Article

Study of the agroecosystem with pipian squash in Cantarranas, Paso de Ovejas, Veracruz

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Abstract

The objective was to analyze the pipian squash agroecosystem to identify problems, energy and financial efficiency comparing dry seed production to when it is given added value (jamoncillo, fudge in English) in the community of Cantarranas Municipality of Paso de Ovejas, Veracruz, Mexico. This research was conducted in 2018 using participatory techniques and semi-structured interviews, financial analysis and energy productivity analysis. The degree of interaction and communication between farmers was analyzed with the UCINET program. It was found that the state of Veracruz ranks seventh in the production of pipian seed nationwide, the municipality of Paso de Ovejas occupies the fifteenth place in the state. The energy analysis showed higher energy productivity for the value-added product of pipian (jamoncillo) in contrast to the seed production. The financial analysis showed low profitability for seed production (price in 2017: Mex \$20.00 kg^{-1}). Low connectivity was found in the farmers' network, resulting in individual marketing generating low incomes for the producer. There is a need to adopt more sustainable forms of pipian squash production and to promote a small industry in the region.

Keywords: cybernetic controller, participatory research, productive potential.

Reception date: February 2021
Acceptance date: May 2021

Introduction

Archaeological remains suggest that the domestication of *Cucurbita argyrosperma* Huber, commonly known as pipian or pipian squash, occurred in central Mexico. The remains found in the Tehuacán Valley, Puebla, date back more than 7 000 years (Lira, 1995). The Cucurbitaceae family includes 118 genera and 825 species worldwide. According to recent taxonomic and floristic studies, it comprises 141 taxa: 128 wild and 13 cultivated (Lira *et al*., 2002).

Several species are important to the farmer's economy as a cash crop and some others have cultural value among various rural communities in Mexico, due to their use as food and medicine. One of these species is *Cucurbita argyrosperma* (Lira *et al*., 2002), commonly known as pipian squash. The pulp and shell of this squash (by-product) have a yield between 3.8-28 t in fresh per hectare (Garza *et al*., 2010), which could be useful in livestock feeding, silage or dehydrated. As well, it can be used as a source of pigments in diets for laying birds due to its high content of carotenes (Dorantes-Jiménez *et al*., 2016).

It is important to note that squash is a fruit of great nutritional value for its high content of carbohydrates, soluble fiber, protein, oil of carotenoid compounds, precursors of vitamin A, β carotene, cryptoxanthin and lutein (Hernández, 2009). The fruits vary in size, shape and color. The range in size goes from 14 to 50 cm long and from 14 to 25 cm in diameter, piriform or claviform in the thinnest part, it has seeds 1.5 to 3 cm long and 0.7 to 1.7 cm broad, flat, elliptic to lanceolate (Dorantes-Jiménez *et al*., 2016). Normally, for sowing, producers prefer seeds with gray, thin and uniform margin, white testa since they have greater weight than seeds with wide edges (Merrick and Bates, 1989).

The seeds contain 28% oil and 30% protein (FAO, 2018) and their consumption is common in Mexico and Central America. In addition to Mexico, its cultivation has been recorded in countries such as Guatemala, Honduras, El Salvador, Nicaragua, Costa Rica and Panama (Hernández y León, 1994). Squash seed oil provides great health benefits, being an unsaturated oil with a content of 60 to 90% oleic acid and linoleic acid (Rossel *et al*., 2018).

According to agricultural statistics from SIAP (2018), 16 states in Mexico are engaged in the production of pipian squash. The state of Veracruz occupies the seventh place and the state of Campeche the first, with a total of 28 665 ha cultivated. In 2018, the cultivated area in Veracruz was 716 ha (SIAP, 2018). In the state of Veracruz, 26 municipalities grow pipian squash. Among them, Paso de Ovejas, located in the central area of the state, occupies the fifteenth place, with an approximate rainfed area of 24 ha. This crop is important due to the growing demand for seeds in the local, state and national market.

Pipian squash is preferably grown under rainfed conditions in sandy and clay soils with good drainage and a medium content of organic matter, in humid and sub-humid tropical climates. In general, it is sown in late May and early June with the presence of the first rains, and it is harvested from September to December (Garza *et al*., 2010).

The concept of agroecosystem began to be used in the mid-twentieth century. In this regard, Hart (1985) defines the agroecosystem as an arrangement of physical components, a set or collection of things, united or related in such a way that they form and act as a unit, an entity or a whole. This concept has evolved and it is understood that the agroecosystem is a system that must be studied as an organized totality (Martínez-Dávila and Casanova-Pérez, 2018), where its understanding involves knowing its structure and functioning, and its social, economic and environmental attributes in an appropriate scale and context (Pérez-Vázquez and Trinidad-Leyva, 2019). That is, every system has a structure related to the arrangement of its components and has a related function of how the system acts.

An exploratory investigation of the region of interest made it possible to determine the priority problems regarding the crops of greater socioeconomic importance, highlighting the cultivation of pipian squash. Coupled with the scarce scientific information of this crop under an approach of agroecosystems. Therefore, the need to generate scientific information on the importance of this crop for the central area of the state of Veracruz was raised to allow an understanding of its structure and operation at different hierarchical levels. The objective was to study the current situation of the agroecosystem with pipian squash in Cantarranas, Municipality of Paso de Ovejas, Veracruz.

Materials and methods

The focus of this research was a mixed quantitative and qualitative analysis of the agroecosystem, conducted from February to April 2018. At the municipal level, the study was conducted in Paso de Ovejas, Veracruz. At the farm level, it was carried out in the community of Cantarranas. The community is located at 220 m altitude with a warm sub-humid climate (Aw0). The average annual temperature is 25.7 °C and the average annual rainfall is 1 196 mm. The selection of this community was due to the relevance of the cultivation of pipian squash.

The information was collected through the official database SIAP (2018) to know the cultivated area in three hierarchical levels (basin, municipality and crop). The community of Cantarranas was visited, taking a representative sample of 20%, which corresponds to 42 pipian farmers. The flow of inputs and outputs of the agroecosystem was analyzed through a financial analysis and energy balance (Fluck, 1995). Two production systems of pipian cultivation were compared, one where the production of seed is marketed in dry and another where the seed is given added value (jamoncillo, fudge in English). As well, the level of organization of the agroecosystem controller in the territory of interest was studied (Figure 1).

To design the study, an exploratory tour was carried out to determine the priority problems and to consider the agricultural activity of greater importance and that provides more incomes to the farmers. The community of Cantarranas is located at an altitude of 220 m. The climate of the area is defined as sub-humid tropical (Aw0) with an average annual temperature of 25.7 °C and an average annual precipitation of 1 196 mm.

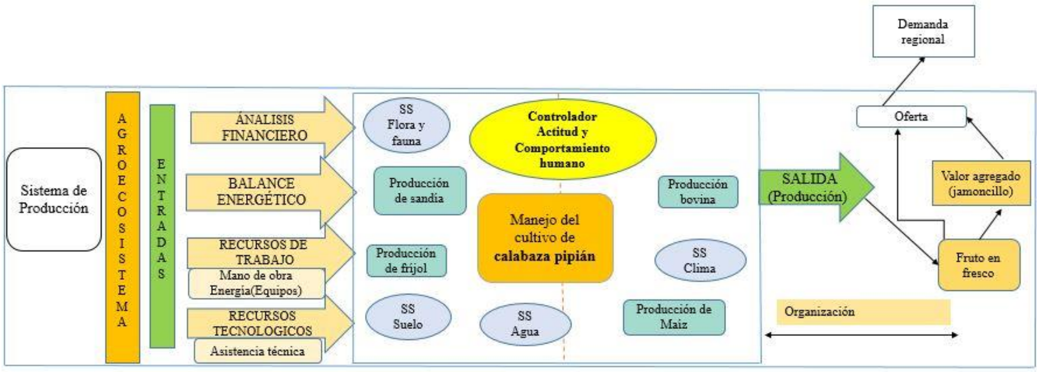

Figure 1. Model of the agroecosystem with pipian squash in the region of Cantarranas, Paso de Ovejas Veracruz.

At the basin level, the QGIS program was used to identify the areas of greatest agroecological aptitude for growing pipian. At the municipal level, semi-structured interviews were conducted with key actors (Municipal Representative for Agricultural Development and District Chief 006-La Antigua) and to obtain information on pipian production. At the crop level, participatory research techniques (semi-structured interview, brainstorming, problem tree, classification) and a questionnaire were used. In a meeting with 42 producers of pipian squash from the community of Cantarranas, Veracruz and using various participatory dynamics, problems were identified and prioritized, in the presence of the ejido authority.

To obtain the collaborative network and the level of communication between farmers, the UCINET software was used. Three measures of centrality were determined: range, intermediation and degree of closeness; using a graphical network, several relationships were established, including the percentage of density, Kuz (2016). Through a semi-structured interview, information was collected in the community of La Ternera, Veracruz, to describe the added value (jamoncillo candy). A structured questionnaire was used for financial analysis, collecting data on costs and revenues from seed production and value added (jamoncillo). The estimated financial indicators were: benefit/cost ratio (B/C), net present value (VAN) and internal rate of return (TIR), Infante (1998).

The same questionnaire was used to make energy budgets, recording inputs (inputs) and outputs (production) of the agricultural system in terms of direct and indirect energy. Energy values in British thermal unit (BTU) were assigned to all inputs and outputs. In the case of the production of jamoncillo, the costs and inputs used for its production were recorded. Energy productivity was estimated according to the methodology of Fluck (1995); Pardo (1987).

Results and discussion

Pipian Squash at the state and municipal level

According to data from SIAP (2018), the states with the greatest potential for pipian squash production are: Veracruz, Campeche, Yucatán, Tamaulipas, part of Oaxaca, Michoacán, Jalisco, Nayarit and Sinaloa (Figure 2). Pipian squash thrives in tropical and subtropical regions, it is distributed at a wide range of altitudes, ranging from sea level to 1 800 m (Ayvar *et al*., 2007). At the state level, its cultivation is concentrated in the north and center of the state and partially in the south.

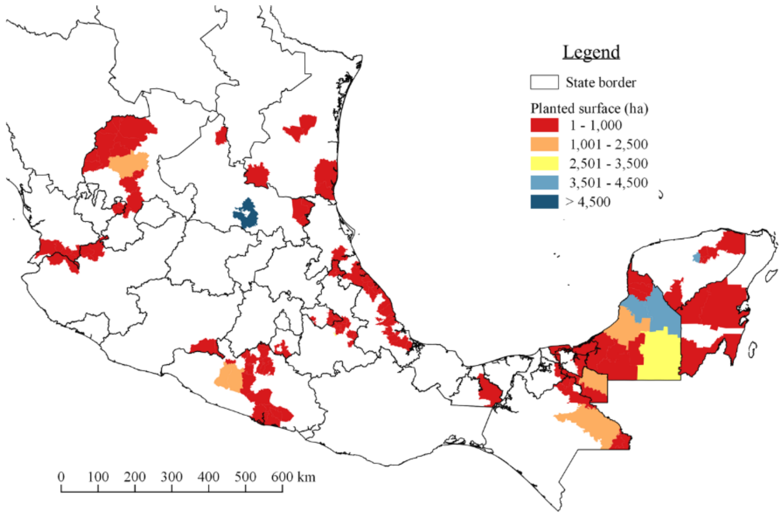

Figure 2. States with the highest production potential for the cultivation of pipian squash (*C. argyrosperma*).

The municipality of Paso de Ovejas is in the fifteenth place in production with a cultivated area of 24 ha. Production is also concentrated in the central part, particularly in the municipalities of Alto Lucero, Actopan, La Antigua, Puente Nacional, Paso de Ovejas and Úrsulo Galván (SIAP, 2018). The most important communities in the municipality of Paso de Ovejas that grow pipian squash are: Mata Mateo, Cantarranas, Acazónica, Angostillo, as well as La Ternera and Mata de Jobo that belong to the municipality Puente Nacional (Figure 3).

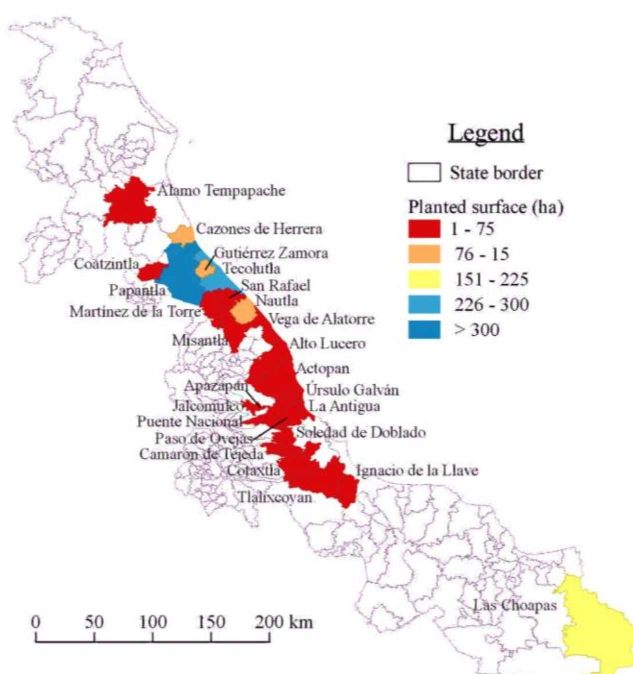

Figure 3. Municipalities of the state of Veracruz with the highest production potential for the cultivation of the pipian squash (*C. argyrosperma*).

Farmers pointed out: 'About 15 years ago, I used to grow pipian squash associated with corn and papaya, but the pipian squash has generated more incomes so now we plant it as a monoculture to get more production'. However, its monoculture has generated a higher incidence of pests and diseases.

In various parts of Mexico, the cultivation of pipian squash is important in traditional agricultural systems (Whitaker and Davis, 1962). The traditional production system involves the association mainly of corn (*Zea mays*), squash (*Cucurbita argyrosperma*) and beans (*Phaseolus vulgaris*). It also represents a background of traditional knowledge and conservation practices of the genetic diversity of crops adapted to their environment, soils and climatic factors, and regional cultural and socioeconomic preference (Canul *et al*., 2005).

As Ebel *et al*. (2017) comment, the association of corn, beans and squash, which underlines the production potential of diversified production systems. In addition to the cultivation of pipian squash, during the rainy season, some farmers grow watermelon, corn and papaya. However, there is a lack of a technological package that contributes to raising the productivity and profitability of the crop. In addition, there is not enough information regarding the factors that limit the production chain of pipian seed in the preparation of dishes and sweets.

Porta *et al*. (2003) comment that one of the factors that limit low yields in production are those related to the physicochemical characteristics of the soil. In this regard, foliar fertilization is an efficient method as a complement to soil fertilization, especially in the growth stages, which is reflected in the yield of the crop, especially in the production of dry seeds (Díaz-Nájera *et al*., 2015). Since the cultivation cycle of pipian squash lasts only 3 months, from sowing to harvest, its monoculture can cause the decrease of nutrients in the soil (Ayvar *et al*., 2007).

Regional problems of pipian squash cultivation

The results of the problem tree showed that the main threat of this crop is drought, due to the eventuality of the rains, increasingly scarce and poorly distributed during the season. Another problem is the variation in the price of the seed (once harvested). In 2014, the price was \$41.00 kg^{-1} (Mexican pesos) and it was a fairly profitable harvest, but as of 2017, the price has been \$18.00-20.00 kg^{-1}, price that only covers the minimum production costs.

The farmers comment: "this price is due to the fact that currently the total production is currently hoarded by an organized group, which has a purchase and sale contract with another supplier". Another problem identified was a reduction in yields as it was continuously planting on the same plots under the monoculture system. This generates high production costs for producers, due to conventional fertilization and pest and disease control. An additional problem are pests and diseases, a larva (*Spodoptera exigua* Hübner) that pierces the tender fruit and mosaic virus that affects the photosynthetic capacity of the crop and yield.

The fruits are harvested in August and the seeds are dried along the road for a couple of sunny days. In case of having an unforeseen rain during the drying of the seed, this causes them to moisten, causing loss in the quality and appearance of the seed. It is reported that the use of

Bayfolan Forte increases the yield in pipian squash up to 50%, due to its composition in macro and micronutrients, which could be an alternative to reduce fertilization costs (Díaz-Nájera *et al*., 2015).

Sequi (2004) mentions that the application of micronutrients via foliar has become an important practice for producers, because it corrects the nutritional deficiencies of plants, favors the good development of crops, in addition to improving yield and commercial quality. It is important to mention that there are no technicians to advise and train producers in the production of pipian squash, mainly in the implementation of more environmentally friendly agroecological practices, as well as in issues of value addition.

Undoubtedly, this would considerably improve agricultural production systems and producer incomes. For instance, producers do not prune their crop, if apical dominance is eliminated in the primary and secondary creeping stems, it could promote the development of short and early side vines, with greater fruiting, and it would allow them to have higher planting densities and increase the yield and profitability of the crop (Ayvar *et al*., 2004).

The cultivation of pipian squash occurs preferably in sandy loam and clay loam soils with good drainage and a medium content of organic matter. Typically, growers use thin-edged seeds because they have more weight than wide-edged seeds. The crop presents important pests, this because these pests have created resistance to the agrochemicals that are applied. All producers claimed to have problems with the green worm (*Diaphania hyalinata* L. or *D. nitidalis* Stoll) being borers of vines and tender fruits; that hibernate as a pupa on the ground (Bautista and Vejar, 1999).

Therefore, to control pests and diseases, farmers should use a wide range of agrochemicals with values of up to $750.00 per crop cycle. Weed control is based on the application of herbicides, preferably twice per crop cycle. The first after planting and the second when the vine is still manageable (1 m in length).

As soon as the squash fruits appear, they apply agrochemicals such as Denim 19 CE or Furadan 350 L. The problem of powdery mildew (*Erysiphe cichoracearum* DC) is more severe during drought conditions. The average cultivated area per farmer is 1-10 ha. The average reported yield is around 600-700 kg ha^{-1}. This coincides with George (1999), who points out that the average yield ranges between 0.5 and 1 t ha^{-1}.

Social networks of the community of Cantarranas, Paso de Ovejas Veracruz

The average age of farmers was 62 years. In the analysis of the network, the density of the social factor was 1. 6% of the interrelation between farmers in Cantarranas, which corresponds to a low level of interaction. Thirteen subgroups were determined, which means that most producers work alone with minimal intercommunication. Two farmers (Adán S and Pedro H) had the highest degree of intermediation and reference.

Two other farmers (Mario Q and Antonio D) had the highest degree of closeness and therefore, they have the greatest ability to access all the other nodes in the network (Figure 4). Mario Q obtained the highest degree of closeness and intermediation and therefore, within the community, he is one of the main actors for supporting training services, technology transfer, information communication.

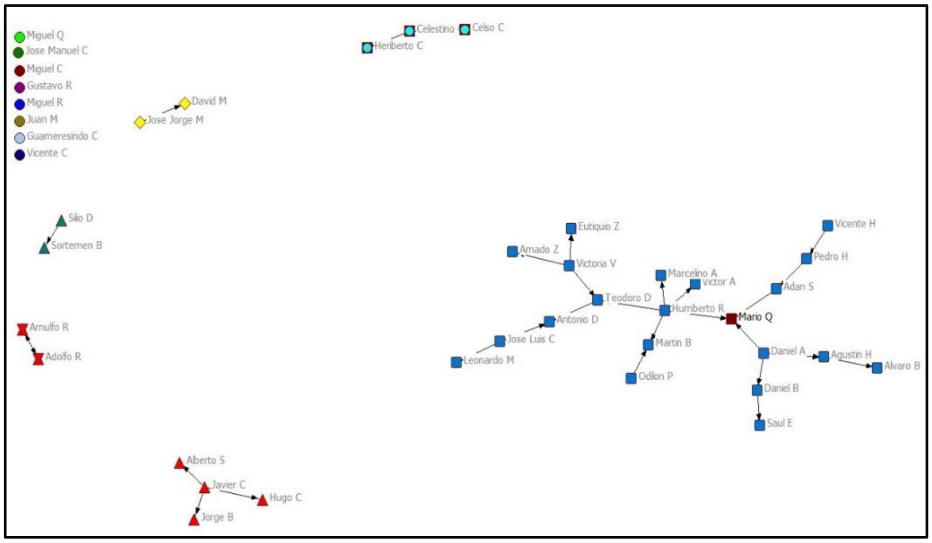

Figure 4. Analysis of the network of farmers in the community of Cantarranas, Paso de Ovejas, Veracruz.

The actors of the network acquire social roles according to the form and type of inputs they handle, so they come to fulfill specific functions, in organizational aspects, managers, innovators, designers, adopters, diffusers, integrators, trust, among others (Nuñez, 2008). If the producers of the pipian squash agroecosystem do not have an adequate organization, they cannot be inserted into the market (Ireta *et al*., 2018).

Production costs and financial indicators of the pipian squash agroecosystem

Activities such as drying the seed, cleaning the land, plowing, clearing brush, fertilizing and spraying agrochemicals have the greatest weight in the total cost of production (Figure 5). This coincides with Ireta *et al*. (2018), who pointed out that soil preparation, seed, fertilization, herbicide, phytosanitary control, labor; have the greatest impact on the total cost of production.

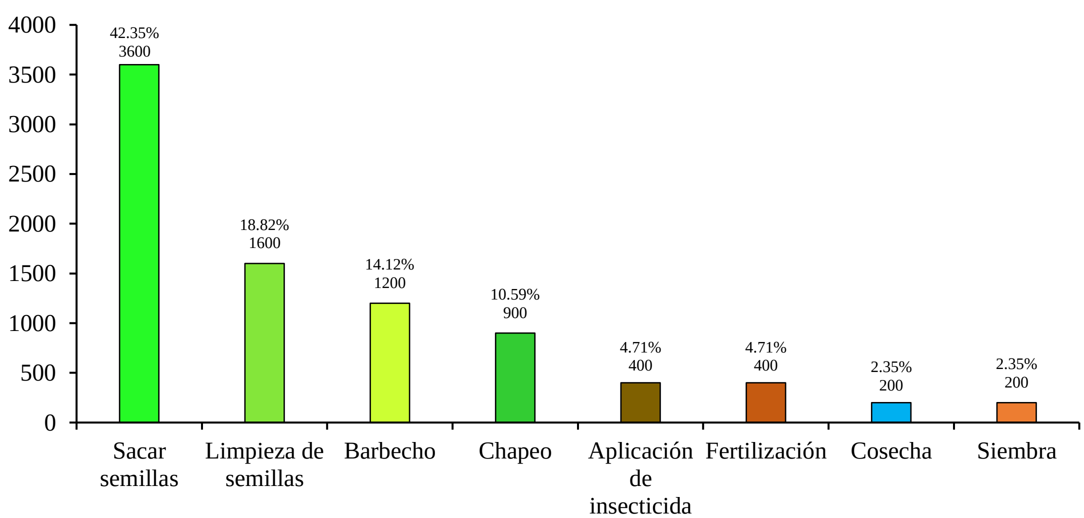

Figure 5. Distribution of production costs in the cultivation of pipian squash.

The financial indicators (break-even point, cost/benefit ratio) of the value-added pipian seed were higher compared to the value of dry pipian seed. The results indicate that the break-even for dry seeds is Mex \$22.00 kg^{-1}. Nevertheless, when value is added to the seed and they are sold as a jamoncillo candy, a higher income is obtained (Table 1), with a cost/benefit ratio of 1.03.

Table 1. Financial indicators of fresh production and value added in pipian squash by annual cycle.

Type of production	Cost (\$ ha^{-1})	B/C	VAN	TIR
Pipian seed (dried)	10 570.00	0.13	1 430.00	8%
Jamoncillo (candy)	47 370.00	1.03	20 276.00	22%

Energy balance of production of dry seed and with added value (jamoncillo)

The preparation of agro-industrial processes such as jamoncillo is carried out in a traditional way by families of Mata de Jobo and it is their main source of income. A key informant said the sale takes place year-round, but the highest demand comes in September and October, with the ‘Day of the Dead’ festivities.

The total energy used for dry seed is less than that of the value-added product (Table 2). The regional market for pipian derivatives (jamoncillo and pipian sauce) includes municipal markets, well-established shops and hawkers in the cities of Xalapa, Huatusco, Coscomatepec, Veracruz and Cardel, which includes a transport price of 100-150 pesos.

Table 2. Result of the energy balance of pipian squash as a fresh and value-added product (jamoncillo).

Inputs	Units	Quantity	Total energy			Energy productivity
			Both products	seed	Jamoncillo	
Tractor	Btu \$	2100	27 747 300			
Nitrogen	Btu kg	1	72 156			
Herbicide	Btu kg	4	1 079 162			
Insecticide	Btu kg	2	438 628			
Wages	Btu h	328	17 755 624			
Subtotal				47 092 870		6.795E-06
Firewood	Btu kg	320	5 713 920			
Other costs	Btu Mex\$	0.03	400 221 770			
Subtotal					405 935 690	7.883E-07
Total	Btu		453 028 561			7.06E-07

Conclusions

The cultivation of pipian squash in the central area of the state of Veracruz (municipalities of Paso de Ovejas and Puente Nacional) has a great importance in the economy of the producers. However, in recent years, it presents important problems that put its permanence as a monoculture at risk, this due to the fall in the price, eventuality and scarcity of rains, pests and diseases and low organization of producers to insert themselves in the market of this seed. Value addition can be an option to achieve higher revenues.

The abandonment of the traditional cultivation of pipian (in association with corn and papaya) can be an option that needs to be valued from the various social, financial and environmental dimensions. However, the practice of monoculture is representing a high cost of production, reducing profits. Regarding the social factor, it is found that the density was 1.6% of the interrelation between producers, which corresponds to a low level of connectivity and therefore low level of organization.

The financial analysis showed a low profitability for dry seed (price of Mex $20.00 kg in 2017) compared to added value (jamoncillo candy). The value-added scheme had a higher energy productivity, compared to the production of dried pipian seed. It is recommended that alternatives for the use of the by-product of pipian squash (the pulp and shell of squash) in animal feed, mainly in cattle, pigs and poultry, should be explored.

Acknowledgements

Thanks to the National Council CONACYT for the grant awarded to the first author. To the Postgraduate College, Veracruz *Campus*, for the financial support provided. To the producers and authorities of the communities of Cantarranas and La Ternera for their collaboration and information.

Cited literature

Ayvar, S. S.; Bahena, M. A.; Doribel, C. M.; Durán, R. J. A. y De Luna, M. J. G. 2004. Rendimiento de la calabaza pipiana en respuesta a la poda y la densidad de población. Rev. Fitot. Mex. 27(1):69-72.

Ayvar, S. S.; Mena, A. V.; Durán, R. J. A.; Cruzaley, R. S. y Gómez, M. N. O. 2007. La calabaza pipiana y su manejo integrado. Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias (INIFAP)- CBTa 176, Fundación Produce de Guerrero AC, Campo Experimental Iguala y CSAEGRO. Iguala, Guerrero, México. 26 p.

Bautista, M. N. y Vejar, G. C. 1999. Lepidópteros más comunes en las hortalizas. *In*: hortalizas, plagas y enfermedades. Anaya, R. S. y Romero, J. N. (Ed.). Editorial Trillas. México, DF. 255-281. p

Canul, K. J.; Ramírez, P. V.; Castillo, F. G. y Chávez, S. J. L. 2005. Diversidad morfológica de calabaza cultivada en el centro-oriente de Yucatán, México. Rev. Fitot. Mex. 28(4):339-349.

Díaz-Nájera, J. F.; Michel-Aceves, A. C.; Ayvar-Serna, S.; Alvarado-Gómez, O. G.; Durán-Ramírez, J. A.; Tejeda-Reyes, M. A.; Solís-Aguilar, J. F. y Díaz-Ceniceros, H. L. 2015. Fertilización foliar en calabaza pipiana (*Cucurbita argyrosperma* Huber) en Apipilulco, Guerrero. Agraria. 12(3):101-110.

Dorantes-Jiménez, J.; Flota-Bañuelos, C.; Candelaria-Martínez, B.; Ramírez-Mella, M. y Crosby-Galván, M. M. 2016. Calabaza Chihua (*Cucurbita argyrosperma* Huber), alternativa para alimentación animal en el trópico. Agro Productividad. 9(9):33-37. file:///c:/users/usuario/downloads/agroproductividadixoctubre2016baja.pdf.

Ebel, R.; Pozas, C. J. G.; Soria, M. F. y Cruz, G. J. 2017. Manejo orgánico de la milpa: rendimiento de maíz, frijol y calabaza en monocultivo y policultivo. Terra Latinoam. 35(2):149-160.

FAO. 2018. Organización de las naciones unidas para la alimentación y la agricultura. http://www.fao.org/tempref/GI/Reserved/FTP_FaoRlc/old/prior/segalim/prodalim/prodveg/cdrom/contenido/libro11/cap2.htm.

Fluck, R. C. 1992. Energy in Farm Production, Energy in World Agriculture, 6, Amsterdam. Elsevier. 13-52 pp.

Garza, O. S.; Núñez, G. H. C.; Serrano, E. A.; Huez, L. M. A. y López, E. J. 2010. Comportamiento diferenciado de líneas, híbridos y criollos de calabaza arota (*Cucurbita argyrosperma* Huber) en primavera y otoño. Biotecnia. 12(3):3-13.

George, R. A. T. 1999. Vegetable seed production. 2nd (Ed.). Cabi Publishing. USA. 328 p.

Hart, R. D. 1985. Conceptos básicos sobre agroecosistemas. Catie. Turrialba, CR. 161 p.

Hernández, B. J. E. and León, J. 1994. Neglected crops 1492 from a different perspective. Food and agriculture organization of the United Nations. FAO plant production and protection series No. 26. Published in collaboration whit the Botanical Garden of Córdoba, Spain, as part of the etnobotánica 92 programme (Andalusia, 1992). 348 p.

Hernández, M. S. 2009. Multiplicación *in vitro* vía organogénesis en calabaza. Agronomía Mesoam. 20(1):11-22.

Infante, V. A. 1998. Evaluación financiera de proyectos de inversión. (Ed.). Norma. Bogotá, Ciudad de México, 5. Panamá, San Juan Barcelona Caracas. 401 p.

Ireta, A. R.; Pérez-Hernández, P.; Bautista-Ortega, J. y Rosas-Herrera, E. L. 2018. Análisis de la red de calabaza chihua (*Cucurbita argyrosperma* Huber) en Campeche, México. Agrociencia. 52(1):151-167. https://www.researchgate.net/publication/323129044.

Martínez-Dávila, J. P. and Casanova-Pérez, L. 2018. Epistemic and conceptual orphanhood in the sustainability of agroecosystems. Sustainability of Agroecosystems. 1(1):1-16.

Merrick, L. C. and Bates, D. M. 1989. Classification and nomenclature of *Cucurbita argyrosperma*. Baileya. 23(2):94-102.

Kuz, A.; Falcol, M. y Giandini, R. 2016. Análisis de redes sociales: un caso práctico. Computación y sistemas. 20(1):89-106. Doi: 10.13053/CyS-20-1-2321.

Lira, S. R.; Villaseñor, J. L. and Ortiz, E. 2002. A proposal for the conservation of the family cucurbitaceae in México. Biodivers. Conserv. 11(10):1699-1720. Doi: 10.1023/A:1020303905416.

Lira, S. R. 1995. Estudios taxonómicos y eco geográficos de las Cucurbitaceae Latinoamericanas de importancia económica. Systematic and ecogeographic studies on crop genepools. 9. International Plant Genetic Resources Institute. Roma, Italia. http://www.fao.org/library/library-home/en/.

Núñez, E. J. F. 2008. Exploración en la operación y modelización de redes sociales de comunicación para el desarrollo rural en zonas marginadas de Latinoamérica. Estudios de casos: red nacional de desarrollo rural sustentable (Rendrus) y red iniciativa de nutrición humana. Tesis doctoral. Universidad Politécnica de Cataluña, Cátedra UNESCO en sostenibilidad. Barcelona, España. 7-15 pp.

Pérez-Vázquez, A. y Leyva-Trinidad D. A. 2019. Análisis comparativo de los principales enfoques de investigación de los sistemas agrícolas. Agro Productividad. 12(6):31-37.

Porta, C. J.; López-Acevedo, M. R. y Roquero, C. D. 2003. Edafología para la agricultura y el medio ambiente. Editorial Mundi Prensa. 3ª (Ed.). Madrid, España. 928 p.

Pardo, R. 1987. Small-scale forest enterprises. AO Food and agriculture organization of the united nations, Rome. Inter. J. Forestry Forest Industries. 39(3):157-158. http://www.fao.org/docrep/s4550e/s4550e00.htm.

Rossel, K. D.; Ortiz, H. L.; Amante, A. O.; Durán, G. H. M. y López, M. L. A. 2018. Características físicas y químicas de la semilla de calabaza para mecanización y procedimiento. Rev. Investigación de la Universidad de la Salle Bajío. 10(2):61-77.

SIAP. 2018. Servicio de Información Agroalimentaria y Pesquera. Secretaría de Agricultura, Ganadería, Desarrollo Rural, Pesca y Alimentación. Cierre de producción agrícola por cultivo http://nube.siap.gob.mx/cierreagricola/.

Sequi, P. 2004. Los micro elementos en la nutrición vegetal. Instituto experimental para la nutrición de las plantas. 3ª (Ed.). Ediciones Mundi Prensa. Italia. 78 p.

Whitaker, T. W. and Davis, G. N. 1962. Cucurbits, botany, cultivation and utilization. Interscience. Publishers, Inc. New York. 249 p.