Article

Preferences and perceptions associated with improved maize seed according to producers from Veracruz Central, Mexico

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Abstract

In order to know the variables that motivate the decision to plant improved seeds of INIFAP origin, 100 questionnaires were applied to corn producers in eight municipalities of Central Veracruz during 2015. The socioeconomic variables associated with planting decisions were: closeness of the point of sale (r= 0.9451) and knows (r) the seeds of the INIFAP (r= 0.9199). The most important technical variable was: to recognize advantages over creole seeds (r= 0.6162). The most important perceptual characteristics ($p< 0.0001$) that motivate the seed of INIFAP seed were: tortilla flavor (r= 0.558), and aptitude for nixtamalization (r= 0.4369). The INIFAP was positioned (78%) in the regional market with materials H-520 and VS-536, whose technical advantage is the grain yield, compared with native materials. The perceptual characteristics that the interviewees perceive in the H-520 and that favor their sowing are, good taste of tortilla (r= 0.4117), apt for nixtamalization (r= 0.4115), good consistency (r= 0.2583) and yield/mass and tortilla (r= 0.2366). The variety VS-536, is perceived with good aroma (r= 0.3315), good cooking time (r= 0.2124), and yiel /mass and tortilla (r= 0.2311). The data indicate that the perceptual characteristics do not favor the INIFAP materials, nor do the current forms of dissemination motivate the sowing of their seeds, and it has been the recommendation of friends and family the most important influence (r= 0.5336).

Keywords: hybrids, perceptual variables, socioeconomic variables, varieties.

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Introduction

Mexico is a center of origin and diversification of corn (*Zea mays* L.), at least 59 races have been classified by their morphological and isoenzymatic characteristics, this diversity is the result of an ancestral practice of genetic improvement of Mesoamerican peoples (Donnet *et al*., 2013). It is considered that the cave of San Marcos, Tehuacan, shows an area of domestication of maize from Teocintle (*Zea mays* ssp. *parviglumis*) for about 9 000 years, (Vielle-Calzada *et al*., 2015). The dispersion of corn in the world occurred mainly after colonization and today, along with wheat and rice, is one of the three most important cereals for human and animal food, and its cultivation is distributed in almost 100 million of hectares in 125 countries in the world (González-Castro *et al*., 2013).

The history of corn integrates the process of nixtamalization, consisting of soaking the grain in hot water to which lime is added, to soften the hard layer of the grain, but its secondary results were more important, since in addition to facilitating grinding, it improved its nutritional qualities, adding calcium, and favoring the health of consumers' bones and teeth (Vargas, 2014). The social importance of corn in Mexico is very high, since it is consumed daily in the form of tortillas (Fernández-Suárez *et al*., 2013), observing an annual per capita consumption of 70 kg (Retes *et al*., 2014) and providing 38.8% of the proteins and 45.2% of the calories, to the Mexican population, especially rural.

The maize is grown in practically the whole Mexican territory and of the total planted area, 80% is seasonal, where more than 2 million small-scale producers plant it mainly for self-consumption, but contribute significantly to food security (Fernández-Suárez *et al*., 2013). Mexico ranks fourth worldwide as a producer of corn, recording a total of 25 480 000 t produced for the 2014-2015 agricultural cycle (González-Merino and Avila-Castañeda, 2014) while in Veracruz, during 2014, 570 318 were planted has, positioning itself as the third producer at the national level (SIAP, 2014). However, the yields are contrasting in different regions of the country, since states such as Sinaloa produce from 7 to 12 t ha^{-1} and in marginal zones it is obtained from 300 to 500 kg ha^{-1} (Espinosa-Calderon *et al*., 2002), on the other hand, Mexico does not cover domestic corn demand and imports up to 10 million tons of grain annually (González-Merino and Ávila-Castañeda, 2014).

In the National Institute of Research, Forestry, Agriculture and Livestock (INIFAP), the production of improved seeds began in 1942, and since 1991 has released 168 improved varieties of maize between hybrids and varieties of free pollination, with the former destined to agronomic provinces of higher quality and the second, to the lower quality (Espinosa-Calderón *et al*., 2009). At the same time, the diffusion of the improved seed is carried out through methods that Larqué-Saavedra *et al*. (2014) called “hard and by vertical transfer”, since they begin with research, testing, validation and transfer, following a model established in 2005, which assigns researchers the task of handling the transfer and research; the diffusion is done through printed publications (books, brochures or triptychs), demonstration events, short courses and talks to producers.

The publications are distributed among the producers and visitors during the demonstration events, but in some way, their impact on the use of improved seeds is unknown. In this regard, several authors also point out the importance of considering sociocultural variables and the preferences of producers, in addition to technical variables, to meet their expectations and facilitate the adoption of improved seeds (Ademiluyi *et al*., 2014; Bonatti *et al*., 2014; Umar *et al*., 2014; Ricker-Gilbert *et al*., 2015).

Considering the above, the objective of this work was to identify the variables, which from the point of view of the producer motivate the decision to plant improved seeds of INIFAP origin in Central Veracruz, Mexico.

Materials and methods

During 2015, we worked in Veracruz Central, in the municipalities with the largest planted area: Cotaxtla, Ignacio of the Llave, The Antigua, Medellin, Puente Nacional, Soledad of Doblado, Tlalixcoyan, and Veracruz, very close to the INIFAP Experimental Field, where genetic improvement of corn is carried out. Around it, small seed producing companies are also located, which buy from INIFAP parents and certified seed, elaborate the materials and supply the grain producers. In 2014 for the area of work, the yields per hectare were from 3.61 to 5.5 t ha^{-1}, and the average planted was 3.5 ha, showing low yields and peasant-type farmers (SIAP, 2014).

The sample of producers was obtained from the lists obtained in corn demonstration events previously carried out, combining the use of respondent-driven sampling (RDS), designed to study hidden or difficult-to-access populations. This method facilitates the study of populations that lack a specific pattern or a fixed spatial location area (Heckathorn, 2007). The RDS begins with the identification of informants who fulfill the function of "seeds" in the lists of demonstrative events, so that their selection is not random, and they recommend others.

The selection is conceived as a Markov process of first order, since the characteristics of a new informant depend theoretically on the characteristics of the informant who has recruited it and the saturation of the sample is obtained when, after the succession of the necessary linkages, achieves stability (Mantecon *et al.*, 2008). The basic principles of sampling consider that informants must be recognized as members of the target population and that their social networks are sufficiently dense to achieve a chain of informants.

For this reason, 100 survey cards were applied to producers of grain corn; open and closed multiple-choice questions were considered to obtain socioeconomic and perceptual information on knowledge and use of improved seeds; the first refers to concrete situations such as: age, schooling, planting maize at the time it responds, knowing the improved seeds, as well as the institutions that produce it, and the forms of dissemination of INIFAP (technical brochures or demonstration plots). The perceptual variables sought to identify the appreciations of the grain producers, in relation to traits and uses of the seed at the moment of consuming it (flavor, aroma, smell) and cultivating it (plant architecture, yields, comparison with seed of other companies and creole varieties), as arguments that justify their decision making.

Perceptual variables are important because they are part of a complex network of continuous interaction between the natural and the social environment. The perception and the point of view of the people form a necessary element for the integral comprehension of a situation, and constitute a social construction, product of the interaction of the material and immaterial dimensions. The information obtained was analyzed with the statistical package XLSTAT v. 2014.5.03 with descriptive statistics, the Kruskal-Wallis test and Spearman's r coefficients.

Results and discussion

As characteristics of the interviewed producers, the most abundant age group was that of 41 to 60 years old, with average schooling of 6 years, similar to the group under 40 years old, and higher than that of the group > 61 years old (Kuskal Wallis <0.05). The area planted was similar by age group, without statistical difference (Kruskal-Wallis, p> 0.05), which has a general average of 3.4 ha, indicating peasant producers.

Most of the interviewees sow seeds of INIFAP origin (51%) or sow them together with other brands (27). Table 1 shows the socioeconomic variables associated with the decision to plant the improved seed.

Table 1. Association of socioeconomic variables with the decision to plant improved seed.

Variables	Percentage	[4]r
Seed generated by the INIFAP	79	-
Age	-	0.1899^{ns}
Scholarship	-	0.1948^{ns}
Size of the home	-	0.1834^{ns}
They prefer to plant improved seed	95	0.432^{**}
Know the seeds generated by INIFAP	77	0.9199^{**}
Sowing improved seed from other brands	42	-0.2817^{*}
[1]Know the forms of dissemination of INIFAP	24	-0.1593^{ns}
Closeness of the point of sale	78	0.9451^{**}
[2]Know Institutions that generate corn seed	65	0.0152^{ns}
[3]Difficulty in accessing official information on improved seeds	77	-0.2329^{*}

[1]= demonstration plots, courses, publications; [2]= Autonomous University of Chapingo, Postgraduate College; [3]= literature, events, technology, advice; [4]= Spearman's r; *= p<.05; **= p<.01; ns= not significant.

The proximity of the point of sale and the fact of knowing (r) the seeds generated by the INIFAP observed strong association with the use of INIFAP seed. This coincides with Ghimire *et al*. (2015), who found that the adoption of new improved rice varieties by farmers in Nepal depended on access to seeds and knowledge of the materials. A medium association was also observed, when farmers prefer to plant improved seed. On the other hand, when the producer sows seed of other brands and has difficulty accessing information on improved seeds, he observes negative correlation coefficients.

It is surprising that producers point out the difficulty of access to information, when they are physically close to the Experimental Field, perhaps the dissemination mechanisms that were thought as a bridge to reach the producers have stopped working. Also, since the grain producers buy the improved materials from the small regional seed producers, who in turn buy the parents from INIFAP, the sale of seeds is the action that makes them the true links between INIFAP and the producer.

The above data allow us to define the need to improve and develop an innovative technology transfer performance to share innovations and create new products, according to the expectations of the users. It is important to consider in seed generation, variables related to market performance, to obtain customer loyalty and market growth. The orientation to the client, with the introduction of new products or participative processes will allow to adapt new materials to the market and anticipate future needs (Camison and Puig, 2014). It is also possible to motivate the use of improved seed through agreements and technical accompaniment with seed producers, as they lead and position the INIFAP seed.

For example, in Nepal, Ghimire *et al*. (2015) it was found that the diffusion and adoption of innovations in rice producers was favored with participatory methods and technical accompaniment. Similarly, in Kenya, Ouma *et al*. (2014) and in South Africa, Sibanda *et al*. (2016), found that the determinants of adoption and the intensity of use of improved varieties of corn, is associated with technical support and distance to the input markets.

The impact of the media on the sowing of improved seeds showed that the forms of dissemination of INIFAP are not the most important (22%) and the recommendations of agrochemical stores and municipalities (16%) participate, but the networks social (recommendation of friends or relatives) were the most important means in percentage (40%) and statistically more important (Table 2).

Table 2. Association of the media with the decision to sow maize seed INIFAP.

Forms of diffusion	(%)	[1]r
Producers who sow seed INIFAP	78	-
Diffusion INIFAP	22	0.2821[*]
Recommendation of friends and family (social networks)	40	0.5336[**]
Others (recommendation of agrochemical store and municipal governments)	16	0.1001[ns]

[1]= r de Spearman; [*]= $p< .05$; [**]= $p< .01$; [ns]= not significant.

This coincides with the findings of Bonatti *et al*. (2014), who in a study conducted in San Luis, Argentina, identified that in addition to public and private institutions, producers resort to other channels of dissemination such as family and neighbor social networks. Lopes *et al*. (2015) indicate that in East Timor, the probability of adopting a new variety is strongly related to the social networks of farmers. The above points out that forms of social organization can be used for the development of seed production groups and for disseminating technology.

In Oaxaca, Mexico, Orozco-Ramírez *et al*. (2014), when analyzing the use of varieties by indigenous farmers, they found that the networks of exchange of seeds and belonging to the ethnic group were decisive in their adoption and distribution. In this case, the dissemination methods of INIFAP are weakly associated with the planting decision. The results coincide with those obtained by Larqué-Saavedra *et al*. (2014), in a similar analysis on the cultivation of wheat, where the statistical analysis of the "decision tree" to determine the existence of any significant relationship between attendance at courses, demonstrations, advice and publications of INIFAP, with the category of the Seed in use, did not show any significant relationship, it is assumed that the use of seed certified by the producers is due to the fact that the buyers demand higher quality. Rendon-Medel *et al*. (2015) in adoption studies, pointed out that the main restriction in the extension processes is in the use of the demonstrative, non-participative component.

Table 3 shows the technical characteristics that favor the use of INIFAP seed, and that could be key to articulate the generation of seed with the demands of producers.

Table 3. Technical characteristics associated with the decision to sow seeds of INIFAP origin.

Variables	Porcentaje	[1]r
Seed of origin INIFAP	78	-
Advantages over the seeds of other companies	27	0.1835^{ns}
Recognize advantages over creole seeds	76	0.6162^{**}
Good plant architecture	56	0.3938^{**}
Good yield per hectare	56	0.3067^{**}
Better price than creole corn	49	0.1761^{ns}
Better selling than creole corn	53	0.1745^{ns}

[1]= r de Spearman; $^{*}= p< .05$; $^{**}= p< .01$; ^{ns}= not significant.

According to this, a large part of the producers recognize that the INIFAP seed has advantages over the native maize, showing good correlation with the planting decision, while good plant architecture and good yield per hectare, although they are perceptual variables and come from the empirical observation of the respondents, stand out as technical variables with median association. Good yield is a special feature of the INIFAP seeds, a trait that makes the production of seed and grain profitable, also important for Kalinda *et al*. (2014) in the adoption of improved maize seed varieties in Zambia, since they favor income expectations.

The 27% of respondents, find no difference between the INIFAP seeds, compared with other brands, or price or sales competitiveness, compared to the creole. Although there are arguments that favor the regional positioning of INIFAP seeds, yields are decisive. In terms of positioning, the INIFAP seeds have impacted a farmer-type producer with a traditional production approach, as Luna *et al*. (2012), they are not important clients for large transnational seed companies.

These arguments constitute a good reason to favor the competitiveness of peasant production and rural development in the areas of impact. Considering the type of producer that attends the INIFAP, it also shows that the decision making of the producer moves away from the paradigm of economic rationality, and that even some would qualify as irrational (they move away from the parameters of *homus economicus*), because they do not consider the parameters of efficiency and economic benefit, reiterating the need to strengthen support to this sector by the INIFAP. This is very important, since even using milled seed, when producers prefer to maintain traditional knowledge, they incur certain limitations to initiate efficient and effective production processes, and their transaction costs rise, decreasing profitability (Amaya and Lanuza, (2013).

At this point, the creation of new knowledge transfer spaces would not only strengthen the corn sector that is served, but also make producers more competitive to face the market and new technological challenges.

Among the perceptual characteristics that favor the use of the improved INIFAP seed, the flavor of the tortilla and the aptitude for nixtamalization stand out, which are determining factors in the regional use of the seed of INIFAP origin (Table 4).

Table 4. Association of perceptual characteristics with the seed of origin INIFAP.

Qualities	Percentage	[1]r
NIFAP Seed	78	-
Warehouse life	31	0.0802^{ns}
Tortilla flavor	86	0.558^{**}
Tortilla aroma	76	0.3281^{**}
Tortilla color	74	0.318^{*}
Consistency	58	0.1582^{ns}
Grain hardness	40	0.2205^{*}
Suitability for nixtamalization	79	0.4369^{**}
Cooking time	39	0.0096^{ns}
Performance / dough and tortilla	54	0.2138^{*}

[1=] r de Spearman; $^{*}= p< .05$; $^{**}= p< .01$; ^{ns}= not significannt.

Flavor of the tortilla and aptitude for nixtamalization, obtained good and medium statistical associations respects, while aroma and color of tortilla, as well as grain hardness and yield for dough and tortilla showed medium to low associations (Table 4). It is worth adding that the characteristics indicated show the preferences of the producers based on self-consumption. The ability to nixtamalization not only improves the taste of the tortilla, according to Vela (2011), improves the nutritional value of corn and increases in the body the concentration of calcium 20%, phosphorus 15% and iron 37%. The aroma according to the producers, is an important quality when making the tortilla and the color white or cream is preferred to other colors, because in Mexico the

colors are associated with specific cultural circumstances, for example, yellow corn is considered as food for animals and red, purple or black colored corn, to traditional festivities such as the day of the dead, easter and patron saint festivities (Cuevas-Mejía, 2014).

The impact of perceptual characteristics on the use of improved seeds by producers is highlighted, as in Kenya, Timu *et al*. (2014), found that farmers perceived differentiated attributes in the seed used, because in the improved varieties stood out characteristics that favor production and marketing, while in the premises, attributes of consumption (flavor and ease of cooking). Sibiya *et al*. (2013) mentioned that it highlighted a perceptual characteristic in the use of maize varieties in South Africa, and it was the white color of the grain; likewise, in Zimbabwe, Machida *et al*. (2014), when exploring preferences for corn varieties, found that the "Hickory King" variety was used only for domestic consumption due to its flavor, white color, size, hardness and high density [of the grain]. The foregoing can be said that the importance of the perceptual variables in the decision of sowing and the consumption of the product are associated with a type of peasant producer that does not seek the maximization of income via cost reduction, but the direct consumption of the grain.

The INIFAP seed is positioned in 78% of the regional market, only with the materials H-520 and VS-536, which have advantages in relation to the creoles, according to the producers (Table 5).

Table 5. Perceptual characteristics associated with materials H-520 and VS-536.

Qualities	[1]r	
	H-520	VS-536
Warehouse life	0.0667^{ns}	-0.0326^{ns}
Tortilla flavor	0.4117^{**}	0.189
Tortilla aroma	0.1856^{ns}	0.3315^{**}
Tortilla color	0.1017	0.159^{ns}
Dough consistency	0.2583^{**}	0.0295^{ns}
Hardness	0.1747^{ns}	-0.1106^{ns}
Suitable for nixtamalization	0.4115^{*}	0.1777^{ns}
Cooking time	-0.0679^{ns}	0.2124^{*}
Performance / dough and tortilla	0.2366^{*}	0.2311^{*}

[1]= r de Spearman; *= $p< .05$; **= $p< .01$: ^{ns}= no significativo.

The H-520 is used for the good flavor of the tortilla and its aptitude for nixtamalization, with coefficients of medium value, the good consistency of mass and yield/mass and tortilla, obtained weak associations. The VS-536 material is associated with good tortilla aroma, cooking time and yield/mass and tortilla, all variables with low correlation coefficients. The data indicate that the producers differentiate the seed and prioritize the importance of self-consumption, with culinary perceptions. In this regard, Lunduka *et al*. (2012) found that the specific attributes of the different maize varieties in Malawi are an important influence in their use and local varieties of maize are popular for a series of favorable characteristics for processing, consumption, storage, the

proportion of flour achieved, and the taste. In South Africa, the characteristics of corn preferred by farmers are the landraces, due to its flavor, the possibility of saving seed for planting and yield (Sibiya *et al*., 2013).

Finally, policies that increase the productivity of maize are very important, but more important, those that contribute to reduce restrictions on the adoption of farmers because they are the ones that can improve household food security (Ouma *et al*., 2014) and they are the diversity of traits, beyond grain production, such as the attributes of production, transformation and consumption, valued by farmers and mentioned by other authors; thus, in the countries south of the Sahara, Africa, the main barriers to the adoption of drought-tolerant corn were the lack of availability of improved seeds, inadequate information, lack of resources, high seed prices, and attributes perceived in the different varieties (Fisher *et al*., 2015), while in Malawi, a study by Ricker-Gilbert *et al*. (2015) on the adoption of improved maize varieties in Malawi suggests that greater attention should be given to post-harvest management (management and use of seed), when seeking to promote the adoption of improved varieties.

Conclusions

The most important socioeconomic variables associated with the decision of the producer to plant INIFAP seed were the proximity of the place of purchase and know the seeds of INIFAP and, to a lesser degree, the preference for sowing improved seed instead of creole. The forms of dissemination of INIFAP are not important to motivate the producer to plant the INIFAP seed, with social networks being more relevant through the recommendation of friends and family. The most important technical variables associated with the planting decision were: recognizing advantages over native maize and plant architecture and good yields per hectare with less importance. The perceptual characteristics that motivate the producer to plant improved seed were: taste of the tortilla and aptitude for nixtamalization, showing the importance of self-consumption in peasant production, so attention must be paid to attributes of a perceptual nature in addition to yield, to increase adoption and meet the demands of farmers and the market.

The regional positioning of the INIFAP seed is defined only by the materials H-520 and VS-536. The outstanding characteristics according to the producers are good taste of tortilla and aptitude for nixtamalization of the H-520 and the aroma of the tortillas for VS-536. Given that the expectations of the grain producers seem not to be satisfied with the characteristics of the seed produced by the INIFAP and given that the current forms of dissemination of the institution have little impact on potential buyers due to the difficulty of accessing the information , it is necessary to generate new ways of disseminating and transferring improved seeds through inclusive and participatory mechanisms with small and medium-sized seed producers and grain producers, to preserve the regional market, for which they would have to compete with large companies private or transnational.

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