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Communication

Drivers and Consequences of the First *Jatropha curcas* Plantations in Mexico

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Abstract: *Jatropha curcas* has received great attention and national support by Mexican authorities interested in promoting cash crops to alleviate poverty and rural crises. Thus, several states have implemented programs to sponsor its cultivation and research. This paper analyzes the policies generated by the Mexican government to promote the establishment of *Jatropha* plantations for biofuel purposes. The supporting schemes, the state-of-the-art national research and the environmental implications of establishing this new crop were reviewed to assess their impact on small-scale producers that participated in these programs. Scientific research on native germplasm indicates the existence of great diversity in Mexico, including non-toxic ecotypes, from which highly productive varieties are being developed. However, when the plantation programs started, producers were not technically or economically prepared to face the risks associated with this new crop, nor was there a good internal supply-chain. Consequently, some programs have been abandoned and the low productivity and income generated by the plantations have not satisfied producer expectations. Thus, there is a need to review the national strategy to support this crop and to develop a well-structured biofuel market in the country for the success of *Jatropha* plantations in Mexico.

Keywords: Mexican *Jatropha*; bioenergy policies; Mexican research

1. Introduction

Although Mexico is one of the 10 largest petroleum producers and exporters, there is an increased concern in the country for the future of national reserves, which have declined since 2000 [1], and also for the environmental impacts from its excessive consumption, as the primary source of energy in Mexico is petroleum [2]. Therefore, new initiatives have been considering the use of clean energy to supply national and international demands. In this regard, in 2006, the Secretary of Energy (Secretaría de Energía.) (SENER) provided studies to determine the feasibility of producing bioethanol from the cultivation of sugarcane, sweet sorghum and cassava and biodiesel from rapeseed, soybean, *Jatropha*, sunflower and safflower [3]. The SENER suggested that these biofuels could be used when blended with petroleum in the Mexican transportation system to reduce CO_2 emissions to the atmosphere. This proposal was publicly announced in 2008 by President Felipe Calderón [4], and the "Law of Development and Promotion of Bioenergy" (Ley de Promoción y Desarrollo de los Bioenergéticos) was also promoted in that year [5], together with the "Law for the Sustainable Use of Energy" (Ley para el Aprovechamiento Sustentable de la Energía) [6]. Both laws promote and regulate research and production of biomass for energy purposes without compromising food security. These regulations were especially directed to provide incentives for the agriculture sector, in crisis since 1980 [7], by supporting employment generation and the development of rural communities planting biofuel crops. Within this strategy, the SENER launched a program for the introduction of bioenergy sources [8] to emphasize its support for the Mexican countryside by procuring incentives to stimulate the establishment of energy crops to produce biodiesel and bioethanol. The program considered the introduction of biofuels as additives to petro-fuels and the investment of more than four million dollars over the following five years to enable the domestic refining industry to be able to provide these additives. The Secretary of Environment and Natural Resources (SEMARNAT) (Secretaría del Medio Ambiente y Recursos Naturales) was responsible for verifying sustainability issues related to biofuels, and the Secretary of Agriculture, Livestock, Rural Development, Fisheries and Food (SAGARPA) (Secretaría de Agricultura, Ganadería, Desarrollo Rural, Pesca y Alimentación) was responsible for implementing rural programs, such as sugar beet, sugarcane and sweet sorghum to produce bioethanol and castor plant, oil palm and *Jatropha* to produce biodiesel [9]. SAGARPA assigned economic resources to support projects for seed production and the propagation of these cultivars, and although the SENER [8] warned of the need to achieve greater development in the biofuel processing industry to satisfy projected goals, several states in Mexico focused their rural development policies on the establishment of biofuel crops, such as *Jatropha curcas*.

This paper reviews and analyzes the Mexican policies and directions followed to promote and establish the first *Jatropha* commercial plantations. It also considers the Mexican research on *Jatropha* plantations, the technical and economic support provided to the first producers and the introduction of alien germplasm to the country as important key factors for the first results obtained by the producers.

2. Methodology

In order to perform a thorough analysis on the results of the first commercial planting of *Jatropha* at the level of the state and that for small-scale producers, we first researched the legal framework

and the national trends over the years 2006 to 2008, when the first plantations were established. Subsequently, we analyzed the national and state strategies for planting and marketing *Jatropha*, considering economic, technical and environmental factors. Finally, we conducted a search for national research on this species in order to have an overview of the national capabilities for establishing a crop for which there were no previous experiences. Consulted documents included research papers, master's and doctoral theses, state and national journalistic notes, statistics and legal texts available to the public. Our experience with *Jatropha* research helped to select and organize verifiable information presented in this document.

3. Results

3.1. The Mexican Drivers for Jatropha Cultivation

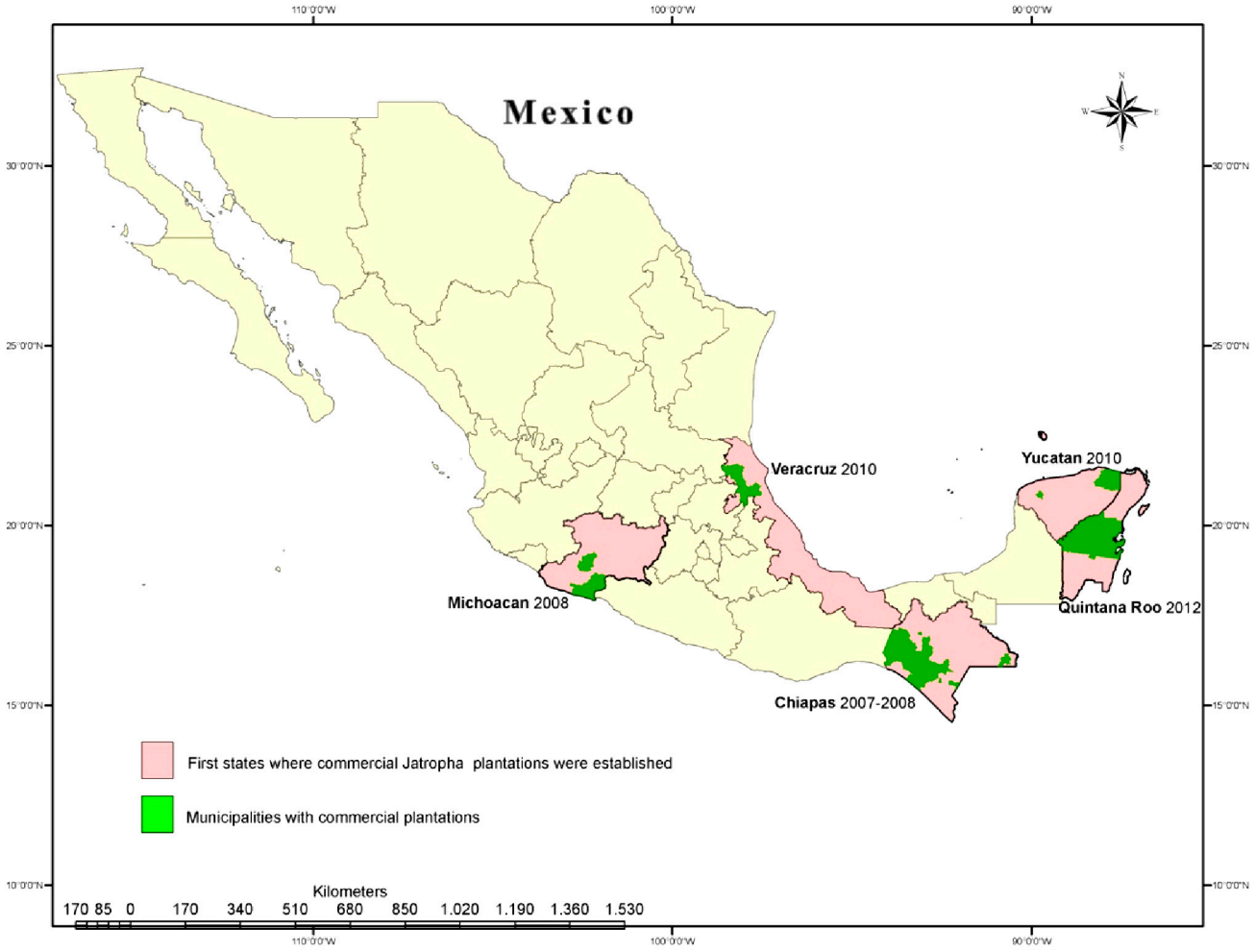
Due to the international boom in *Jatropha* around the world, official information provided by SENER [3] considered *Jatropha curcas* as one of the promising crops for biofuel purposes. This decision was also based on the following considerations: (1) the species is not used in the food-chain; and (2) the well-known reputation that its seeds are rich in good quality oil and that the plant is able to grow in low fertility soils with little nutrient supplementation or other care [10,11]. Therefore, cultivars that are able to grow and produce fruits under poor conditions would allow for their establishment on many eroded lands in Mexico. Hence, the cultivation of *Jatropha* not only would be useful for the agro-industry, but also would help to rehabilitate soils and enhance the reforestation of deforested lands. Thus, it was feasible for the National Forest Commission (CONAFOR) (Comisión Nacional Forestal) to provide incentives for commercial plantations to use *Jatropha* [3]. Since 2007, this commission has operated a national program having a specific title, "Piñón de Aceite (Piñón de Aceite = Pinion Oil), *Jatropha curcas*", to provide economic support to land owners and communal land-holders cultivating this plant [12]. This crop also received publicity and economic support from other government agencies, such as the National System for Oil Production (Comité Nacional Sistema Producto Oleaginosas) and the National Research Institute for Forestry, Agricultural and Livestock (INIFAP) (Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias), who considered that future European goals for substituting a percentage of diesel with biodiesel would increase the demands for *Jatropha* biofuel, ensuring good international prices. INIFAP estimated that the potential lands for *Jatropha* cultivation in Mexico were more than 2.6 million hectares [13]. The study also mentioned that the best soils and climate for this species were located in the southeast of Mexico. Given this information, in 2007, various southeastern states in Mexico planned to cultivate thousands of hectares (ha), including Veracruz (200,000), Yucatán (6000), Michoacán (6000) and Chiapas (20,000) [14].

3.2. The Actors Leading the First States to Cultivate Jatropha

By 2006 and 2007, some state governments, such as Chiapas, Michoacán, Yucatán, Quintana Roo and Veracruz (Figure 1), decided to openly announce their support for *Jatropha* plantations, partly to alleviate their rural crises with national incentives and partly to lead the way as future providers of alternative energy for developed countries [15,16]. The state of Chiapas announced the most ambitious bioenergy project, proclaiming the achievement of additional goals, such as support for farmers,

reforestation, mitigation of effects from climate change, the use of marginal and degraded lands and national and foreign investment to create jobs. To meet these goals, the state of Chiapas created the Institute of Bioenergetics and Alternate Energies in 2007 (IBEA) (Instituto de Bioenergéticos y Energías Alternativas) and also installed a biodiesel refinery, with up to 20,000 liters of daily capacity, as well as planned to use the product in the public transportation system in its capital, Tuxtla Gutierrez. Additionally, the government proposed the establishment of ten thousand hectares of *Jatropha* plantations to provide fuel for the local bio-refinery [7]. In Michoacán, the state, together with international companies, supported the establishment of cultivars and one commercial bio-refinery to produce and sell biodiesel from *Jatropha* to the rest of the country with a capacity of nine million liters per year [17,18]. Furthermore, the governments of Yucatan, Veracruz and Quintana Roo sought the collaboration of foreign investors in the oil processing chain, while promoting the establishment of plantations of this species among local farmers, with the state providing the seedlings and CONAFOR the economic stimulus [19–21].

Figure 1. States and municipalities where the first commercial *Jatropha* plantations were established. Data compiled from [7,15,22–24].



3.3. Technical and Economic Support Schemes

3.3.1. The Financial Assistance Scheme

To promote the establishment of *Jatropha* plantations, the state governments provided the seeds for sowing, while CONAFOR offered a subsidy to producers consisting of 120 minimum wages per year when the program started in 2008 and 2009, increasing to 135 the next year. However, this institution conditioned its support on the establishment of at least four ha with 1600 plants per ha per producer. The survival of 70% of the plants during the first year was another requirement [12]. Additional materials required and labor costs for harvest had to be covered by producer holdings or by any additional local state subsidy. Tables 1 and 2 show the number of producers applying for subsidies or involved in the first plantations and the main reasons they sought to cultivate *Jatropha*. Data from CONAFOR only corresponds with those plantations receiving support from this organization. Independent reports correspond to journalistic notes or government presentations that included producers planning to apply or applying to receive support from *Jatropha* programs and plantations not registered by CONAFOR.

3.3.2. Requirements for Establishing Plantations and Technical Support

In order to provide financial subsidies, both national and state programs are required to fulfill certain requirements [12], such as: (1) specialized technical assistance to manage plantations; technical advisors must be approved by CONAFOR as qualified personnel to assist in planting this specific species; (2) the location of the site must be inside the municipalities approved by CONAFOR, who considered the map of potential growing areas provided by INIFAP [13] to determine proper land use; and (3) the seedlings to establish plantations must come from nurseries approved by CONAFOR.

3.4. Environmental Implications

3.4.1. Origins of the Germplasm

Jatropha curcas has its origins in Mexico and Central America [25]. Thus, it is possible to find native plants in many states of the country, like Michoacán, Chiapas, Yucatan, Quintana Roo and Veracruz [26]. However, most of them are wild or have been grown with little human care and are simply used as living fences and/or for medicinal purposes by locals that did not consider their commercial applications [27]. Additionally, studies on seed productivity in the native provenances were not available at the time of the first commercial plantations, so it was risky to start commercial plantations without having elite Mexican accessions. This situation led to authorities in charge of the programs to decide on the importation of seeds from countries where commercial plantations already existed, such as India and Thailand [7,16], sites where germplasm would have evolved under different conditions, would have less genetic diversity [28,29] and would be more susceptible to new diseases. As a result, in Chiapas, the seeds presented less than 40% germination, and the resulting seedlings showed poor development in 76% of the plots [7].

3.4.2. Phytosanitary Situation

The importation of foreign seeds to propagate *Jatropha* in Mexico would generate several problems related to the performance of plantations and with the risk of introducing unknown pests in areas where they settled. In the state of Chiapas, the bacteria, *Ralstonia solanacearum*, which was not reported previously in specimens collected from Chiapas, was detected in crops developed with the Indian seeds after two years of establishment [30]. In the states of Yucatan and Quintana Roo, labor workers have reported an unknown disease that has drastically reduced productivity [31]. The pathogen, *Colletotrichum capsici*, has been reported in about 25% of the plantations of these states [32], and it may be the cause of these losses.

3.4.3. Agricultural Schemes

Our research study suggests that for the states of Yucatan, Quintana Roo and Michoacan, where demands to produce *Jatropha* come mostly from private resources interested in huge volumes of production [19,22], the selected agricultural schemes were monocultures in order to maximize production. In the states of Chiapas and Veracruz, CONAFOR, the main promoter of *Jatropha*, conditioned its economic support to the establishment of no less than 1600 plants per hectare (3 × 2 m) and more than 70% survival, most producers also opted for the establishment of *Jatropha* as a monoculture to ensure a higher number of plants [7]. These monocrops in some cases displaced Mexican traditional crops, such as maize and beans or polycrops, and some producers, who did not want to displace their traditional crops, cleared or deforested their lands to plant *Jatropha*.

3.5. Economic Results

According to one study performed in central Chiapas regarding the first producers, less than 25% were satisfied with their results, due to the low productivity of the plants and the lack of governmental support [7]. Other research found net losses of 10%–35% among 133 producers in central Chiapas [33], and another revealed that almost 49% of the first producers of *Jatropha* in three municipalities of the state had abandoned their cultivation by 2012 [34]. There is no data available on the current situation of the plantations in this state. In Michoacan, one study covering three rural communities indicated that more than 50% of the small-scale producers were not satisfied with the results of their plantations, because the production investment was higher than expected and the prices of the seeds were lower than the prices they used to receive for other crops, such as lemons, sorghum and corn [18]. Although one international company still maintains a webpage informing of the high-scale production of *Jatropha* cultivars, it has not been updated since 2011 [35]. In the states of Yucatan and Quintana Roo, journalistic notes reported that crops were severely affected by uncontrolled pests, and most labor workers in the *Jatropha* chain lost their jobs [31], although there are still private companies growing *Jatropha* there. For the state of Veracruz, these authors did not find public information from the results of the plantations established there.

3.6. Current State Policies

Currently, in the state of Chiapas, the new administration has abandoned *Jatropha* projects as part of their strategy to promote rural development, the last institute created and dedicated to promote biofuels (IRPAT) has been closed and the state biodiesel refinery has been abandoned, to the dismay of producers. A similar situation occurred in the state of Michoacán, where the bio-refinery is no longer operating. Both bio-refineries were closed due to the low inputs they were receiving, which, in the case of Michoacán, affected operational profits [36,37]. The states of Michoacán, Yucatan and Quintana Roo do not have any dependency on promoting biofuels (Table 1). The state of Veracruz is the only one maintaining a dependency (INVERBIO (Instituto Veracruzano de Bioenergéticos)) on promoting biofuels, but until now, there was no available information on successful projects from *Jatropha* plantations in the state [38]. At the national level, until 2013, CONAFOR still provided economic support to establish a total of 8000 hectares of *Jatropha* in several states of the country [39], while SAGARPA still maintains its program to support research projects on biofuels and the propagation of oily plants, with *Jatropha* being among them [40].

Table 1. First actors involved in *Jatropha* plantations reported by the National Forest Commission (CONAFOR) and other sources.

Data	Michoacan		Veracruz		Chiapas		Quintana Roo *		Yucatan	
Source	CONAFOR	[20]	CONAFOR	[14]	CONAFOR	[7]	CONAFOR	[24]	CONAFOR	[25]
Surface (ha)	716	7428	13	2590	4202	7000	496	1200	4751	13800
Number of farmers	-	636	-	1500	-	3000	10	18	3 agro-industries	2 agro-industries
Period	2008–2011		2009–2010		2007–2011		2012		2010–2011	
State institution supporting biofuels			+INVERBIO		+IBEA (2007–2008) +IRPAT (2008–2011)					

* Although it is inferred that plantations could be established since 2010, no official records were found until 2012. -, This information was not found. +INVERBIO (Instituto Veracruzano de Bioenergéticos). +IBEA (Instituto de Bioenergéticos y Energías Alternativas). +IRPAT (Instituto para la Reconversión Productiva y la Agricultura Tropical).

3.7. National Research on Jatropha Germplasm

3.7.1. The National Germplasm

In Mexico, *Jatropha* has been found in various states, including Tamaulipas, Veracruz, Tabasco, Yucatán, Quintana Roo, Chiapas, Oaxaca, Guerrero, Michoacán, Sinaloa, Sonora, Puebla, Hidalgo, Morelos and Guadalajara [41,42]. Although most of the plants are toxic, due to the presence of alkaloids, known as phorbol esters, which cause a laxative effect, stomach pain and other discomfort on humans, in Mexico, it is possible to find non-toxic plants, mainly in the region of Totonacapan, in places, such as Papantla in Veracruz, Huasteca in Hidalgo and Sierra in Puebla. Indeed, in many towns of these regions, there is a long history of their use in traditional dishes [26].

3.7.2. Research on National Germplasm

Even though some research on Mexican *Jatropha* existed before 2006, there was no precise information on the agronomic characteristics of the germplasm, since most investigations were performed by academics interested in possible ethno-botanical and food applications, as the Mexican edible ecotypes were still underutilized [26,27,]. Since the years 2006 and 2007, national specimen collections were started by INIFAP [29] and other research centers in Michoacán, Chiapas, Morelos and Veracruz. Collectively, research has found a higher genetic diversity in morphology, flowers and fruits, oil content, fatty-acid composition, toxicity and grain yield in the Mexican provenances when compared with Asian and African provenances [28,29,43].

In order to improve the national germplasm for biofuel applications, INIFAP established 422 provenances in experimental plots located in fourteen states of the country. By 2011 and 2012, after identifying the most promising strains, INIFAP reported five elite and highly productive varieties (producing more than one ton per hectare and more than 50% oil content in seeds). INIFAP also expressed the need to continue with more studies to improve these findings [29,43,44], as close to five years is needed to determine actual plantation production capabilities [44].

By 2009, the National Autonomous University of Mexico (UNAM) (Universidad Nacional Autónoma de México) was also studying the productivity of local germplasm in the state of Morelos [45]. UNAM was interested in the non-toxic germplasm, in addition to the biofuel purposes; thus, non-toxic and toxic specimens were part of the studies. By the year 2008, the *Jatropha* Network (JN) was initiated with the support of the National System of Plant Genetic Resources for Food and Agriculture (SINAREFI-SAGARPA) (Sistema Nacional de Recursos Fitogenéticos para la Alimentación y la Agricultura). Six research institutions were the first members of the JN: Colegio de Postgraduados, University of Veracruz, Developing Center of Biotic Products from the National Polytechnic Institute (Centro de Desarrollo de Productos Bióticos del Instituto Politécnico Nacional (IPN-CEPROBI)), INIFAP, Technological University of the Huasteca (Universidad Tecnológica de la Huasteca) and the private company, Jatro Bioenergy and Oil Seeds. This network studied not only *Jatropha curcas*, but also the completely native genus *Jatropha* in Mexico. Its primary achievements, reported until 2011, have been the morphological and chemical characterization of more than 200 provenances of *J. curcas* collected from five states. The JN also sent seeds to the national germplasm bank for their preservation and determined the toxicity in collected specimens. The JN identified four samples with oil contents higher than 65%, while participant institutions established experimental plots with promising germplasm in their campuses [46]. Despite this valuable information, the JN has not published more reports after this date; however, it has funded the promotion of regional dishes prepared with *Jatropha* seeds and flour at the First and Second Festival of Agrodiversity and Agroproducts organized by the Agriculture Ministry in 2012 and 2013.

4. Discussion

4.1. National Policies and Their Implications in the Production Chain

By the time of establishment of the first *Jatropha* commercial plantations in Mexico, the SENER proposed that PEMEX (the national oil company (Petroleos Mexicanos)) would have to acquire

biofuels and bioethanol for their use as fuel additives in the three main cities of the country, Mexico City, Guadalajara and Monterrey. This goal is still printed in the SAGARPA program to be met by 2012 [40]. However, now, in 2014, there is no legislation to coerce the compulsory use of biofuels by PEMEX, and this compromise is still not fulfilled. Here, it is important to point out that Mexico still has a national monopoly on the distribution and use of fuels, through the national company, PEMEX. Therefore, private markets to purchase fuels are practically nonexistent. This means that, without government support or technology to use these new energies, there are no national markets for biofuels. Thus, only those who have enough resources to process seeds and export the oil are able to continue growing *Jatropha*, making it very difficult for small-scale producers to sell their product. Similar experiences have been reported in some African countries, where the application of different models of contractual arrangements have been established to solve these problems [47]. In this regard, the law for the promotion and development of biofuels still needs improvement, since it has not considered direct incentives for those that desire to participate in the biofuels industry [5]. Mexican politicians need to analyze and review this law and other national regulations to stimulate the production chain of biofuels to ensure a good income for primary producers, rather than just focusing on exportation expectations, out of the reach of the majority of Mexican producers. Good examples of biofuel success at the national level can be taken from Brazil, which made agreements with manufacturers to develop modified vehicles, implement legislations to blend bioethanol and biodiesel with petro-fuels and support large investment in research and technology developments to perfect the transformation processes and reduce manufacturing costs [48].

4.2. Analyzing the Technical and Financial Support Schemes

For the states of Chiapas and Michoacán, where more plantations have been established (Table 1), the insufficient financial support for the years that this crop requires for its establishment until it is profitable and the deficient technical advice to properly grow the cultivars and protect against the diseases that severely affected the plantations were the main reasons of dissatisfaction among producers [7,18,22,33,34]. A similar situation might happen in Yucatan and Quintana Roo, where producers are searching for financial help to cope with the unexpected events in their plantations [31]. In this regard, if we examine Table 2, we can see that economic support was a major reason for establishing this new crop among small-scale producers. Therefore, the quantities provided by CONAFOR to establish *Jatropha* were not sufficient for this type of crop at small-scale volumes. The low profitability of *Jatropha* has also been reported as a major problem for small-scale producers in countries like Kenya and India [49]. Therefore, Mexican state governments should consider longer-term periods for supporting this crop or the establishment of polycrop systems to increase incomes during the first years for the case of small-scale producers. Regarding technical support, it is important to consider that, although national and state programs required specialized technical support to manage plantations [12], by the time the programs started, it was unlikely for the technicians in any region of the country to have experience in this type of monoculture. For example, the first guides for *Jatropha* cultivation in Mexico were not published until the second semester of 2011 [29,43]. Therefore, the knowledge of seed quality and requirements for fertilizers and pest control were still under development by the time the plantations were initiated. These conditions promoted improper

selection, packaging and long-term storage of seeds imported to Mexico. Consequently, they presented serious problems for germination (less than 40% was documented in Chiapas), and seedlings had very little vigor, resulting in fewer healthy seedlings in the plantations; and neither producers nor technicians were able to respond to the problems with this crop. The case of Veracruz is special; it possesses and has used non-toxic *Jatropha* as a food in various rural towns for several centuries [26]. Here, unofficial information indicates that small-scale producers rejected the imported seeds provided by the state and continued growing their non-toxic plants and selling their seeds for food uses inside their region. It is likely, however, that the income generated here is not big enough to figure in any public statistical information.

Table 2. Two main reasons to cultivate *Jatropha* according to producers.

State	Main reason	Reference
Michoacan	To sell seeds to the biodiesel processing plant; CONAFOR grant	[18]
Veracruz	CONAFOR grant; state government support	[14]
Chiapas	To earn income from the sale of *Jatropha* seed; CONAFOR grant	[7]
Quintana Roo	To sell seeds to the projected biodiesel plant, which would export biodiesel; state government support	[21]
Yucatan	To sell seeds to the projected biodiesel plant, which would export biodiesel; state government support	[23,24]

4.3. Analyzing Agricultural Schemes and Ecological Consequences

Given that most *Jatropha* plantations are monocrops, that they replace traditional crops, such as maize and beans or polycrops, and lead to deforestation only to be replaced with *Jatropha* [7,18,50,51], there are ecological implications: (1) it cannot be claimed that *Jatropha* was used for restoration purposes or that *Jatropha* had positive effects on soil restoration, since most of the plantations were established on farmlands, and there are no studies of soil restoration from *Jatropha* establishment on eroded lands in Mexico; (2) the new diseases that imported *Jatropha* seeds brought to Mexico could be a risk for national germplasm and other crops; (3) the presence of *Jatropha* pests has forced producers to use agrochemicals to control them, increasing the dependence on external inputs and delivering more contaminants to the environment; and (4) in places where producers deforested land to plant *Jatropha*, there may be some loss of water catchment capacity and biodiversity. Therefore, some actions are required in order to avoid these negative ecological impacts. Mexico should improve its Law for the Sustainable Use of Energy [6], ensuring that biofuels shall not originate from primary forest, highly biodiverse grasslands and carbon-rich areas, such as is established in the European Union [48].

4.4. Socio-Economic Impacts

It is difficult to estimate the economic impacts of the first *Jatropha* plantations, since their number is undefined. CONAFOR and independent sources show different data. It is possible that some government authorities inflated the number of producers in their presentations to attract the attention of citizens, creating a false impression of a real boom in this crop, which is reflected in the journalistic

notes and private presentations shown in Table 1. All this publicity could also have attracted the attention of the first small-scale producers who thought they could easily improve their income. Therefore, they had overly high expectations for this crop. Thinking that *Jatropha* would generate good incomes, most producers established monocrops; where payback depended only on *Jatropha* plants, which came from imported seeds of dubious quality. Later, the bio-refineries in Chiapas and Michoacán were closed [37]. Therefore, at present, places to sell the seeds are uncertain, discouraging many small-scale producers from a preference for growing this product. Despite the losses among small-scale producers, large *Jatropha* plantations have generated new jobs for landless workers [50], and some prospective studies show possible good profits in the middle-term if biodiesel is exported and the cultivation of non-toxic *Jatropha* and poly-cultures are applied by small-scale producers [36,51]. In this regard, the national non-toxic germplasm is a great resource, not only for biofuel purposes, but also for food. Thus, national research to develop an elite non-toxic material is a key for the success of Mexican *Jatropha* plantations.

5. Conclusions

Although *J. curcas* is a plant with high potential for biofuel production and Mexico possesses non-toxic germplasm, which can be exploited for additional food uses, its cultivation in the Mexican field is uncertain at this moment. The commercial plantations require more investments in soil preparation, fertilization, watering, pests and disease control, with increasing costs that are higher than the subsidies provided by the government, making plantations at this time unprofitable for small-scale producers. Therefore, the success of biofuel projects, like *Jatropha* in Mexico, require that public policies encourage the use of alternative energies and the development of appropriate technologies for plantations and oil processing through subsidies for biofuel transformation chains and the generation of new biofuel consumers.

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Author Contributions

Ofelia Andrea Valdés conceived the study, collected information and analysed data, Caupolicán Muñoz analysed data and review the document. Arturo Perez analysed data, review and approved the document.

Conflicts of Interest

The authors declare no conflict of interest.

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