Opportunities for innovation in maize hybrid seed products: Insights from Guatemala and El Salvador

Meliza Peña, Jason Donovan, and Pieter Rutsaert

Abstract

Across Central America, dozens of locally owned small and medium-scale maize enterprises (maize SMEs) have emerged in the past few decades, which now represent a critical source of hybrid maize seed for small-scale farmers. Typically, these enterprises acquire foundation seed from public breeding programs, which they then multiply, process, and package, to sell to government agencies and NGOs. The future growth prospects of these maize SMEs depends, in part, on their ability to launch new seed products and diversify their marketing channels to include sales to retailers. This brief explores demand-side opportunities for new maize hybrids in Guatemala and El Salvador. We conducted 27 interviews, including with 10 maize SMEs (six in Guatemala and four in El Salvador), and triangulated the information with national agricultural research and extension systems, international seed companies, and seed retailers. Our study identified the requirements for maize products related to end-use (e.g., green maize[1] and silage), processing (e.g., maize for the snack industry and blue maize for restaurants and processors), and production (e.g., shorter maturity cycles). Maize SMEs recognized the potential future shift toward early-maturity products if the tendency for the delayed onset of the rainy season continues.

Key Points

- Historically, maize SMEs in Central America have depended on seed sales to government and NGOs. In Guatemala, this has changed, and maize SMEs have expanded their distribution network. In El Salvador, since 2024, SMEs have sought their own distribution networks. Multinational seed companies have dominated hybrid maize seed sales to larger-scale maize producers. The largest market segment for hybrid maize has been the segment for grain that is white in color, intermediate-late maturity, and used for human consumption. Given the rapid economic and climate changes in the region, an opportunity exists for new discussions on the seed products required for the future and related investment opportunities.
- Our interviews with maize SMEs and seed stakeholders revealed opportunities to design new maize products aligned with end-use (e.g., green maize and silage), processing (e.g., maize for the snack industry and blue maize for restaurants and processors), and growing practices (e.g., shorter maturity cycles).
- By identifying unrecognized requirements for maize seed products, our results provide inputs for discussions on product design in a region where maize plays a critical role in food security and economic development. Future market intelligence efforts can further support these discussions by focusing on the current size of these segments and their future growth trajectories.
- The potential for public-sector breeding programs to achieve impact in the region will also depend on support to maize SMEs to help them build market share in competitive seed markets (e.g., innovative product portfolios, decreased production costs, innovative marketing).

[1] Green maize refers to maize harvested before full maturity, which is typically used to make corn-on-the-cob, known in Spanish as *elote*. The cobs are commonly eaten roasted or boiled, and the kernels can be used in traditional dishes such as tamales.

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Acronyms used in this brief

CENTA	Center for Agricultural and Forestry Technology
CIMMYT	International Maize and Wheat Improvement Center
ICTA	Institute of Agricultural Science and Technology
Maize SMEs	small and medium-scale maize seed enterprises
NARES	national agricultural research and extension systems
SPMSs	seed product market segments
TPP	Target Product Profile

Introduction

Maize forms a critical element of food security in Central America. Maize production in the region is carried out mainly by small-scale farmers without irrigation and with relatively few purchased inputs (Eitzinger et al. 2012). Overall productivity is low, at roughly 1.5 to 2.5 tons per hectare. The production situation has become more complicated in response to climate change. Rainfall patterns are more erratic, with droughts having become more severe and frequent (Eitzinger et al. 2012; Pons 2021; Calvo-Solano et al. 2018; Eash et al. 2019). One tactic to support small-scale maize producers in production and marketing has been the production and distribution of new hybrid maize seed products. However, hybrid maize seed systems in Central America depend heavily on government-financed seed production and distribution. Compared to countries such as Mexico, donor-funding for maize breeding and seed systems development in Central America has been limited (see Donovan et al. 2022b and Donovan et al. 2024 for discussions on donor interventions in maize breeding in Mexico).

Since the 1990s, maize seed systems in Central America have relied on privately owned seed companies for seed production and, in some cases, seed distribution. Large-scale multinational seed companies are well established in the region, providing hybrid maize seed products to commercially oriented farmers. However, dozens of small and medium-scale maize seed enterprises (maize SMEs[2]) also exist, which work closely with the public sector and are often better positioned to supply seed to small-scale farmers, who typically have limited access to improved seed. This gap in seed access highlights a key motivation for supporting maize SMEs, which can complement rather than directly compete with multinationals by serving this underserved market segment. Maize SMEs have traditionally multiplied seed obtained from public breeding programs, after which the resulting seed is bagged and sold to government agencies. For maize SMEs to grow and develop their operations, they will need to move beyond bulk government purchases and expand their commercial relations with maize farmers, either directly or via retail networks. Their success in building commercial marketing channels will require that they have innovative seed products that farmers are willing to seek out and purchase. SMEs must identify market opportunities with which their products can stand out; for example, by responding to requirements for maize seed that are currently unmet in the market.

Government and donor-funded maize breeding programs can help maize SMEs by supporting their access to new genetic material. However, this will require that maize SMEs, as well as maize breeding programs, have a deeper understanding of the evolving seed requirements of farmers, processors, and consumers and translate these needs into the design of future seed products. Given that the lag between the initial idea of a new seed product and the commercial launching of the product can be 10 years or more, breeding programs need forward-looking intelligence on seed requirements and the potential for impact from investments in the products that would meet these requirements. CGIAR has been working to better align its hybrid maize breeding efforts with the current and future requirements for hybrid maize seed products. Recently, CGIAR's Seed Product Market Segment Database (SPMSD) catalogued around 600 seed product market segments across relevant crops. These segments are defined based on eight criteria that capture the requirements of farmers – such as production environment, production system, and maturity cycle – and the needs of consumers and processors, including end-use and color (Donovan et al. 2022a).

In Latin America, CGIAR has identified five key SPMSs for hybrid maize. These segments collectively cover approximately eight million hectares, representing 20% of the region's maize production area (FAOSTAT 2022). The remaining 80% includes other segments of smallholder and subsistence-oriented farmers, often using local seed. These segments might represent untapped opportunities for maize SMEs. The largest SPMS corresponds to white maize grown in tropical

[2] In this study, we define maize SMEs as commercial operations that produce from 50 to 3,000 tons of seed annually, which they sell to governments, retailers, and farmers. They take various business organizational forms, which include privately owned businesses, cooperatives, and NGOs.

lowlands for human consumption, followed by white maize in mid-altitude tropical zones, also for human consumption, and yellow maize in tropical lowlands for animal feed. Additional segments include blue maize grown in mid- and high-altitude tropical regions for human consumption and yellow maize in mid-altitude areas for animal feed (Global Market Intelligence Platform 2024). For each segment, unique Target Product Profiles (TPPs) outline the essential traits and thresholds that new seed products must meet to satisfy the needs of farmers, processors, and consumers (Donovan et al. 2022a). Looking ahead, market intelligence aims to identify how these segments might shift in the future in response to the changing requirements of farmers, processors, and consumers. This could create opportunities for maize SMEs to invest in product design and marketing (assuming that maize breeding programs have the products available or could design them relatively quickly).

In general, discussion has been limited on the future requirements in Central America for hybrid maize. Our study focuses on Guatemala and El Salvador, two important maize-producing countries in Central America, to analyze the current products offered by maize SMEs and explore the opportunities involved in developing and distributing new hybrid maize products. By evaluating the changing needs of small-scale farmers, specifically those who currently use improved seed or are transitioning toward its use, and who might also be small-scale commercial producers, and the growing role of SMEs in these nations, and considering their contexts and resource constraints, the study provides practical insights to inform breeding programs and support the creation of specialized products. This approach could foster a more inclusive, resilient, and sustainable maize sector in Central America.

Methodology

Data collection took place in June and July 2024 through in-person interviews with representatives from NARES, maize SMEs, multinational seed companies, and seed retailers. In total, we conducted 27 interviews (15 in Guatemala and 12 in El Salvador) using a purposive sampling approach to select the participants. Table 1 summarizes the distribution of the interviews by actor category and country.

A structured questionnaire guided data collection from each group of informants. The questionnaire covered the current product offerings of maize SMEs and identified opportunities and challenges associated with the development and distribution of new hybrid maize seed products. A qualitative analysis of the collected data was conducted, providing deeper insights into the context in which the maize SMEs operated and their requirements for advancing hybrid development. Preliminary findings and their implications for the SPMSs were discussed and validated in collaboration with CIMMYT maize breeders.

Table 1. Key informants interviewed by country.

Key informants	Guatemala	El Salvador
Maize SMEs	6	4
NARES	1	3
Multinational seed companies	2	2
Maize seed retailers	6	3
Total	**15**	**12**

Results

Overview of maize SMEs

The maize seed industry in Guatemala and El Salvador is shaped by the specific socioeconomic contexts of each country. In Guatemala, maize SMEs consist of 16 privately owned enterprises and a relatively recent NGO focused on maize seed production. In El Salvador, cooperatives of small producers dominate the landscape, with about 10 SMEs in total, of which only two are privately owned enterprises. Despite differences in structure, maize SMEs in both countries reported common challenges, such as limited financial resources, a shortage of staff dedicated to marketing activities, and restricted seed conditioning capacity. Table 2 describes the sampled maize SMEs, highlighting key aspects such as their origins, main activities, and organizational structures.

Maize seed production

The NARES, the Institute of Agricultural Science and Technology (ICTA) in Guatemala, and Center for Agricultural and Forestry Technology (CENTA) in El Salvador, play an essential role in supporting maize SMEs in both countries, with these SMEs relying heavily on CENTA and ICTA to obtain germplasm. This dependency is more pronounced in El Salvador, where all maize SMEs exclusively use germplasm provided by CENTA. In Guatemala, while ICTA remains the primary source, some maize SMEs have diversified their access by using germplasm from CIMMYT or private companies. Most of the seed products offered by maize SMEs are hybrids that have been available through NARES for more than 30 years. However, a few Guatemalan maize SMEs demonstrate greater innovation in their product portfolios. For instance, the NGO, in collaboration with CIMMYT, has developed

new hybrids enriched with high iron and zinc content, while another SME reported producing its own hybrids, and yet another sources genetic material from a U.S. company under a royalty-based agreement. CIMMYT provides germplasm to NARES for evaluation and potential release of new hybrids, which can then be made available to SMEs; however, the flow of germplasm from NARES to SMEs is not always seamless, as there are not efficient mechanisms for technology transfer, highlighting opportunities to strengthen this link.

Seed production volume varies significantly among maize SMEs. In Guatemala, the largest maize SME produces more than 3,000 tons annually, distributing 25% within the country, 25% to El Salvador, and exporting the remainder to other Latin American markets, including Mexico, Colombia, Honduras, and Ecuador. Conversely, smaller SMEs in Guatemala produce less than 200 tons per year on average, primarily targeting niche markets in the high valleys, a region with limited maize production, as well as other regions of the country, focusing mainly on smallholder farmers. Much of the maize produced by these small-scale producers is used for household consumption or is sold in local and regional markets, reflecting a mix of subsistence and small-scale commercial activity. In El Salvador, maize SMEs achieve higher production volumes, averaging around 1,000 tons annually. Their production has been closely tied to government procurement programs, which distribute seeds free of charge to smallholder farmers. Table 3 provides detailed insights into the germplasm sources, product portfolios, and production volumes of the sampled maize SMEs.

The seed market

In both countries, multinational enterprises such as Bayer Crop Science, Corteva, and Syngenta predominantly control the improved maize seed market. Estimates from representatives of these firms suggested that their market share exceeded 80% of the total in both countries, leaving the remaining percentage to be supplied by SMEs. The seed market for SMEs in Guatemala and El Salvador has unique characteristics shaped by local dynamics and marketing structures. In Guatemala, SMEs such as international companies use retail distribution networks through agro-dealers. Typically, producers who purchase seeds from international companies have access to advanced technologies, including agrochemicals and fertilizers, and tend to cultivate more fertile soils, resulting in higher yields. In contrast, farmers opting for seeds from SMEs frequently face technological and input limitations, and often work in more challenging terrains, such as slopes. Retailers emphasized that smallholders seek affordable seed options with shorter maturity cycles and resilience traits, but many lack consistent access because of distribution gaps. This reflects unmet seed demand for which maize SMEs might be well positioned to serve.

Table 2. Overview of sampled maize SMEs.

Characteristic	Guatemala (n=6)	El Salvador (n=4)
Type of maize SMEs	• Mostly private + 1 NGO	• Mostly cooperatives + 2 private
Years of establishment	• Mainly in the 1980s and 1990s • The NGO was founded in 2014	• Varied, some since the 1980s
Origin	• Links with ICTA and Cristiani Burkard Seed Company[3]	• Links with Cristiani Burkard
Main activities	• Seed production • Agricultural machinery rental • Cultivation of maize, sugar cane, tomatoes, sorghum	• Seed production • Cultivation of sorghum, maize, peanuts
Conditioning facilities	• Most use ICTA facilities for seed conditioning, • two SMEs operate their own conditioning plants	• Most use CENTA facilities for seed conditioning • One SME operates its own conditioning plant
Number of employees	• From 13 to 15 full-time • The largest SME and the NGO employ more staff	• From 13 to 15 full-time

[3] Many El Salvador and Guatemala maize SMEs trace their origins to seed production, initially linked to the Salvadoran company Cristiani Burkard. Monsanto acquired this company in the 1980s.

Table 3. Maize germplasm sources and maize seed production by SMEs.

Aspect	Guatemala	El Salvador
Primary source of germplasm	Three SMEs obtain their germplasm from ICTA	CENTA
	Three maize SMEs use CIMMYT lines	
	One uses germplasm from a U.S. company	
Portfolio	Two SMEs exclusively use the hybrid H83	Exclusively the hybrid H59
	The NGO has launched three hybrids in the past five years, and one is set to be launched soon	
	The largest SME has six hybrids, four of which were launched in the last five years	
	The last two have three hybrids: one with its own germplasm and the other with germplasm from a U.S. company	
Annual seed production	The largest SME produces 3,000 tons per year	Approximately 1,000 tons by SMEs (linked to government demand)
	The other SMEs produce fewer than 200 tons annually	

Two novel efforts by maize SMEs in Guatemala have the potential to influence seed market growth trajectories. First, one maize SME, which is also an NGO, has promoted the adoption of new hybrids with high iron and zinc content by local SMEs, offering a 50% subsidy on production costs. This NGO markets a large portion of these seeds, aiming to increase their adoption among SMEs in both Guatemala and El Salvador. Development projects provided the funding required for the large subsidies – a precarious situation, especially considering recent major reductions in development funding in the region. Second, several maize SMEs with research capabilities are expanding their sales to other Central American and South American markets.

In contrast, the maize seed market in El Salvador has traditionally been linked to government programs that distribute free seeds to smallholders. However, a political shift in 2024 transformed this landscape, replacing direct distribution with an electronic credit card system that allows producers to choose what to purchase. According to one distributor, "producers often prioritize buying agrochemicals and fertilizers over seeds." This change poses significant risks for maize SMEs, as they hold inventories of seeds intended for government distribution, and, lacking a presence in retail markets, they face the risk of loss. Some maize SMEs are attempting to establish their own distribution networks, while others are seriously considering exiting the maize seed production business. This policy shift has also affected the maize research system led by CENTA, diminishing capabilities and thus jeopardizing the production of basic seed for hybrid H59 and the release of new hybrids. In response, some SMEs are exploring new ways to access genetic material to remain competitive in the industry.

Future requirements for seed products

SMEs and maize stakeholders identified key requirements for the design of new products, considering both the end-use demands of consumers and processors and the needs of smallholder farmers. These requirements reflected the growing demand for maize in emerging markets and the specific production challenges in Central America. Multinational and regional companies are actively entering these emerging markets. They typically leverage large distribution networks, strong marketing capabilities, and brand recognition to quickly scale high-volume hybrid products, primarily targeting medium- and large-scale farmers. In contrast, maize SMEs rely on close relationships with smallholder farmers and a more localized network. Although SMEs face competition from these larger companies, their ability to serve niche markets and small-scale producers provides a competitive advantage that helps sustain their relevance in the market. Table 4 provides an overview of these requirements, highlighting critical aspects such as end-use, maturity type, and production conditions.

Discussion

Traditionally, the design of new seed products in breeding programs has focused on the growing requirements of producers, prioritizing agronomic aspects such as yield, production environment, resistance to key pests and diseases in the region, and the adaptability of hybrids to various agroecological stresses. The current market segmentation for maize for Latin America reflects this focus. Our study sought to identify potentially unrecognized requirements for maize seed based on discussions with maize SMEs and retailers. Our findings identified the following unrecognized requirements:

Table 4. Future requirements for new seed products.

End-use requirements	Smallholders' requirements
Hybrids for the snack industry: Grains with specific characteristics that improve chip texture, optimize flour processing, and extend the shelf life of the product.	**Hybrids with shorter maturity cycles:** Adapted to production cycles that are becoming shorter and more erratic.
Hybrids for green maize: Varieties with desirable agronomic and sensory traits, such as good cob size, pleasant texture, and long shelf life.	**Drought-tolerant hybrids:** Capable of withstanding increasingly frequent dry periods within the growing season.
Hybrids for silage: Varieties with low lignin content, high succulence, good digestibility, and abundant leaf biomass.	**Hybrids resistant to emerging diseases:** Including resistance to *Diplodia* (caused by *Diplodia* sp. and *Fusarium* sp.) and maize stunt virus transmitted by the insect vector *Dalbulus maidis*.
Colored hybrids: Intended for industry and the production of traditional products, with traits similar to those of native maize.	–

1. **Hybrids for the snack industry:** The snack industry in Guatemala, El Salvador, and other Central American countries is experiencing sustained growth with significant expansion potential. Currently, most maize used in this industry is imported; however, a growing market for domestically produced maize has emerged in recent years. This presents a strategic opportunity to develop local varieties adapted to the region's agroecological conditions and with specific characteristics required for the snack industry. Interviewees estimate a potential demand of approximately 12,000 hectares per cultivation cycle in each country, equivalent to 1.5% of Guatemala's annual planted area and 4% in El Salvador. Developing specific hybrids with optimal attributes could not only meet this demand but also decrease reliance on imports, thus benefiting local SMEs involved in seed production and farmers supplying this formal market.

2. **Hybrids to meet demand for green maize:** Green maize holds culinary and cultural relevance in Guatemala and El Salvador. Its demand has increased considerably because of its increased value in local markets and expansion into export markets. In El Salvador, this niche is estimated to require seeds covering more than 10,000 hectares annually, representing approximately 3.5% of the total area allocated to maize cultivation. Although most commercial hybrids are primarily developed for dry grain production, hybrids for green maize stand out for being specifically selected or evaluated based on their sensory quality when consumed fresh. Currently in both countries, only one variety is used for green maize, marketed by an international company, and, although it has some favorable characteristics, it is not entirely suitable for this purpose. Providing hybrids with the desired agronomic and sensory characteristics (i.e., good cob size, pleasant texture, and long shelf life) offers SMEs the chance to introduce specialized seed products and enables smallholders to capture higher-value market opportunities. Studies from Mexico (Hellin et al. 2011) have documented strong consumer demand for green maize, suggesting that developing varieties tailored to this market could further boost demand.

3. **Hybrids for silage:** Silage is increasingly important for improving the efficiency of milk and meat production. As demand grows, livestock producers are seeking feed sources that provide high nutritional value and consistent supply throughout the year. Maize hybrids specifically designed for silage production are developed to maximize traits such as biomass yield, energy content (primarily from starch), fiber quality, and digestibility, factors essential for supporting ruminant nutrition and improving feed conversion efficiency (Ferraretto et al. 2014). Although this niche is partially served by international companies, local SMEs have a significant opportunity to enter this market with products specifically designed to meet these needs. Small-scale farmers' ability to supply high-quality silage maize consistently will be key to tapping into this expanding market. Developing hybrids that offer improved palatability and greater biomass production could address current demand while overcoming the limitations of existing seed options.

4. **Colored maize seed for gastronomic markets:** Blue maize could represent a niche and high-value market opportunity in Guatemala, especially in specialized markets that value its quality and unique properties. Compared with traditional white maize for human consumption, this type of maize could offer farmers higher profitability, provided they have access to specialty markets. Potential markets include gourmet gastronomy, local restaurants, and the snack industry. Although this niche might be the smallest among those identified, its appeal lies in consumers' willingness to pay premium prices for differentiated products. Small-scale farmers' engagement with these specialized markets will depend on their capacity to produce maize with consistent quality and the infrastructure to reach gourmet and restaurant buyers. In Mexico, studies such as Blare et al. (2020) have demonstrated strong consumer preference for blue maize products, particularly in out-of-home consumption. This suggests potential for expansion into other Central American countries where consumers might also appreciate this unique offering.

Looking ahead

A viable strategy for SMEs' development could focus on creating new seed varieties to target these smaller, less saturated market niches in which competition from international companies is less intense. This approach offers greater opportunities for differentiation and establishing a strong market position.

Success in these markets requires implementing an integrated strategy encompassing three key elements: (1) strengthening the linkage between regional and national breeding programs led by NARES, thus ensuring that SMEs have reliable access to high-quality genetic material and new hybrids tailored to SMEs' needs and niche market demands; (2) establishing effective cooperation and technology transfer mechanisms between NARES and SMEs to facilitate the development, research, and adoption of new hybrids; and (3) designing and implementing marketing strategies that foster the creation of efficient value chains. This could include developing retail markets and triangulating relationships between maize SMEs, producers, and niche markets, thus ensuring a continuous and sustainable product flow. In addition, supporting maize SMEs in areas beyond germplasm access such as technical assistance, financial support, logistical coordination, infrastructure, and provision of key R&D can be critical to enhancing their operational capacity, market competitiveness, and ability to adopt and promote new products (Donovan et al. 2022a). These integrated actions could significantly enhance SMEs' competitiveness and promote the sustainable development of seed systems in Guatemala and El Salvador.

However, given the relatively small size of these market niches compared with that of the primary markets for white maize for human consumption and the exploratory nature of this study, it is essential to conduct additional analyses in other Latin American countries. Such studies will enable a more comprehensive evaluation of the relevance and potential of these niches and determine the feasibility of investing in regional breeding programs to effectively address the needs of these specialized markets. Future lines of research should also include the development of business and pipeline investment cases, encompassing assessments of the potential profitability for smallholder farmers growing these crops, analyses of consumers' willingness to pay, mechanisms to connect farmers to these markets, and projections of adoption rates along with the costs of achieving them.

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