Ex Ante Analysis of New Forage Alternatives for Farms with Dual-Purpose Cattle in Peru, Costa Rica, and Nicaragua

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Abstract

The objective was to perform an ex-ante economic evaluation of new, legume-based forage alternatives available to farmers in Latin American tropical lowlands. These alternatives included grasses of the *Brachiaria* genus and the legumes *Stylosanthes guianensis, Cratylia argentea*, and *Arachis pintoi*. Case studies, involving farmers participating in the CIAT-led Tropileche Consortia convened by ILRI, were conducted in the forest margins of Pucallpa (Peru) and in the hillsides of the dry tropics of Esparza (Costa Rica) and Esquipulas (Nicaragua). A linear programming farm model developed by CIAT to maximize income was used for this analysis. Animal management parameters were based on farm averages at each reference site evaluated so that they represented current management conditions. Similarly, the model incorporated the prices of inputs and products typical of each country. A constant herd size was assumed for all alternatives evaluated. Production costs per kilogram of milk were estimated as the maximum expression of competitiveness, using three cow productivity parameters: the current average production per lactation (800 kg in Peru, 1,000 kg in Nicaragua, and 1,350 kg in Costa Rica); and two postulated parameters: 1,500 kg/lactation and 2,000 kg/lactation. For all forage options, key factors analyzed were (1) milk production costs resulting from implementing each forage alternative; (2) the investment required to establish each option, assuming the same number of milking cows and herd fertility; (3) the feasibility of obtaining credit with a local bank to invest in a forage alternative; and (4) the percentage of pasture area on the farm freed for other uses as a result of establishing one of the forage alternatives.

Results indicated that the forage alternatives evaluated significantly improved the competitiveness of dual purpose farms in the hillsides of Nicaragua and Costa Rica, reducing the cost of producing milk between 13% and 37% with increased stocking rates, releasing up to 36% of area allocated to pastures. However, under current commercial banking conditions (real interest rates of 13% in Costa Rica and 18% in Nicaragua with payback periods of 5 years), the implementation of the options evaluated were not financially viable except for the establishment of Cratyla with sugarcane for dry-season feeding and Stylosanthes for pre-weaned calves. For all options to be implemented with commercial credit, a longer payback period was needed (8-10 years) and lower real interest rates (5-10%). The case of the forest margins of Pucallpa, was different, as none of the forage options evaluated, except Stylosanthes for pre-weaned calves, improved the competitiveness of farms under current management and production conditions due to low milk yields per cow and low proportion of herd in milk, which increased depreciation cost/cow to levels which were not viable. In addition, Pucallpa has an excess supply of forage biomass from a reduced herd inventory during the 80s and a limited fresh milk market which makes adoption of improved forages low attractive by farmers.

Introduction

The incorporation of new areas has been the main source of animal production growth in the extensive systems of Latin America. However, marginal lands with higher productivity have already been exhausted, and only remote areas with low fertility soils in environmentally fragile ecosystems remain unused, resulting in greater intensification of those areas currently under production (FAO 1996; Table 1).

Table 1 shows that, of the total increases in milk and beef production, productivity per cow during the 1990s was responsible for about 82% of this increase and biological herd growth was responsible for only 18% . In contrast, during the previous three decades, herd growth was responsible for about 70% of total increases in production and only about 30% was accounted for increments in productivity per cow. Therefore, these changes suggest that the increase in milk and beef production during the 90s are mainly a result of on-farm improvements such as establishment of improved forages, increased levels of supplements, and genetic improvement, and much less the result of incorporating new land and cattle into the livestock activity. This argument is supported by the fact that pasture area during the 90s have increased at a rate of only 0.2% per year.

The role of forage supplements, such as legumes, produced on the farm to strategically balance dietary nutrients, has been widely documented (Pizarro and Coradin 1996). Evidence from several ecosystems have shown the beneficial effects of introducing improved grasses and legumes into farms, including increased milk and meat production; reduced erosion; increased soil fertility, water retention, and biological activity; similar increases in crop productivity, and reduced fertilizer demand (Argel and Ramírez 1996; Miles et al. 1996).

Objectives

This study aimed to perform an ex ante economic evaluation of new forage alternatives available to farmers in Latin American tropical lowlands. Case studies, involving farmers participating in the Tropileche Consortia, were conducted in the forest margins of the humid tropics of Pucallpa (Peru) and in the hillsides of the dry tropics of Esparza (Costa Rica) and Esquipulas (Nicaragua).

Methodology

Every farmer participating in the Tropileche Consortia at the reference sites was interviewed to obtain data on production systems, use of resources, prices of inputs and products, and technologies used. Secondary information was also gathered on the region where the farms were located.

A linear programming agricultural model was used for analysis. This model, developed by CIAT to fit on one electronic sheet, maximized on-farm income.

Current Situation

Current land use and productivity

Table 2 shows the averages of cattle inventory, milk production, and land use on dual-purpose farms in Peru, Costa Rica, and Nicaragua.

The largest average herd size is found in Costa Rica (47 cows and 72 AU), followed closely by Peru (31 cows and 50 AU) and Nicaragua (29 cows and 45 AU). Daily milk production per cow is highest in Costa Rica (5.0 kg), followed by Nicaragua (3.7 kg), and lowest in Peru (3.0 kg). The low milk production in Peru may be attributed to milk market constraints (which is discussed later in more detail), rather than to differences in animal genotype, also expressed by the low percentage of milking cows found in Peru (42%), compared with Costa Rica (60%) and Nicaragua (58%).

Most of a farm's area is sown to pastures, ranging from 75% for Peru to 94% for Nicaragua. The largest proportion of forest is found in Peru (23%), while the smallest is in Nicaragua (4%). The average area planted to crops in Peru is 1.5 ha and in Nicaragua 0.7 ha. Crops are grown for subsistence and include rice, beans, and maize. In Costa Rica, the area under crops is larger (4.6 ha) and crops more diversified (rice, maize, beans, sugarcane, cashew, and fruits such as mango and melon).

Most of the area sown to pastures is covered with "naturalized" species of low productivity, for example, jaragua grass (*Hyparrhenia rufa*) in Costa Rica and Nicaragua. Only a small percentage is sown to improved pastures (11% in Costa Rica, 15% in Peru, and 24% in Nicaragua); these are mostly degraded to some extent and receive no nitrogen fertilization. Stocking rates are thus similar in all countries, averaging 0.9 AU/ha.

Prices of resources and capital investment

Table 3 indicates the prices of resources and capital investment in dual-purpose farms by country. Farmgate prices of milk differ markedly from country to country, ranging from US$0.22/kg in Esquipulas, Nicaragua, to US$0.32/kg in Pucallpa, Peru, with Costa Rica in between at $0.28/kg. However, the price received for milk in both Peru and Nicaragua refers to milk "straight out of the cow," whereas the milk in Costa Rica has been cooled to 5 ° C and is therefore of higher quality.

The price of beef (culled cow) is similar in Peru and Costa Rica ($0.60/kg liveweight), but less in Nicaragua ($0.50/kg). However, animal prices are higher in Costa Rica, followed by Peru. In Nicaragua, prices are much lower, not only for milk and beef, but also for animals.

Likewise, labor costs differ dramatically among the countries; a day's wages may range from $1.75 in Nicaragua to $8.80 in Costa Rica, including social benefits. These differences in labor costs are what most affect the cost of establishing forage alternatives, which are highest in Costa Rica and lowest in Nicaragua.

Land values also differ considerably, ranging from $200/ha in Pucallpa, Peru, to $2,364/ha in Esparza, Costa Rica. Factors such as a high level of public infrastructure, proximity to markets, and long social and economic stability increase land values at Esparza, relative to Pucallpa or Esquipulas (Nicaragua). The commercial value of a farm in Costa Rica therefore averages $280,000, compared with $53,000 in Peru and $45,000 in Nicaragua. In all three countries, land and cattle constitute the main investments. Land value accounts for 77% of the capital invested in Costa Rica, 40% in Nicaragua, and 28% in Peru; and cattle accounts for 15% in Costa Rica, 41% in Nicaragua, and 56% in Peru.

Production costs and income

Table 4 gives an estimate of direct production costs during 1997, gross income, net cash flow, family labor wages, current income and return to capital investment. Labor costs comprise the most important production cost in Peru (43%) and Costa Rica (63%), and the second most important in Nicaragua (32%). This item includes family labor, valued at the minimum wage. The expenditure in feed supplements, for example, concentrates and mineral salts, was the fourth most important item in Peru and the second most in Costa Rica, and the most important in Nicaragua.

Total milk production costs differ significantly among the three countries, ranging from $0.20/kg in Esquipulas, Nicaragua, to $0.23/kg in Esparza, Costa Rica, to $0.29/kg in Pucallpa, Peru. Production costs in Nicaragua are low mainly because labor is 5 times cheaper than in Costa Rica and 1.05 times than in Peru.

Because of the low milk production per cow (3.0 kg/cow per day) and the small size of the milking herd (i.e., 10.6 cows), production costs in Pucallpa, Peru (Table 2), are high, compared with counterparts in Costa Rica and Nicaragua. These costs are also above the international value of milk, which is $2,000/metric ton, equivalent to 130 g powdered milk/L or $0.26/kg liquid milk (Table 4).

Most gross sales come from milk (60% in Peru, 76% in Costa Rica, and 74% in Nicaragua). Remaining sales are represented by the income generated by the sale of weaned calves and culled cows.

Monthly family income is about $270 in Pucallpa, Peru; $586 in Esparza, Costa Rica; and $147 in Nicaragua. This income is equivalent to a day's wage of $8.90 in Peru, $19.27 in Costa Rica, and $4.83 in Nicaragua. However, these wages are approximately twice the national minimum wage in Peru and Costa Rica and almost triple that of Nicaragua.

The real annual return on capital investment for 1997 was very low in Costa Rica (1.37%), followed by Nicaragua (2.53%), and highest in Peru (2.87%). The reason why Costa Rica presents the lowest income return, despite having higher family income and labor wages, is because the land value of the average farm in Costa Rica is high ($280,000/farm). In contrast, unit values of both land and animals are lower in Peru or Nicaragua.

Ex Ante Evaluation of Forage Alternatives

This study aimed to conduct an ex ante economic evaluation of new promising forage alternatives adapted to soils of low to intermediate fertility. These alternatives included grasses of the *Brachiaria* genus (i.e., *B. brizantha*, *B. decumbens*, *B. dictyoneura*), and the legumes *Stylosanthes guianensis*, *Cratylia argentea*, and *Arachis pintoi*.

The legume *S. guianensis* is highly digestible and palatable, and commonly used by farmers as a strategic supplement for pre-weaning calves under direct grazing. Because the simulation model used in this study does not discriminate by animal type, a partial budget methodology was used to evaluate 'Stylo' for pre-weaning calves.

The legume *C. argentea* is an ideal shrub for protein banks and can be used, combined with sugarcane, as protein supplement during the dry season for all animal types, especially milking cows, under the cut-and-carry system.

The legume *A. pintoi* is evaluated in association with *Brachiaria* grasses under direct grazing. Table 5 shows the nutritional parameters and biomass production at different reference sites for all forage alternatives tested in this study with the simulation model.

Animal management parameters were based on farm averages at each reference site evaluated so that they represented current management conditions (Tables 2 and 4). Similarly, the model incorporated the prices of inputs and products typical of each country (Table 3).

The case study consisted of the average farm participating in the Tropileche Consortia at each site. Therefore, for Peru, this was a farm with 57 ha; in Costa Rica, 78 ha; and in Nicaragua, 50 ha. Similarly, the herd size was the average of farms at each site, being 31 cows in Peru, 47 in Costa Rica, and 29 in Nicaragua (Table 2).

A constant herd size (the same number of milking cows) was assumed for all the alternatives evaluated. Production costs per kilogram milk were estimated as the maximum expression of competitiveness, using three cow productivity parameters: the current average production per lactation (800 kg in Peru, 1,000 kg in Nicaragua, and 1,350 kg in Costa Rica); and two postulated parameters: 1,500 kg/lactation and 2,000 kg/lactation.

Productivity parameters may be analyzed according to: (1) the genetic potential of the animals, that is, whether the milking herd can respond to improved diets, and/or (2) differences in pasture management. That is, a given pasture of jaragua grass may induce higher cow productivity, if the cow has access to adequate shade and fresh water at all times, if weeds are controlled, and if the paddocks are rotated adequately for grazing and resting. Herd fertility (i.e., calving rate) was assumed to remain constant, even after implementing forage options.

For each reference site, the prevailing conditions and four alternative scenarios were evaluated:

> *Prevailing conditions* consist of a farm totally covered with naturalized or degraded pastures (e.g., jaragua grass in Esparza, Costa Rica, and Esquipulas, Nicaragua, and degraded native pastures in Pucallpa, Peru), and supplements given during the dry season. In Pucallpa, Peru, supplements consisted of molasses, maize, or bran from breweries, all of which are available in the region. In Costa Rica, farmers used molasses, a commercial concentrate, and *pollinaza* (a type of manure from chickens being fed with concentrates for fattening). In Nicaragua, molasses and commercial concentrate were evaluated.
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> *Alternative 1.* The commercial supplements are replaced by *C. argentea* + sugarcane for the dry season. During the rainy season, the herd grazes paddocks of naturalized grasses. In Peru, this alternative was evaluated with only *Cratylia* (i.e., no sugarcane), because the lack of a marked dry season does not justify the investment of sugarcane.
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> *Alternative 2.* The naturalized grass is replaced by *Brachiaria* spp. and *C. argentea* and sugarcane are also established for dry season feeding.
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> *Alternative 3. Brachiaria* spp. are established in association with *A. pintoi*, and *C. argentea* is also planted with sugarcane. That is, all the forage alternatives are established on the same farm.
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> *Alternative 4.* Using the partial budget methodology, the establishment of *S. guianensis* for feeding pre-weaning calves was evaluated, using data that were already generated by farms of the Tropileche Consortia in Nicaragua and Peru and by extrapolating this information to Costa Rica.

For all the different forage options, the key factors to analyze were (1) milk production costs resulting from implementing each forage alternative; (2) the investment required to establish each option, assuming the same number of milking cows and herd fertility; (3) the feasibility of obtaining credit with a local bank to invest in a forage alternative; and (4) the percentage of pasture area on the farm freed for other uses as a result of establishing one of the forage alternatives.

Results and Discussion

Costa Rica

Current situation. Figure 1 shows the production cost per kilogram of milk according to forage option. Costs per kg of milk are higher when using the pasture commonly grown in the area (i.e., jaragua grass), because farmers must provide supplements for their animals during the 5-month dry season. At 1,350 kg per lactation, milk production cost is US$0.31/kg and the price received is $0.28/kg. That is, the farmer reaches a break-even point when selling weaned calves; the income obtained is similar to the minimum wage.

Production costs decrease as cow productivity increases. Thus, changing from a cow that produces 1,350 kg in a 270-day lactation (i.e., 5.0 kg/cow per day) to one that produces 1,500 kg (or 5.55 kg/day) reduces costs from $0.31/kg to $0.29/kg. When a cow produces 2,000 kg, costs are reduced to $0.23/kg, using the same jaragua grass and supplements of molasses mixed with chicken manure to supply those nutrients deficient in the jaragua grass pasture.

Jaragua grass + *Cratylia argentea* + sugarcane. With this forage option, the need for purchasing concentrates, molasses, or chicken manure for the dry season can be eliminated completely. Based on the nutrient content indicated in Table 5, this forage option is capable of maintaining production during the dry season, even in cows producing 2,000 kg per lactation (or 7.4 kg/day).

At 1,350 kg per lactation, production costs per kg milk are reduced by 10%, compared with the current situation (jaragua + concentrate or chicken manure) and by 7% when production levels are at 1,500 kg per lactation. However, at 2,000 kg per lactation, production costs do not differ because a restriction was imposed on the model regarding the use of chicken manure. In Costa Rica, although chicken manure can be purchased at local farms, it must be purchased throughout the year. The model therefore chose the purchase of commercial concentrate during the dry season in cows producing 1,350 kg and 1,500 kg per lactation, but jaragua grass cannot support a production of 2,000 kg per lactation without there being additional protein and energy supplements throughout the year. In this case, the most inexpensive source was chicken manure, which makes the farm highly competitive, because of the manure's availability throughout the year.

Currently, chicken manure is cheap, costing $0.08/kg; it has a high crude protein content of 17% and 60% digestibility. This combination of factors makes chicken manure a highly viable option. However, its price may rise as its popularity increases, which would make the *Cratylia* + sugarcane option even more attractive. Chicken manure from layers has a high calcium content (2.25%, DM basis), and, to prevent poisoning from excess calcium, no more than 4 kg DM of chicken manure/cow are given per day. This is equivalent to a calcium level of 1% of the animal's daily feed intake (NRC 1988).

The investment required to implement this option on a farm with an average herd of 47 cows in Esparza is about $6,000 (8.9 ha of *Cratylia*, 1.8 ha of sugarcane, and a chopper).

Figure 2 shows the real interest rate with which this investment can be paid, depending on cow productivity and assuming that the farmer devotes 50% of the marginal income received as product of this forage alternative. The real interest rate in Costa Rica is currently 13% (24% nominal interest; 11% annual inflation) and the maximum credit available is on a 5-year term with 1 year of grace. Under these conditions, the credit cannot be paid unless cows produce 2,000 kg per lactation. With a productivity of 1,500 kg per lactation, this credit can be paid if real interest is lower (between 5% and 10%) and the terms of payment longer (about 10 years).

This situation deserves attention from policy makers. If politicians put pressure on farmers to compete in open market economies, then farmers should have the option of lower interest rates that reflect the opportunity cost of money in the international market, currently at real interest rates between 6% and 9% over a 15-yr period.

The implementation of this forage option does not release areas for other uses. It only replaces the use of externally purchased supplements.

***Brachiaria spp.* + *Cratylia argentea* + sugarcane.** Returning to Figure 1, the option to establish *Brachiaria* instead of jaragua grass and additionally establish *Cratylia* with sugarcane for dry-season feeding reduces milk production costs even more (from $0.27/kg to $0.18/kg, depending on the productivity of the milking cow). This option reduces production costs proportionally between 13% and 28%, compared with prevailing conditions on most of farms of the central Pacific region. Costs are reduced, not only because no supplements are purchased, but also because the area allocated to maintaining the same herd of 47 cows is lower, thus reducing the need for labor to maintain paddocks and fences.

Figure 3 shows the percentage of pasture area released as a result of intensification caused by the establishment of these options. With this forage alternative, 27.5% of the area currently allocated to livestock could be released and still maintain the same herd size of 47 cows, that is, from 83 to 59.1 ha. The jaragua grass was replaced by 53.5 ha of *Brachiaria*, 4.6 ha of *Cratylia*, and 1.0 ha of sugarcane, thus releasing 23.9 ha that could be put to other uses.

The investment required to establish these forage options was about $18,500. However, if farmers are to invest in these options, milk productivity per cow must increase under current real interest rates in order to pay back the credit (Figure 4). With current productivity levels, especially that of 1,500 kg per lactation, there is no way that credit can be paid. However, with a productivity level of 2,000 kg per lactation, a credit at the current 13% interest rate in Costa Rica may be paid, provided that the term be expanded from the current 5-yr period to one of 10 years.

***Brachiaria spp.* + *Arachis* + *Cratylia* + sugarcane.** All improved alternatives are established on the same farm. Milk is therefore produced at a lower cost compared with the other alternatives (dropping from $0.25/kg under prevailing conditions, at 1350 kg per lactation, to $0.17/kg, with a productivity of 2,000 kg per lactation). This option is 20% to 30% less expensive than jaragua grass + supplements. Furthermore, a larger area can be released away from livestock to other uses (36.5%, equivalent to 31.2 ha).

This investment involves the establishment of 47 ha to *Brachiaria* spp. in association with *A. pintoi*, 3.7 ha to *C. argentea*, and 1.0 ha to sugarcane, and requires $21,000. However, as with the previous alternative, a farmer who wants to establish these options cannot repay credit, except where productivity per cow is 2,000 kg per lactation and terms are about 10 years (Figure 5). With the current credit conditions of a real interest rate at 13% and payable in 5 years, these forage alternatives will not be adopted in Costa Rica, unless the capital to make these investments comes from the farmers' own income. The *C. argentea* + sugarcane alternative ($6,000/farm) would be the most feasible, but the other alternatives with *Brachiaria* spp. requiring investments of $18,500 to $21,000, would be almost impossible since these sums represent the farm net income of over 3 years.

***Stylosanthes* species.** The partial budget methodology was used for this alternative because the simulation model did not allow alternatives to be evaluated by animal category. The Tropileche Consortia is validating this forage alternative as a strategy for feeding pre-weaning calves, especially during the dry season.

Based on preliminary data from Nicaragua (Soza and Fariñas 1997) and extrapolating to Costa Rica, Table 6 shows marginal profitability in using *Stylosanthes* to feed pre-weaning calves, assuming that the average farm with 47 cows produces 35 calves per year (Table 2).

Under management with *Stylosanthes* sp., 6.5 ha are required to feed these calves during the dry season period. The average weight gain per calf is 300 g/day (under traditional management, calves lose weight). The investment required is about $1,075/farm, for a marginal gain, at the end of the dry season, of close to $2,000 (i.e., $57/calf more than under traditional management). This alternative has more probability of being adopted because the initial investment is less and can be quickly recovered through calf weight gain (calves are sold at 8 to 10 months of age). The farmers can invest the resulting income without having to resort to credit.

Nicaragua

Prevailing situation. The situation in Esquipulas, Nicaragua, is similar to that of Costa Rica in that the forage alternatives evaluated significantly reduced production costs. Figure 6 shows milk production costs of different forage options, according to cow productivity. Under prevailing conditions, milk production costs are US$0.26/kg, while the price received is $0.22/kg. In other words, on selling weaned male calves, the farmer receives, overall, a

break-even income, similar to the minimum wage.

However, this situation could improve if cow productivity was higher. The nutritional quality of jaragua grass, as indicated in Table 5, is capable of maintaining cows producing up to 1,500 kg per lactation without additional supplements, during the rainy season, and cows producing 2,000 kg per lactation, given both energy and protein supplements, throughout the year. Even with jaragua grass, milk production costs can be reduced to as low as $0.20/kg, depending on pasture management (e.g., degree of cover, weed control, paddock rotation, shade, availability of water to animals, and appropiate resting periods).

***Cratylia argentea* + sugarcane.** As in Costa Rica, this forage option completely eliminates the need for supplements during the dry season.

Production costs are reduced by 31% (from $0.26/kg to $0.18/kg) with the current productivity per cow in the area, compared with those farms in Esquipulas that depend on jaragua grass and must use concentrate supplements during the dry period. Similarly, production costs can be reduced to as low as $0.14/kg with a productivity of 1,500 kg per lactation and to $0.12/kg with a productivity of 2,000 kg.

In Esquipulas, the establishment of this forage option on an average farm with 29 cows would require an investment of about $4,600. This investment would cover the establishment of 5 ha of *C. argentea*, 2.4 ha of sugarcane, and the purchase of a gasoline- or diesel-powered chopper (rural electrification is scarce in this part of the country).

Figure 7 shows the real interest rates at which this investment could be paid, depending on cow productivity and assuming that the farmer allocates 50% of the marginal income resulting from this forage option to pay back the credit received. Nicaragua’s current financial system offers an 18% annual real interest rate for agricultural credit, with a maximum term of 5 years. This forage option is not financially viable under these conditions, with the current levels of milk production. However, when cow productivity is 1,500 kg per lactation, paying credit under prevailing conditions is feasible, because real interest as high as 22% can be paid over a 5-year term. When the productivity level is 2,000 kg per lactation, the situation is still more viable.

The Ministry of Agriculture/World Food Program (MAG-WFP) dairy development project grants credits to small-scale milk producers at a 10% real interest rate, payable over 5 years, although the maximum amount granted is $3,000/farm. This provides an excellent opportunity to foster and promote this forage option because it significantly improves the competitiveness and income of small-scale milk producers by reducing production costs.

***Brachiaria spp. + Cratylia argentea* + sugarcane.** This forage alternative reduces milk production costs at levels similar to the *C. argentea* + sugarcane option with current milk production levels of 1,000 kg, and even 1,500 kg, per lactation. As a result, at these levels of milk production, no incentive exists for choosing this forage option because capital investment is much higher than that required for the option without *Brachiaria* spp. (i.e., only *C. argentea* + sugarcane).

The capital investment required for this option is about $10,900 (39.1 ha to *Brachiaria* spp., 2.0 ha to *C. argentea*, and 1.0 ha to sugarcane) versus $4,600 for the *C. argentea* + sugarcane option. With production levels at 2,000 kg per lactation, production costs are reduced, compared with the *C. argentea* + sugarcane option ($0.14/kg versus $0.15/kg, respectively). However, this reduction is very small and does not compensate for the investment made.

Nevertheless, this forage option frees 22.1% of the area currently under pastures (Figure 8), amounting to a net area of 7.9 ha that the farmer can devote to other uses (i.e., fruit, reforestation), which is not possible with the *C. argentea* + sugarcane option. Despite being expensive, the *Brachiaria* spp. + *C. argentea* + sugarcane option is therefore considered the most viable option for farms located in hillsides with steep slopes.

Figure 9 shows the interest rate that a farmer can pay for credit to invest in this forage option. Because the price of investment is so high, paying the credit at current levels of production (i.e., 1,000 kg per lactation) would be impossible. However, it could be paid if the investment increases cow productivity by 50% (from 1,000 kg to 1,500 kg per lactation) and if terms for payment are extended to 10 years, at a real interest rate of 10%. With production levels at 2,000 kg per lactation, this forage option is financially viable because it would be possible to pay real interests between 10% and 20%, depending on the terms established.

***Brachiaria spp. + Arachis pintoi + Cratylia argentea* + sugarcane.** As in Costa Rica, this forage option involves the establishment of all alternatives. Milk is produced at a lower cost than that of all the other forage options considered in this study, decreasing from $0.17/kg with the current production level to $0.10/kg at 2,000 kg. This alternative therefore reduces production costs between 35% and 44%, compared with the prevailing situation in Esquipulas (i.e., jaragua grass supplemented with concentrates during the dry season).

To establish this alternative, each farm has to invest about $12,300 (29.8 ha to *Brachiaria* spp. in association with *A. pintoi*, 2.5 ha to *C. argentea*, 1.1 ha to sugarcane, and a chopper). This forage option frees 32.8% of the area currently under pastures and still maintains the same herd size (Figure 8). That is, 16.4 ha can be devoted to other uses.

Figure 10 shows the real interest rates at which credit can be paid to establish this forage alternative. With current cow productivity at 1,000 kg per lactation, paying back a credit would not be feasible because of the high investment of capital, even with a 10-year term. However, this alternative could be financially attractive if production per cow is increased by 50% to 1,500 kg per lactation and with financing over 10 years and a real interest rate of 10%. Thus, under the current commercial banking conditions (a 5-year term and 18% real interest) it is not possible to adopt this technology thru credit.

***Stylosanthes* species.** Preliminary data on the use of *Stylosanthes* sp. for feeding pre-weaning calves were obtained from a farm in Esquipulas (Soza and Fariñas 1997). Using the partial budget methodology, Table 7 shows the marginal profitability of the use of this forage option. Under traditional management, pre-weaning calves remain grazing with the dam during the morning and are then separated in the afternoon under a roofed corral until the following day. The calves consume the equivalent to one-fourth of the udder plus the residual milk from milking. The alternative assessed consisted in introducing the calves to a paddock of *Stylosanthe*s sp. during the afternoon and then spending the night in confinement, as under traditional management, until the next morning milking.

Under traditional management, calves usually lose weight, especially toward the end of the dry season when the availability of both forage and milk is reduced. According to preliminary data obtained by Soza and Fariñas, the investment required to maintain 24 calves during the three most critical months of the dry season was $675, consisting in the establishment of 4.5 ha to *Stylosanthes* (1.5 ha per month). The daily weight gain was 300 g, in contrast to traditional management, where weight loss was 222 g/day. A marginal income of $47/calf ($1,128 per lot) was thus generated, equivalent to 42.7% more income than for traditional management.

These data suggest that this alternative is extremely viable because the marginal income compensates the initial investment ($1,128 versus $675). This forage option can also be established without credit, especially in situations where the opportunity cost for family labor is low, as in the case of Nicaragua, since the open unemployment rate in the rural sector is estimated at about 52%.

Peru

The case of Pucallpa, Peru, differs from those of Costa Rica and Nicaragua. One characteristic is that the annual precipitation is higher (2,000 mm versus 1,200 mm in Costa Rica and Nicaragua) and more evenly distributed. The dry season in Pucallpa lasts only 3 months and not 6 as in Esparza and Esquipulas. As a result, no signifficant water deficit occurs in Pucallpa, enabling grass to grow throughout most of the year.

Another important characteristic of Pucallpa is that milk production per cow is very low (3 kg/cow per day, Table 2), especially when considering that the dry season is practically nonexistent. This characteristic may be due to several factors: (1) low genetic potential of cows; (2) limited nutrient availability in the grass, resulting from high pasture degradation in low fertility soils; and/or (3) a constrained milk market.

Daily fresh milk production in the area of Pucallpa barely reaches 2,500 L, and cattle numbers have dropped from 82,000 head of cattle in 1986 to the current 26,000 head as a result of activities of the Sendero Luminoso ("Shining Path") terrorist group and cattle rustling. The city of Pucallpa, with a population of 300,000 inhabitants, does not have a milk pasteurizer plant. As a result, milk consumption in Pucallpa is mostly in the form of evaporated milk imported from other Peruvian cities. The raw milk market is thus very small. Four of the nine farmers who collaborate with the Tropileche Consortia thought that if they increased milk production on their farms they would have problems marketing the extra milk. The other five farmers sell their milk to the "School Milk Program", a state project that provides milk for school children.

Another factor that restricts the small market for raw milk is the substitution of protein sources in Pucallpa. One kilogram of dry matter (DM) of crude protein from "chico" fish of the Ucayali River is priced at US$2.90 throughout the year, while that of milk is $8.80. Protein from milk is therefore 303% more expensive than protein from fish. Cassava and rice are the main sources of energy, both being significantly cheaper than milk in DM equivalents. As a result, the raw milk market in Pucallpa is limited to the upper class population and its possibilities of growth are severely limited, unless a milk pasteurizer plant is established in Pucallpa to substitute the evaporated milk imported from Lima. The demand for locally produced milk will then increase, but at a price lower than the current price to compete with milk produced in other regions of Peru.

Prevailing conditions versus the alternatives evaluated. Figure 11 shows milk production costs for the different forage alternatives evaluated in the study. Unlike other sites, the most profitable alternative (i.e., with the lowest costs) under prevailing conditions in Peru is the one currently used by farmers. The most competitive alternative is to maintain the herd on native pastures and provide, for the 3-month dry season, brewers yeast from the local beer brewery, a viable option because it is abundant, very cheap to transport, and nutritious ($0.15/kg DM, 22% CP, and 65% IVDMD).

With this alternative, milk production costs are $0.33/kg, and the price received by farmers is $0.32/kg. The income received for male calves allows the farmer to receive an income that is slightly more than the minimum wage, while milk income pays for variable costs.

This alternative would also be the most attractive where cow productivity is 1,500 kg per lactation or even 2,000 kg. Neither did the forage alternatives *Brachiaria* + *Arachis* or *Brachiaria* + *Cratylia* succeed in reducing milk production costs to levels below those of native pastures supplemented with brewers yeast.

On the assumption that brewers yeast may cease to be a viable option for supplementation, maize was evaluated as an alternative. Its price is currently $0.23/kg. For the alternative, *Brachiaria* + *Arachis* and/or *Cratylia*, to form part of the solution, and with the current milk production levels at 800 kg per lactation, maize prices must rise to $0.38/kg (a 65% increase) so that milk production costs equal those of the current alternative. With milk yields at 1,500 kg per lactation, maize prices must rise by 9% to equal the production costs of both alternatives evaluated.

The main reason why none of the improved forage alternatives can compete with native pastures + brewers yeast is because of the high capital investment in relation to the percentage of milking cows in the herd, which induces a high pasture depreciation per cow. Pucallpa has 41% of the herd in milk while this figure is close to 60% in Costa Rica and Nicaragua (Table 2). To offset this effect, the percentage of milking cows in the Pucalpa herd must be increased throughout the year to a minimum of 53%, or the stocking rate must be increased from the current 0.9 AU/ha to 1.3 AU/ha by introducing more animals. Under current conditions, degraded native pastures cannot support these high stocking rates and the forage alternatives tested could become viable.

From the financial viewpoint, Figures 12 and 13 contain the real interest rates that a farmer from Pucallpa would pay if he or she invested in any of these forage alternatives. Peru has the highest real interest rate of the three countries, with a real interest of 34% (44% nominal; 10% annual inflation). Even if the investment in these forage alternatives was economically superior, the real interest rate in Peru is so high that farmers would not have the option of intensifying production. They would not be able to pay the 34% real interest in any scenario (not even if cow productivity were 2,000 kg per lactation or terms of payment were over 10 years). In the best of cases, the highest real interest rate which could be paid was 15%.

However, the advantage of establishing these forage alternatives in Pucallpa is that both options release significant areas of pasture for other uses, such as reforestation and/or conservation (Figure 14). In the case of *Brachiaria* spp. + *C. argentea*, the area released accounts for 35.4% (i.e., 20.2 ha) and, in the case of *Brachiaria* spp. + *A. pintoi* + *C. argentea*, it is 48.1% (i.e., 27.4 ha).

***Stylosanthes* species.** The case of the *Stylosanthes* alternative is different because preliminary data obtained at Pucallpa (Vela 1997) show that this option is highly profitable for pre-weaning calves. In Pucallpa, the meat-to-milk price ratio is much lower (i.e., 3.1:1), thus much more favorable to milking cows, whereas, in Nicaragua or Costa Rica, this ratio is high

(4:1), meaning that, in Central America, fattening calves is more profitable.

Table 8 indicates that the investment required to feed eight pre-weaning calves is $680 (i.e., $85/calf) and the marginal income received was $720 from the additional milk sold. Calf weight gain was similar, whether with *Stylosanthes* or with the traditional system, but milk production (in the bucket) increased by 1 liter per cow (22%) per day. This technology may be readily accepted by small-scale farmers in the short term because it increases their incomes from milk sales without affecting calf development and using relatively small areas of *Stylosanthes*-based pastures. Consequently, this forage alternative is perhaps the only one in Pucallpa to have good possibilities of being adopted.

Summary and Conclusions

The forage alternatives evaluated in this study significantly improved the competitiveness of dual-purpose farms in Esparza, Costa

Rica, and in Esquipulas, Nicaragua, by increasing farmers' net income, reducing milk production costs, and releasing (i.e., intensifying) area for other uses such as reforestation or conservation. In both countries, the forage alternatives completely eliminated the need for supplements (i.e., concentrates, molasses, or chicken manure) during the dry season. In these regions, farms conducting dairy activities were therefore less dependent on external inputs and price changes, and thus less vulnerable to risks.

However, this situation did not hold true for Pucallpa, Peru, where none of the forage alternative evaluated, except *Stylosanthes* for pre-weaning calves, improved the competitiveness of farms under current management and production conditions. The main reason was that the percentage of milking cows was much lower (41%). Depreciation per milking cow was, accordingly, very high, and thus the investment made in the forage alternative was not compensated, especially when production per cow (3 kg/cow per day) and stocking rate (0.9 AU/ha) were very low for an ecozone where water deficit was relatively minor during the dry season.

The forage alternatives, except for *C. argentea* + sugarcane in Costa Rica and Nicaragua and *Stylosanthes* sp. to feed calves in all three countries, reduced the area needed to maintain the same herd size. This makes intensification possible by releasing areas that could eventually be allocated to conservation and/or reforestation.

Although all forage alternatives, except in Peru, helped make dual-purpose farms more competitive, the current financial conditions of livestock credit of the three countries interfere with their potential adoption. While the opportunity cost of capital and the conditions of payment in the international market are at 6%-9% real interest per year to be paid over 15 years, the financial market in these countries differs radically. The real interest rates currently governing agricultural credit are about 13% for Costa Rica, 18% for Nicaragua, and 34% for Peru, all payable within 5 years.

Because small farmers living in areas similar to those described in this study have levels of income between one and three minimum wages (Table 4), they cannot make investments in new forage alternatives unless they have access to credit.

Given the current credit conditions of these countries, the adoption rate of new forage alternatives by small-scale farmers will be low because the interest rates and current terms for credit make adoption almost impossible. Under global trade liberalization schemes that induce Latin American farmers to compete with other countries, producers should have the option of accessing credit under conditions similar to those found internationally if they are expected to survive in open market economies.

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Table 1. Annual growth (in percentage) in milk and beef production, cattle inventory, and area under pastures in tropical Latin America during 1961-1995.

Variable	1961-1969	1970-1979	1980-1989	1990-1995

Milk production	4.6	3.3	2.5	3.2
Beef production	3.7	3.9	2.5	2.9
Cattle inventory	3.2	3.7	1.6	0.6
Area sown to pastures	1.4	0.6	0.6	0.2

SOURCE: FAO (1996).

Table 2. Averages of cattle inventory, milk production, and land use on dual-purpose cattle farms in Peru, Costa Rica, and Nicaragua (n = number of farms).

Variable	Peru (n = 9)	Costa Rica (n = 7)	Nicaragua (n = 4)
Cattle inventory (no.)			
Milking cows	10.6	28.0	16.9
Dry cows	20.1	19.3	12.0
Heifers	21.9	16.1	14.5
Calves	15.7	35.1	15.3
Bulls	1.3	2.0	1.3
Total animal units (AU)[a]	49.8	71.7	45.3
Daily milk production (kg)			
Total	32.1	139.9	62.5
Per cow	3.0	5.0	3.7
Milking cows (%)	41.5	60.1	58.5
Land use (ha)			
Native pastures	48.3	69.1	37.5
Improved pastures	8.4	8.7	12.2
Agriculture	1.5	4.6	0.7
Forest/fallow	17.7	9.1	2.3
Total	75.9	91.6	52.7
Area under improved pasture (%)	14.8	11.2	24.5
Stocking rate (AU/ha)	0.88	0.92	0.91

a. Cow = 1.0; heifer = 0.7; female calf = 0.3; bull = 1.3.

Table 3. Prices (in US dollars) of resources and capital invested in dual-purpose farms in Peru, Costa Rica, and Nicaragua (n = number of farms).

Variable	Peru (n = 9)	Costa Rica (n = 7)	Nicaragua (n = 4)
Prices			
Milk ($/kg)	0.32	0.28	0.22
Meat ($/kg culled cow)	0.60	0.60	0.50
Labor ($/man-day)[a]	4.40	8.80	1.75
Land ($/ha)	200	2,364	347
Lease of pasture ($/cow per month)	3.00	4.30	3.00
Cow ($/each)	500	550	350
Heifer ($/each)	450	500	250
Weaned calf ($/each)	150	170	100
Bull ($/each)	700	700	600
Establishment of improved grass ($/ha)	250	270	225
Establishment in association with *Arachis* ($/ha)	340	370	310
Establishment of *Stylosanthes* ($/ha)	150	165	150
Establishment of *Cratylia* ($/ha)	400	420	390
Establishment of sugarcane ($/ha)	NA	550	500
Capital invested ($/farm)			
Land	15,244	216,522	18,287
Livestock	29,561	42,260	18,538
Shed, corral, and equipment	2,000	12,896	2,125
Improved pastures[b]	1,050	1,175	1,372
Fences[c]	4,752	6,822	4,597
Total	53,147	279,675	44,919

. Includes social benefits, estimated at 24% for Peru, 43% for Costa Rica, and 17% for Nicaragua.

b. The capital invested was estimated at 50% of establishment cost, multiplied by the area in improved pastures on each farm.

c. An average of 5,280 m was estimated for farms at Pucallpa, 7,580 m for Costa Rica, and 5,108 m for Nicaragua, at an average investment of $0.90/m with 4 wires separated by posts placed every 3 m.

Table 4. Direct production costs, gross income, net cash flow, and wages for family labor on dual-purpose farms in Peru, Costa Rica, and Nicaragua (in US dollars) (n = number of farms).

Variable	Peru (n = 9)	Costa Rica (n = 7)	Nicaragua (n = 4)
Direct production costs ($/farm per year)			
Hired labor	257	5,586	1,155
Family labor[a]	1,606	3,212	630
Total permanent labor (no. of workers/farm)	1.16	2.74	2.83
Supplements	683	2,848	2,205
Animal health	784	224	390
Maintenance of infrastructure and equipment	727	1,617	817
Others	318	549	427
Total	4,375	14,036	5,624
Cost/kg milk[b]	0.29	0.23	0.20
Cost of labor as % of total	43	63	32
Gross income ($/farm per year)	6,018	17,856	6,759
Milk	3,643	13,572	5,019
Beef from culled cows	970	1,490	760
Veal	1,405	2,794	980
Net flow[c]			
$/farm per year	1,643	3,820	1,135
$/ha of pasture per year	29	49	23
$/cow per year	54	81	39
Wages for family labor[d]			
$/man-day	8.90	19.27	4.83
Number of times the minimum wage	2.02	2.19	2.76
Annual return on invested capital (%)[e]	2.87	1.37	2.53

a. Assessed as minimum wage and including social benefits.

b. Based on direct production costs, multiplied by the percentage of total income from the sale of milk + culled cows, and estimated at 76.7% for Peru, 84.3% for Costa Rica, and 85.5% for Nicaragua.

c. Gross income minus direct costs.

d. Gross income minus direct costs and not including the opportunity cost for family labor.

e. Net flow/farm per year, divided by the capital invested.

Table 5. Forage parameters used to run the model for dual-purpose cattle farms at different reference sites in Costa Rica, Nicaragua, and Peru.

Parameters[a]	Jaragua	*Brachiaria*	*Arachis*	*Cratylia*	Sugarcane
Duration of crop (years)	20	10	10	20	10
Rainy season					
Edible biomass production (kg DM/ha)[b]	2,500	3,500	1,000	2,000	10,500
CP (%)	8	9	20	15	3.5
CP digestibility (%)	50	60	70	70	20
IVDMD (%)	45	55	55	55	60
Dry season					
Edible biomass production (kg DM/ha)[c]	500	700	0	500	0
CP (%)	3	4	20	15	2
CP digestibility (%)	40	50	60	60	20
IVDMD (%)	30	35	50	50	60
Losses to trampling (%)					
During the rainy season	25	25	25	10	0
During the dry season	20	20	20	10	0
Maximum transfer of biomass from the rainy to the dry season (kg DM/ha)[d]	750	625	625	2,000	10,500

. DM = dry matter; CP = crude protein; IVDMD = in vitro dry matter digestibility.

b. Biomass production in both the rainy and dry seasons in Pucallpa, Peru, was estimated to be 20% greater than in Costa Rica and Nicaragua for all forage alternatives because of higher rainfall.

c. Equivalent to 20% of the biomass production during the rainy season.

d. Equivalent to 25% of the biomass production during the rainy season for grasses and 100% for *Cratylia* and sugarcane.

Table 6. Marginal profitability from using *Stylosanthes guianensis* to feed pre-weaning calves in Costa Rica. (Adapted from data by Soza and Fariñas, 1997.)

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Variable	Traditional management	*Stylosanthes*
Number of calves	35	35
Days of evaluation	90	90
Required investment (6.5 ha @ $165/ha)[a]	NA	$1,075
Calf weight (kg)		
Initial	130	130
Final	110 (-18%)	157 (+21%)
Daily weight gain (g/calf)	-222	+300
Total production value ($1.20/kg)	$4,620	$6,594
Marginal income during the period	0	$1,974 (+42.7%)

a. Assuming a dry matter production of 1,500 kg/ha and with a 20% loss to trampling.

Table 7. Marginal profitability from using *Stylosanthes guianensis* to feed pre-weaning calves in Nicaragua. (Based on data from Soza and Fariñas, 1997.)

Variable	Traditional management	*Stylosanthes*
Number of calves	24	24
Days of evaluation	90	90
Required investment (4.5 ha @ $150/ha)[a]	NA	$675
Calf weight (kg)		
Initial	130	130
Final	110 (-18%)	157 (+21%)
Daily weight gain (g/calf)	-222	+300
Total production value ($1.00/kg)	$2,640	$3,768
Marginal income during the period	0	$1,128 (+42.7%)

a. Assuming a dry matter production of 1,500 kg/ha, with a 20% loss to trampling.

Table 8. Marginal profitability from using *Stylosanthes guianensis* to feed calves in Pucallpa, Peru. (Based on data by Vela, 1997.)

Variable	Traditional management	*Stylosanthes*
Number of calves	8	8
Days of evaluation	90	90
Required investment (2 ha @ $340/ha)	NA	680
Calf weight		
Initial	90	90
Final	137	137
Daily weight gain (kg/calf)	525	525
Milk produced per cow (kg/day)	4.5	5.5
Total milk production value during the study period	$3,240	$3,960
Marginal income	0	$720 (+22.2%)

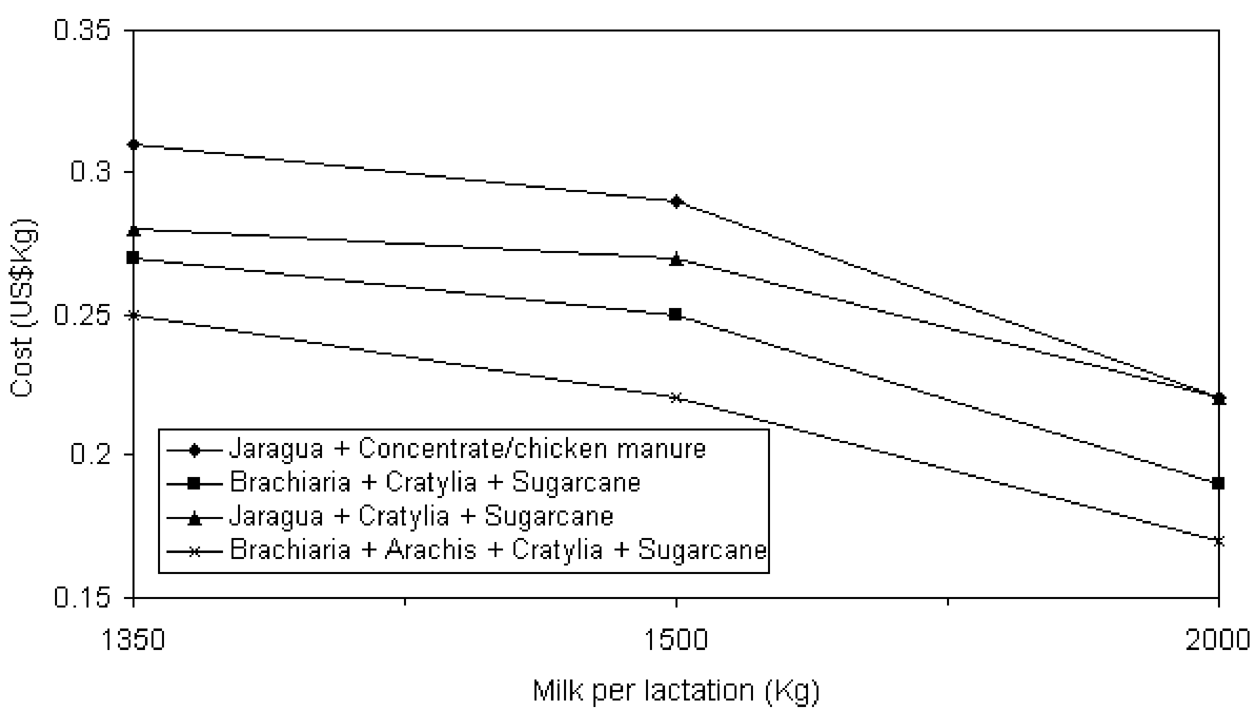

Figure 1. Cost of producing milk with different forage feeding alternatives assuming the same herd size, Costa Rica.

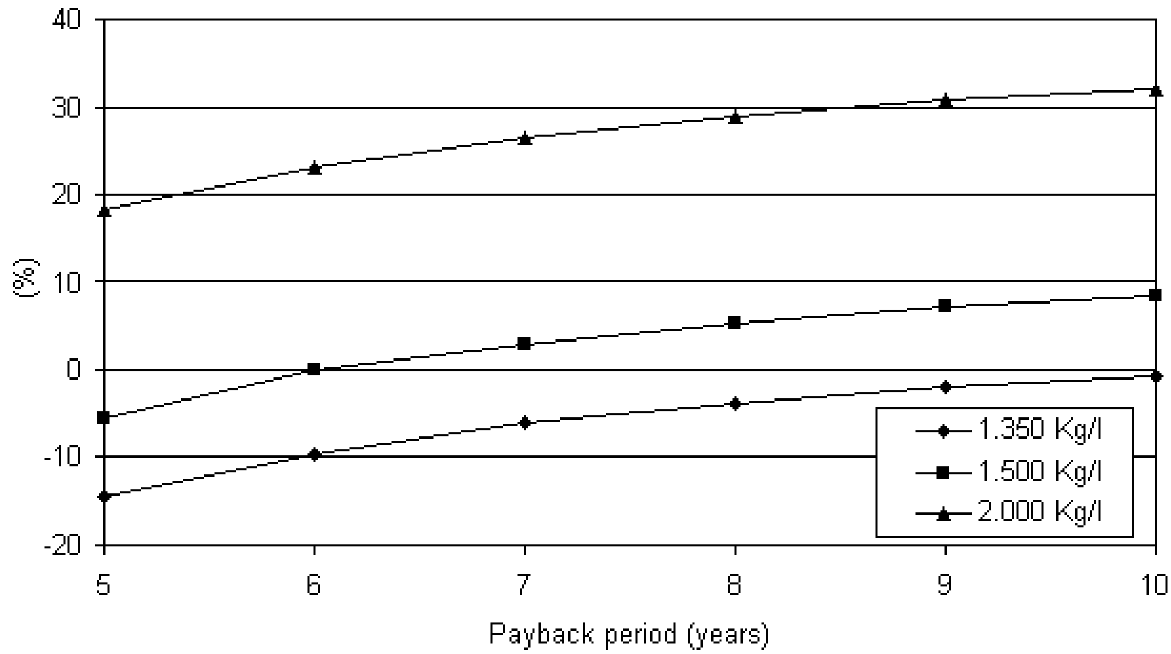

Figure 2. The real interest rate can be paid adopting Cratylia argentea and sugarcane according to different levels of milk production (kg per lactation), Costa Rica.

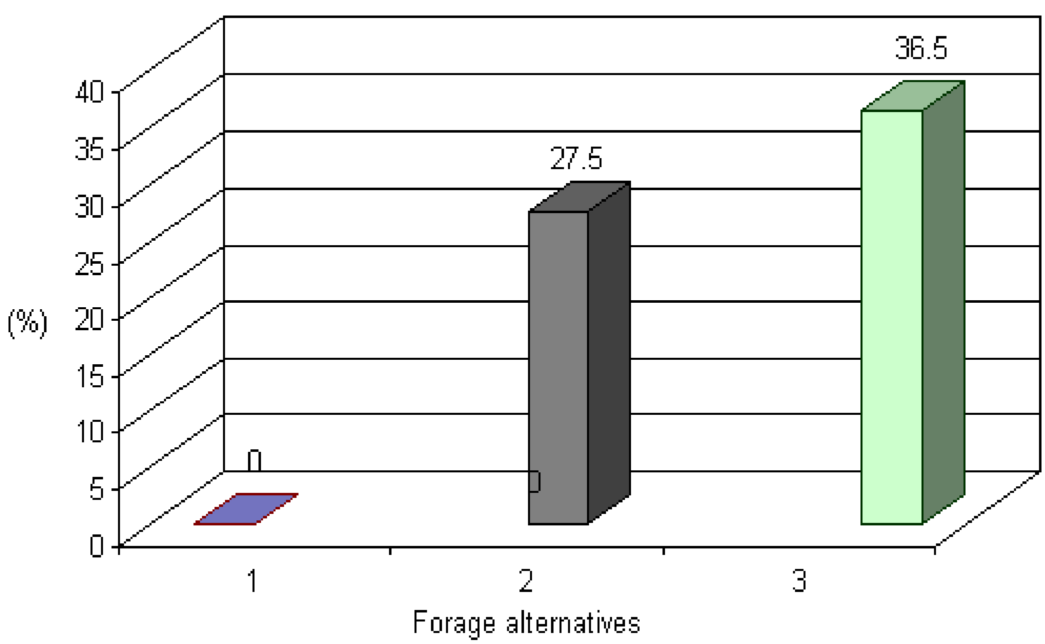

Figure 3. Percentage of pasture area that could be allocated to other uses as a result of adopting improved forage options, assuming constant herd size, Costa Rica. (1 = Cratylia argentea + sugarcane; 2 + Brachiaria spp. + C. argentea + sugarcane; 3 = Brachiaria spp. + Arachis pintoi + C.argentea + sugarcane)

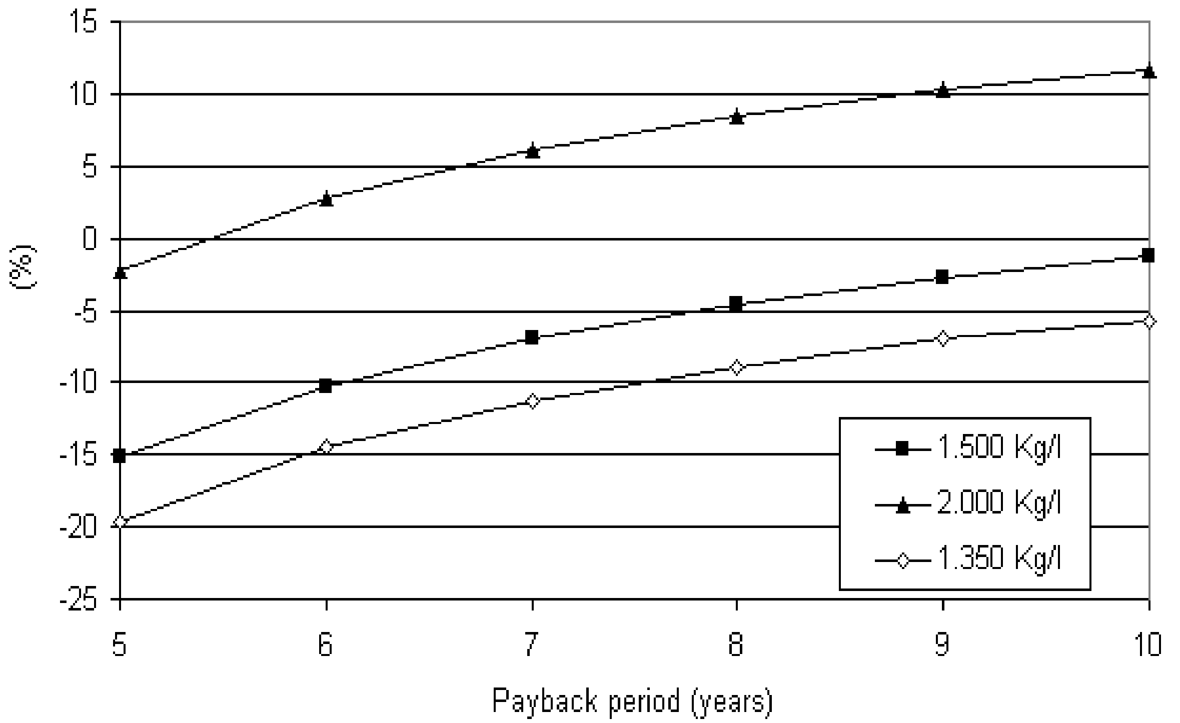

Figure 4.The real interest rates that can be paid by adopting the forage option Brachiaria spp.+ Cratylia argentea+sugarcane according to different levels of milk production (at kg per lactation), Costa Rica. To pay credit, 50% extra income must be allocated

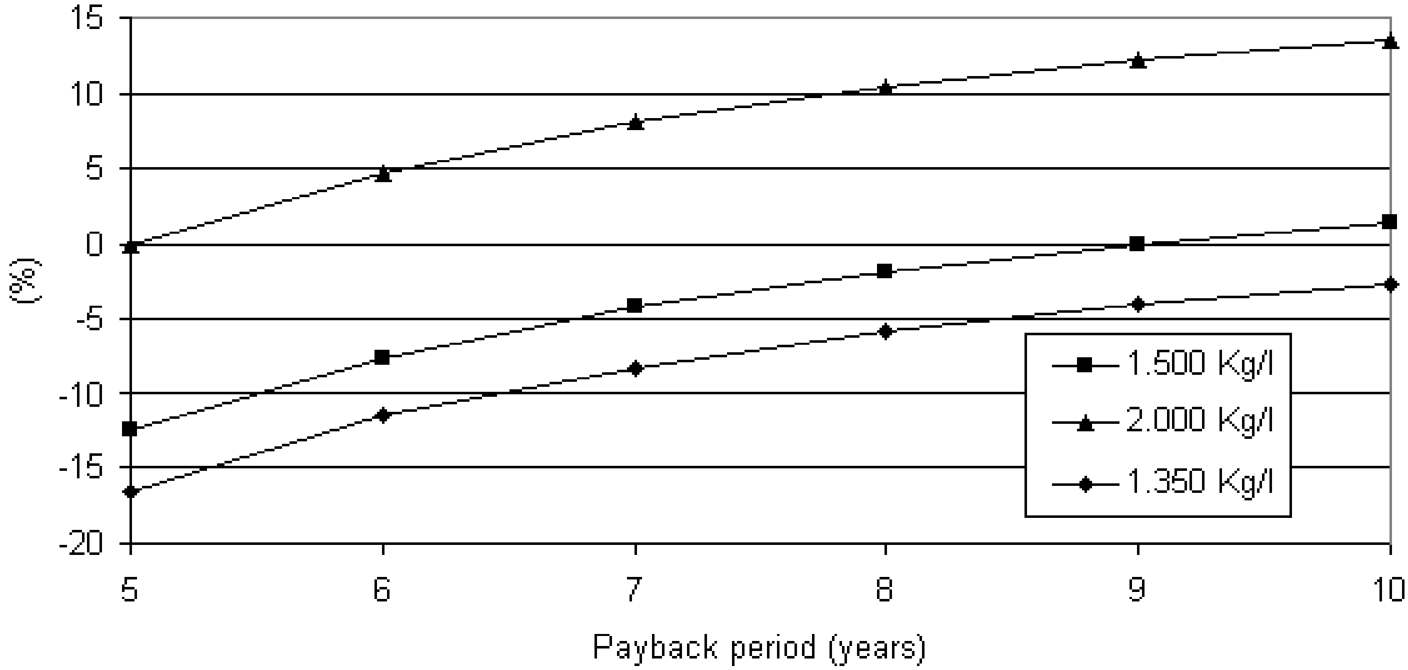

Figure 5. The real interest rate that can be paid by adopting Brachiaria grass to be planted in association with Arachis pintoi, together Cratylia argentea + sugarcane , according to difeferent levels of milk production(at kg per lactation), Costa Rica. To pay credit, 50% of extra income must be allocated.

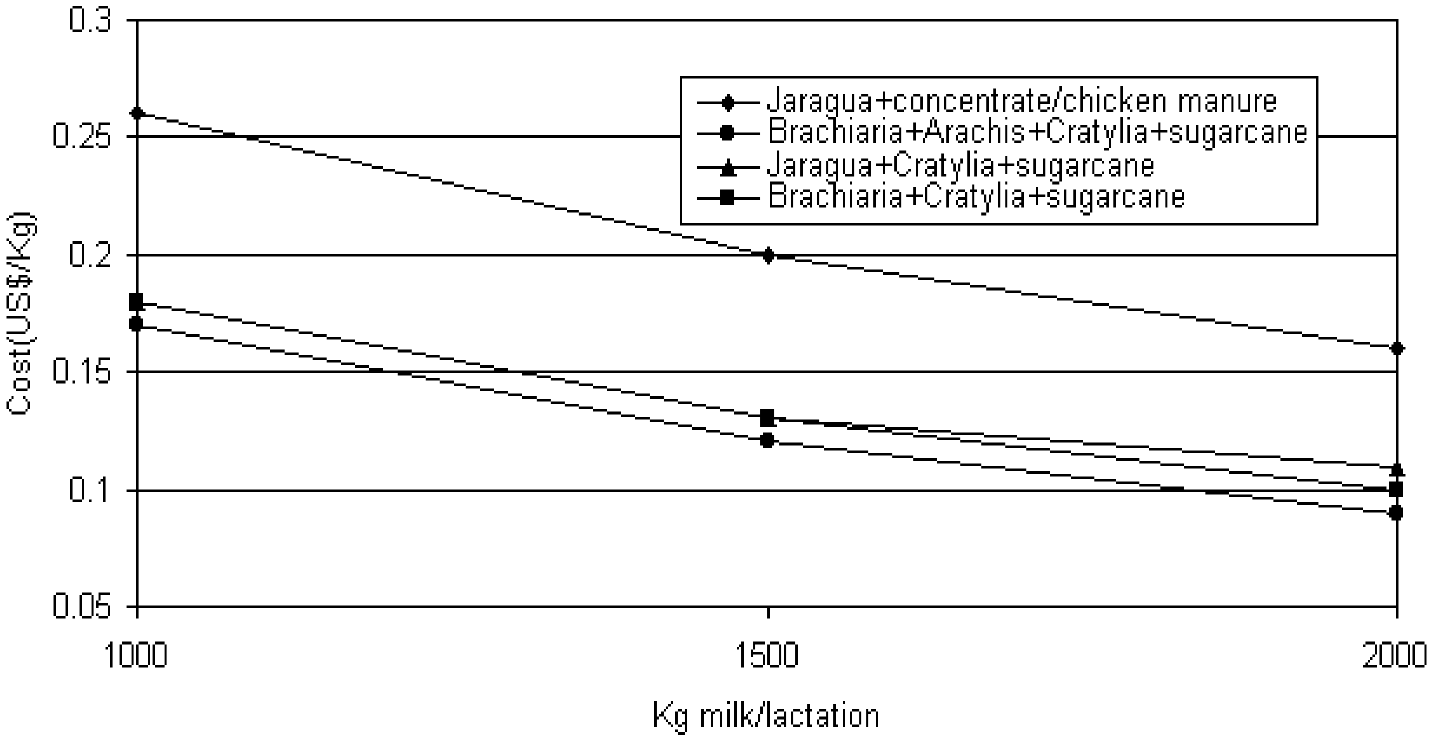

Figure 6. Cost of producing milk with different forage feeding alternatives assuming the same herd size, Nicaragua.

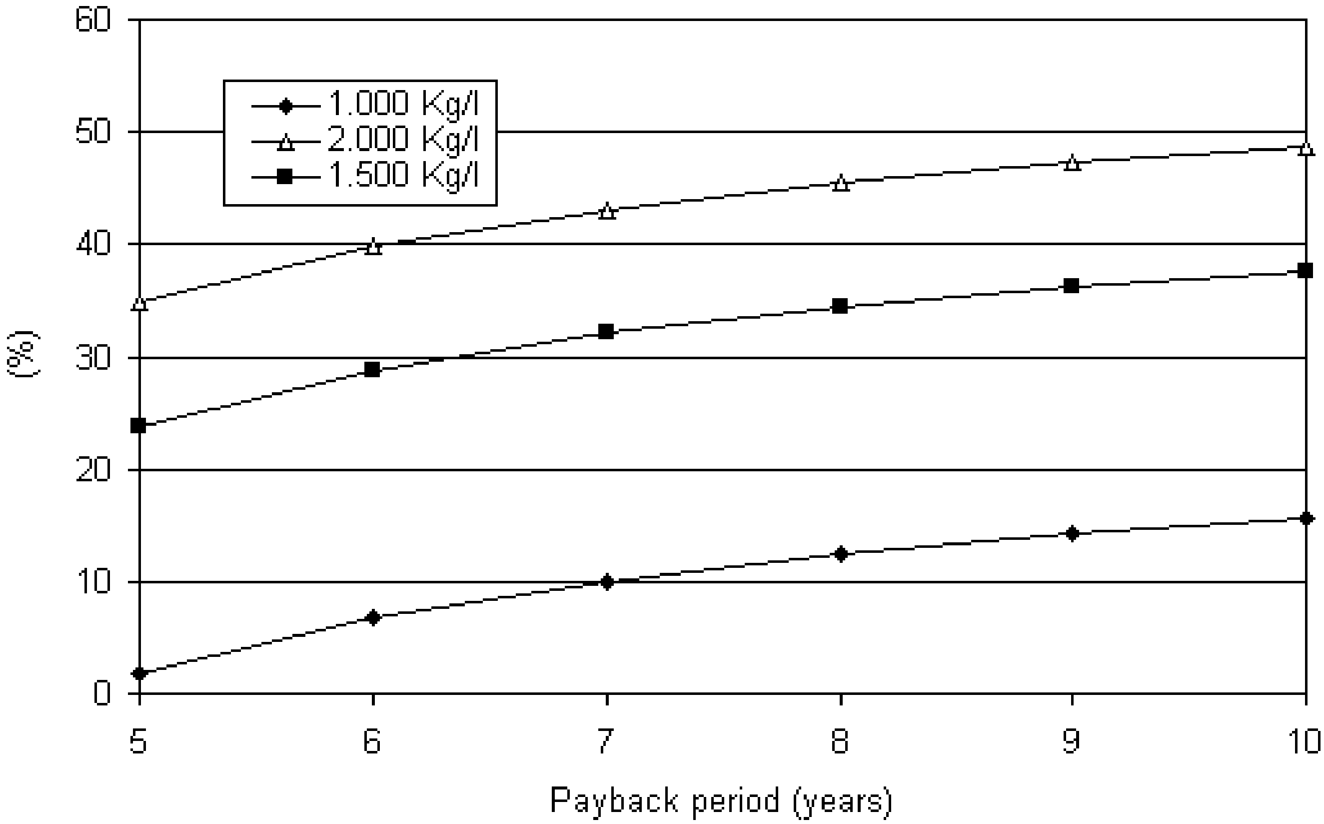

Figure 7. The real interest rate that can be paid by adopting *Cratylia argentea* + sugarcane, according to different levels of milk production (at kg per lactation), Nicaragua. To pay credit, 50% extra income must be allocated.

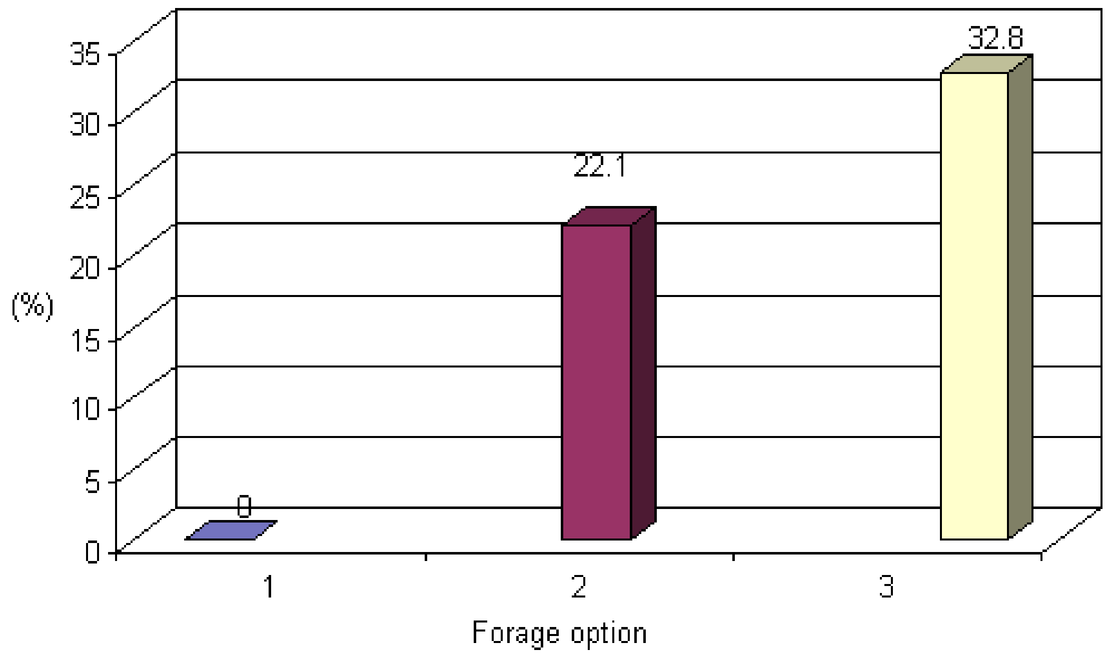

Figure 8. Percentage of pasture area that could be allocated to other uses, if improved forage alternatives were adopted, assuming constant herd size, Nicaragua. (1= Cratylia argentea + sugarcane; 2= Brachiaria spp. + C. argentea + sugarcane; 3= Brachiaria spp. + Arachis pintoi + C. argentea + sugarcane.)

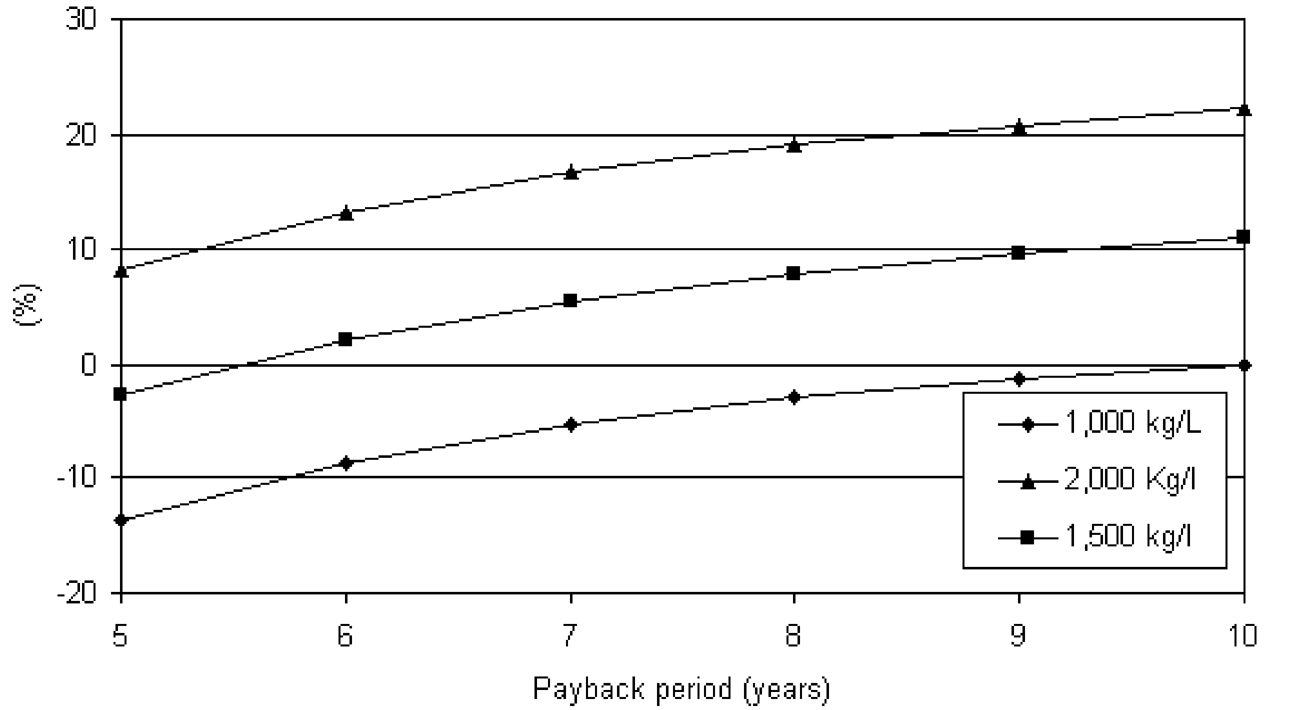

Figure 9. The real interest rate that can be paid by adopting *Brachiaria spp*. + *Cratylia argentea* + sugarcane, according to different levels of milk production (kg per lactation), Nicaragua. To pay credit, 50% extra income must be allocated.

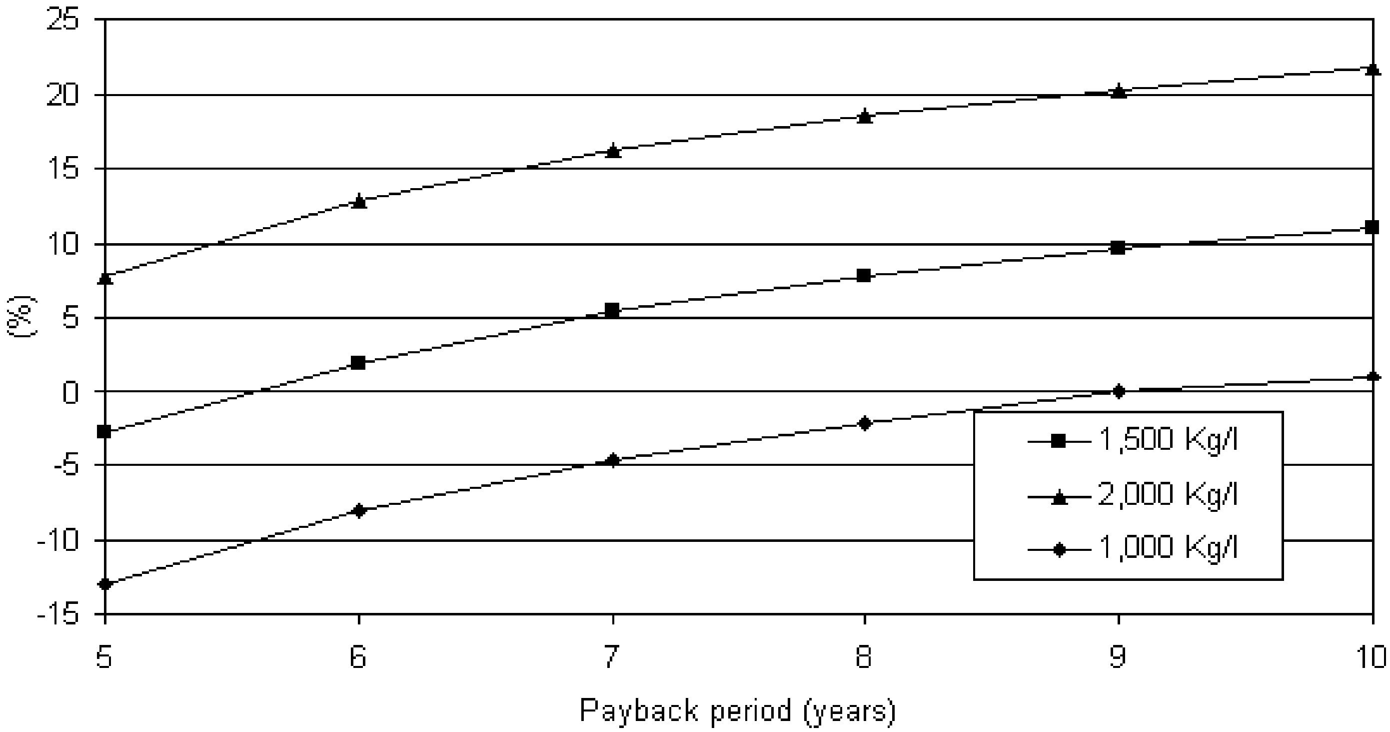

Figure 10. The real interest rate that can be paid by adopting *Brachiaria spp*. + *Cratylia argentea* + sugarcane, according to different levels of milk production (kg per lactation), Nicaragua. To pay credit, 50% extra income must be allocated.

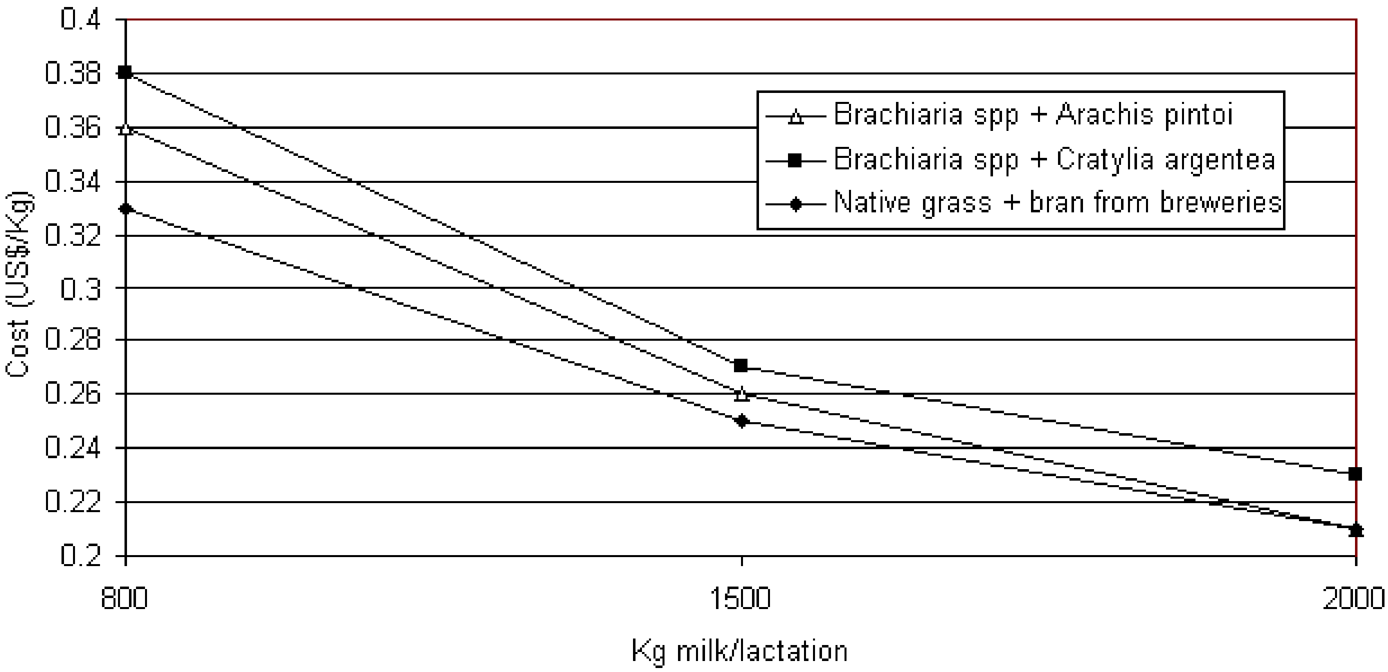

Figure 11. Cost of producing milk with diferent forage feeding alternatives assuming the same herd size in Peru.

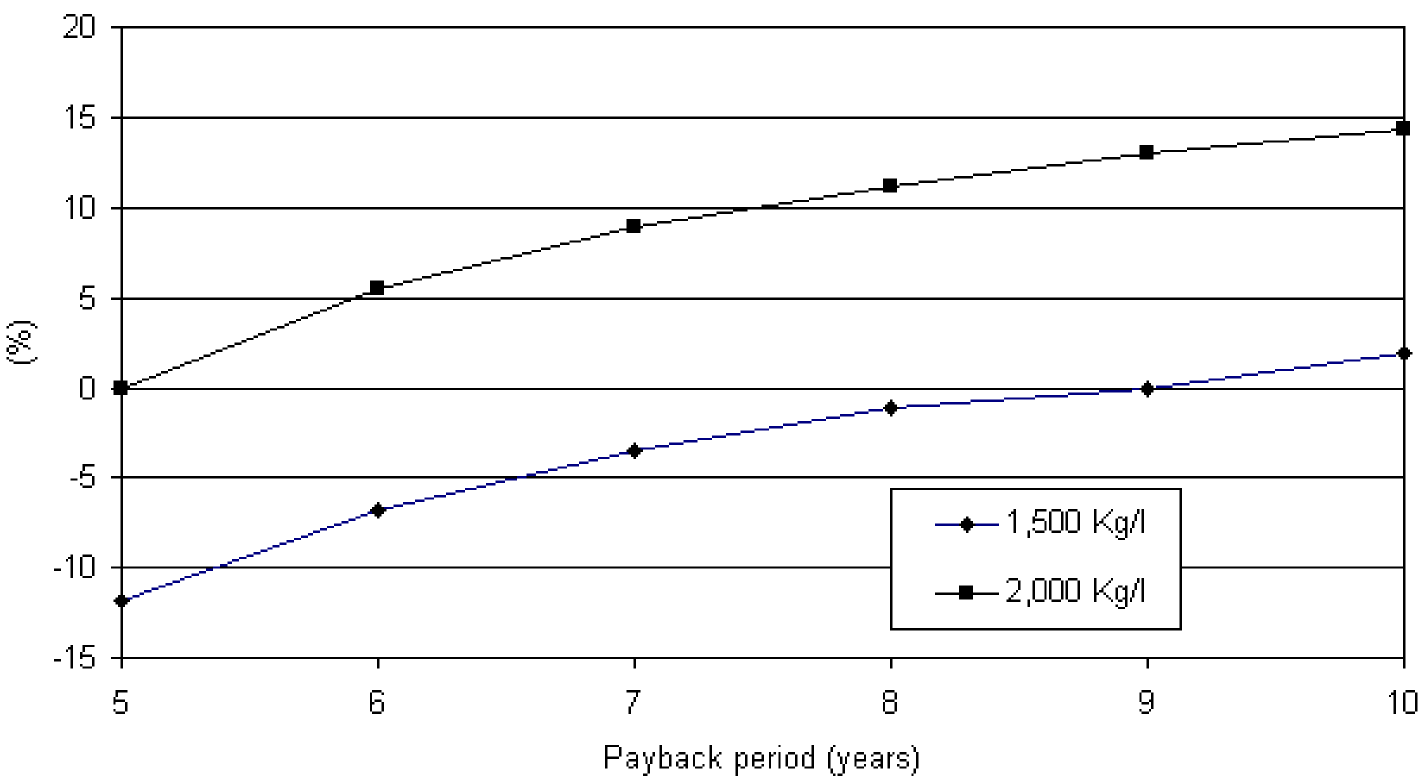

Figure 12. The real interest rate that can be paid by adopting *Brachiaria spp.* + *Cratylia argentea*, According to different levels of milk production (kg per lactation), Peru. To pay

credit, 50% extra income must be allocates.

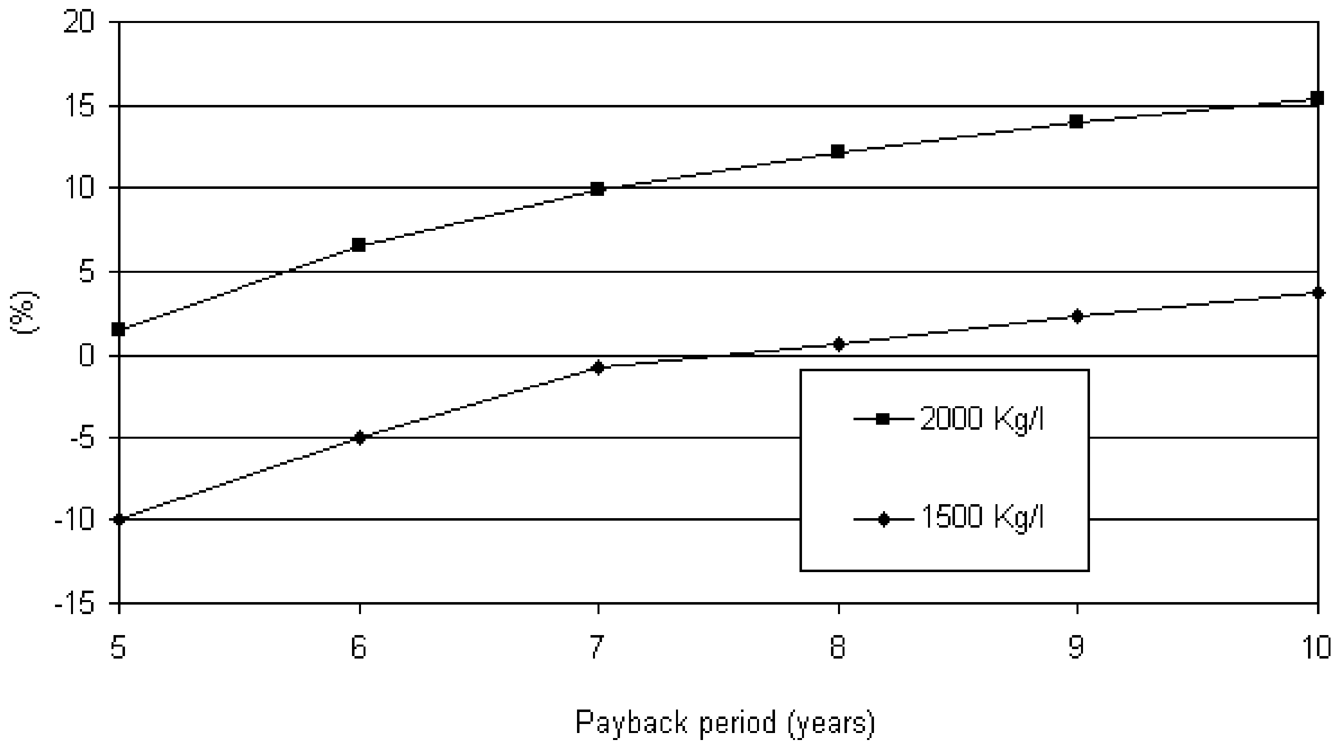

Figure 13. The real interest rate that can be paid by adopting *Brachiaria spp*. + *Arachis pintoi*, according to different levels of milk production (kg per lactation), Peru. To pay credit, 50%^extra income must be allocated.

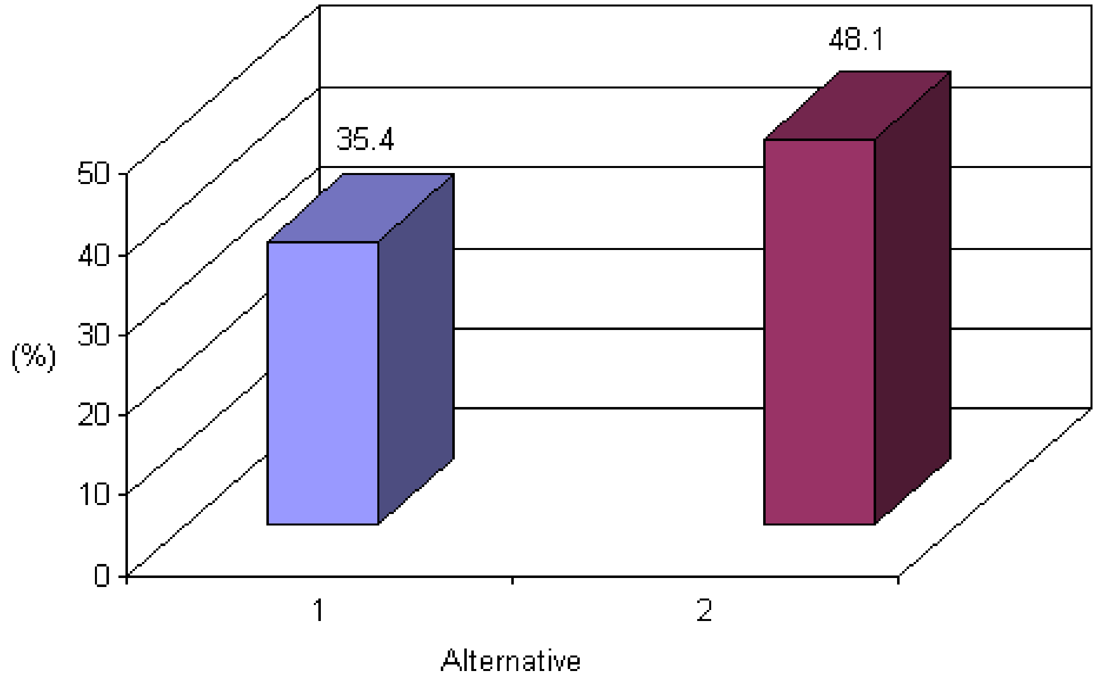

Figure 14. The percentage of pasture area that could be allocated to other uses if improved forage alternatives are adopted, assuming constant herd size, Peru. (1 = *Brachiaria spp*. + *Cratylia argentea*; 2 = *Brachiaria spp*. + *Arachis pintoi* + *Cratylia argentea*.)