

RESEARCH PAPER

Current state of and perspectives on cocoa production in Mexico

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Abstract

O. Díaz-José, J. Aguilar-Ávila, R. Rendón-Medel, and V.H. Santoyo-Cortés. 2013. Current state of and perspectives on cocoa production in Mexico. Cien. Inv. Agr.40(2): 279-289. Cocoa is one of the principal agricultural and cultural resources of the humid Mexican tropics. At present, the cocoa system is facing an unprecedented production crisis in relation to several factors, including the presence of frosty pod rot (*Moniliophthora roreri*), plantation neglect and low farm profitability. The aim of this study was to formulate a medium-term plan for cocoa production in Mexico by constructing a Technology Roadmap (TRM). Using an econometric model, production statistics were analyzed for national and international data. Producers participated in 185 surveys, and 82 interviews were performed with key actors in the production chain. The results showed that from 2000-2011, Mexico's cocoa production decreased by 43.7%, contrary to the increase seen in most cocoa producing nations during that time. The TRM indicates that a six-year period is needed to implement the plan, which would involve integration of pest management, introduction of good agricultural practices and management, participation in breeding, improvement of quality and promotion of national cocoa. These actions require the participation of all production chain stakeholders to encourage farmers to take part in the specialized production of Mexican fine aroma cocoa.

Key words: Cocoa, Mexican cocoa, frosty pod rot, technology roadmap, *Theobroma cacao*.

Introduction

An effective and well-informed policy is necessary to revive cocoa (*Theobroma cacao* L.) production in Mexico. Cocoa is one of the most important agricultural and cultural resources of the humid tropics. The crop is grown on 61,344.2 ha that

are distributed mainly in the states of Tabasco (66.9%) and Chiapas (32.7%), and it represents an important source of income for nearly 41,000 families (OEIDRUS, 2012). New areas were planted during the cocoa golden age (from the mid 70s to early 90s), and the total production and yield per hectare increased (Carrasco-Linares and Ramírez-Díaz, 1992; Gonzalez-Lauck, 2005). Currently, production of cocoa faces an unprecedented crisis that is being caused by frosty pod

rot or moniliasis (*Moniliophthora roreri* [(Cif and Par.) Evans *et al.*]), poor plantation management and low yield, among other things.

Frazen and Borgerhoff Mulder (2007) proposed that diversification and increased productivity in the short term are necessary to ensure income for small cocoa producers. The International Cocoa Organization (ICCO) also suggested the generation of national trademarks and badges to guarantee product traceability and social responsibility, which have become relevant to the global cocoa sector (ICCO, 2010).

In Mexico, many investigators have studied cocoa production from different perspectives, including production cost (Cruz-Jimenez, 2008), commercialization (Martínez-Gallardo, 2008), plantation floral diversity and microfauna (Ramírez-Meneses, 2009), cocoa producer association participation for cocoa gathering and commercialization (Córdova-Avalos *et al.*, 2008), and evaluation of the sustainability of conventional and organic systems (Priego-Castillo *et al.*, 2009). In these studies, the primary recommendations were focused on the search for market opportunities, increased competitiveness and the implementation of rescue strategies for cocoa crops.

An appropriate rescue strategy requires the distribution of relevant information to declining farms; not only regarding market opportunities, but also regarding actions for the medium to long term that permit the consolidation of cocoa production as an economically profitable activity for the producer. In this regard, Cordova-Ávalos *et al.* (2001) explain the need for a national strategic plan, the mission of which should be the rescue of the cocoa polyculture system; a system that has already shown economic and ecological sustainability.

The formulation of a strategy requires specific information about the current trends in cocoa culture and the prevailing situation in the country, so it requires a medium term definition of

prospective activity. From this information, it is possible to develop guidelines in the short to medium term for cocoa production development.

Current information regarding cocoa production dynamics is insufficient in Mexico; Furthermore, formulation of a development strategy based on a detailed characterization of producers and their plots is in an uncertain early stage. Therefore, the first objective of the present study was to characterize the current cocoa production industry for the major producing states in Mexico (Chiapas and Tabasco) by evaluating production dynamics and collecting cocoa producer surveys. The second objective was to define a preferred cocoa production development perspective based on the construction of a Technology Roadmap.

Materials and methods

This study first addressed the details of production trends for the principal producing countries. Questionnaires were completed by cocoa producers and key production chain members were consulted. This information was systematized and analyzed with the aid of experts to formulate a viable and well informed proposal for reactivating cocoa production.

Activity characterization

Production dynamic. An econometric model was applied that registers production growth and desegregates percentages of change (Contreras-Castillo, 1999; Leos-Rodríguez, 1980; Zarazúa-Escobar *et al.*, 2011). The fundamental principle was to start with the production change over the 2000-2011 period and to determine whether this change was explained by an increase in cultivated surface, an increase in yields or an interaction between both effects. Based on this model, a productive trend analysis for Mexico was made relative to the principal producing nations for the last twelve years. The following formula was used:

$$P_T = A_0 Y_0 + Y_0 (A_t - A_0) + A_0 (Y_t - Y_0) + (A_t - A_0)(Y_t - Y_0)$$

where:

P_T = Production change for the period of analysis

$A_0 Y_0$ = Production during the base period

$Y_0 (A_t - A_0)$ = Quantification of the contribution per surface

$A_0 (Y_t - Y_0)$ = Quantification of the contribution per yield

$(A_t - A_0)(Y_t - Y_0)$ = Quantification of the combined effect of surface and yield.

A = Average cultivated surface at the start of the analysis period (2000) in ha.

A_t = Average harvested surface at the end of the analysis period (2011) in ha.

Y_0 = Average yield at the start of the period analyzed (2000) in t ha⁻¹.

Y_t = Average yield at the end of the period analyzed (2011) in t ha⁻¹.

Principal characteristics. Information was obtained from a simple random sampling with 90% reliability (FAO, 1998) by including a total of 465 plots that received technical support in 2009 from the Program on Humid Tropics (Programa Trópico Húmedo) of the Mexican Department of Agriculture (Secretaría de Agricultura Ganadería Desarrollo Rural Pesca y Alimentación, SAGARPA). The size of the sample was 185 producers, with 136 in

Tabasco from 6 municipalities and 48 in Chiapas from 5 municipalities.

The questionnaire was divided into four sections; the first section covered the characteristics of the cocoa plantations and included open questions about the producers and plantations such as the producer's age, amount of schooling, and years of experience in cocoa production as well as the amount of cultivated surface, the number of cocoa varieties on the plantations, the age of the cocoa plantations, the plant density and the average dry cocoa yield.

The second part of the questionnaire covered the cost of production and yields; it contained with questions about the economic resources invested in activities, namely annual weed control, fertilization, the application of fungicides and insecticides, mixture for sealing the pruning incision, grafting, shadow regulation, irrigation, pruning, drain rehabilitation, removal of diseased fruits and plant renewal and harvest. The third part covered good agricultural practices (GAP) and was integrated with a list of ten agricultural practices that were classified in terms of their frequency and importance to management of frosty pod rot (Table 1).

Weighted variables were substituted for each of the observations on a calculation sheet. Based on

Table 1. Frequency of good manufacturing practice (GMP) performance for cocoa and GMP weighting in 2011.

Description	Frequency of GMP performance (%)	Weighting ¹
Weed control	96.2	1
Pruning	16.8	5
Maintenance pruning	61.1	3
Pruning rehabilitation	7.0	5
Regulation shade	20.5	5
Maintenance of drains	12.4	5
Fertilization	18.4	5
Removal of diseased fruits	57.3	3
Application of pesticides to control pests	24.3	4
Application of pesticides for disease control	15.1	5

¹The weighting was defined based on the frequency obtained for each activity; the higher the frequency, the lower the activity value due to the importance of these actions for handling frosty pod rot.

the construction of indicators for evaluating rural development programs as proposed by Santoyo *et al.* (2002), the Good Agricultural Practices Index (GAPI) was constructed for use on a national level and for the three main producing regions using the following formula:

$$GAPI = \left(\sum_{i=1}^{10} CP_i(n \cdot 10) \cdot 5 \right) | 100$$

where

GAPI = Good Agricultural Practices Index

CP = Cultivation practices considered in the survey

n = size of the sample

The fourth section covered other producer activities for cocoa plantations.

The questionnaires were validated using three pilot tests in each of the study regions before the formal application was sent to producers. Data were analyzed with SPSS 15.0 software.

Technology Roadmap

The Technology Roadmap (TRM) is a tool with technological, strategic and planning support. It is based on a graphic representation of the principal strategic factors and milestone definitions that make it possible to carry out the necessary actions with the resources required for strategy implementation (Phaal *et al.*, 2004). It is used by businesses, industries, and geographic regions

or countries to support specific strategies (McDowall, 2012). For the present work, the TRM process was carried out in three phases as follows: a regional analysis of capacities and opportunities for cocoa production, roadmap design and implementation and finally, an evaluation of the initiatives proposed by experts and technicians responsible for giving technical advice to cocoa producers.

In the first phase, key production chain members were consulted during personal interviews; these key members were selected on the basis of the Mapping of Major Players methodology (Rendón-Medel *et al.*, 2009). The participants were representatives of all echelons of the production chain (Table 2). Open interviews were performed to collect information about the regional production capacity, the areas and the opportunities for improvement of cocoa production. This phase was completed during the first semester of 2011. Innovation inventories were produced by research institutions, and recent information was examined regarding the support provided to the production chain by government institutions. The second phase consisted of the construction of a trusted group of 10 to 18 participants from industry, academia, government and trade organizations to design an appropriate road map. Finally, the principal TRM proposals were subjected to validation during two participatory workshops with producers, cocoa experts, technicians and agro-industry representatives.

Table 2. Key actors and number of surveys performed in 2010 and 2011 in the main cocoa-producing regions.

Description	Survey numbers
Labor organization representatives	18
Agribusiness representatives	5
International organizations	3
National investigators	3
Regional technicians	25
Public officials engaged in the promotion of cocoa culture	17
Societies of Rural Production (S.P.R.)	5
Craft workshops making chocolate	6
Total	82

Results

Cocoa production reduction in Mexico

The cocoa production change in Mexico during the 2000 to 2011 period was negative, with an average annual growth rate (AAGR) of -1.3. A large reduction in cultivated surface area explains the resulting data. The opposing trend

was identified for the main productive countries, in which production grew steadily. The Ivory Coast is the biggest cocoa producer and showed an extensive degree of growth, whereas the rest of the countries presented intensive growth. In the Latin American context, the main producing nations, with the exception of Mexico, showed marked production increments that are primarily attributable to yield increases (Table 3).

Table 3. Intensive and extensive increase of world cocoa production in ten selected countries, 2000-2011.

Region	Country	Increase ¹ (Pt)	Surface ¹ (Y ₀ (A _t -A ₀))	Yield ¹ A ₀ (Y _t -Y ₀)	Interaction (A _t -A ₀)(Y _t -Y ₀)
America	Mexico	-43.7	-38.0	-7.7	2.0
	Brazil	10.2	-1.0	11.4	-0.1
	Ecuador	21.5	9.4	11.1	1.0
	Colombia	10.7	3.1	7.4	0.3
Africa	Ivory Coast	7.4	13.0	-4.9	-0.7
	Ghana	43.3	13.9	23.6	5.8
	Nigeria	30.0	8.7	18.9	2.3
	Cameroon	30.5	17.5	10.3	2.6
Asia and Oceania	Indonesia	38.4	14.2	19.7	4.5
	Malaysia	-77.6	-99.3	49.2	-27.5

¹Data were obtained from the following databases: FAOSTAT (2011), ICCO (2010) and SIAP (2011).

Tabasco is the principal cocoa grain producer state in Mexico (67.2%), and it showed a higher productive reduction (AAGR was -46.2) than the nation as a whole, and Chiapas (31.9% of the national production) registered a lower value than Tabasco (the AAGR was -33.8). The Tabasco data showed surface reduction (-46.6) as the only cause, but in Chiapas, a higher value was shown for yield reduction (-20.9) with respect to surface reduction (-15.3). The resulting AAGRs were -2.7 and -2.9, respectively. Oaxaca and Guerrero continued to reduce the cultivated surface at an annual rate of 2.5 and 2.8%.

Principal activity characteristics

Production is performed on small farms with trees that surpass the optimum productive age, and the resulting yields are low (Table 4). The predominant cocoa genetic material is trinitario (74.6%), followed by foreign (19.2%) and finally

criollo (7.0%). A polycrop production system is used in which both wood and fruit trees coexist. The Good Agriculture Practices Index (GAPI) is low, and the highest value at a regional level was registered in northern Chiapas (0.26), followed by the Soconusco (0.20) and finally Chontalpa (0.19).

In addition to cocoa, crops such as banana (95.1%), sugar cane (93.5%), corn (89.2%) and grasses destined for extensive type livestock production (87.9%) grow in the production units (the values in parentheses indicate the percentage of cocoa

Table 4. Main features of cocoa plantations in Mexico.

Features of the plantation	Mean	Average
Surface (ha)	1.8	2.8
Age of plantations (years)	33.4	140.9
Density (trees per ha ⁻¹)	615.6	80992.0
Profit (MX\$ per ha ⁻¹)	2214.3	40873743.0
Costs (MX\$ per ha ⁻¹)	3724.3	11443394.0
Yield (kg per ha ⁻¹)	372.0	124048.2
I _{GMP} ¹	0.2	0.023

¹Good Manufacturing Practices Index.

producers with the indicated crop). The profits obtained from cocoa sales are low and production costs are considered high with respect to the resulting economic benefit. The average age of the producers is 57.9 years who have an average of 4.8 years of schooling and a mean of 31.6 years of experience in cocoa cultivation.

Measures to reactivate production in Mexico

Six productive cycles was determined to be an adequate period for developing actions to promote improved cocoa cultivation. Two market milestones were used to present the proposals generated by the work groups and in the applied interviews (Figure 1). Four products or services were identified, namely plantation rehabilitation, cocoa quality, cocoa renewal and Mexican fine flavor cocoa; however, plantation rehabilitation was the highest priority and was scheduled to be developed immediately. For this purpose, execution of Integrated Pest Management (IPM) programs was proposed to counteract the yield reduction

from moniliasis in the short term. On the other hand, good agricultural management practices were considered to increase cocoa quality and supply better grains to the national industry.

Agro-industry representatives noted that the selection of grains, the elimination of foreign material and the quality of the ferment are critical points that need to be addressed during the harvest phase. The renewal of plantations should be focused on criollo materials, preferably for white or pink almonds, which requires the implementation of participatory plant breeding with the goal of accelerating this task. For this study, participatory plant breeding is understood as a strategy for plant breeding that is carried out in close collaboration with local actors, mainly producers and investigators, to accelerate the selection process and the development of promising genetic material. At present, the participatory plant breeding developed in Mexico included the selection and conservation of criollo white almond materials, the flavor and aroma of which are appreciated in international markets (Aguirre-Medina, 2009).

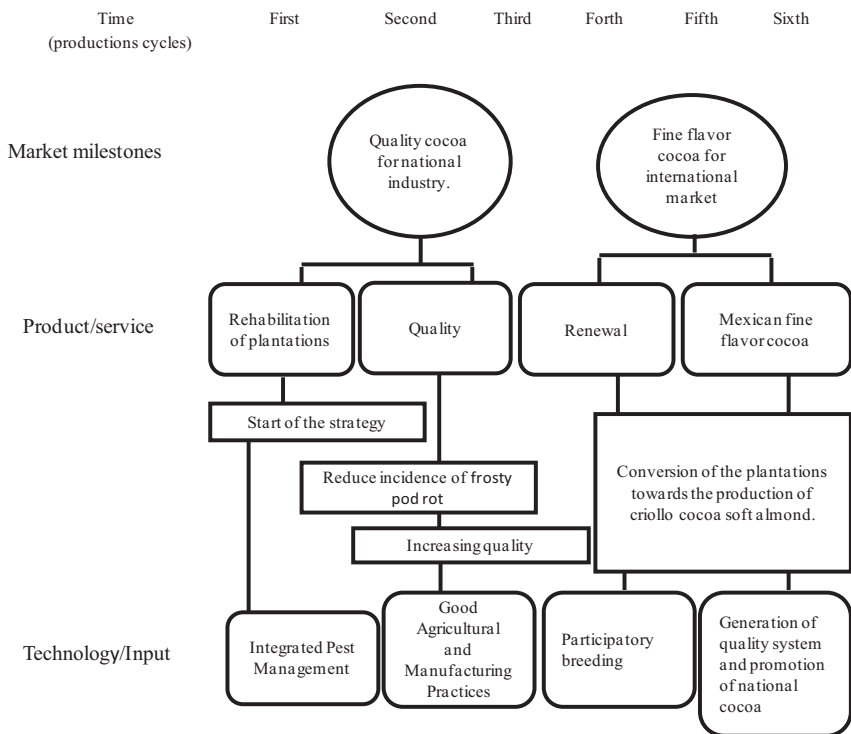


Figure 1. Technology Roadmap for cocoa culture in Mexico.

Finally, the generation of a quality and promotional system for national cocoa was proposed to take advantage of the market paradigm held by Mexico as the center of domestication of the species, which will guarantee the quality of the products.

Discussion

This work has documented the reduction in cocoa production, defined the characteristics of this reduction and devised strategic actions to promote resurgence of cocoa production in the medium term. Recent studies regarding cocoa production in Mexico have noted a decrease in production and the factors that explain this situation, that is, the presence of frosty pod rot since 2005 (Phillips-Mora *et al.*, 2006), aging producers, old plantations (Avenidaño-Arrazate *et al.*, 2011; Priego-Castillo *et al.*, 2009), farm abandonment, low quality cocoa grains and lack of knowledge needed to compete in international markets (Gonzalez-Lauck, 2005; Ogata, 2007). However, those works focused on identification of problems and specific activities needed to develop strategies in the medium term and were performed in a shallow fashion. In the present research, the production dynamics in Mexico are compared to those of other countries; the level of land abandonment and main activity characteristics were documented and the actions necessary for revitalizing cocoa production in the medium term were put forth in a clear and consistent manner.

The results suggest that the reduction of cocoa production in Mexico does not correlate with a global trend or a Latin-American trend. With the exception of Malaysia, African and Asian countries rapidly developed the cocoa production, which was based mainly on yield increments. The yield increment is directly related to the global trend in international cocoa grain prices since 2000, which have led to the intensification of cocoa culture (ICCO, 2010; Phillips-Mora and Wilkinson, 2007). Therefore,

countries with low harvest volumes and delayed development have a comparative advantage if they fulfill differentiated markets instead of engaging in direct competition with the main cocoa producing countries. At the national level, these results suggest that 43.7% of the national harvest was lost from 2000 to 2011 because of damage caused by fungus, which concurs with Phillips-Mora and Wilkinson (2007). This fungus problem led to the logging of 19,326.45 ha of cocoa plants from 2004-2005, which explains how such a large reduction in the cultivated surface occurred during such a short period of time (OEIDRUS, 2012).

However, the main producer states (Tabasco and Chiapas) exhibited differences in factors that explain the production behavior. The reduction in cocoa grain quantities in Tabasco is explained by cocoa plantation logging to grow more profitable crops or engage in other agricultural activities; in Chiapas, the yield reduction is related to a reduction in harvest volume.

With regards to activity characterization, the low GAPI value clearly reflects the abandonment of plantations by the management; this behavior leads to low yields and low profits. At the current time, cocoa production focuses on small properties belonging to older producers. These older producers need to hire additional personnel for agricultural practices such as pruning and weed control, and these practices must be done periodically and require more physical effort; these practices ultimately increase the cost of production. Coupling this situation with scarce economic benefits has led to the abandonment of plantations. Another critical point is the low educational level of cocoa producers; according to Engler and Toledo (2010), this low educational level negatively impacts tool adoption rates relating to management and planning records.

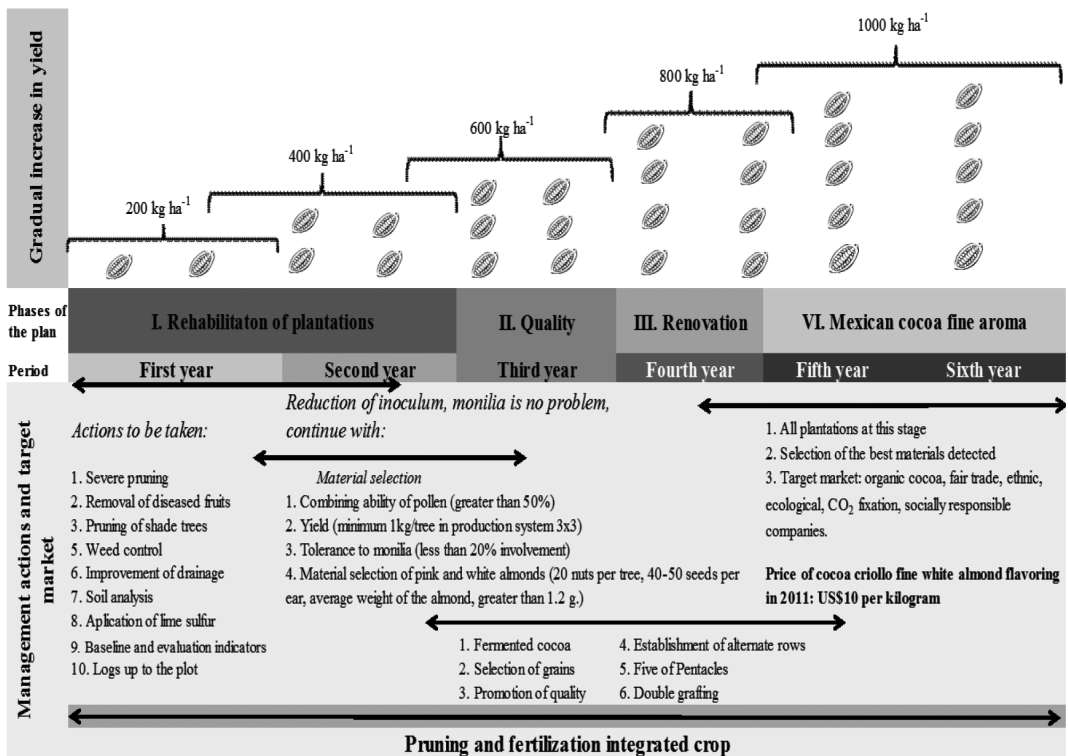
González-Lauck (2005) reports that the abandonment and de-capitalization of cocoa plantations began in the 1990s, with the drop in grain

prices and the increase in cocoa imports by the national industry. Without a secure market, the plantations were neglected and the producers become pickers.

On the other hand, there is a great wealth of knowledge among cocoa producers about polyculture cocoa production because most producers have many years of experience. This knowledge can be used to formulate production strategies as a result of modern production techniques and traditional producer knowledge. In this respect, Gastó *et al.* (2009) mentioned that updating the knowledge and skills of the producers through technical assistance is important for improving production sustainability.

The development of a Technology Roadmap (TRM) facilitates the formulation of a Development Plan for Cocoa Production in Mexico (Figure 2). The plan focuses on the production of a criollo variety of white almond Mexican fine flavor cocoa (known as Caramelo 1) to promote the resurgence of cocoa activity. This Caramelo 1 variety was selected because it has been recognized as one of the best cocoas in the world by the International Cocoa Awards (Méndez, 2010).

Proposals that were established to reactivate production include attending a local market in the short term and growth of the country’s participation in international fine flavor cocoa markets. These actions were documented by Beganovic *et*



Phase I. It consists of actions of IPM to counteract the effect of monilia, rehabilitate and start planting in farm selection of promising materials. The parameters were set in the participatory workshops in collaboration with Victor Hugo Porras Umana.

Phase II. Includes actions to improve the quality of the grain reaches the national agribusiness. We clarified that at this stage requires the involvement of agribusiness to implement an incentive mechanism based producer grain quality obtained, because to date it does not exist.

Phase III and Phase IV. With the selected materials begins renewal of plantations until more of criollo cocoa to achieve a relevant and consistent supply.

Figure 2. Development plan for cocoa production in Mexico.

al. (2010) in view of the expansion of a national chocolate industry and a higher demand for quality cocoa grains. This finding is reinforced by Anga (2012), who ensures that the international market will demand single origin cocoa during the next few years from the supply chain.

In summary, cocoa production in Mexico has decreased by 43.7% because of a reduction in the cultivated surface. The country is experiencing an opposing trend to that of the positive growth seen in the main cocoa producing countries. There is a high level of plantation abandonment; however, it is possible to revitalize production through actions that address the grain quality required by the national agro-industry and a growing international demand for single-origin, fine-flavor cocoa. The development of a TRM allows us to formulate a plan in the medium term to improve this agricultural activity.

The findings of this study contribute to the generation of recent information about cocoa production in Mexico and the perspectives necessary to develop new activities. This information can be used to design new public policies related to promotion. The producers will find useful information for making decisions about their plantations. Finally, investigators may find valuable elements to more effectively articulate the demands of research, development and innovation.

The main contribution of this work is the development of a Technology Roadmap that may be applied to other crops or sectors. However, the

development of an adequate TRM implies the joint work of various actors in the production chain, mainly producers, research centers and government authorities.

The main achievement of this study is its definition of how cocoa production must continue in the medium term. Its main limitation lies in the fact that more specific indicators regarding the realization of good agricultural practices were not used to document the abandonment of plantations at a microregion or municipality level. In the future, a deeper analysis of this situation is required; an analysis of bidimensional models may be necessary to find the main differences between the two main states of cocoa production. Finally, it should be noted that a system of integral planning, such as the one developed in this work, is dynamic and must be modified according to environmental and personnel changes; therefore, a periodic and shared review is obligatory.

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Resumen

O. Díaz-José, J. Aguilar-Ávila, R. Rendón-Medel y V.H. Santoyo-Cortés. 2013. Situación actual y perspectivas de la producción de cacao en México. Cien. Inv. Agr. 40(2):279-289.

El cacao es uno de los recursos agrícolas y culturales más importantes del trópico húmedo mexicano. Actualmente, el sistema cacao enfrenta una crisis productiva sin precedentes debido a varios factores, entre ellos: la presencia de moniliasis (*Moniliphthora roleri*), abandono de plantaciones y baja rentabilidad en las fincas. El propósito de este trabajo fue formular un plan de mediano plazo para el desarrollo de la cacaocultura en México, a través de la caracterización y construcción de un Mapa de Ruta Tecnológica (MRT). Mediante un modelo econométrico, se analizaron las estadísticas productivas nacionales e internacionales. Se aplicaron 185

encuestas a productores y se realizaron 82 entrevistas a actores clave de la cadena productiva. Los resultados evidencian que durante el periodo 2000-2011, México presenta una tendencia contraria en el crecimiento de la actividad con respecto a la mayoría de las naciones productoras de cacao y su producción disminuyó 43.7%. El MRT indica que el periodo para la ejecución del plan es de seis años e involucra acciones de manejo integrado de plagas, incorporación de buenas prácticas agrícolas y de manejo, mejoramiento genético participativo, generación de sistemas de calidad y promoción del cacao nacional. Esto requiere de la participación de todos los actores involucrados en la cadena productiva, con el propósito de llevar a las fincas hacia la producción especializada de cacao mexicano fino de aroma.

Palabra clave: cacao, cacao mexicano, moniliasis, mapa de ruta tecnológica, *Theobroma cacao*.

References

- Aguirre-Medina, J.F. 2009. Historia y situación actual del cacao. In: Alonso-Baez, M., and J.F. Aguirre-Medina (eds.). Manual de producción de cacao. INIFAP. Tuxtla Chico, Chiapas. 109 pp.
- Anga, J.M. 2012. Annual report. International Cocoa Organization. Commonwealth House. London, United Kingdom. 71 pp.
- Avendaño-Arrazate, C.H., J.M. Villareal-Fuentes, E. Campos-Rojas, R.A. Gallardo-Méndez, A. Mendoza-López, J.F. Aguirre-Medina, A. Sandoval-Esquivel, and S. Espinosa-Zaragoza. 2011. Diagnóstico de cacao en México. Universidad Autónoma Chapingo. Texcoco, México. 80 pp.
- Beganović, J., J.P. Chauvin, H. García, S. Khan, and C. Ramírez-Bulos. 2010. The Mexican chocolate cluster. The microeconomics of competitiveness. Harvard University. Cambridge, MA. 31 pp.
- Carrasco-Linares, L.R., and F.J. Ramírez-Díaz. 1992. La agroindustria cacaotera mexicana ante el Tratado Trilateral de Libre Comercio. UACH-CIESTAAM. Chapingo, México. 37 pp.
- Contreras-Castillo, J.M. 1999. La competitividad de las exportaciones mexicanas de aguacate: un análisis cuantitativo. Revista Chapingo Serie Horticultura 5:393-400.
- Córdova-Avalos, V., J.D. Mendoza-Palacios, L. Vargas-Villamil, F. Izquierdo-Reyes, and C.F. Ortiz-García. 2008. Participación de las asociaciones campesinas en el acopio y comercialización de cacao (*Theobroma cacao* L.) en Tabasco, México. Universidad y Ciencia 24:147-158.
- Córdova-Avalos, V., M. Sánchez-Hernández, N. Estrella-Chulim, A. Macías-Layalle, E. Sandoval-Castro, T. Martínez-Saldaña, and C.F. Ortiz-García. 2001. Factores que afectan la producción de cacao (*Theobroma cacao* L.) en el Ejido Francisco I. Madero del Plan Chontalpa, Tabasco, México. Universidad y Ciencia 17:93-100.
- Cruz-Jimenez, J. 2008. Análisis de los costos de producción de cacao en el Ejido Xochimilco Viejo municipio de Ostucán, Chiapas. M.S. Thesis. Instituto de Estadística, Socioeconómica e Informática. Colegio de Postgraduados. Montecillo. Montecillo, Texcoco, México. 86 pp.
- Engler, A., and R. Toledo. 2010. An analysis of factors affecting the adoption of economic and productive data recording methods of Chilean farmers. Ciencia e Investigación Agraria 37:101-109.
- FAO. 1998. Encuestas agrícolas con múltiples marcos de muestreo: Programas de encuestas agropecuarias basadas en diseños de muestreo con marco de áreas o doble marco de selección (de áreas y de lista). Series de Desarrollo Estadístico. FAO. Roma. 32 pp.
- FAOSTAT. 2011. Food and Agricultural commodities production. FAO. Available online at: <http://faostat.fao.org/site/339/default.aspx> (Website accessed July 7, 2011).
- Franzen, M., and M. Borgerhoff Mulder. 2007. Ecological, economic and social perspectives on cocoa production worldwide. Biodiversity and Conservation 16:3835-3849.
- Gastó, J., L. Vera, L. Vieli, and R. Montalba. 2009. Sustainable agriculture: unifying concepts. Ciencia e Investigación Agraria 36:5-26.

- Gonzalez-Lauck, V.W. 2005. Cacao en México: competitividad y medio ambiente con alianzas (Diagnóstico rápido de producción y mercadeo). United States Agency International Development. Chemonics International Inc. 93 pp.
- ICCO. 2010. The world cocoa economy: past and present. Executive committee, one hundred and forty-second meeting. International Cocoa Organization (ICCO). London. 46 pp.
- Leos-Rodríguez, J.A. 1980. Surplus transfer and terms of trade in Mexican agriculture. Ph.D. Thesis. University of California. Berkeley. 250 pp.
- Martínez-Gallardo, J.B. 2008. Diagnóstico de la comercialización del cacao (*Theobroma cacao* L) neocriollo y convencional en el Cunduacán, Tabasco, México. M.S. Thesis. Colegio de Postgraduados, Campus Tabasco. H. Cárdenas Tabasco, México. 105 pp.
- McDowall, W. 2012. Technology roadmaps for transition management: The case of hydrogen energy. *Technological Forecasting and Social Change* 79:530-542.
- Méndez, L.E. 2010. Finca la Joya da prestigio mundial al cacao de Tabasco. Milenio. Villahermosa, Tabasco. Available online at: <http://www.milenio.com/cdb/doc/impreso/8874254> (Website accessed July 10, 2010).
- OEIDRUS. 2012. Oficina Estatal de Información para el Desarrollo Rural Sustentable en el Estado de Tabasco. Oficina Estatal de Información para el Desarrollo Rural Sustentable (OEIDRUS). Tabasco. Available online at: <http://www.campotabasco.gob.mx/> (Website accessed 7 July 2011).
- Ogata, N. 2007. El cacao. *Biodiversitas* 72:1-5.
- Phaal, R., C.J.P. Farrukh, and D.R. Probert. 2004. Technology roadmapping: a planning framework for evolution and revolution. *Technological Forecasting and Social Change* 71:5-26.
- Phillips-Mora, W., A. Coutiño, C.F. Ortiz, A.P. López, J. Hernández, and M.C. Aime. 2006. First report of *Moniliophthora roreri* causing frosty pod rot (moniliasis disease) of cocoa in Mexico. *Plant Pathology* 55:584-584.
- Phillips-Mora, W., and M.J. Wilkinson. 2007. Frosty pod of cacao: a disease with a limited geographic range but unlimited potential for damage. *Phytopathology* 97:1644-1647.
- Priego-Castillo, G.A., A. Galmiche-Tejeda, M. Castellán-Estrada, O. Ruiz-Rosado, and A. Ortiz-Ceballos. 2009. Evaluación de la sustentabilidad de dos sistemas de producción de cacao: estudios de caso de unidades de producción rural en Comalcalco, Tabasco. *Universidad y Ciencia* 25:39-57.
- Ramírez-Meneses, A. 2009. Diversidad florística y macrofauna edáfica en plantaciones agroforestales de cacao en Cárdenas, Tabasco. M.S. Thesis. Colegio de Postgraduados, Campus Tabasco. H. Cárdenas Tabasco, México. 99 pp.
- Rendón-Medel, R., J. Aguilar-Ávila, J.R. Altamirano-Cardenas, and M. Muñoz-Rodríguez. 2009. Etapas del mapeo de redes territoriales de innovación. CIESTAAM-Universidad Autónoma Chapingo. Chapingo. 47 pp.
- Santoyo, V.H., P. Ramírez, and M. Suvedi. 2002. Manual para la evaluación de programas de desarrollo rural. Editorial Mundiprensa, Universidad Autónoma Chapingo/CIESTAAM. Chapingo, México. 245 pp.
- SIAP. 2011. Cierre de la producción agrícola por cultivo SAGARPA. Mexico. Servicio de Información Agroalimentaria y Pesquera (SIAP). Available online at: <http://www.siap.gob.mx> (Website accessed 22 June 2011).
- Zarazúa-Escobar, J.A., G. Almaguer-Vargas, and S.R. Márquez-Berber. 2011. Redes de innovación en el sistema productivo fresa en Zamora Michoacán. *Revista Chapingo Serie Horticultura* 17:51-60.

