differ (P<0.05).

Table 5. Land use efficiency per farm of different performance groups.

	Very low (n = 24)	Low (n = 13)	Medium (n = 23)	Top (n = 16)
Annual net livestock income (US\$/ha of pasture and other forages ¹)	-59.61b ²	163.34a	173.33a	215.28a
Annual net farm income from crops and livestock (US\$/ha of arable land)	53.32b	145.92a	186.39a	219.30a

¹ Cut-and-carry forages, maize and sorghum for silage.

² Within rows, means followed by different letters differ (P<0.05).

and other forages (cut-and-carry, maize and sorghum for silage), including beef, milk and sales of young stock, was negative for very low performers, while low, medium and top performers all recorded substantial profits.

Net farm income (including all annual and perennial crops, milk, beef and young stock sales) per ha of arable land was low but positive for the very low performers, and similar to that for livestock income per ha of pastures and other forages for the remaining groups.

Market conditions

In Olancho, the majority of farmers sold to intermediaries, who collected milk at the farm gate and resold it to artisan milk processing plants, where it was processed into cheese. For 95% of the farms, it was always possible to sell the milk produced. When supply exceeded demand, for instance around Christmas and Easter, they processed their milk to curd cheese, which was sold easily in the villages but at a lower price. Some top performers, with higher production volumes, sold to milk collection centres, benefiting from a comparatively high and constant milk price throughout the year.

Price per litre of milk in the dry season exceeded that in the wet season, with the biggest difference being for top performers (Table 6).

Milk production in performance groups

Daily milk yields/cow increased progressively ($P < 0.05$) from low to top performers in both wet and dry seasons (Table 7). Production cost per litre of milk during the dry season declined progressively from very low to top producers ($P < 0.05$; Table 7), while cost per litre in the wet season was higher in the very low group than in the remaining groups. For a deeper interpretation of the production parameters and production conditions, the following sections treat the performance groups separately, referring to Figure 2 and Tables 7 and 8. To complete the picture of dry season milk production, the overall trends are summarised after the results of the groups are presented.

Very low performers. About 17% of the very low performers used no purchased feed or farm supplements, relying largely on naturalised pas-

ture and weeds as dry season feed. A further 43.4% did not purchase supplements but relied on maize stover of low quality, with only 4.3% having cut-and-carry forage. About 39% of the low performers fell into the “concentrate trap”, purchasing supplements without recouping these expenses in milk production. Of these, 17.4% used only concentrates, 8.6% combined concentrates and molasses and 13% used low quality farm feed such as dry pasture and maize stover combined with the purchased supplements. Only 17.3% of the very low performers had cut-and-carry forages, usually of better quality, but in limited quantity. Even in the rainy season, 16.6% still fell into the concentrate trap.

About 42% of the very low performers did not milk in the dry season and up to 90% of those who did not milk in the dry season did not purchase dry season feed. Bodyweight losses were common in these circumstances.

Low performers. All 13 low performers produced at least some milk during the dry season and spent less on animal nutrition than very low performers. Labour per cow was used more efficiently than among very low performers because they had more cows in milk.

Dry season feeding strategies among the low performers were:

- Low-input low-output system: crop residues (maize stover) and dry pasture.
- Exclusive use of purchased supplements.
- Insufficient conserved forage because of first year of adoption.
- Combination of farm feed and purchased inputs. More farm feed of low quality than high quality.

In the dry season, 69.2% of the low performers used purchased supplements, which was their most expensive item in the production cost budget.

Medium performers. All medium performers produced milk during the dry season.

Dry season feeding strategies of medium performers included:

- No purchased or home-produced forage on 9 farms. At the present production level, there was no need for them to purchase or to produce supplements owing to favourable site conditions: improved pastures and pastures near rivers, which stayed green during the dry season, and abundance of crop residues.

Table 6. Dry and wet season milk prices for different performance groups.

		Very low (n = 24)	Low (n = 13)	Medium (n = 23)	Top (n = 16)
Dry season milk price (US cents/L)	Mean	26.1b ¹	25.1b	25.7b	27.8a
	SD	2.48	3.49	2.74	2.63
Wet season milk price (US cents/L)	Mean	19.2	20.0	18.1	19.1
	SD	3.80	3.74	2.94	4.68

¹ Within rows, means followed by different letters differ ($P < 0.05$).

Table 7. Dry and wet season milk production and costs for different performance groups.

		Very low (n = 24)	Low (n = 13)	Medium (n = 23)	Top (n = 16)
Production costs in dry season (US cents/L)	Mean	49.4d ¹	16.9c	12.4b	8.6a
	SD	34.27	6.01	4.95	3.81
Production costs in wet season (US cents/L)	Mean	21.7b	5.9a	5.8a	5.6a
	SD	21.24	4.12	3.47	3.94
Supplementation cost in dry season (US\$/cow/month) ²	Mean	4.81	4.67	3.50	7.33
	SD	9.26	4.61	5.95	11.08
Forage production costs in dry season (US\$/cow/month)	Mean	0.28b	1.78a	2.42a	1.84a
	SD	1.39	3.92	4.00	2.46
Dry season milk yield (L/cow/d)	Mean	1.77c	2.52c	3.98b	5.88a
	SD	2.10	0.80	1.42	2.87
Wet season milk yield (L/cow/d)	Mean	4.12c	4.48bc	5.10b	6.80a
	SD	2.08	1.93	1.52	3.35

¹ Within rows, means followed by different letters differ ($P < 0.05$).

² Farm and purchased supplements.

Table 8. Frequencies of use (%) of dry season feed sources in different performance groups.

	Very low	Low	Medium	Top
Dry naturalised pasture and weeds	17.4	7.7	26.1	12.5
Only purchased feed	26.1	23.1	0.0	12.5
Only farm-produced feed ¹	43.5	23.1	30.4	31.3
Mixture of purchased and farm feed	13.0	46.2	43.5	43.7

¹ Includes: crop residues, improved pasture, cut-and-carry forages, conserved forage and self-made concentrates from farm-produced ingredients.

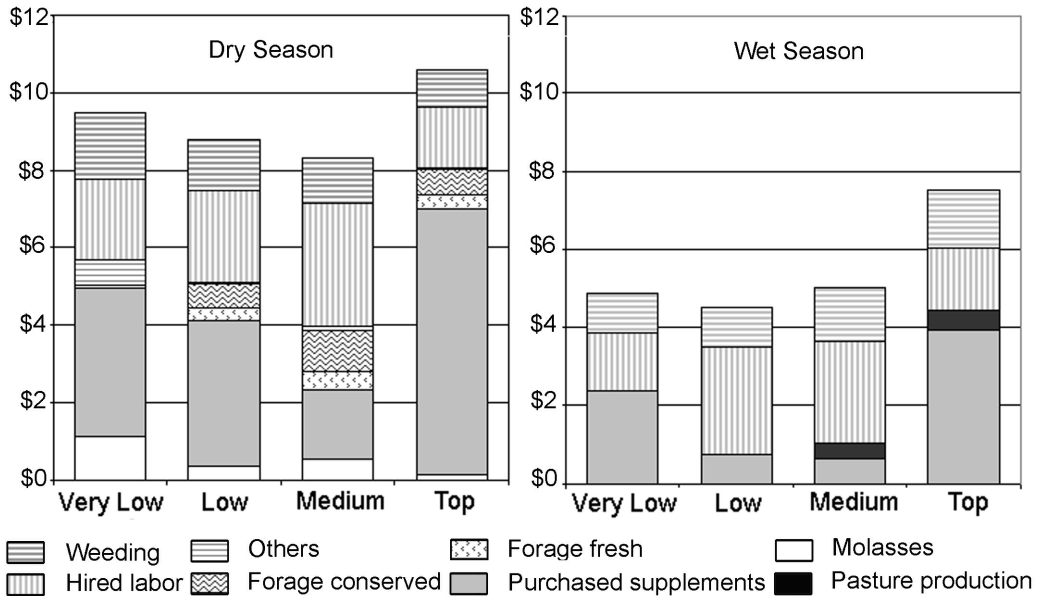


Figure 2. Monthly expenses for milk production (US\$/cow in milk) in different performance groups in dry and wet seasons.

- High quality farm feed: conserved forage.
- Combination of conserved forage and purchased supplements.
- Fresh maize and dry sorghum, cut-and-carry forage, usually complemented with commercial concentrate.

Differences in management resulted in the production costs per litre of milk in the dry season falling below those of the low and very low performers. No medium performers relied on purchased inputs alone and medium performers had the highest percentage of improved pastures (Table 4).

Medium performers used comparatively little purchased supplements, relying largely on a variety of farm-produced dry season feedstuffs. Costs of production for farm-produced forages were higher than in the other groups. In the dry season, medium performers used forages in various ways, including supplementation with fresh and conserved forages. This increased the cost for hired labour per production unit.

Top performers. Two situations existed among the top performers: Some generated a high income per cow without purchasing supplements, while others relied strongly on purchased supplements. On some farms, milk production rose in the dry

season owing to better care and feeding. The dry season feed was of better quality than wet season feed, which usually consisted of higher levels of pasture and less concentrate.

The variety of dry season feeding strategies was greatest among top performers:

- Few farmers did not feed supplements or produce forage. These farms had very favourable locations as well as sufficient land with pastures that stayed green. They were located at higher elevations, where the length of the dry season was only 2–3 months and drought was less severe than at lower elevations.
- Some farmers in similar climatic conditions fed molasses.
- Frequent strategies included: feeding of cut-and-carry grasses, sufficient quantities of cut forage maize and sorghum, grazing of crop residues, accompanied with the previously mentioned feed items. These farm-feeds enabled low-cost milk production. Concentrate was always a part of the diet.
- Six of the top performers belonged to the advanced group, which used 3–6 sources of feed in adequate quantities: conserved forage (hay and silage), cut-and-carry grasses, maize and sorghum for forage and crop residues. Purchased inputs were used in considerable quantities.

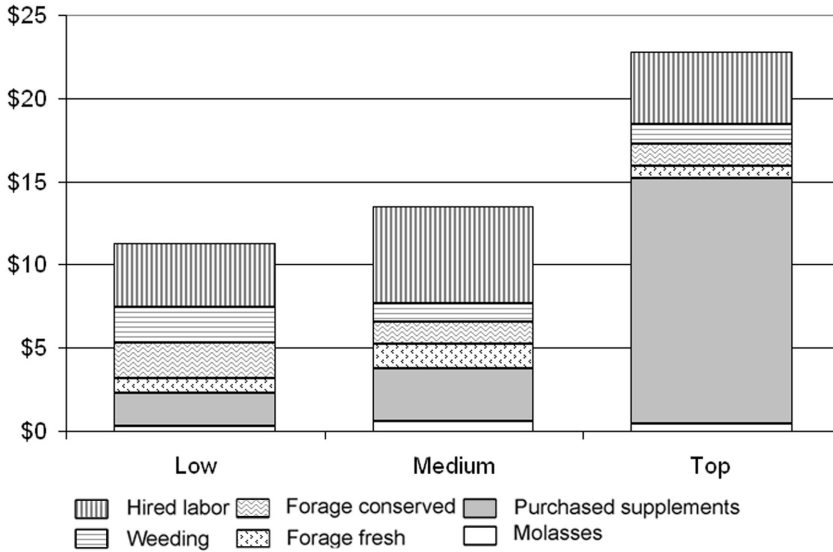


Figure 3. Monthly expenses for milk production (US\$/cow in milk) for advanced farms in different performance groups in the dry season.

Advanced farms among performance groups. Since the advanced farmers were selected because they utilised forage technologies to a greater extent than the remaining farmers, it might be assumed that they would all belong to the top performers group. The economic assessment of these farms did not necessarily demonstrate what could be achieved with an appropriate use of forage technology. Advanced farmers in the top performing group spent about 5 times as much on purchased supplements as the medium performers (Figure 3).

The sequence from low to top performers among advanced farms showed the following trends:

- From low to top performers, overall expenses and the expenses for purchased supplements used per cow rose in parallel with the value per cow.
- Where the performance level was highest, the relative importance of forages declined and expenses for commercial concentrates increased.

Overall performance of the groups. Dry season production costs/L milk declined ($P < 0.01$) progressively from very low to top performing groups. Production costs in the dry season for medium, low and very low performers were generally at least twice those in the wet season (Table

7). The profit margins per litre of milk produced increased from low performers (8 US cents/litre) to medium (13 US cents/litre) and top performers (19 US cents/litre).

During the wet season, when pasture feed was abundant, only 18.9% of the farms purchased feed supplements, compared with 57.9% in the dry season. Monthly forage production cost per cow in the dry season was lowest for very low producing farms, because very low quantities were produced. A breakdown of production costs (Figure 2) showed how farmers in different production classes varied in their use of purchased supplements and hired labour in particular. The variation in dry season feed sources used by different production groups (Table 8) highlighted that no medium producers relied solely on purchased feed, although about 25% of very low and low performers used only purchased feed. However, there was no fixed pattern for the sources from which feeds were drawn.

Very low and low performers showed the highest dependency on purchased supplements, while feed produced on farm was more widespread with medium and top performers.

Although 26% of the medium performers relied solely on naturalised pasture and weeds in the dry season, their situation was different from that on other farms. Their relative success was a

result of favourable conditions available on their farms that provided more feed in the dry season, including improved grasses and large quantities of crop residues. Mixing farm and purchased feed was common practice where milk production was profitable in the dry season.

Discussion

This study has highlighted factors which contribute to the different production levels and profitability on dairy farms in Honduras. As has been demonstrated in dairy systems throughout the world, adequate nutrition and appropriate genetics are essential if high efficiency of resource usage is to be achieved. In general, performance levels of farmers were determined by the genetic potential of their herds and their ability to provide adequate nutrition for the dairy herd, especially during the dry season. Although fed at various intensities, purchased supplements proved to be the most important cost driver in the dry season and were fed on 62% of the farms.

Top performers occupied this position because they based their milk production on high levels of commercial concentrate feeding to animals with high genetic potential for milk production. This strategy paid off well as the herds produced more milk per unit of feed cost. Although input costs were higher than in the low and medium performing herds, especially during the dry season, the superior herds were more profitable. However, rising concentrate prices may make this strategy less profitable in the future. While feed costs were lower for low and medium performers, the herds were of a lower genetic potential. This resulted in lower yields and lower net income in these herds. As performance increased from very low to medium, costs for farm-produced feed and the variety of farm feed used rose as expenses for purchased supplements declined.

Very low and low performers did not benefit adequately from their herds. They were in a situation in which they fed purchased supplements, driven by the necessity to ensure the herd survived during the dry season. This situation of using purchased concentrate to replace farm feed to maintain the herd can be described as the bottom of the concentrate trap. Expenses were high and minimal or no returns were generated. Concentrates should be used only to enrich the

diet with proteins and carbohydrates and not as substitutes for forages.

Very low performers experienced feed shortages in the dry season, as was reflected in the low incidence of improved pastures, their dependency on naturalised pasture of low nutritional value and their high expenses for purchased supplements. They were unable to increase the proportion of improved pasture on their farms as they lacked surplus cash for this purpose. As a result, their cows were markedly underfed and many farmers did not milk for sale during the dry season but used the little milk available to feed calves. In some cases, herd sizes were small and the milking period was confined to the wet season, a good strategy for those farms with insufficient farm feed resources. This resulted in a disruption to cash flow during the dry season. The family labour force was an under-utilised resource among very low performers. Although herd sizes were mostly small, labour costs (hired labour plus family labour) per cow were comparable with those of the top performers. An added problem was the low genetic potential for milk production of cows in very low performing herds. The higher return from crops, as compared with livestock, among this group indicated that these farmers were more efficient at crop production than livestock production. However, ceasing cattle production and increasing crop production was not a viable option, because they lacked adequate land for crop production and crop failure was frequent owing to large climatic variability between years. On the other hand, returns per ha suggested that low performers were better at livestock production than at crop production. About 23% of the low performers were extra large farms, which concentrated on extensive beef production. The genetic potential for higher milk production in the dry season generally existed in herds of low performers, because wet season milk yields were similar to those of medium performers and the value per cow was also similar. Limited use of farm-produced feed, *e.g.* conserved forage, in these herds was a serious impediment to increasing milk yields at this time. There is potential for low performers to work more profitably by changing their dry season feeding strategy to involve more high-quality farm feed, since lack of forage and excessive supplement use made them less productive than the medium performers. While production costs per litre of milk during the dry season were higher

for low than for medium performers, both genetic composition of the herds and market values of the milking cows were similar. Medium performers were significantly more cost-efficient in milk production than low performers, reflecting the better management of the herds rather than better genetic potential of the cows. Lower production costs per litre on medium performers' farms were achieved by using a greater variety of dry season feeding strategies than low performers, with more farm-produced feed and less purchased commercial concentrates.

While herd size varied across categories, more than 60% of low performers had small herds, which could suggest that they were too small to be efficient, especially in the use of labour. However, 25% of the low performers were extra large herds, so high cow numbers did not necessarily produce economies of scale. All herd sizes were well represented among medium performers, indicating that profitable milk production could occur, irrespective of the size of the herd. Significantly, nearly 50% of the top-performing herds carried fewer than 50 cows.

The analysis of advanced farms showed they were at several stages of an integrated change to the livestock production system, which was the key to success. Some advanced farms had sufficient high-quality forage available but performance was lower than expected, as the genetic potential of their herds could not take full advantage of the higher nutritional levels available. Successful advanced farms had high value, and thus high-quality milking cows. These crossbred animals were able to transform concentrate and high-quality forage into milk profitably. When high-quality forage was fed to cows with low potential, the system performed poorly.

In addressing the situation, the inefficiency of the very low performers should be remedied by inducing technical change. Any interventions should aim at improving the forage feed base in both dry and wet seasons, as well as the genetic potential for milk production of the herds. One obvious benefit would be the generation of a continuous cash flow through year-round milk production. Possible initiatives would include the subsidised sowing of well adapted improved grasses (e.g. *B. brizantha* cv. Toledo) and their conservation. Cut-and-carry grasses could also be promoted where the terrain is appropriate. Sowing of legumes, e.g. *Lablab purpureus*, as an intercrop species with maize would increase both

maize yield and quality of stover post-harvest (CIDICCO 1997; Cook *et al.* 2005). In parallel with these forage-based measures, provision of adequate crossbred bulls to farmer groups would improve the genetic potential of the milking cows. Technical assistance in pasture management and rearing of heifers would complement the package.

Possibilities for intervention for low performers lie in the improvement of the farm feed base by promoting a more adequate pasture management (rotational grazing and the use of organic and chemical fertilisers), the restoration of degraded unproductive pasture land (Holmann *et al.* 2004b) and the improvement of maize stovers with legume intercrops. The use of legume hay (e.g. *Vigna unguiculata*, *L. purpureus* or *Mucuna pruriens*) to supplement cut-and-carry forage has proven to increase milk yield (Nyambati *et al.* 2003). The analysis of the numbers of cows in milk in different seasons showed that better timing of insemination would make the use of their existing feed resources more profitable, without changing the feed baseline. It might be possible to improve the profitability of even medium and high performers by modifying their feeding strategies. Holmann (2001) suggested that a mix of sugar cane and forage from the shrub legume *Cratylia argentea* could replace up to 70% of the commercial concentrate in the rations for cows without decline in milk yield. *Cratylia* is well adapted to soils of low fertility and long dry seasons. This strategy would result in considerable cost savings.

Conservation of forage as hay and silage is a strategy that needs to be promoted among low and medium performers. The research of Reiber *et al.* (2008) showed how adoption was increased in the department of Yoro in Honduras. In 2002/2003 only 11 farms had silos, when the promotion of silage making was initiated. Subsequently, 5 prototype farms were established. Field days were held, and farmers received training and were personally assisted by a technician, who was a 'prototype' farmer himself. By 2006, farmer-to-farmer promotion of the benefits of silage became an increasingly important factor for the adoption of silage making in Yoro, and adoption had risen to about 102 farmers (about 23% of all farmers) in 2007.

Top performers used more dry season feed sources than the remaining farmers, and their expenses for purchased supplements were

about twice as high as those of medium performers. However, there was still scope for them to enhance dry season forage use and conserve high-quality forages to substitute for concentrates. The expensive dependency on commercial concentrates in these systems could possibly be reduced by a sound use of legumes and enhanced use of conserved forage.

While all farmers could benefit from improved forage options, adoption of these forage options is most probable among top and medium performers. They have the financial reserves to try out new technologies and their herds have the genetic potential to respond to high-quality feed. Once technologies are known locally, the possibilities of a further spread to low and very low performers will be enhanced.

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