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Economic Analysis of Tropical Forages in Livestock Systems in the Eastern Plains of Colombia

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Abstract

70% of the Colombian livestock production are characterized by extensive production systems, which usually show low productivity levels, low land use efficiency and often lack environmental sustainability. This is related to native or naturalized grasses and degraded pastures that generate limited forage supply, both in biomass and quality, especially in the dry season. The International Center for Tropical Agriculture (CIAT) and its partners are working on the selection and development of improved forages able to adapt to diverse soil and climatic conditions of the lowland tropics, while increasing productivity levels and reducing the environmental impact of livestock production. However, the establishment of these new forage technologies implies higher investment and management costs for the producer, which could limit their adoption.

This paper evaluates the financial viability of the implementation of new forage technologies, in this case of improved pastures and scattered trees in livestock systems, and compares them to the traditional production system with native/naturalized pastures. The developed model is based on a cash flow analysis and a Monte Carlo simulation, and includes uncertainty factors in the variables identified as critical (e.g., meat price, productivity). Research took place in 2015 in the Casanare Department in the Eastern Plains of Colombia.

The results indicate that investment in improved pastures is profitable with an incremental net present value (NPV) of US$ 45 and an internal rate of return of 18%. The system in association with scattered trees was not profitable due to the high initial investment costs and time expectations for achieving improvements in production parameters. Both evaluated alternatives were only evaluated for livestock income, not taking into account additional income that might arise from the trees (e.g., fruits, wood). The feasibility of investment is highly sensitive to changes in the selling prices of the meat and expected returns.

The technologies evaluated in this study showed to be an alternative to improve production efficiency and profitability of livestock farms. However, strategies and / or incentives need to be developed that aim at reducing the high initial costs of systems in association with scattered trees.

Keywords: Improved forages, Monte Carlo simulation, profitability analysis, risk analysis, silvo-pastoral systems

Introduction

Colombia has nearly 42.3 million hectares dedicated to agricultural activities, of which 80% correspond to pastures destined to livestock production (DANE, 2015). 81.4% of this land is currently managed by small cattle farmers in extensive production systems (FEDEGAN, 2014). These systems are characterized by low productivity levels, low soil use efficiency and negative effects on the environment, such as high greenhouse gasses (GHG) emissions per unit product, soil and water degradation, biodiversity reduction and deforestation (Bacab, Madera, Solorio, Vera, & Marrufo, 2013; FEDEGAN, 2014). Nevertheless, this sector also holds a high potential to mitigate such impacts, increase productivity and adapt to climate change events, through the adoption of more sustainable production practices (Gerber et al., 2013; Peters et al., 2012).

One of the main issues associated with the low productivity indexes is the low biomass production and limited feed supply in several regions of the country, which is in most cases related to the use of native grasses and degraded pastures (FEDEGAN, 2014). In contrast, improved forages and associations of forages and trees have shown to be more sustainable production systems, allowing a more efficient resource use, adaptation to extreme climatic conditions, increases in productivity and reductions of the environmental impact (FEDEGAN, 2014; Murgueitio 1999). In terms of productivity, research has found that improved forages allow important productivity and profitability increases in livestock production, resulting from a reduction of production costs, higher stocking rates, higher animal productivity per unit of area, significant net income increases and better financial indicators (Holmann, Argel, & Pérez, 2008; Rincón & Flórez, 2013; Rodriguez, Bautista, Dias, Stachetti, & Espinoza, 2015).

Although these systems show many benefits, their implementation requires an additional investment (for establishment and management), which is often hindering the adoption and dissemination (Alonzo, Ibrahim, & Prins, 2001; Chi & Yamada, 2002). Therefore, it is critical to estimate the profitability of investing in such production systems and to provide the producers with solid criteria to make sound financial decisions. In this sense, this research has the objective to evaluate the financial viability of establishing improved forages in livestock systems.

Material and Methods

Research took place in 2015 in the Casanare Department in the Eastern Plains of Colombia as a part of the research project "*Clima y Sector Agropecuario Colombia -Adaptación para la sostenibilidad productiva*" between CIAT and the Colombian Ministry of Agriculture (MADR).

Two investment alternatives were considered in this study: (1) improved grasses as monoculture, and (2) improved grasses in association with scattered trees. Both alternatives were compared to the traditional production scenario using native or degraded pastures.

The methodology applied for evaluating the financial viability of improved pastures in cattle production followed a three-stage process: (1) Construction of a discounted cash-flow model (10 year period) taking into account the associated benefits (animal productivity in kg/ha/yr) and costs related to the initial investment and management of each alternative; (2) development of a Montecarlo simulation model (5,000 iterations; software @Risk-Decision Tools Suite of Paladise), to consider risk levels of critical variables for each alternative (animal productivity, prices of meat, investment costs); (3) estimation of the profitability indicators Net Present Value (NPV), Internal Rate of Return (IRR), Probability of NPV<0. Three scenarios were considered (with a direct effect in stocking rate for each year) for the estimation of the profitability indicators:

(1) Normal Scenario (N): A reduction of pasture cover of 45% in the fifth year was assumed; (2) Optimistic Scenario (O): A reduction of pasture cover of 30% in the fifth year was assumed; (3) Pessimistic Scenario (P): A reduction of pasture cover of 70% in the fifth year was assumed.

The information used for calculating forage performance was obtained through field measurements, expert consultations, secondary data and literature review. For the sake of simplicity, in the evaluation of both alternatives, only livestock related income was considered, additional income that might arise from the trees (e.g., fruits, wood) was not taken into account.

Results and Discussion

With regard to field data and secondary information for the study area, the adoption of improved pastures and improved grasses in association with scattered trees results in higher average animal stocking rates (0.27 animals/ha under native/degraded pastures versus 2 animals/ha under an improved system) and average daily live weight gains (167 g/animal/d versus 287 g/animal/d), leading to an 11-fold increase in animal productivity. This in turn leads to higher per hectare incomes of US$ 929 for improved pastures and US$ 970 for improved pastures associated with scattered trees, compared to US$ 97 for native/degraded pastures. On the other hand, different from the native/degraded pastures, both evaluated alternatives require an initial investment (US$ 1,090/ha for improved pastures and US$ 1,187 for improved pastures associated with scattered trees). Major cost drivers in this context are for the improved pastures inputs (62%), machinery (27%) and labor (8%). The addition of scattered trees implies further costs related to tree planting (e.g., hole digging, tree planting), seedling purchase and transport, and tree protection and pruning during the first year. Included in the investment costs are pasture renewal measures (year 5) which result from e.g., soil compacting. With regard to the management costs of both alternatives, fertilizing and weed control on a yearly basis was included, as it guarantees persistence and high productivity of the meadow (Rincón et al., 2010). In addition to that, animal management costs and animal purchase were included, both associated to the higher animal stocking rate under both alternatives (Table 1).

Table 1 Productive parameters, investment and management costs per production system

	Native/degraded Pasture[1]	Improved Pasture[2]	Scattered Trees+ Improved Pastures[3]
Productive parameters ha^{-1} año^{-1}			
Animal stocking rate (AU/ha)	0,27	2	2
Live-weight gain (g/animal/day)	77-258	130-445	310-486
Animal productivity (kg/ha/year)	18-37	294-402	352-480
Investment and management costs del sistema[4]			
Initial investment (US$/$ha^{-1}$)[5]	0	1,090	1,187
Management costs (US$/$ha^{-1}year^{-1}$)[6]	12.7	179	231
Renewal measures (US$/$ha^{-1}$)	0	292,5	292,5
Animal purchase (terneros de 200 kg)	65,17	482,7	482,7
Average income (US$/$ha^{-1}year^{-1}$)[7]	96,55	929,47	970
Animal management (($/cabeza/año)[8]	19.26	11.32	11.32

[1]Native Savanna species such as Axonopus Purpussi; [2]Species *Brachiaria humidicola, Brachiaria decumbens*; [3]Improved pastures such as *Brachiaria humidicola, Brachiaria decumbens* associated with shadow trees;; [4]Representative Market Exchange Rate for 2016; [5]Pasture establishment and fencing costs (inputs, machinery, labor); [6] Costs for fertilization, weed control, pruning and trimming, fence maintenance and controlled burning (only for native pasture); [7]Average annual income generated through meat sales; [8] This includes vaccination (every 6 months), deworming (every 6 months), and supplementation (40 g/animal/d mineral salt for improved pastures; 90 g/animal/d for native/degraded pastures).

The results of the financial evaluation suggest that the establishment of improved pastures as monoculture is profitable under all evaluated scenarios. The model shows a positive NPV of US$ 49 and an IRR of 18% under the normal scenario (N). This represents an improvement of the NPV of 86% when compared to native/degraded pastures. The uncertainty with regard to the variables productivity and meat sales price is evidenced by the results of the success probability (NPV<0) the evaluated alternative shows. The system with scattered trees is not profitable under the N and P scenarios resulting from the high initial investment necessary (e.g., tree protection during the first year, slow tree growth delaying improvement of productive parameters). However, this study focused only on the benefits with regard to animal productivity and did not consider additional income that might result from planting trees (e.g., firewood, timber, fruits, eco-system services).

Table 2 Profitability indicators per production system

	Scenarios	NPV	IRR	Probability (NPV< 0)
Improved Pasture	N	$49.78	18%	48.60%
	O	$290.3	32%	10.14%
	P	$40.1	18%	50.77%
Native Pasture		$18.19	--	11.23%
Scattered Trees+ Improved	N	-$120.6	13%	97.60%
Pastures	O	$25.17	17%	65.63%
	P	-258.86	9%	100.00%

Conclusions and Outlook

The results of this study indicate that investment in improved forages as monoculture is promising for the researched area and can contribute to improve efficiency and sustainability of production systems. This in turn has a direct effect on the producers' income and welfare. The high costs of tree establishment make the alternative of improved pastures associated with scattered trees not profitable, when additional effects, such as direct productivity effects from the trees and ecosystems services are not included in the economic calculation. For promoting the adoption of such an alternative in the researched area, which under environmental aspects could make sense, it will be necessary to develop strategies that aim at reducing the initial costs. Additional research on identifying and quantifying ecosystem services provided by those systems can contribute to the development of incentives and strategies that could generate additional income for producers and change profitability of the systems positively. More research is needed for including other environmental and economic benefits from these systems (trees by-products) into the model as this was neglected in this study for the sake of simplicity.

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