Agricultura, Sociedad y Desarrollo

TYPOLOGY OF DRY CHILI PEPPER PRODUCERS IN ZACATECAS, MEXICO

Blanca Isabel **Sánchez-Toledano**[1], Mercedes **Borja-Bravo**[2*], Sergio **Arellano-Arciniega**[2]

[1]Campo Experimental Zacatecas, Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias. Km. 24.5 carretera Zacatecas-Fresnillo, Calera de Víctor Rosales, Zacatecas, México. 98500
[2]Campo Experimental Pabellón, Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias. Km. [3]2.5 carretera Aguascalientes-Zacatecas, Pabellón de Arteaga, Aguascalientes, México. 20670.
*Corresponding author: borja.mercedes@inifap.gob.mx

ABSTRACT

Chili pepper is a vegetable of commercial importance that is cultivated globally. In Mexico, the state of Zacatecas is the first place in surface sown for the production of dry chili pepper, and the number of farmers devoted to this crop highlights its socioeconomic importance. The characterization of farmers according to their management, productive, social and economic variables allow to understand the technologies used and decision-making at the level of production unit to develop differentiated policies by production system. Therefore, in this study the objective was to analyze and identify the types of dry chili pepper farmers in Zacatecas. The data were gathered through a survey with 66 dry chili pepper farmers in Zacatecas, Mexico, and they were analyzed through conglomerates, one-factor analysis of variance, multidimensional scaling and correspondence analysis. The results suggest three types of farmers: 1) traditional, 2) intermediate, and 3) entrepreneurial. Of the farmers, 78.7% were found in the last category, which explains the competitiveness of the crop in face of other product systems and other states of the Mexican Republic.

Keywords: *Capsicum anuum*, characterization, competitiveness.

INTRODUCTION

Chili pepper is a vegetable of commercial importance that is grown globally, since according to FAO (2022), the production of fresh and dry chili peppers was 40.3 million tons in 2020, of which 88.76% corresponded to the fresh product for consumption. The national cultivated surface ranges around 149,693 ha, of which more than 90% are irrigated (SIAP, 2022).

Zacatecas occupies the first place in the country in surface sown for dry chili pepper production and the main producing municipalities in the state are Fresnillo, Villa de Cos, Calera, Guadalupe and Pánuco. In the year 2021, the surface cultivated to obtain dry chili pepper was 29,932 ha with a production value of $2,889,665 thousand pesos MX (SIAP, 2022). The crop generates more than 4 million direct jobs and its importance lies in the consumption by Mexican people, which is of 17.2 kilograms per person per year (SIAP, 2020). Sánchez-Toledano *et al*. (2022) mention that the production chain of dry chili pepper in Zacatecas was located in a position of sustenance due to its high socioeconomic importance and competitiveness; however, to hold this position it is necessary to implement strategic projects focused on increasing the production value. However, the agriculture and livestock policies implemented consider farmers as homogeneous subjects, generating non-differentiated support and technical assistance programs that are far from the reality

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(Guillem *et al.*, 2015). Therefore, the characterization of farmers based on management, productive, social and economic variables allows understanding production technologies, on the one hand; and on the other, it provides information for decision making at the level of production unit, for the development of policies differentiated by types of production systems (Betancourt *et al.,* 2005; Borja *et al.,* 2018).

Typology is a construction or grouping of producers, plantations or farms that present a specific similarity or dissimilarity in some characteristics (Paz, 1999). This concept is not new, for since the 1960s the Commission on Agricultural Typology of the International Geographical Union was established with the aim of establishing criteria, methods and techniques to typify agricultural production systems globally (Kostrowicki, 1977). In Mexico, the Economic Commission for Latin America and the Caribbean (ECLAC) attempted to identify differences between peasant and entrepreneurial agriculture as a principle for the State to formulate public policies for rural development, considering the heterogeneity of producers (Schejtman, 1982). Thus, different countries have identified ways to typify their agriculture and livestock farmers, which has served as instrument to optimize the allotment of public resources. Likewise, the importance of the typology lies in the programs and actions for sustainable rural development executed by the Federal Government, which specify and recognize the socioeconomic and cultural heterogeneity of the subjects and, therefore, take into account the different types of producers (Torres, 2013). Specifically, Borja-Bravo *et al*. (2016) highlight that this type of analysis is important for the following reasons: a) to allow the design of federal and state policies based on the socioeconomic characteristics of different groups of farmers; b) to focalize government backing towards those groups of farmers that need it most, or else for those where a faster impact of the policy is expected; and c) to identify the leading competitive farmers that can serve as an example to improve the standard of living of other producers.

There are several studies on the typification of farmers in Mexico, such as the bean production systems in Zacatecas (Reyes *et al.,* 2009), peach in Estado de México (Larqué *et al.,* 2009), grape in Aguascalientes (Borja-Bravo *et al.,* 2016), corn in Chiapas (Sánchez-Toledano *et al.,* 2018; Martínez *et al*., 2020), guava (Borja *et al.*, 2018), and citruses (Pantoja and Servín, 2022), to mention a few. Derived from the importance of dry chili pepper farming in the state of Zacatecas, the objective of this study was to analyze and identify the types of dry chili pepper farmers in Zacatecas, Mexico, with the aim of obtaining information to support the design of public policies for specific strata of producers.

METHODOLOGY

Study area

The study was carried out in the potential production zone and was stratified by surface, production, yield and rural price of chili pepper in the state of Zacatecas. Consequently, the municipalities surveyed were: Calera de Víctor Rosales, Noria de Ángeles, Guadalupe, Pánuco, Villa Hidalgo, Vetagrande and Zacatecas (Figure 1). The area of study presents

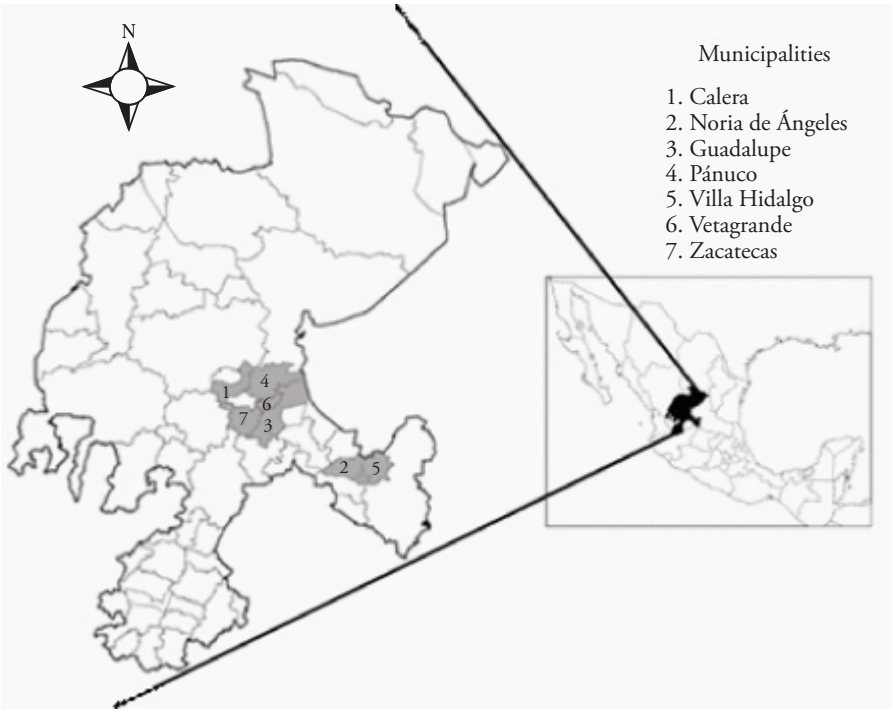

Figure 1. Municipalities that form the study area.

altitudes in a range of 2,000 to 2,500 masl, with semi-dry and temperate cold climates, mean annual rainfall of 510 mm and minimum average temperature of 3°C and maximum average of 30°C (INAFED, 2010; INEGI, 2022).

Sample size

The information was gathered through a personalized survey conducted with a sample of 66 dry chili pepper farmers according to the registry of producers in the state of Zacatecas. The size of the sample was calculated based on the formula of finite populations with a significance level (α) of 5% (Z=1.96) and a maximum error level of 11.82 % (Sánchez *et al.,* 2013). Prior to the survey application, pilot tests were carried out to ensure the clarity of the questions and to minimize errors (n=10). The survey was conducted between September and November of 2021, and the participating individuals did not receive any economic remuneration.

Data collection

The variables included in the questionnaire were grouped following the classification by Knowler and Bradshaw (2007) as described next: age, education, members of the household, access to services, land tenure, seniority as farmer, surface planted, technical assistance, organization, infrastructure available, production cost, income, perception of

risk, credit or agricultural insurance, commercialization, and attributes of the fruit that they consider to be important for its trade.

Information analysis

With the information obtained, a database was built with twenty-five variables, of which fourteen showed significant statistical differences and were used for the typification of dry chili pepper farmers (Table 1).

The data were analyzed through a conglomerate analysis (CA), which was conducted in two stages; first, a hierarchical cluster analysis was made to graphically detect the number of groups through Ward's criterion (1963) and then a k-means cluster analysis was conducted with the objective of refining the groups by socioeconomic variables, lifestyles and relevant attributes (Pérez, 2004). With the data obtained, a one-factor analysis of variance was carried out, which allowed the study of the differences of each segment.

In addition, the most important attributes of chili pepper for farmers were measured in a scale of five points, where the producer chose the level of importance assigned to each attribute at the time of selecting a fruit (1: "without importance", 2: "of little importance", 3: "moderately important", 4: "important", 5: "very important"). This was analyzed through multidimensional scaling (MDS). The purpose of MDS is transforming the judgements of the consumer of similarity or dissimilarity in distances represented in a multidimensional space (Hair *et al.,* 1998). The form of commercialization was studied through a correspondence analysis. The analyses mentioned were carried out with the statistical analysis software SPSS Statistics 21 (IBM, 2022).

Table 1. Variables used to typify farmers.

Variable	Name
X_1	Age
X_2	Gender
X_3	Education
X_4	Years of being devoted to chili pepper farming
X_5	Members in the family
X_6	Land tenure
X_7	Total hectares
X_8	Surface of dry chili pepper
X_9	Yield
X_{10}	Total cost
X_{11}	Price
X_{12}	Benefit-cost ratio
X_{13}	Type of market
X_{14}	Type of irrigation

RESULTS

Description of the sample

The farmers surveyed were 40 to 60 years old, 97% were men and only 3% women. Regarding education, 13.6% did not have studies, 27.2% studied primary school, 31.5% secondary, 15.5% high school, and only 12.2% had university studies. The land tenure was *ejido* in 85% of the cases and for the remaining 15% it was smallholding; on average they have been cultivating chili pepper for 10 to 20 years. Of the farmers, 80% cultivated the guajillo variety, and other varieties that are planted in the state are pasilla, morrón, poblano, ancho, mulato, chile de árbol and puya. The farmers surveyed do not belong to any farmers' organization in 95% of the cases. In addition, 68% of the farmers received some technical assistance and have some credit (61%), primarily for the purchase of inputs (15%) and payment of labor (15%). Of the farmers, 65% mentioned that they have received some backing from the state government.

Differentiation of dry chili pepper farmers according to their socioeconomic characteristics

Based on the results obtained in the hierarchical CA, three segments of producers could be identified which were called: traditional (cluster A), intermediate (cluster B), and entrepreneurial (cluster C) (Figure 2) with significant differences (Wilk's Lambda; $p \leq 0.001$).

The first group from the sample was identified as "traditional" and it represented 7.6% of the sample. The second group, "intermediate", was formed by 13.7% of the sample; and the third group, called "entrepreneurial", was the one of highest percentage (78.7 %) (Figure 2).

Characterization of the groups of dry chili pepper farmers

To be able to corroborate the differences between the groups or segments of farmers, analysis of variance tests were conducted for each of the factors used in the classification; the results were statistically significant ($p \leq 0.001$) and are presented in Table 2.

Traditional farmers: the members of this group had an average age of 55 years, secondary school education, and the time they have been producing dry chili pepper was 28 years. The members of the family were five on average, and the land tenure was *ejido*. They had 10 hectares in total for the production of their crops and four of them were devoted to the production of dry chili pepper. The average yield of dry chili pepper was 1.5 tons per hectare, which was sold at $87,000 per ton. The production costs ranged at $94,515 per hectare and had a benefit-cost ratio of 1.38.

Intermediate farmers: they were 50 years old, with four members in the family. The total hectares on average were 33 and 12 of them were devoted to the dry chili pepper production. The average yield was 2.5 tons per hectare, so they had a benefit-cost ratio of 1.81.

Entrepreneurial farmers: they were characterized for being young farmers with an age of 39 years; they had the largest total surface and devoted to the production of dry chili

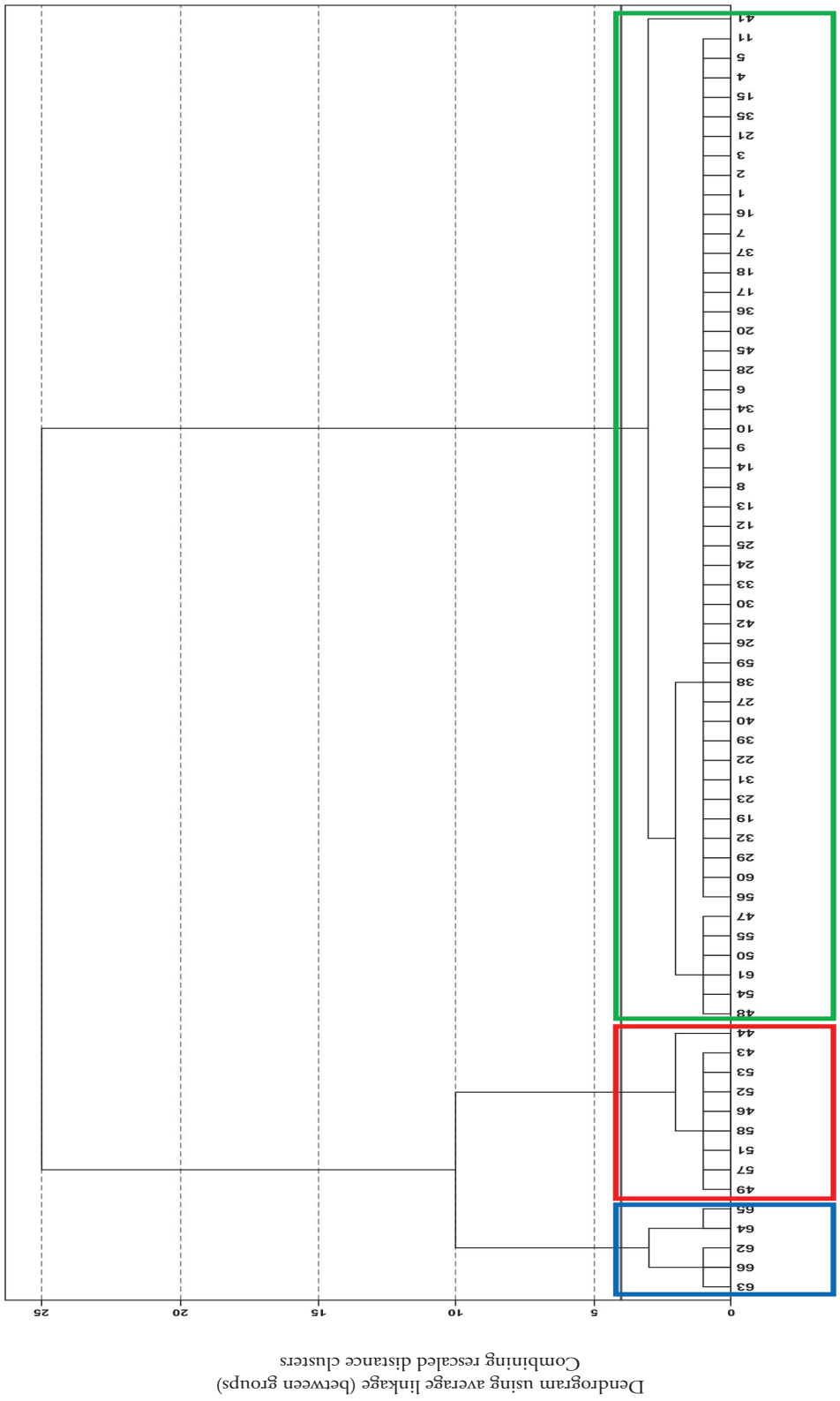

Figure 2. Dendrogram of dry chili pepper farmers in Zacatecas.

Table 2. Average values of key variables for the different groups of dry chili pepper farmers.

Variables/groups	Traditional	Intermediate	Entrepreneurial
Age	55[a]	50[b]	39[c]
Gender	Masculine[a]	Masculine[a]	Masculine[a]
Education	Secondary[a]	Secondary[a]	Secondary[a]
Years of being devoted to dry chili pepper farming	28[a]	24[b]	20[c]
Members in the family	5[a]	4[b]	4[b]
Land tenure	Ejido[a]	Ejido[a]	Ejido[a]
Total hectares	10[b]	33[a]	36[a]
Surface of dry chili pepper (ha)	4[b]	12[a]	15[a]
Yield (t ha^{-1})	1.5[c]	2.5[b]	3.5[a]
Total cost ($/ha)	94,515.00[c]	120,125.00[b]	135,522.00[a]
Price ($ t)	87,000[a]	87,000[a]	87,000[a]
B/C R	1.38[c]	1.81[b]	2.25[a]
Type of market	State[a]	National[b]	National and international[c]
Type of irrigation	Gravity[a]	Spray[b]	Drip[c]

pepper. The average yield was 3.5 tons per hectare; they also had better quality production (first-class fruit) and reached a benefit-cost ratio of 2.25; they were the producers who supply the national and international market.

Commercialization of dry chili pepper in Zacatecas

The multivariate analysis by correspondence indicated the dependency ($\chi 2$ = 137.1; p <0.001) between the way of packing and the destination market. This analysis indicated that the first two dimensions accumulated 96.3% of the total inertia (Figure 3). As was expected, the trademark was associated to those producers who sell to international markets; the national market uses packaging and the sale is carried out in sacks and in bulk in state and municipal markets. However, 81.6% of the farmers do not know the final destination of their product.

The main problems that producers observe in the commercialization of chili pepper in Zacatecas were, in the first place, the low sale price, followed by the phenomenon of intermediaries (Figure 4). Likewise, 91.6% of the farmers consider that their product fulfills the characteristics that the market demands.

The analysis of preferences expected through the MDS revealed that there were two dimensions that best explained the spatial configuration with a stress index of 0.0011, which indicated a good adjustment between the model and the data (Kruskal, 1964). The results showed that the most important attributes for the dry chili pepper farmers are variety, color, maturity and absence of damages or lesions in the fruit (Figure 5, Quadrant II and IV). The attributes such as shape of the fruit, degree of spiciness, and size were the least relevant (Figure 5; Quadrant III).

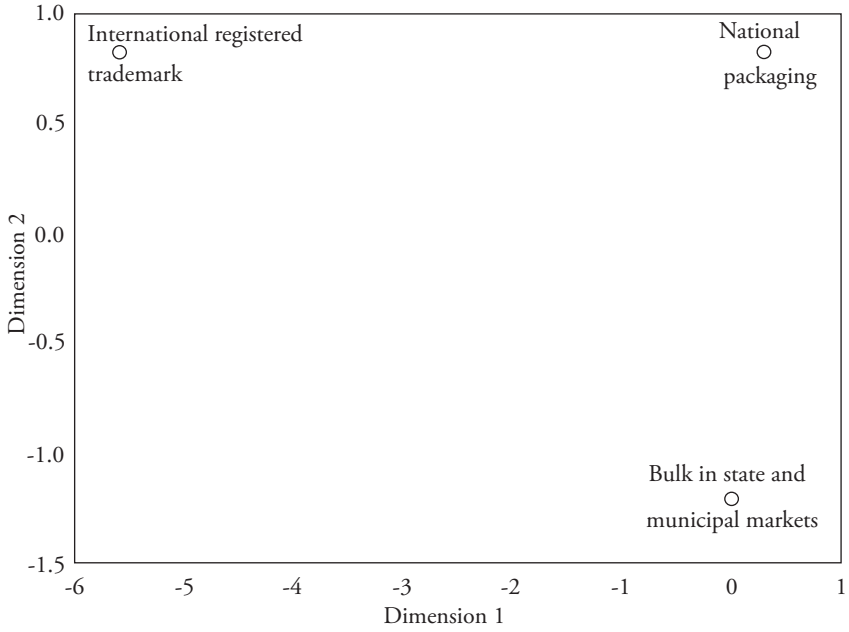

Figure 3. Average bi-dimensional positioning of the destination market and ways of packaging for dry chili pepper.

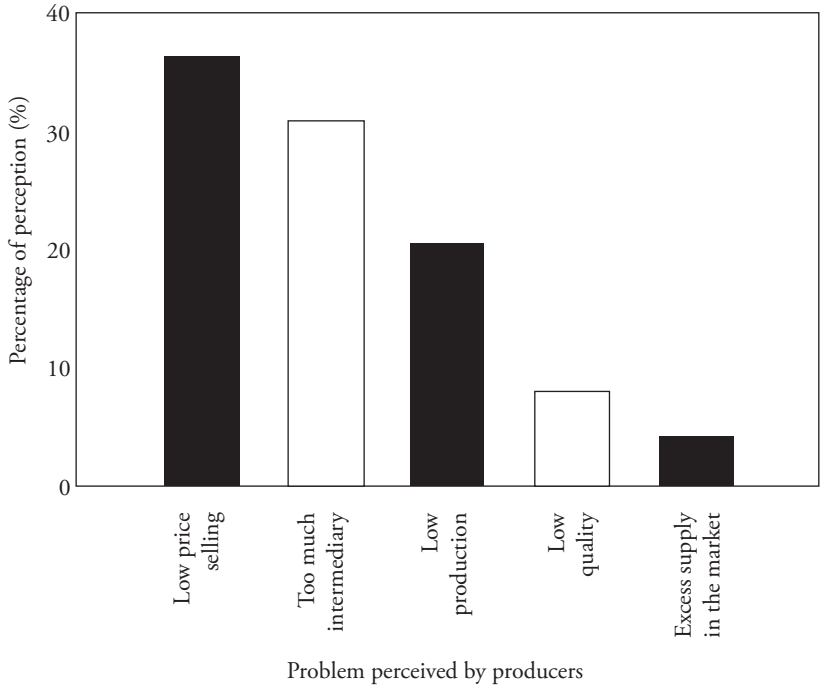

Figure 4. Main problems that dry chili pepper farmers observe in Zacatecas.

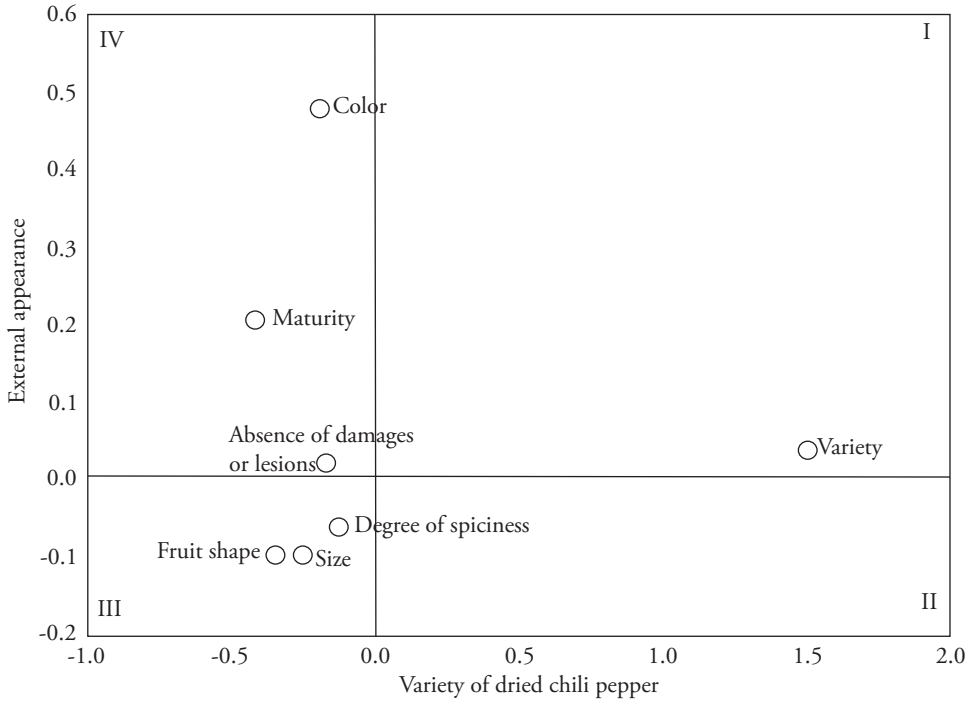

Figure 5. Bi-dimensional representation of the main dry chili pepper attributes for farmers.

DISCUSSION

The state of Zacatecas occupies the first place as dry chili pepper producer in Mexico, and this farming tradition was seen in the classification obtained in the analysis where 78.7% of the farmers belong to the entrepreneurial group. The types of dry chili pepper farmers identified have important differences around the size of the plots that are destined to the production, and these results were similar to those reported by Reyes *et al.* (2006), who stratified the dry chili pepper farmers in Zacatecas by size of the plot and use of technology. Another similarity that was observed in the types of farmers obtained in this analysis was that as the farmer had a greater surface destined to the chili crop for drying, the technology used and the yield by hectare were higher.

This behavior can be explained based on what was described by Carrillo-Martínez *et al.* (2019), who mentioned that this trend is due to the size of the plot having great influence in the yields because the farmers with larger surface, as in the case of the entrepreneurial, tend to modernize some agricultural practices and the nutrition of the crop. The plots that belong to entrepreneurial producers were characterized by having a drip irrigation system; although it is only one technological component in the production process, the use of this system implies modifications in the agronomic management of the crop, particularly in the implementation of irrigation and the efficiency in the application of fertilizers (Ramos *et al.,* 2002). According to Aguilar *et al.* (2005), the use of fertigation increases

the utilization of water and of the nutrients given to the plant and minimizes the loss of fertilizers and, consequently, increases the profits for producers.

The three types of dry chili pepper farming were profitable and these results are also similar to those reported by Reyes *et al.* (2006) and Carrillo-Martínez *et al.* (2019). It is assumed that the agrifood chain of dry chili pepper in Zacatecas is profitable and this explains why despite the agroecological limitations that producers face, they continue with sowing chili pepper for fresh and dry consumption. In addition to this, Sánchez-Toledano *et al.* (2022) mentioned that it is a chain that has socioeconomic and competitive importance for the state, which positions it as strategic for the agricultural sector of the state. Regarding the commercialization, an important point is packaging; it is related with the place where farmers allocate their product. The main aim of the packaging is to maintain the level of quality possible. Therefore, since the beginning of the post-harvest, a correct management should be carried out and in the case of the exports, they should follow international guidelines (Acosta *et al.,* 2021).

The problems that dry chili pepper farmers face agree with what was found in the national Agriculture and Livestock Production Survey (*Encuesta Nacional Agropecuaria*, ENA) (INEGI, 2017), which shows that 51.5% of the national agricultural production was sold to intermediaries and only 25% was sold directly to the consumer, because the sale to intermediaries presents the advantage that they purchase all of the production and pay in cash. However, it means a large disadvantage because they pay low prices, which affects the profit of small-scale producers (Bojórquez, 2021). The most important attributes that dry chili pepper farmers observe are similar to the attributes that consumers have mentioned in other products, where the external appearance, that is the color, the maturity and the absence of damages or lesions in the fruit are necessary for an adequate commercialization and, therefore, to gain the preference of the consumer (Sánchez-Toledano, 2021).

CONCLUSIONS

Based on the study, it is concluded that dry chili pepper farmers from Zacatecas are classified into three groups: 1) traditional, 2) intermediate, and 3) entrepreneurial. In this last category, there were 78.7% of the farmers, which explains the competitiveness of the crop in the presence of other product systems and other states of the Mexican Republic. As consequence, decision makers will have to consider the heterogeneity between producers and the characteristics that differentiate them.

The members of the chain should work towards the same objective according to their area of influence. Therefore, the chili pepper farmers from the state of Zacatecas ought to achieve consistency in the fruit quality, through the use of adequate techniques in cultivation and harvest.

This research represents the first approach of perceptions about the attributes preferred by farmers. However, it is necessary to conduct a study about preference and acceptance from consumers. This would allow to compare results and to define strategies that help dry chili pepper farmers of the region. However, the importance of the typology of producers

lies in obtaining information to sustain the design of public policies for specific strata of producers. This is so because usually agriculture and livestock production policies implemented consider farmers as homogeneous subjects, generating programs for support and technical assistance that are far from reality.

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