The Seeds of the Mexican Countryside

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ABSTRACT

Objective: The objective of this work is to make an analysis of the types of seeds use by Mexican farmers and their relationship with Local Seed Systems (SLS) and Formal Seed Systems (SFS).

Design/methodology/approach: The work consisted of a bibliographic review about the types of seeds available for the Mexican countryside and their seed systems. In addition, to identify some priorities and strategies for its strengthening.

Results: In Mexico, derived from its climatic, edaphic, geophysical heterogeneity, cultural social and economic diversity. It has caused both landraces and improved seed to coexist in the SLS and SFS. However, there is a predominance in the use of landraces in SLS of 70 to 80%. Therefore, it is considered a priority to conserve traditional selection, management, conservation and use practices that have caused the wide inter- and intraspecific diversity of landraces. However, more research needs to be carried out and its legal framework strengthened. In the case of improved seeds located mainly in SFS, it is considered to promote their use in vegetables and the ornamental sector.

Limitations on study/implications: The work developed could be complemented with the participation and interviews of decision makers in seed policies in Mexico and the review of processed in other countries.

Findings/conclusions: In Mexico the use of native and improved seeds coexists. To satisfy the demand for food, all types of seeds are important and both the SLS and the SFS but differentiated public policies are required for their attention and the definition of a specific legal framework for landraces.

Keywords: improved seed, landraces, selection, management.

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INTRODUCTION

Seeds are one of the main inputs for agricultural production. Having quality seeds, culturally relevant and adapted to different ecological niches is the foundation for food security and sovereignty (Kuhlmann and Dey, 2021). In Mexico, according to the Federal Law on Seed Production, Certification, and Commerce, seeds are defined as: "those obtained from the fruit after the fertilization of the flower, the fruits or parts thereof, as well as parts of plants or whole plants used for the reproduction and propagation of different plant species" (DOF, 2018). In Mexico, farmers mainly use native and improved seeds. This last one is generally certified by the SNICS (National Service of Seed Inspection and Certification), which is responsible for coordinating activities related to the production,

certification, and trade of seeds (SAGARPA, 2005). According to the seed law, seeds are categorized as: certified, approved, and declared (DOF, 2018). These are multiplied from original (or genetic), basic registered, and certified seed categories. However, landraces can also achieve these categories if the varieties are registered in the National Catalogue of Plant Varieties (CNVV) (DOF, 2018; Domínguez-García *et al.*, 2019; Escárraga-Torres *et al.*, 2021), as explained below.

Types of Seeds Used by Mexican Farmers

In Mexico, different types of seeds are used by farmers (Domínguez-García *et al.*, 2019; Escárraga-Torres *et al.*, 2021). The type of seed they use depends on soil conditions, climate, geophysical factors, water availability, land tenure, surface area size, production potential, marketing channels, type of agroecosystem, among other factors (Almekinders and Louwaars, 1999; Thijssen *et al.*, 2008). The main types are:

Landraces

Landraces is defined as seed that is selected, managed, and preserved by the farmers themselves. It is adapted to the specific conditions of each ecological niche. Additionally, over the years, farmers select characteristics according to their needs and uses (Hernández-Sandoval *et al.*, 2023). These seeds can be grouped into races or varietal groups, which have been shown to share their evolutionary history but are not completely homogeneous because the process of obtaining them is dynamic and continuous (CONABIO, 2024a). However, due to management practices, curiosity, or interest from the farmers, as well as natural biological aspects, landraces can be combined with improved seeds, closely related wild relatives, or materials from neighboring farmers. This generates a wide intra-specific diversity (Bellon, 1996; Casañas *et al.*, 2017). Most studies have documented this interaction between different types of seeds and their management, selection, and conservation in maize (Bellón, 1996). However, this is not well understood for other crops important to Mexican food and agriculture, such as beans, squash, and chili peppers, among others. Therefore, landraces are fundamental for generating more inter- and intra-specific diversity, serving as the basis for food production for self-consumption. Moreover, they are adapted to conditions of biotic and abiotic stress that improved seeds may not be able to tolerate (Almekinders and Louwaars, 1999; Hernández-Rodríguez *et al.*, 2020). Farmers produce their own landraces for each agricultural cycle (CONABIO, 2024a; Hernández-Sandoval *et al.*, 2023). According to INEGI (2019), the use of landraces in Mexico represents 61.77%.

It is considered that there is no legal framework for the conservation, strengthening, legal protection of seeds, and the rights of farmers who have generated this diversity for thousands of years (Domínguez-Martínez *et al.*, 2019; Escárraga-Torres *et al.*, 2021). Exceptions are made for native maize, which, according to Escárraga-Torres *et al.* (2021), can be seen as a milestone with the Federal Law for the Promotion and Protection of Native Maize. This law aims to consider the activities of production, commercialization, and consumption of native maize as a cultural manifestation and an obligation of the State to guarantee the right to nutritious, sufficient, and quality food, and to define

the mechanisms for the protection and promotion of maize (DOF, 2020a). Some states have similar laws, such as Michoacán, with the Law for the Promotion and Protection of Creole Maize as the Food Heritage of the State of Michoacán de Ocampo (Official State Gazette, 2011), and Tlaxcala with the Law for the Promotion and Protection of Maize as Original Heritage, in Constant Diversification, and Food Heritage for the State of Tlaxcala (Official State Gazette of Tlaxcala, 2011). Similarly, due to its importance in food and other uses, it is necessary to document the wide intra-specific diversity of the seeds of crops introduced in Mexico, a situation similar to that occurring worldwide (Pilling *et al.*, 2020). For example, Hernández-Sandoval *et al.* (2023) identified five types of broad beans with different common names and morphologies in indigenous communities of Amealco, Querétaro. These are diversifying through the management of the farmers. Therefore, it is very likely that seed populations of introduced species may disappear due to environmental, social, or economic factors without being documented. Additionally, Mexico does not have official statistics on the production of intra-specific diversity of any crop (SIAP, 2023). For example, there are no statistics on maize production by race.

In Mexico, it is possible to produce certified seed (a category explained in the following section) from landraces, as long as the variety as registered in the National Catalogue of Plant Varieties (CNVV). Among the necessary requirements is morphological characterization based on the technical guidelines for varietal description outlined in the Federal Law of Plant Varieties, later referred to as the Law of Plant Varieties (Domínguez-Martínez *et al.*, 2019; SNICS, 2024d). Therefore, in Mexico, according to the legal framework, a Mexican farmer can plant landraces with the certified, approved, and declared categories considered in the Seed Law (DOF, 2018), which has not yet been fully implemented in the country. This is because it is generally small farmers who possess such seeds and lack the technical capacities and infrastructure to carry out the registration. To encourage the registration of native varieties, public agricultural research institutions must advise and support the producers to achieve this registration.

It should be noted that common-use varieties have been registered in the CNVV with the aim of documenting the inter- and intra-specific diversity of native crops (González-Santos *et al.*, 2015). Additionally, having records of the origin of the variety helps prevent potential cases of piracy (Domínguez-Martínez *et al.*, 2019). Notable registrations include 61 common-use varieties of nopal, 30 of marigold (*Tagetes* L.), 30 of xoconostle (*Opuntia* spp.), and 10 of pitaya (*Stenocereus* spp.), among others (SNICS, 2024b) (Table 1). However, given the diversity that exists in Mexico, this is considered not to be representative.

Improved Seed

Improved seed refers to seed obtained through any method of genetic improvement. These seeds are defined as new, homogeneous, stable, and with distinctive characteristics. They are generated for specific conditions of altitude, soil, water availability, nutrients, and uses (Bellon, 1996; Zeven, 1999; Casañas *et al.*, 2017; Domínguez-Martínez *et al.*, 2019). Generally, this seed is used in irrigated areas and areas with good rainfall, with farmers who have financial resources, often associated with large land holdings and agro-industrial crops such as sorghum, barley, and wheat. The main regions using this seed

Table 1. Common-Use Varieties Registered in the National Catalogue of Plant Varieties by SNICS. Prepared with data from SNICS.

Crop	Number of varieties
Agave (*Agave* spp.)	12
Cempoalxóchitl (*Tagetes* L.)	30
Chayote [*Sechium edule* (Jacq.) Sw.]	10
Dahlia (*Dahlia* Cav.)	6
Guava (*Psidium guajava* L.)	5
Nopal (*Opuntia* spp.)	61
Poinsettia (*Euphorbia pulcherrima* Willd. ex Klotzsch)	3
Pitahaya [*Hylocereus undatus* (Haw.) Britton & Rose]	2
Pitaya (*Stenocereus* spp.)	10
Hawthorn (*Crataegus* L.)	5
Tigridia [*Tigridia pavonia* (L. f.) Redouté]	9
Echeveria (*E. gibbiflora* DC. y *E. pallida* E. Walther)	4
Xoconostle (*Opuntia* spp.)	30

in Mexico are Sinaloa, Jalisco, Tamaulipas, certain regions of the Highlands, Bajío, and the Altiplano (DOF, 2020b). According to INEGI (2019), 24.88% of the seed planted in Mexico is certified improved seed, while the rest is landraces.

SNICS is responsible for ensuring compliance with the requirements established in the Rules for Seed Qualification, specific to each crop, from field establishment, storage, and commercialization (Córdova-Téllez *et al.*, 2017; Domínguez-Martínez *et al.*, 2019). Quality parameters are related to physiological, phytosanitary, genetic, and physical quality. Physiological quality refers to the seed's ability to produce viable propagation material; phytosanitary quality refers to the assessment and determination of the presence or absence of pathogenic organisms in the seed lot; genetic quality refers to the genetic identity of the seed; and finally, physical quality refers to the measure of the seed's physical purity (DOF, 2018).

SNICS has 33 rules for seed qualification (Table 2) (SNICS, 2024c). Therefore, the necessary instruments are available only to certify seeds of these crops. If there is interest in another crop, it is first necessary to define the technical rule for seed qualification according to the "Official Mexican Standard NOM-001-SAG/FITO, 2015, which establishes the criteria, procedures, and specifications for the preparation of guides for varietal description and rules for determining the quality of seeds for planting" (DOF, 2015).

The qualification rules mentioned in Table 2 highlight that there is no rule for the qualification of seeds for certain crops that Mexico exports, such as: tomato (*Solanum lycopersicum*), berries (various species), broccoli (*Brassica oleracea*), lemon (*Citrus*×*limon*), lettuce (*Lactuca sativa*), cucumber (*Cucumis sativus*), and asparagus (*Asparagus officinalis*) (SIAP, 2023). This aligns with the National Seed Program published in the DOF (2020b), which states that most vegetable seeds are imported. It is considered necessary

Table 2. Rules for Seed Qualification, in accordance with international standards issued by SNICS.

Cereals	Forage	Fruit	Vegetables	Industrial	Ornamental
Oats (*Avena sativa* L.)	Alfalfa	Avocado	Garlic	Sesame	Chrysanthemum
rice (*Oryza sativa* L.)	Pastures (11 species)	Coffee	Pumpkin	Cotton	Rose
Cereals (oats, barley, rye, wheat and triticale	Sorghum	Coconut tre	Onio	Peanut	
Chickpea		Nopal	Pepper	Canola	
Corn		Papaya	Potato	safflower	
Millet			Husk tomato	Bean	
Wheat				Sunflower	
				Faba bean	
				Castorbean	
				Soja	

to conduct a specific study of vegetable seeds to understand the mechanisms that farmers use for planting. The ornamental sector is also relevant for Mexico, as approximately 14,936 hectares are dedicated to ornamental horticulture, with a production value of $5,192,931,852.89. The most produced species are rose (*Rosa* spp.), sunflower (*Helianthus annuus*), gerbera (*Gerbera jamesonii*), and lily (*Lilium candidum*). In the case of roses, in 2022 they were cultivated in 10 states, with a production of 10 million 37 thousand dozen (SIAP, 2023). However, technical rules for the qualification of seeds are only available for roses and chrysanthemums, and ornamental seeds are still not certified in Mexico (SNICS, 2024). In the opinion of the authors of this article, it is likely that, by integrating the seed certification process, cases of illicit use of varieties with national and international breeder's certificates will decrease.

Based on historical records from 1988 to 2023, the production of certified seed has not exceeded 350,000 tons. The years with the highest production of certified seed were 1989 with 340,000 tons, 2008 with 300,000 tons, and 2014 with 325,000 tons. Some of the factors that have influenced production include the disappearance of Seed National Producer (Productora Nacional de Semillas - PRONASE), the involvement of the private sector, and government programs that give preference to certified seeds, among others (Domínguez-Martínez *et al.*, 2019; SNICS, 2019). Additionally, not all crops that have a technical rule for seed qualification are certified. For example, chrysanthemums (*Chrysanthemum coronarium*), roses (*Rosa* spp.), castor beans (*Ricinus communis*), and squash (*Cucurbita* spp.) can be produced in the declared category. On average, seeds from 22 crops are certified (Domínguez-Martínez *et al.*, 2019; Córdova-Téllez *et al.*, 2018). For instance, during the spring-summer 2023 agricultural cycle, the production of certified seed was 47,068.46 tons from 142 varieties including rice, oats, peanuts, coffee, barley, beans, corn, Brachiaria grass, sorghum, soybeans, and triticale (SNICS, 2024b).

The seed law also includes the category of habilitated seed, which farmers can use for planting. It is defined in the law as "seed whose propagation or production process has not been verified, or if verified, does not fully meet any of the genetic, physical, physiological,

or phytosanitary quality characteristics, with tolerance parameters defined in the specific Rules for Seed Qualification of each crop" (DOF, 2018). Another type of seed available to Mexican farmers for planting improved seeds is the declared category. In this category, the characteristics are not evaluated by SNICS; they are provided directly by the producer or seller on the label with the requirements established in Article 33 of the Seed Law. This means that the label must include information such as the variety name, germination percentage, and purity percentage (DOF, 2018; Domínguez-Martínez *et al.*, 2019).

Genetically Modified Seed

According to INEGI (2019), only 0.18% of the seeds planted in Mexico are genetically modified, with cotton and soybeans being the primary species. The use of this type of seed is regulated by the Law on Biosafety of Genetically Modified Organisms (DOF, 2022) and undergoes a series of processes and tests before it can be used by farmers. No new permits have been issued since 2019; prior to that year, permits were authorized for cotton, wheat, alfalfa, Mexican lime, Valencia sweet orange, beans, soybeans, and corn (CIBIOGEM, 2024). From 2018 to 2024, there has been ongoing discussion about the possibility of banning the use of genetically modified organisms in Mexico, specifically for corn.

Distribution of Seeds in Different Seed Systems

Authors such as Domínguez-Martínez *et al.* (2019), Torres *et al.* (2014), and DOF (2022b), mention the types of seeds used in two main systems: the Local Seed System (SLS) and the Formal Seed System (FSS), which are explained below.

Local Seed System

In the Local Seed System (LSS), landraces are generally used in all the hybridizations (Castillo and Goodman, 1995; Casañas *et al.*, 2017). In this system, within the same cycle and in the same area, seeds are obtained for the next planting cycle, while the grain is used for self-consumption or commercialization. As a result, the farmer is self-sufficient in seed production (Almekinders and Louwaars, 1999). Additionally, seeds are selected according to needs and uses. Exchange and access occur through customs and traditions. In the SLS, seeds can be inherited from parents, borrowed, purchased, or given by neighbors or family members. In fact, it is possible for farmers to obtain seeds at no cost (Bellon, 1996; Thijssen *et al.*, 2008). It is estimated that this system in Mexico represents between 70 to 80% (INEGI, 2019). However, it faces several issues, such as some native varieties having characteristics that represent disadvantages for farmers. For example, low yield, susceptibility to lodging, long cycles, among others. These issues should be addressed with participatory plant breeding programs in the short, medium, and long term, according to the specific needs of the regions. Sustainable alternatives for the storage of seeds and grains are also needed to prevent loss or the use of toxic chemicals. Additionally, there are social and economic factors leading to the decline of this system, such as the aging of farmers without generational replacement, lack of interest from young people in agriculture, migration, and changes in family activity organization (Louwaars & Simon de Boef, 2013). For example, in the Otomi communities of Amealco, Querétaro, it is noted that what was

once a family-wide activity is now maintained only by elderly individuals (Hernández-Sandoval *et al.*, 2023).

It should be considered that the Local Seed System (LSS) consists of various types of agroecosystems present in Mexico. CONABIO (2024b) identifies at least 30 different types, such as milpas, terraces, chinampas, family gardens, and backyards. However, a large part of the country remains undocumented. In these, different seed sources, management methods, conservation types, and even species with varying degrees of domestication are used. It is agreed with Escárraga-Torres *et al.* (2021) that the LSS and its seeds have been little studied, with significant gaps in the legal framework. This coincides with Bautista-Ramírez *et al.* (2022), who mention that research on seeds is mainly focused on physiological, sanitary, and physical quality, with few studies related to conservation, management, selection, and diversity.

Formal Seed System

The FSS in Mexico is primarily supported by the Seed Law and the Plant Variety Law. In this system, improved seeds are used, which can either undergo the certification process (certified seed) or not (declared seed) (Domínguez-Martínez *et al.*, 2019). It is likely that 0.8% of transgenic seed, as indicated by INEGI (2019), is used in this system. The FSS is associated with specific regions of the country and is used for monoculture production. This system depends on the LSS to obtain the seed from which genetic improvement programs are carried out, as described by Almekinders and Louwaars (1999). The disadvantage is that farmers become dependent on this input, having to purchase seed for each planting cycle (Thijssen *et al.*, 2008). Additionally, the FSS has drawbacks, such as weak or nonexistent cultural ties with consumers. Its cultivation requires large energy investments, as well as specific distribution methods (Casañas *et al.*, 2017; Zeven, 1999). The FSS faces difficulties in meeting the needs of small farmers with limited resources and in marginal conditions because these farmers usually require small quantities, which represents a challenge in seed distribution (Zeven, 1999; Bellon, 1996; Thijssen *et al.*, 2008). Additionally, the demand for seeds varies significantly between agricultural cycles, depending on the production of the previous season and the economic resources available to farmers (Hernández-Rodríguez *et al.*, 2020).

Coexistence of Seed Systems in Mexico

In Mexico, both the Local Seed System (LSS) and the Formal Seed System (FSS) coexist, with the former being predominant. This dominance may be attributed to the country's climatic, edaphic, and geophysical heterogeneity (Llorente and Ocegueda, 2008). Additionally, the cultural diversity with the presence of 62 indigenous groups contributes to a wide range of ecological niches where various local varieties have evolved and adapted. This has led to Mexico being the center of domestication for 251 species (Clement *et al.*, 2021), as well as the different methods of management, selection, and conservation primarily implemented in the LSS. In contrast, the FSS is limited to specific areas of the country as previously mentioned. However, most federal and state government efforts focus on providing improved seeds to farmers.

The latter may not adapt to the conditions faced by farmers in the LSS and could lead to the loss of landraces due to substitution. The National Seed Program (DOF, 2020b) proposed increasing the use of improved seeds in the country, but it is considered that this should not be generalized. Priorities should be defined; for example, it may be a priority for export vegetables and the ornamental sector. However, in the SLS, it is necessary to promote the use of landraces and preserve traditional practices of selection, management, conservation, and exchange that have led to the noted intra-specific diversity. Both systems are considered important for ensuring food production, but they have specific seed requirements and face different issues that need to be addressed separately.

CONCLUSIONS

In Mexico, farmers primarily plant landraces and, to a lesser extent, improved seeds, which can be certified, authorized, or declared according to the seed law. Landraces are generally used in the Local Seed System, while improved seeds are used in the Formal Seed System. Therefore, there is a coexistence of systems. Each presents different needs in terms of seed type and faces specific ecological, social, economic issues, and gaps in the legal framework. Thus, differentiated public policies are required for both types of seed systems to ensure food security and sovereignty for Mexicans.

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