The production of *Avena sativa* AV25-T (Altoandina) silage as a business model for the higher tropics of Colombia

Keywords: Forage conservation, *Avena* Altoandina, climate change, specialized dairy production, agribusiness.

Key messages:

- Dairy production in the Colombian higher tropics (>2,000 m elevation) depends on the climatic conditions. Because of climatic variability, the availability of forage resources for animal feeding is affected throughout the year, generating seasonally marked dairy production.
- Silage production as a business model is a viable option in financial terms for producer associations. Limitations in access to machinery and technical assistance affect the adoption of this practice among independent smallholder and medium-sized producers.
- The forage oat *Avena sativa* AV25-T (Altoandina) has technical characteristics that favor its use as silage rather than the commonly used Porva maize (e.g., precocity, lower costs). Likewise, the production of oat silage generates higher economic benefits than the production of maize silage.

Introduction

Cattle in Colombia are a productive activity with relevance both economically and socially. In economic terms, the cattle sector contributes 21.8% of the agricultural gross domestic product and 1.6% of the national GDP (Fedegan, 2018). On the other hand, it generates 19% of the jobs in the agricultural sector and 6% of the overall national employment (Fedegan, 2018). Specialized dairy production mainly takes place in the higher tropics (>2,000 m elevation) and contributes 45% of the national milk production (Fedegan, 2018). Dairy production and productivity depend, however, on climatic conditions (Enciso et al., 2021; Fedegan, 2018) since those affect the availability of pastures, which constitute the main feed source of cattle in Colombia (Cuesta, 2005; Vargas et al., 2018; Enciso et al., 2021; Fedegan, 2018). Therefore, critical conditions in rainy or dry seasons impair access to high-quality animal feed and lead to strong seasonality in animal production (Vargas et al., 2018; Arreaza et al., 2012; Mendieta et al., 2015).

Forage conservation is a strategy that allows decreasing the vulnerability of animal feeding to climate variability by providing good-quality feed throughout the year (Sánchez and Báez, 2002). Forage resources can be conserved as silage, hay, and haylage. Silage is based on the fermentation of lactic acid bacteria in an environment without the presence of air (Sánchez and Báez, 2002). In the Colombian higher tropics, in particular the highland regions of Cundinamarca and Boyacá departments, making silage is the most common practice of forage conservation since this can be done manually, and the humidity of the environment does not allow for other forms of conservation (J. Castillo, pers. commun., 6 December

2021). Silage is mainly made of ICA-508 maize, also known as Porva maize, in the least technical production systems of the region (Fedegan, 2012, cited by Enciso et al., 2021).

This document suggests the use of *Avena sativa* AV25-T (Altoandina) for silage production in the highland regions of Cundinamarca and Boyacá departments, which has advantages over the traditionally used technology, ICA-508 maize. Among the advantages of Altoandina are its lower labor costs and precocity, and the possibility of sowing and harvesting in both agricultural semesters of the region (J. Castillo, pers. commun., 29 November 2021; Campuzano et al., 2018). In this sense, the objective of this document is to analyze Altoandina oat silage production as a business model and evaluate the economic and financial viability of this practice.

Description of the technology: *Avena sativa* AV25-T (Altoandina)

Altoandina is an oat variety evaluated by Agrosavia as an option for animal supplementation in specialized milk production systems located in the higher tropics of Colombia, such as in the savannah of Bogotá, Alto Chicamocha, and the valleys of Ubaté and Chiquinquirá (Campuzano et al., 2018). It adapts to soils with drainage and porosity. Altoandina can be harvested 132 days after sowing and is thus considered an intermediate cycle crop that can be grown and harvested in both agricultural semesters (Campuzano et al., 2018). In addition, it stands out for being resistant to overturning and having a low incidence of leaf and stem rust. The dry matter (DM) yield of Altoandina depends on the precipitation and rate of fertilization, and varies, on average, from 10.6 to 24.8 tons/ha (Campuzano et al., 2018). Altoandina can be conserved as silage and fed to the cattle herd in times of forage scarcity. Altoandina silage generates benefits in terms of feeding efficiency and environmental impacts, that is, it leads to increased milk production (22 L/cow/day), decreased grazing areas, and decreased urea nitrogen in milk (Campuzano et al., 2018). Altoandina can also be used for other purposes: as a trap crop for the sowing of ryegrass and alfalfa and the renewal of degraded pastures (Campuzano et al., 2018). Table 1 presents the important characteristics of Altoandina.

Table 1. Characteristics of Altoandina in the highlands of Cundinamarca and Boyacá departments.

Characteristic	Average value
Time from sowing to harvest of forage (days)	132
Plant height (cm)	108
Overturning	7%
Average green forage production (t/ha)	24.8
Dry matter content	33%
Crude protein content	7.5%
Total digestible nutrient content	51%
Neutral detergent fiber content	57%

Source: Own elaboration based on Campuzano et al. (2018).

Objectives

- To evaluate the use of Altoandina as a possible alternative business model for silage production in the Colombian higher tropics.
- To compare the economic viability of Altoandina and maize silage in the highlands of Cundinamarca and Boyacá departments.

Data collection and methodological approach

The Business Model Canvas was structured based on the methodology developed by Alexander Osterwalder (2004). It was complemented by an economic and financial analysis in which the associated profitability indicators and risk factors were calculated using @Risk software (Palisade Corporation). The data were obtained through interviews with experts from Agrosavia and by the consultation of secondary information provided by the National Administrative Department of Statistics of Colombia (DANE).

Results and analysis

Financial analysis

In the highlands of Cundinamarca and Boyacá departments, maize silage is a key resource for animal feeding. The most widely used variety is Porva maize (ICA-508), which is the reference point for evaluating Altoandina silage. Altoandina has several advantages over maize: better precocity (it can be harvested 132 days after sowing (DAS) compared with 150–180 DAS for maize) and it can be sown in both agricultural semesters (two harvests versus only one for maize). Maize, however, has a higher yield in both green forage and dry matter (Table 2). On the other hand, planting maize requires more labor, thus causing higher establishment costs than Altoandina. Table 3 details the cost structure of ICA-508 maize and Figure 1 presents the distribution of establishment costs for both technologies.

High-quality maize silage is obtained by including both sugarcane and the highest amount possible of grains (Iriarte, 2013). Sugarcane is commonly ensiled in the region, whereas the maize cobs are sold for human consumption when the prices are high. The subtraction of the cob in the silage relinquishes part of the nutritional quality, leading to low content of protein (8–10%) and high content of fiber (>60%) (J. Castillo, op. cit.), in addition to generating greater variability in the quality of animal feed. Likewise, ethical considerations are involved when using a product destined for human consumption (cob) as animal feed. The problems described for maize silage are unrelated to the production and silage making of Altoandina, which makes it a promising alternative.

Table 2. Comparison of Porva maize (ICA-508) and Altoandina.

Characteristics	**Porva maize (ICA-508)**	**Altoandina (*Avena sativa* AV25-T)**
Harvest time (days after sowing)	150	132
Harvests per year	1	2
Average yield per harvest (t/ha)	Green forage: 70–80 Dry matter: 35–40	Green forage: 50 Dry matter: 15–20

Source: Own elaboration based on Campuzano et al. (2018) and Agrosemval (n.d.).

Table 3. Cost structure of the establishment and silage making of Porva maize in the highlands of Cundinamarca and Boyacá departments.

Establishment costs (COP) of Porva maize (1 ha)

Description	Unit	Unit value	Total value
Soil analysis	1	114,000	114,000
Machinery	hours		
Brush cutter	6	60,000	360,000
California rake (harrow)	3	53,333	159,999
Rigid or locking chisel	8	53,000	424,000
Ditching	6	57,000	342,000
Subtotal			1,285,999
Fertilizer	kg		
Urea 46%	200	2,160	432,000
Ammonium sulfate	150	1,900	285,000
DAP	250	2,687	671,750
KCl	100	3,000	300,000
Triple 15	100	2,700	270,000
Subtotal			1,958,750
Herbicide and insecticide	liters		
Atrazine	3	29,000	87,000
Glyphosate	2	17,000	34,000
Chlorpyrifos	0.5	46,000	23,000
Subtotal			144,000
Seed	kg		
Porva maize (ICA-508)	30	40,000	1,200,000
Subtotal			1,200,000
Labor	days		
Occasional labor	3	30,000	90,000
Manual hilling	8	30,000	240,000
Seeding	2	30,000	60,000
Subtotal			390,000
Subtotal establishment			**5,092,749**

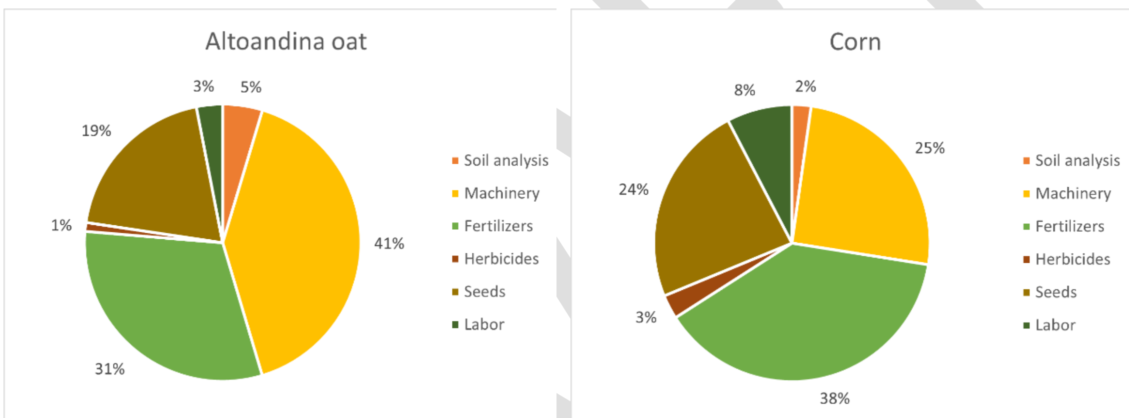
Costs of maize silage making (1 ha)

Description	Unit	Unit value	Total value
Silage in bags (32 t)	hours		
Harvest and chopping	9	50,000	450,000
Subtotal			450,000
Packaging	unit		
Bags	600	1,500	900,000
Subtotal			900,000

Machinery	days		
Silage bag	2	200,000	400,000
Subtotal			400,000
Additives	liters		
Glycerin	30	800	24,000
Sil All	0.09	350,000	31,500
Subtotal			55,500
Labor	days		
Occasional labor	1	30,000	30,000
Subtotal			30,000
Total silage making			**1,835,500**

Source: Own elaboration based on secondary information.

Figure 1. Comparison of the cost distribution (%) between Altoandina and Porva maize ICA-508. **(Inside figure, change Corn to Maize.)**



Source: Own elaboration.

The financial viability of the project was evaluated based on the profitability indicators net present value (NPV), internal rate of return (IRR), and benefit-cost ratio (B/C). The silage production of Altoandina was compared with the silage production of Porva maize ICA-508 as a baseline scenario. The average yield of Altoandina and Porva maize is 17 and 35 t/ha, respectively. For the evaluation of each silage option, a time horizon of 5 years[1] and an average discount rate of 10.85% were used.[2]

Table 4 summarizes the profitability indicators for each of the alternatives. Altoandina allows obtaining two income flows per year because it can be sown and harvested in the two agricultural semesters. It involves high annual costs compared with maize, but the costs per harvest are lower.

Table 4. Summary of profitability indicators for Altoandina and Porva maize.

[1]Average length of land lease contracts in the higher tropics of Colombia (J. Castillo, pers. commun., 29 November 2021).

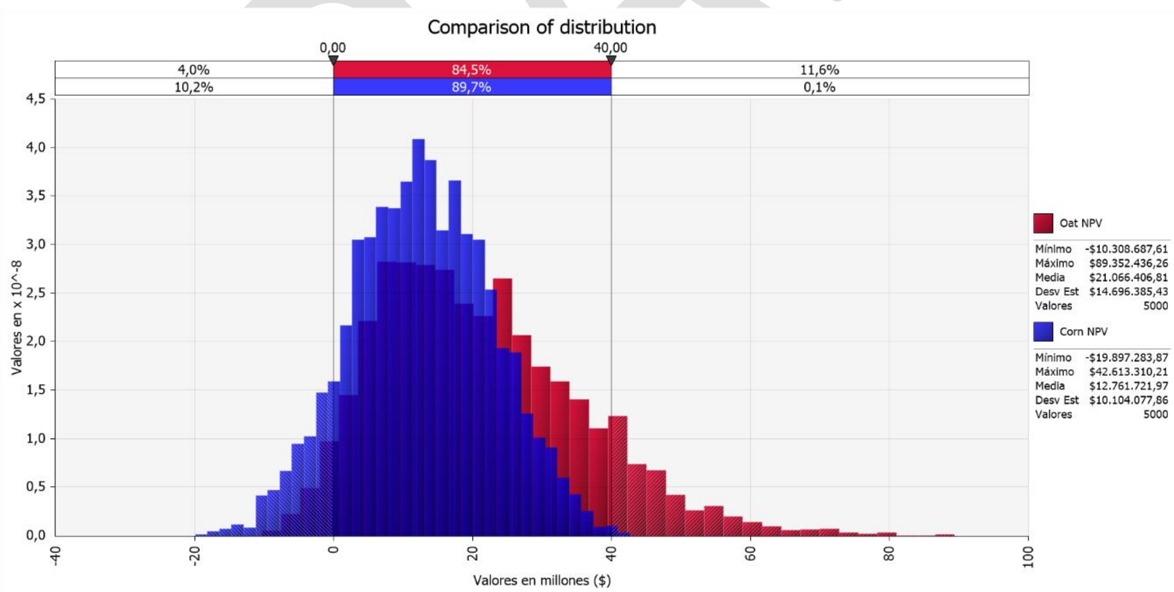
[2]Based on the Finagro credit line, which is established according to the DTF + 7% effective annual rate (Finagro, 2021). The DTF was determined based on the projections of Bancolombia 2021-2025 (Bancolombia, 2021). **(Explain DTF? Write out in English?)**

Profitability indicators	Altoandina	Porva maize ICA-508
Average annual yield (t/ha)	34	35
Total gross income (COP/average annual yield/ha)	14,664,746	11,896,161
Total net income (COP/average annual yield/ha)	6,094,216	5,023,412
Total establishment costs (COP/ha)	4,899,530	5,092,749
Total silage costs (COP/ha)	3,671,000	1,780,000
NPV (COP/ha)	21,084,425	12,923,911
IRR (%)	191	85
B/C ratio	**~~$1.7~~1.7**	**~~$1.4~~1.4**

Source: Own elaboration based on secondary information.

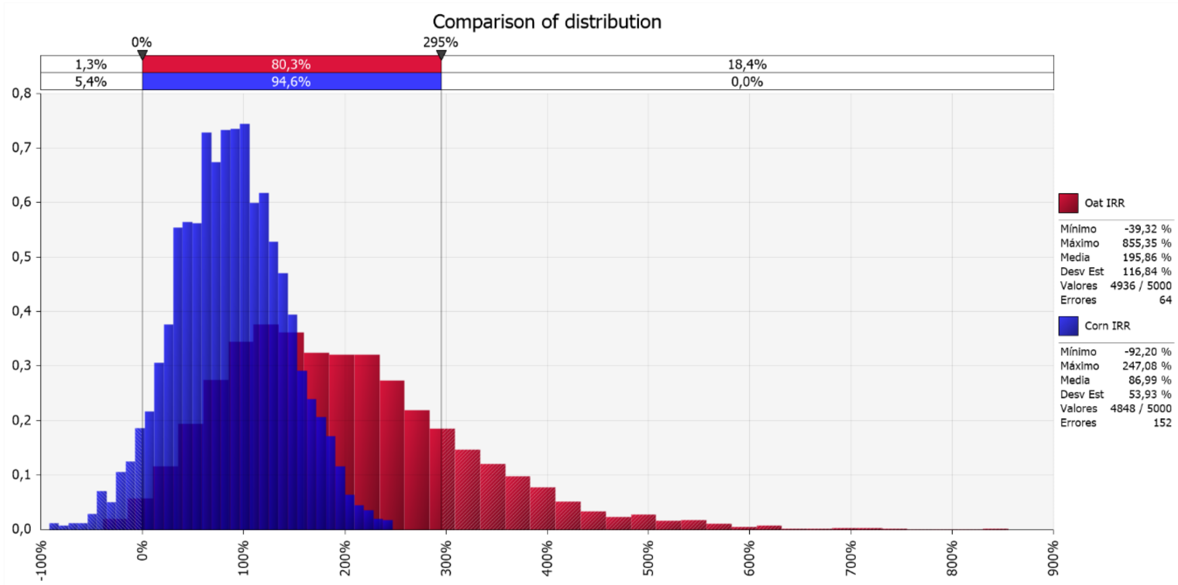
Analyzing the distribution of the profitability indicators shows that the NPV for Altoandina can result in negative values with a 4.1% probability, whereas for maize the probability is 10.9% (Figure 2). The probability that the IRR is less than 0% is 5.3% for maize and 1.3% for Altoandina (Figure 3). The B/C ratio is greater than 1 with a probability of 91.7% for Altoandina and 89.3% for maize (Figure 4).

Figure 2. Comparison of the NPV for Altoandina oat and Porva maize silages. **(Words inside figure need to be in English. Change corn to maize.)**



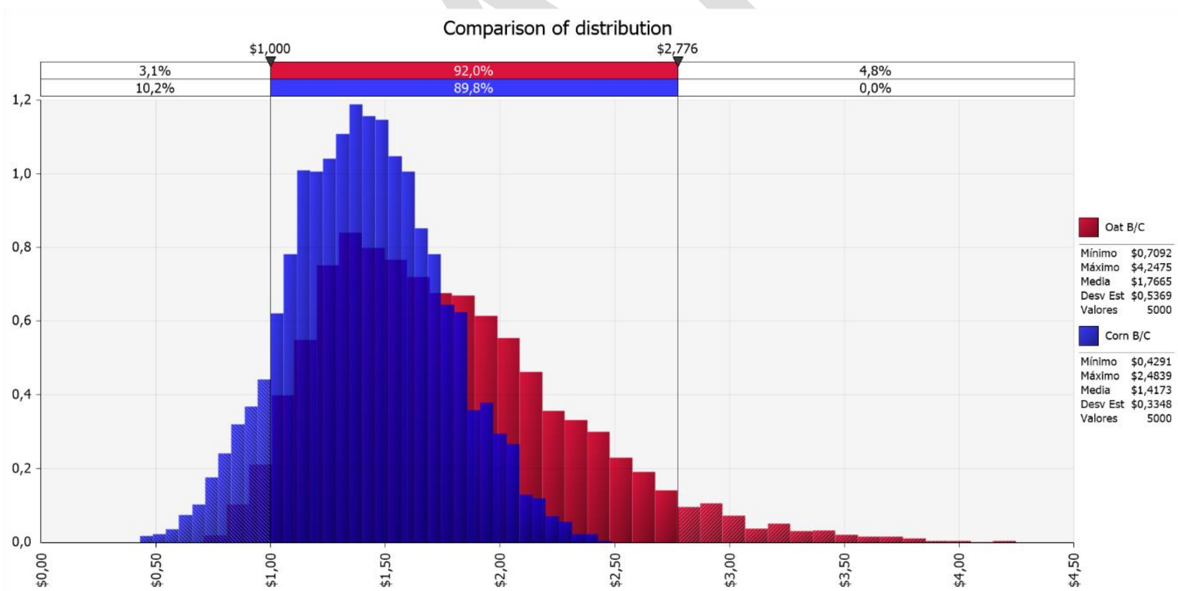
Source: Own elaboration.

Figure 3. Comparison of the IRR for Altoandina oat and Porva maize silages. **(Words inside figure need to be in English and change Corn to Maize.)**



Source: Own elaboration.

Figure 4. Comparison of the B/C ratio for Altoandina oat and Porva maize silages. **(Words inside figure need to be in English and change Corn to Maize.)**



Source: Own elaboration.

Canvas

The business model is executed mainly by producer associations and to a lesser extent by independent producers. This is because of the better access to machinery, infrastructure, and technical assistance for associations than for independent producers. These possibilities are supported by institutional policies, as is the case of Conpes 3675 of 2010, which aims at improving the competitiveness of the dairy sector and supports associations in obtaining access to the resources necessary for feed production and supplementation, such as silage (DNP, 2010).

The value proposition is Altoandina silage sold in 50-kg bags. In addition to its nutritional quality, the bag presentation allows the silage to be preserved in the distribution and feeding phase of the animals. The customer segment is cattle (i.e., dairy) producers affected by climatic variations.[3] Relations with customers and distribution channels depend on the operational plan managed by the producer association. The poor quality of road infrastructure in rural areas, however, is a bottleneck for the distribution channel since it causes losses in the delivery of silage to the animals (J. Castillo, op. cit.). The business model proposes a single source of income: the sale of silage. The price is determined by comparing with the prices for commercial concentrates.

Adequate machinery for sowing, harvesting, and silage making; infrastructure; and access to water sources for sowing are the key resources for the proper functioning of the business model. The key activities are related to the sowing and harvesting of Altoandina. To take advantage of the two agricultural semesters of the year, sowing should be done in March-April and October-December so that it coincides with the rainy seasons and does not involve additional irrigation expenses. Regarding the harvest, in the highland regions of Cundinamarca and Boyacá departments, it can be done after 132 days, approximately (Campuzano et al., 2018), which coincides with the beginning of the dry season.

The key actors for the execution of the business model come mainly from the fields of policy, research, and marketing. Regarding policy, the relevance of the National Federation of Cereal, Legume, and Soy Growers (Fenalce) and the territorial governmental entities (city halls and governorships) stands out. For its part, the Colombian Agricultural Research Corporation (Agrosavia) stands out as the research institution that, in addition to developing Altoandina, is carrying out scaling processes of the technology in different territories through dissemination and promotion activities. In terms of commercialization, Sáenz Fety is the sole distributor of Altoandina seed. Finally, the cost structure considers the establishment and silage making costs of Altoandina[4] (Table 5). Table 6 outlines the nine basic modules of the business model: customer segments, value propositions, distribution channels, customer relationships, key resources, key activities, key partners, revenue streams, and cost structure (Ferreira-Herrera, 2015).

Table 5. Cost structure of the establishment and silage making of Altoandina in the highlands of Cundinamarca and Boyacá departments.

Establishment costs (COP) of Altoandina (1 ha)

[3]These can be the associations that produce the silage or independent producers. The commercialization process depends on internal policies of the association.
[4]The project also considers an initial investment, which is related to the key resources (infrastructure, machinery, and access to water sources). Since these can vary according to the condition of each of the associations, they were not considered in the estimation.

Description	Unit	Unit value	Total value
Soil analysis	1	114,000	114,000
Machinery	hours		
Brush cutter	6	60,000	360,000
California rake (harrow)	5	53,333	266,665
Rigid chisel	7	53,000	371,000
Subtotal			997,665
Fertilizer	kg		
Urea 46%	250	2,160	540,000
Magnesium sulfate (25 kg)	50	1,470	73,500
DAP	50	2,687	134,350
Borax	1	10,000	10,000
Subtotal			757,850
Herbicide			
Partner (g)	0.5	500	250
Glyphosate (L)	2	25,000	25,000
Subtotal			25,250
Seed	kg		
Altoandina	80	6,000	480,000
Subtotal			480,000
Labor	days		
Occasional labor	2	30,000	60,000
Broadcast sowing	0.5	30,000	15,000
Subtotal			75,000
Subtotal establishment			**$2,449,765**

Costs of Altoandina silage making (1 ha)

Description	Unit	Unit value	Total value
Silage in bags (17 t)	hours		
Harvest and chopping	9	50,000	450,000
Subtotal			450,000
Packaging	no.		
Bags	600	1,500	900,000
Subtotal			900,000
Machinery	days		
Silage bag	2	200,000	400,000
Subtotal			400,000
Additives	liters		
Glycerin	30	800	24,000
Sil All	0.09	350,000	31,500
Subtotal			55,500
Labor	days		
Occasional labor	1	30,000	30,000
Subtotal			30,000

Subtotal silage making	**1,835,500**
Total	**4,285,265**

Source: Own elaboration based on secondary information.

Table 6. Canvas business model for Altoandina silage in the highland regions of Cundinamarca and Boyacá departments.

<table>
<tr><th>Key partners</th><th>Key activities</th><th>Value propositions</th><th>Customer relationships</th><th>Customer segments</th></tr>
<tr><td rowspan="5">*National Federation of Cereal, Legume, and Soy Growers (Fenalce)
*Territorial governmental entities
*Agrosavia
*Sáenz Fety</td><td>*Sowing in two agricultural semesters in the rainy season: March-April and October-December
*Harvest: 132 days after sowing</td><td>*Silage in bags (50 kg) of Altoandina.
*Presentation in bags that decrease losses in silage distribution.</td><td>*Associations autonomously manage the operational plan.</td><td>*Cattle (i.e., dairy) producers affected by dry seasons in the highland regions of Cundinamarca and Boyacá departments.</td></tr>
<tr><th colspan="2">Key resources</th><th colspan="2">Distribution channels</th></tr>
<tr><td colspan="2">*Machinery for sowing, harvesting, and silage making
*Infrastructure: purchase or lease of land
*Nearby water sources for sowing</td><td colspan="2">*Associations autonomously manage the operational plan
*Bottleneck: precarious road infrastructure</td></tr>
<tr><th colspan="2">Cost structure</th><th colspan="2">Revenue streams</th></tr>
<tr><td colspan="2">Table 5</td><td colspan="2">*Price: determined by comparing with the prices for commercial concentrates as well as by analyzing the minimum levels of production.</td></tr>
</table>

Source: Own elaboration based on obtained data.

Conclusions

Silage is a feasible strategy for conserving forage in the Colombian higher tropics, thus allowing an increase in feed availability in critical times caused by climatic variability and affecting the production indicators of the dairy production system. Altoandina forage oat silage is a promising alternative to the commonly used Porva maize silage ICA-508 in terms of financial profitability, production indicators, and socioeconomic advantages.

Producer associations have advantages over independent smallholder and medium-scale producers in adopting the proposed business model. Policy instruments such as Conpes 3675 of 2010 allow access to the machinery required for silage production and other activities that encourage the modernization of the dairy sector.

Political and institutional efforts are still needed, however, to overcome bottlenecks related to road infrastructure in rural areas, extension, and technical assistance for smallholder and medium-scale producers, among others. These factors limit the adoption of practices that benefit dairy production, such as silage.

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The views expressed in this document should not be taken as the official views of these organizations.

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About the authors

Irieleth Gallo-Caro is an economist and independent researcher. dgallocaro@gmail.com

Karen Enciso Valencia is an economist and research associate, Tropical Forages Program, Alliance of Bioversity International and CIAT. k.enciso@cgiar.org

Javier Castillo is a research support professional at AGROSAVIA. jcastillos@agrosavia.co

Stefan Burkart is a senior scientist and theme leader, Tropical Forages Program, Alliance of Bioversity International and CIAT. s.burkart@cgiar.org

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