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Brosimum alicastrum Swartz como alternativa para la reconversión productiva de áreas agrosilvopastoriles en Campeche

Brosimum Alicastrum Swartz as an alternative for the productive reconversion of agrosilvopastoral areas in Campeche

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Resumen

Respecto a la especie *Brosimum alicastrum* (Ramón) existen diversas investigaciones sobre sus propiedades nutracéuticas para la alimentación animal y humana, usos medicinales e incluso sistemas de producción. Sin embargo, sigue siendo un taxón, fundamentalmente, silvestre y de nulo manejo silvícola. En virtud de ello, el objetivo del presente trabajo fue analizar algunos de los factores económico-sociales, fisiográficos y de producción que determinan la reconversión de terrenos a plantaciones con Ramón, en el estado de Campeche. Mediante un muestreo dirigido a las zonas con mayor abundancia de la especie, se encuestaron entre septiembre y noviembre de 2018 a 190 productores de los sectores agrícola (94), pecuario (58), forestal (17) y apícola (21). Los resultados indicaron que la edad, escolaridad e ingreso económico familiar que representan los sistemas actuales de producción, no condicionan la reconversión. Por el contrario, aquellos que más la restringen se asocian con la libertad de decisión sobre sus parcelas (tenencia de la tierra), el acceso a las áreas donde *B. alicastrum* se distribuye de manera natural, y la falta de paquetes tecnológicos para su producción y poscosecha. Los productores con mayor disposición a reconvertir sus tierras son los agrícolas y pecuarios; los primeros incentivados por el posible precio de venta del kilogramo de semilla ($23.00 MN), y los segundos por la obtención de forraje alterno de menor costo. En ambos casos, la asesoría y capacitación técnica ayudarían a minimizar los tiempos de adaptación a los nuevos sistemas de producción.

Palabras clave: Adopción, análisis de componentes principales, *Ojuch*, Ramón, tenencia de la tierra, SIG.

Abstract

Research has been generated on the nutraceutical properties of the *Ramón* tree (*Brosimum alicastrum)* for animal and human feeding, medicinal uses and even production systems. However, it remains as a species with natural distribution and no forestry management. Because of this, the objective of the present work was to analyze the economic-social, physiographic and production factors that condition the conversion to *Ramón* tree plantations in the state of *Campeche.* By means of a sampling directed to the zones with a greater cover of the species, 190 farmers of the sectors of agricultural (94), livestock (58), forestry (17) and apicultural (21) sectors were surveyed between September and November, 2018. The results indicate that the age, schooling and family economic income represented by the current production systems do not condition the conversion. On the other hand, the factors that most restrict this conversion are associated with the freedom to make decisions regarding their plots (land tenure), access to the areas where the *Ramón* tree is distributed naturally, and the lack of technological packages for the production and post-harvest of the species. The producers with greater willingness to convert are the farmers and livestock breeders: the former, encouraged by the sales price of 1 kg of seed ($ 23.00 MXN), and the latter, seeking to find alternative fodder at a lower cost. In both cases, technical advice and training would help to minimize the period of adaptation to the new production systems.

Key words: Adoption, principal component analysis, *Ojuch*, *Ramón*, land tenure, GIS.

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Introduction

Brosimum alicastrum Swartz (*Ramón*) is a tree native to Mesoamerica and the Caribbean with a wide distribution in southeastern Mexico; it grows wild in evergreen and sub-deciduous forests (Vega-López *et al.*, 2003). In 2009, the National Forestry Commission (Conafor, 2009) defined *B. alicastrum* as a priority species for the Conservation and Restoration of Forest Ecosystems Programs, due to the importance of its leaves and fruits as food for wildlife; as well as to its value for biodiversity conservation and for the protection of the soil and of water bodies (Hernández-González *et al.*, 2014).

In the *Yucatán* Peninsula, the *Ramón* tree is common in the backyards of Mayan families, who, due to their culture, tend to use all its parts: leaves, stem, seeds, fruit and latex (Peters and Pardo-Tejeda, 1982; Torres-Acosta *et al.*, 2016). Because of its nutritional characteristics as animal and human food, it is considered to have a potential for the livestock feed agro-industry, especially in the sectors: the breeding of pigs, cattle, sheep, poultry, and aquaculture (Lozano *et al.*, 1978; Galindo *et al.*, 2003; Martínez-Yáñez *et al.*, 2010).

Despite all the research carried out around *B. alicastrum*, there is little knowledge about the social acceptance that its commercial plantations might have in the *Yucatán* Peninsula, and specifically in *Campeche*. This is due to the fact that at present, the species is mostly naturally distributed, with very little forestry management (Hernández-González *et al.*, 2014; Vergara-Yoisura *et al.*, 2014).

Vergara-Yoisura *et al.* (2014) highlight the importance that *Ramón* plantations established in the southeast of Mexico would have for the livestock feed agro-industry, since they would guarantee the raw material for their operations.

Moving from a production system based on natural management to one of plantations entails a change from conventional agro-ecosystems, as well as in the organization of production units and the development of markets linked to the diverse products that agro-biodiversity offers. Therefore, productive reconversion is not only a complex technological transformation process but also a socio-cultural and economic one (Caldera *et al.*, 2016).

There are different methodologies —ranging from imposition to persuasion— for stimulating the processes of productive reconversion in the agricultural, livestock and forestry sectors (Soto *et al.*, 2009). In analyzing forest producers in Africa, Rootaert and Franzel (2001) observed that participatory workshops directly involving the producers in the analysis of the potential and limitations of their activity result in a higher degree of conversion to new technologies than when the technology transfer programs are designed by the government. This suggests that the reproductive conversion should consider the idiosyncrasies of the producers, their culture and their interests, as well as the agro-ecological and economic conditions in which it takes place (Soto *et al.*, 2009).

Various studies carried out in Mexico, including those by Aguilar-Gallegos *et al.* (2015) on oil palm (*Elaeis guineensis* Jacq.) plantations in *Tabasco*; by Almaguer-Vargas and Ayala-Garay (2014) on Persian lemon (*Citrus latifolia* Tan.) in regions of *Veracruz*, and by Flores-Trejo *et al.* (2016) on plantations of *rambután* (*Nephelium lappaceum* L.) in the region of *Soconusco, Chiapas*, have shown that substituting perennial species for cyclical ones improves the profitability of the products. According to all three studies, the producers' decision to convert their land should follow the Rovere scale (1999), which considers the following aspects: recognition, knowledge, collaboration, cooperation and partnership. In this regard, Escoto *et al.* (2007) point out that success in the conversion lies in the producers' commitment to use and maintain the process, which is directly linked to its profitability.

Feder *et al.* (1985) provide evidence that productive reconversion requires greater investment on the part of producers and an adaptation process to improve their skills and knowledge. Pérez and Terrón (2004) consider that this is a factor that limits reconversion, given the complexity that it entails in many cases. Soto *et al.* (2009) and García *et al.* (2011) postulate that technical advice and training substantially reduce the period of adaptation to new production systems, and that the interaction and trust that is generated between local actors and trainers are positive triggers.

Age, schooling, gender, land tenure, family income from the activity, links with public and private institutions, government support, available economic resources, agro-climatic environment, years of living in the area of residence, and the relevance of technology are all factors that influence the conversion to new production schemes (Feder *et al.*, 1985; CIMMYT, 1993; Galindo-González *et al*., 2001; Patiño *et al.*, 2012).

Thus, the objective of the present work was to identify some economic-social, physiographic and production factors that condition the reconversion to *ramón* plantations in the state of *Campeche*. For this purpose, a survey was applied with a sample directed to the areas with the highest abundance of the species in order to identify those characteristics of the producers that render them more receptive to reconvert their activity (agriculture, livestock breeding, forestry or beekeeping).

Materials and Methods

Study area

The study considered regions in the state of *Campeche*, in southeastern Mexico, where *Brosimum alicastrum* grows, according to the records of the National Forest and Soil Inventory (INFyS) of the National Forest Commission (Conafor, 2014). These are characterized by a medium sub-evergreen forest cover and high evergreen forest, with clay soils; rainfall ranging between 600 and 4 000 mm, with low water periods of three to seven months; average annual temperature from 18 to 27 ºC, and altitudes in a range from 20 to 1 000 m. The main economic activities are livestock breeding and forestry, in addition to the cultivation of corn, beans, squash, and sugarcane (Inegi, 2015). It should be noted that, during the dry season, the main livestock fed is obtained from the *Ramón* tree.

Data collection

For the sampling of producers, the localities to be analyzed were first selected, based on the identification of the region with the highest abundance of the species of interest in the state of *Campeche*, according to the georeferenced data on point distribution from the National Forest and Soil Inventory (Conafor, 2014) and the use of Geographic Information Systems; the observed richness (abundance) and potential distribution (probability of occurrence) were determined using the Maximum Entropy algorithm. The software used was DivaGis v7.5 (DivaGis, 2017), with a pixel size (resolution) of 30 s (1 km^2). Both techniques were applied according to the methodology described by Hijmans *et al.* (2005).

The observed richness was obtained through a richness analysis, and the potential distribution was obtained by associating the point distribution with the soil and climate variables of *Campeche* (WORLDCLIM, 2019) which delimited areas with different probabilities of presence for *Brosimum alicastrum*, based on its soil and climate requirements. This information made it possible to rule out areas where the *taxon* is not naturally distributed.

Once the region with the greatest abundance of *Ramón* trees was determined, eight locations were selected. The selection criteria were: accessibility, travel distance, and the presence of roads. Between September and November 2018, the inhabitants of the selected localities were surveyed, depending on their availability, references in the region, development of some activity in the agroforestry sector, and the presence of *B. alicastrum* individuals in their plots.

The survey included four sections: 1) Control data: name of the respondent, age in years, locality, schooling in years, occupation and land tenure: private, *ejido*, and communal; 2) Knowledge about the *Ramón* tree, with questions about the local name and the common uses in the region; 3) Socioeconomic aspects of the respondents: number of hectares of their plots, activities that they carry out in their plots: agricultural, livestock or forestry; family income from the activity in Mexican pesos; importance of the *ramón* tree in the region, and, if they commercialize the species: what part of the tree is sold and to what

market it caters: regional, national or international; and 4) Desire to reconvert their plots to *Ramón* tree plantations: limitations for their establishment and cost at which they would sell the kilogram of tree seed.

In addition, a specialist from each of the following institutions was interviewed: *Universidad Autónoma Chapingo* (Autonomous University of Chapingo, UACH), *Colegio de Postgraduados* (Graduate College, Colpos), *Universidad Autónoma de Yucatán* (Autonomous University of Yucatán, UADY), and *Centro de Investigación Científica de Yucatán* (Scientific Research Center of Yucatan, CICY). The interview guidelines considered aspects of economic, social and environmental constraints to the establishment of *Ramón* tree plantations in Campeche. The format for the producer survey and the specialist interview was based on the guide for the design of surveys on the adoption of agricultural technologies proposed by CIMMYT (1993).

Data analysis

The data collected in the survey of producers were captured in a spreadsheet of the R software, and the descriptive (frequencies) and multivariate statistics (Principal Component Analysis, PCA) were made; producers were characterized socio-economically according to their activity, and the factors associated with the reconversion to *ramón* tree plantations were determined.

Results and Discussion

The observed richness and potential distribution obtained by Geographical Information Systems techniques allowed us to determine that, in the state of *Campeche*, *B. alicastrum* is most abundant in *Champotón, Escárcega, Calakmul, Hopelchén,* and *Candelaria* municipalities.

A total of 190 producers were surveyed, distributed in the localities of *Gustavo Díaz Ordaz* (29) and *Nuevo Conhuas* (29), in *Calakmul* municipality; *Miguel Colorado* (26) and *San José Carpizo 2* (20), in *Champotón* municipality; *El Lechugal* (20) and *Justicia*

Social (28), in *Escárcega* municipality; *X-canhá* (21) and *X-maben* (17) in *Hopelchén* municipality. In all cases, the presence of *Ramón* within the production plots of the surveyed producers was corroborated. For reasons of accessibility, *Candelaria* municipality was not considered in the study (Figure 1).
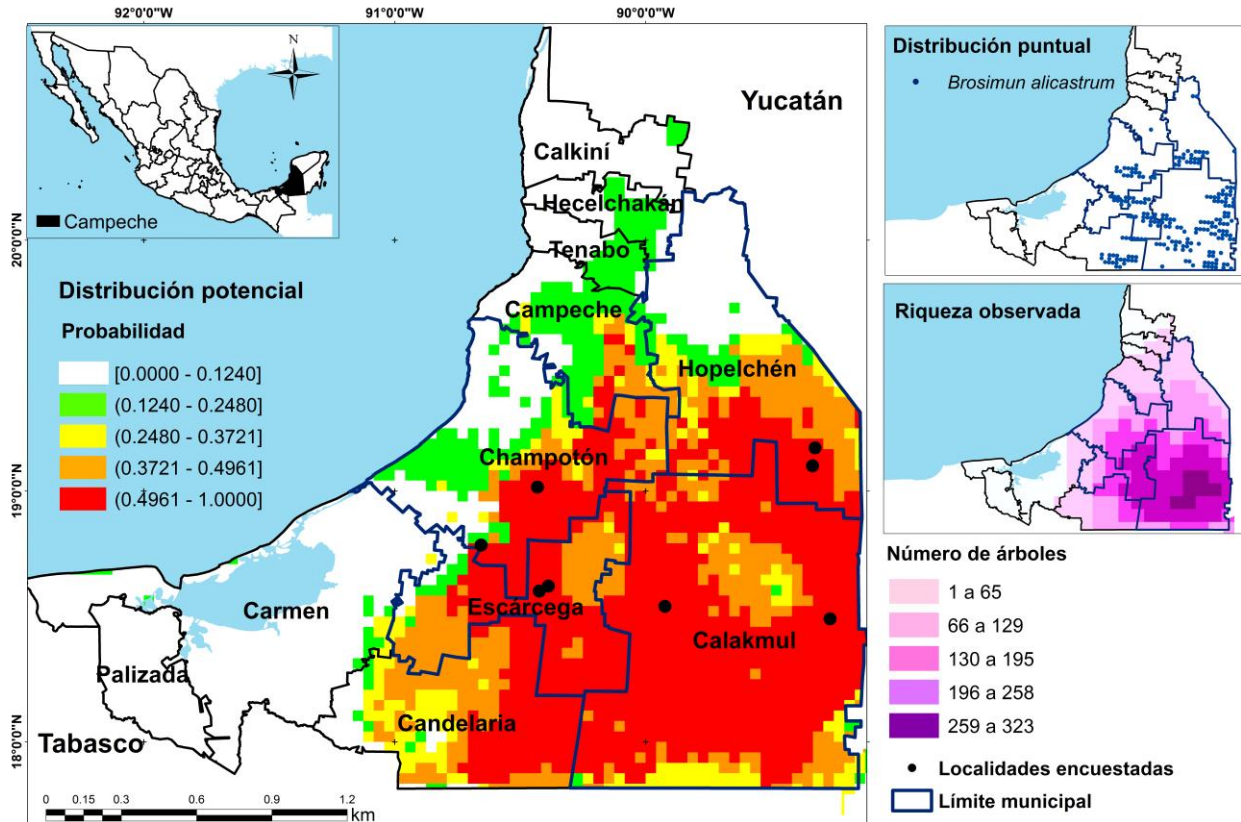
Distribución potencial = Potential distribution ;Probabilidad = Probality; Distribución puntual = Puntual distribution; Riqueza observada = Observed richness; Número de árboles= Number of trees; Localidades encuestadas = Surveyed localities; Límite municipal = Municipality limit.

Figure 1. Spatial distribution of the surveyed localities that were selected from the municipalities with the highest abundance of *Brosimum alicastrum* Swartz.

Socio-economic characterization of producers by activity

Agriculture of cyclic crops, mainly corn and beans, was the activity to which 49.47 % (94) of the producers surveyed were dedicated; the remaining 50.53 % (96) corresponded to the livestock (30.53 %), beekeeping (11.05 %) and forestry (8.95 %) sectors. The common names with which the species is denominated are *Ramón* (80.42 %); *Oox*, Mayan word, (7.46 %); and *Ojuch*, Mayan word, or its variant *ojite* (2.12 %).

Registered uses were as fodder (91.57 %, 174 respondents), lumber or fuel (5.78 %, 11 respondents, and 2.72 %, five respondents, respectively) do not have any use for it. However, its use as fodder is presented as a secondary alternative in periods of low rainfall as indicated by Rojas-Schroeder *et al.* (2017) in southeastern Mexico, who argue that *Brosimum alicastrum* is only used in periods of scarcity of traditional fodder (grasses). Therefore, the *Ramón* tree does not represent a primary input in the region, so that only 4.74 % (9 producers) mentioned marketing the seed for flour production in a regional market.

Table 1 shows that the average age of producers varies between 48 and 50 years, with similar levels of study not exceeding high school. Aguilar-Gallegos *et al.* (2015) cite age as the main condition for conversion among tropical crop producers in southeast Mexico. However, in the case documented herein, the producers that showed greater availability to reconversion were those with private land tenure; this fact is explained by some specialists in the subject due to the freedom of decision that the producers have on their plots.

Table 1. Socioeconomic indicators of the surveyed population and its conversion to *ramón* tree plantations, according to the activity carried out in their production plots.

Activity*	n	Age	Schooling	Production areas		FI**	Reconversion (%)	
				Land tenure	ha		Yes	No
Agriculture	92	48	Elementary school	Private	1 a 5	<10	96.8	3.2
Beekeeping	21	49	Middle school	*Ejido*	10 a 15	10 a 15	82.35	17.65
Forestry	17	40	High school	*Ejido*	10 a 15	15 a 25	87.24	12.76
Livestock breeding	58	50	Elementary school	Private	>15	>25	95.23	4.77

* The main activity that the producers carry out in their production plots was considered; **FI = Family income (thousands of pesos per month). Gross income was considered, not profits.

Factors that condition the conversion to *ramón* tree plantations by activity

In the PCA, the first component (Prin1) grouped the variables of age (continuous variable), schooling (continuous), land tenure (1: Communal, 2: *Ejido*, and 3: Private), number of hectares owned by the producer (continuous) and economic income that represents the activity currently carried out (continuous) explains 38.03 % of the total variance of the data. The second component (Prin2) integrated the variables: Importance of *Ramón* in the region (1: Very low, 2: Low, 3: Medium, 4: High and 5: Very high), price at which it would sell the fruit of the *ramón* tree (continuous) and adoption of plantations (0: No and 1: Yes) explains 29.06 %. Both components explain 67.09 % of the total variance of the data.

Flores-Trejo *et al.* (2016) report that, among *rambután* producers in *Soconusco* (*Chiapas*), age, schooling and income are all factors that limit the conversion to new production systems. The study of *B. alicastrum* grouped these factors under Prin1, in which also, land tenure was a limiting factor (Morett-Sánchez and Cosío-Ruiz, 2017). Prin2 grouped the variables related to the willingness to reconvert, which, according

to Escoto *et al.* (2007), is directly linked to the profitability that the producer expects to obtain with the new production system.

In order to establish which are the limiting and readiness factors that most condition the establishment of plantations, the eigenvectors of the first three components that account for 86.63 % of the total variance of the data were analyzed. Maximum values were extracted and re-categorized by quality (Very low [0.000 - 0.200], Low (0.200 - 0.400], Medium (0.400 - 0.600], High (0.600 - 0.800], and Very high (0.800 - 1.000]) (Pérez-Guel *et al.*, 2016) (Table 2).

Table 2. Main components of the limiting factors and willingness to reconvert conditioning the establishment of *Ramón* tree plantations in *Campeche.*

Factors	Variables	Prin1	Prin2	Prin3	Maxi-mum	Reconversion	
						Limitation	Willingness
Limiting factors	Age	0.549	0.267	-0.017	0.549	Medium	
	Schooling	0.509	-0.114	0.208	0.509	Medium	
	Land tenure	0.922	-0.184	0.334	0.922	Very high	
	Production hectares	0.519	0.373	0.293	0.519	Medium	
	Income from the activity	0.699	0.083	0.208	0.699	High	
Willingness	Importance in the region	0.234	0.649	-0.308	0.649		High
	Price of the fruit	0.261	0.872	-0.381	0.872		Very high
	Willing to reconvert	-0.082	0.738	0.115	0.738		High

It was statistically confirmed in PCA that the factor that most limits the reconversion to *ramón* tree plantations in *Campeche* is land tenure. According to Romero-Navarrete (2015), one of the main obstacles for the development of the Mexican countryside is the lack of legal certainty regarding the ownership of the plots; hence, the producers who presented more willingness to reconvert their production areas were those who have more freedom to make decisions regarding their plots (Morett-Sánchez and Cosío-Ruiz, 2017).

The PCA also established that the sales price per kilogram of seed ($23.00 MN in average) was the factor that most incentivizes the producers surveyed to reconvert

their production areas to *Ramón* tree plantations. In certain regions of *Veracruz*, Almaguer-Vargas and Ayala-Garay (2014) proved that the substitution of perennial species plantations for those of cyclic species improves the profitability for the producers.

Based on the dispersion of the eigenvalues for each of the 190 surveyed producers, they were grouped and differentiated by activity; the factor that most limits reconversion (X axis: land tenure) with the willingness to reconvert (Y axis) (Figure 2). As may be seen, the agricultural sector presented the greatest willingness, followed by livestock breeding, forestry and beekeeping, in a hierarchical order.
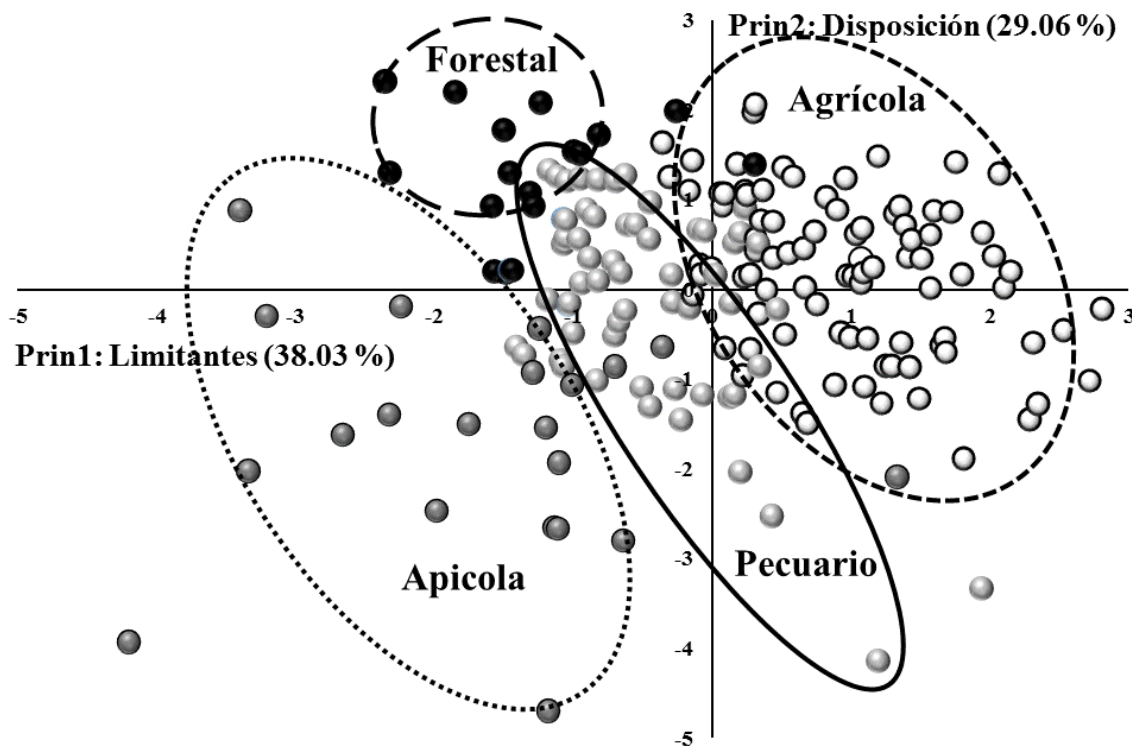
Prin1 = Land tenure (reference scale from left to right: communal-*ejido*-private); Prin2 = Willingness to reconvert (reference scale from bottom to top: very low-low-medium-high-very high).

Figure 2. Limiting factors (Prin1) and willingness (Prin2) to reconvert with *Ramón* plantations, according to economic activity developed in the production plots.

Livestock producers mentioned that their priority is not to abandon the activity, but to achieve silvopastoral systems that will generate a more economically accessible feed for livestock. In this regard, Vergara-Yoisura *et al.* (2014) consider that commercial *ramón* tree plantations can satisfy the demand of the livestock sector and reduce the import of grass.

Flores-Trejo *et al.* (2016) recorded in regions of *Soconusco, Chiapas* that producers of cyclical crops (agricultural sector) are more willing to reconvert their production areas in order to improve the profitability of their plots. However, Pérez and Terrón (2004) point out that, in the process of conversion to perennial species, the agricultural sector is the most vulnerable, with respect to livestock and forestry; this is due to the fact that it is the sector that requires most investment and training; therefore, García *et al.* (2011) indicate that technical advice and training substantially improve the time of adaptation to new production systems.

Finally, Table 3 summarizes the factors that the surveyed producers perceive as the main limitations for the reconversion to *Ramón* tree plantations. In addition to land tenure (32.11 %), they also included as determining factors: the lack of technological packages for the management and production of the species (24.74 %), access to the producing areas where *B. alicastrum* individuals are currently located (22.63 %), and the difficulty to collect the fruits of the tree (14.21 %).

Table 3. Factors perceived by producers as main limitations for the reconversion to *Ramón* tree plantations in *Campeche*.

Sector	Factor	Agriculture	Beekeeping	Forestry	Livestock breeding	Total
Technology transfer	Lack of software packages	11.58	1.05	2.63	9.47	24.74
	Lack of knowledge	0.53	----	0.53	----	1.06
Supply	Acces to production areas	12.63	4.21	2.11	3.68	22.63
	Difficulty to collect	6.84	1.58	3.16	2.63	14.21
	Few trees	1.05	----	----	1.58	2.63
Phytosanitary	Pests and diseases	----	0.53	----	----	0.53
Production spaces	Lack of land	1.58	0.53	----	----	2.11
	Land tenure	15.26	3.16	0.53	13.16	32.11
	Total	49.47	11.05	8.95	30.53	100

In this regard, Vergara-Yoisura *et al.* (2014) document that the problems of access to production areas and post-harvest management of *Brosimum alicastrum* are solved by creating a specific technological package for the species. For their part, Monge and Hartwich (2008) postulate that technical advice and training, complemented by the interaction and trust that is generated between producers and trainers, help to minimize the time period required to adapt to new production systems; in order to do this, it is necessary to go through the process of recognizing, knowing, collaborating, cooperating and associating (Rovere, 1999).

Conclusions

Judging by the results, the age, schooling and family income derived from the current production systems of agricultural, livestock, forestry and beekeeping by the producers in the state of *Campeche* do not condition the conversion to *Ramón* tree plantations. On the contrary, the factors that most restrict it are associated with the freedom to make decisions regarding their plots (land tenure), the difficult access to those areas where *Ramón* is naturally distributed, and the lack of development of technological packages for the production and post-harvest of the species, which is

evidenced by the null silvicultural management of *Ramón* tree plantations. The agricultural and livestock producers are the ones most willing to reconvert: the former are encouraged by the price at which a kilogram of seed would be sold ($23.00 MN), while the latter seek alternative livestock feeds at a lower cost. In both cases, technical advice and training may help minimize the time period required to adapt to the new production systems.

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Conflict of interest

The authors declare that they have no conflict of interest.

Contribution by author

Alberto Santillán Fernández: conceptualization and design of the study, statistical analysis and writing of the final manuscript; Cecilia González Pérez: field data collection and data analysis; Jaime Bautista Ortega: data analysis and drafting of the original manuscript; Zulema Guadalupe Huicab Pech: data analysis and drafting of the original manuscript; Judith Escobar Castillo: preparation of cartographic maps using GIS and data review; Alfonso Larqué Saavedra: review, follow-up of results and writing of the final manuscript.

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