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How Much Can GMO and Non-GMO Cultivars Coexist in a Megadiverse Country?

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The relevance of addressing coexistence between GM, conventional, and organic agricultural production mostly has been driven in industrialized countries by (international) commercial issues and consumer choices. While some of these drivers are also relevant in less industrialized countries, coexistence of the different agricultural options in these countries might be more complex and have indirect consequences that need to be considered in a more integrated way.

Mexico is a megadiverse country and also a center of origin and genetic diversity of many crops of great global economic value, among these maize and cotton. Presently GM cotton, maize, and soybean releases are taking place at different scales in the country. Coexistence of cultivation schemes in maize and cotton represent challenges that should be carefully evaluated. The genetic pool available for future seed development could be compromised; GM constructs have been recently detected in wild cotton populations, while in maize (the main staple food in the country), traditional cultural practices include seed exchange between farmers. For historical and cultural reasons, maize has a different significance to a large part of the Mexican population than any other crop.

On the other hand, cultivation of GM soybean, a non-Mexican crop, has affected negatively the exportation of honey (a major income for rural populations) produced in the southeast, as GM pollen presence has been questioned by importing countries. Further aspects on coexistence issues are discussed in relation to these three cases.

Key words: center of origin, coexistence, genetic diversity, GM cotton, GM maize, GM soybean, honey, Mexico.

Introduction

Modern biotechnology[1] has given rise to the development of new tools directed to solve particular agricultural problems mostly focused to industrialized production systems. The release in the environment and the consumption of genetically modified (GM) crops and their products has been at the center of important debates regarding their benefits and possible risks. In many countries now, the use of GM crops has become one alternative within a vast range of production systems (from the more traditional to the industrialized) that include options (such as organic agriculture) that need to be maintained as viable options for food production.

Coexistence between GM and non-GM crops mostly has been determined by commercial considerations in many industrialized countries, where consumer choice and market demands drive many of the policies and regulatory decisions in agricultural issues (Agriculture and Environment Biotechnology Commission [AEBC], 2003; Boisson de Chazournes & Mbengue, 2005). In the guideline published by the European Commission in 2003, coexistence is referred to as “the ability of farmers to make a practical choice between conventional, organic, and GM crop production, in compliance with the legal obligations for labeling and/or purity standards” (European Commission, 2003, p. L189/36). In this context coexistence is considered more an economical than an environmental issue concerned about the impact of the admixture between crop products originated from different agricultural production systems (Boisson de Chazournes & Mbengue, 2005; European Commission, 2003).

In the context of megadiverse countries, we believe coexistence should be framed by taking into account particular biological, environmental, agricultural, com-

1. *As defined by the Cartagena Protocol on Biosafety to the Convention on Biological Diversity. See the full text at http://bch.cbd.int/protocol/text/.*

mercial, infrastructural, and regulatory aspects in place, in order to have a more inclusive perspective of its possible implications.

Mexico is recognized as one of the 12 megadiverse countries that together possess nearly 70% of global species diversity, as well as a Vavilov center of origin and diversity of more than 100 species of worldwide economic importance and essential for mankind survival, such as chiles, beans, squashes, cotton, maize, vanilla, cocoa, etc. (Hernández-Xolocotzi, 1993; Vavilov, 1994). All of these crops are still under the process of domestication and diversification in the natural and agricultural habitats where they grow, exchanging genetic information with their wild relatives and adapting to new circumstances (Bellon et al., 2009; Montes-Hernández & Eguiarte, 2002; Piñero et al., 2008). Ensuring the conservation and access of the inherent genetic diversity present in the diversity centers of the different crop species is fundamental for the continuous generation of new crop variation. Although *ex situ* conservation in genebanks is indeed necessary, it is an incomplete task if it does not go hand-in-hand with the conservation of the *in situ* processes (human and environmental) that give rise to the evolution and continuous adaptation of these crops and their wild relatives, particularly in the actual climatic change context.

Mexican agriculture is a complex of diverse technologies, derived from the existence of extremely contrasting environments in an imbricated topography, highly culturally diverse communities, and a wide gradient of agricultural production systems that range from subsistence agriculture up to industrialized monoculture production.

The use and environmental release of agricultural GM is ruled by the Law of Biosafety of the Genetically Modified Organisms (LBOGM) and its regulation (DOF, 2005, 2008); both are instruments for the national implementation of the Cartagena Protocol on Biosafety (Secretariat of the Convention on Biological Diversity, 2000, p. 2), which recognizes in its preamble “the crucial importance to humankind of centers of origin and centers of genetic diversity.” The LBOGM translates this concern by giving a special status to the species for which Mexico is a center of origin and center of genetic diversity, especially maize that maintains a special protection regime. According to the definitions of the LBOGM, the geographical areas of the country considered to be the center of origin are those in which the processes of domestication for particular species took place, while morphological and/or genetic diversity, characterized by harboring populations of wild relatives, landraces, or varieties (considered e.g., the total gene pool of the crop) are the aspects that define the centers of genetic diversity.

The law dictates that these species and these areas shall be protected. This protection is backed by the restriction of the presence of GMO version of these species within these areas and by the establishment of specific measures for their protection. In these areas, only GMO varieties other than native species can be released, provided that they have been previously evaluated as not affecting human health or the biological diversity.

In terms of the issues dealing with coexistence, the LBOGM neither specifies particular coexistence measures for the commercial release that could take place for any GM crop, nor considers the establishment of thresholds for the presence of GMO in conventional commodities. On the other hand, labeling of GMO or their products is only permitted if their characteristics differ significantly from conventional products, in a way taking into consideration the principles of substantial equivalence.

The present situation in relation to the release of GM crops in the Mexican context described above underlines the interest of analyzing the coexistence concept from a more integrated perspective. In the next sections we will discuss three examples of agricultural situations that entail coexistence issues pertaining to the main GM crops that have been released in the country: cotton, maize, and soybean.

Cotton

Cotton is the most exploited fiber crop in the world; the initial harvested product is “seed cotton,” which is then separated into seed and lint (Australian Government, Office of the Gene Technology Regulator [OGTR], 2008). In 2011, Food and Agricultural Organization of the United Nations (FAO) estimates showed around 48 million tons of cottonseed and 26 million tons of lint production worldwide (FAOSTAT, 2013). The lint’s long fibers are intertwined to produce fabric for clothing and other products. Short fuzzy fibers and cotton oil obtained through seed crushing are used in different agro-alimentary industrial applications; the product remaining after oil extraction is used as cottonseed meal, usually for animal feed (Australian Government, OGTR, 2008).

Cotton has been harvested in Mexico to produce clothing since pre-Columbian times. Domestication of the cotton species was carried out in parallel by different cultures around the world, and *Gossypium hirsutum* and

G. barbadense were involved in this process on the American continent (Wegier, 2013). Today, 95% of the global cotton production is from *G. hirsutum* and the great majority of its wild populations grow in Mexico (Wegier, 2013), as well as the wild varieties of *G. barbadense*. Besides these two tetraploid species of the *Gossypium* genera, 11 additional diploid species of the subgenera Houzingenia are endemic to Mexico, and they all together represent the genetic diversity occurring in the center of origin of cotton in Mexico (Feng, Ulloa, Perez-M, & Stewart, 2011; Fryxell, 1988; Ulloa et al., 2006; Wegier, 2005, 2007, 2013; Wegier et al., 2010, 2011).

Since 2003 the National Commission for the Knowledge and Use of Biodiversity (Comisión Nacional para el Conocimiento y Uso de la Biodiversidad [CONABIO]), a federal Mexican entity, has funded research projects directed to generate baseline information in order to characterize the wild cotton populations in the country, including their geographical distribution (Wegier, 2005, 2007, 2013; Wegier et al., 2010, 2011). The center of origin and genetic diversity of cotton in Mexico (although it has not yet been defined legally) has been described to include eight metapopulations of *G. hirsutum* distributed along the west and east coasts of Mexico (Wegier, 2013; Wegier et al., 2011). Based on their genetic and ecological characteristics, Wegier (2013) recognizes six genetic diversity centers formed by one or two of the identified metapopulations. Further studies are underway in the case of the related diploid species present in order to have a complete understanding of the genus in Mexico so the areas can be determined.

From an agricultural point of view, volumes of cotton production in the country have fluctuated through time, depending on factors such as pest incidence, variations in international fiber prices, and the increase in the use of synthetic fibers (Financiera Rural, 2011a). From 1990 to 2009, the planted surface in the country diminished 67.7%, (going from 223,000 ha to 72,000 ha), while it increased again to up to 120,000 ha in 2010. By 2012, 668,662 tons of “seed cotton” were produced in 155,000 ha (Financiera Rural, 2011a; SIAP, 2013). Actually, cotton is grown mainly in the northern states of the country, where irrigation is normally available (Baja California, Chihuahua, Coahuila, Durango, Sinaloa, Sonora, and Tamaulipas; Instituto Nacional de Estadística y Geografía [INEGI], 2009; SIAP, 2013).

Mexico is currently a net importer of cotton fiber and it was the main cottonseed importer in 2010/2011, acquiring 29.7% of the cottonseed worldwide—mainly from the United States (preliminary data indicate that in 2010 cottonseed importation reached 179,500 tons)—although self-sufficiency in cotton domestic consumption is a Mexican aspiration, hopefully becoming a net exporter by 2020 (Comité Nacional del Sistema Producto Algodón, 2012; Financiera Rural, 2011a; SIAP, 2013).

GM cotton was first released in Mexico in 1996. Since then, around 430 environmental release applications have been submitted in the three phases considered in the national legislation: experimental, pilot (pre-commercial), and commercial scale (see Figure 1). The area of GM cotton planted in the country has gradually increased and around 90% of the total cotton cultivated in 2011 consisted of GM varieties (more than 180,000 ha out of 198,439 ha planted), providing herbicide tolerance (“Roundup Ready”), lepidopterae pest resistance (Bt), or both traits (AgroBIO México, 2013; SIAP, 2013).

In certain regions of North Mexico there seems to be a tendency towards a total adoption of GM technologies by local farmers, although what drives this process is not yet clear. The initial use of Bt varieties provided clear benefits for farmers in the control of lepidopterae pests; it seems that the incidence of these kind of pests has somehow decreased. However, other effective alternative control measures have also been implemented at the same time and in the same area, making it difficult to measure the relative contribution of each approach to this decrease. The “Mexican National Committee for the Production of Cotton [Comité Nacional del Sistema Producto Algodón]” (2012) guiding plan specifies “conventional cottonseed” as the main limiting factor of those identified for cotton cultivation. All this seems to indicate that the high adoption rates for GM cotton by farmers is in some cases probably induced by a lack of—or low availability of—conventional varieties in the local seed markets. If this is true and this tendency persists, the ability of farmers to choose the kind of cotton they are willing to produce will be seriously impinged, and coexistence will be made impossible.

Nevertheless, when thinking of coexistence in cotton cultivation in Mexico, it not only implies that it is limited to agricultural production systems involving the use of GM or conventional varieties, but it also must include the presence—even hundreds of kilometers away—of populations of wild species or close relatives of cultivars in natural habitats.

The presence of different, and in some cases even multiple, genetic constructions derived from GM varieties has been documented in wild *G. hirsutum* metapopu-

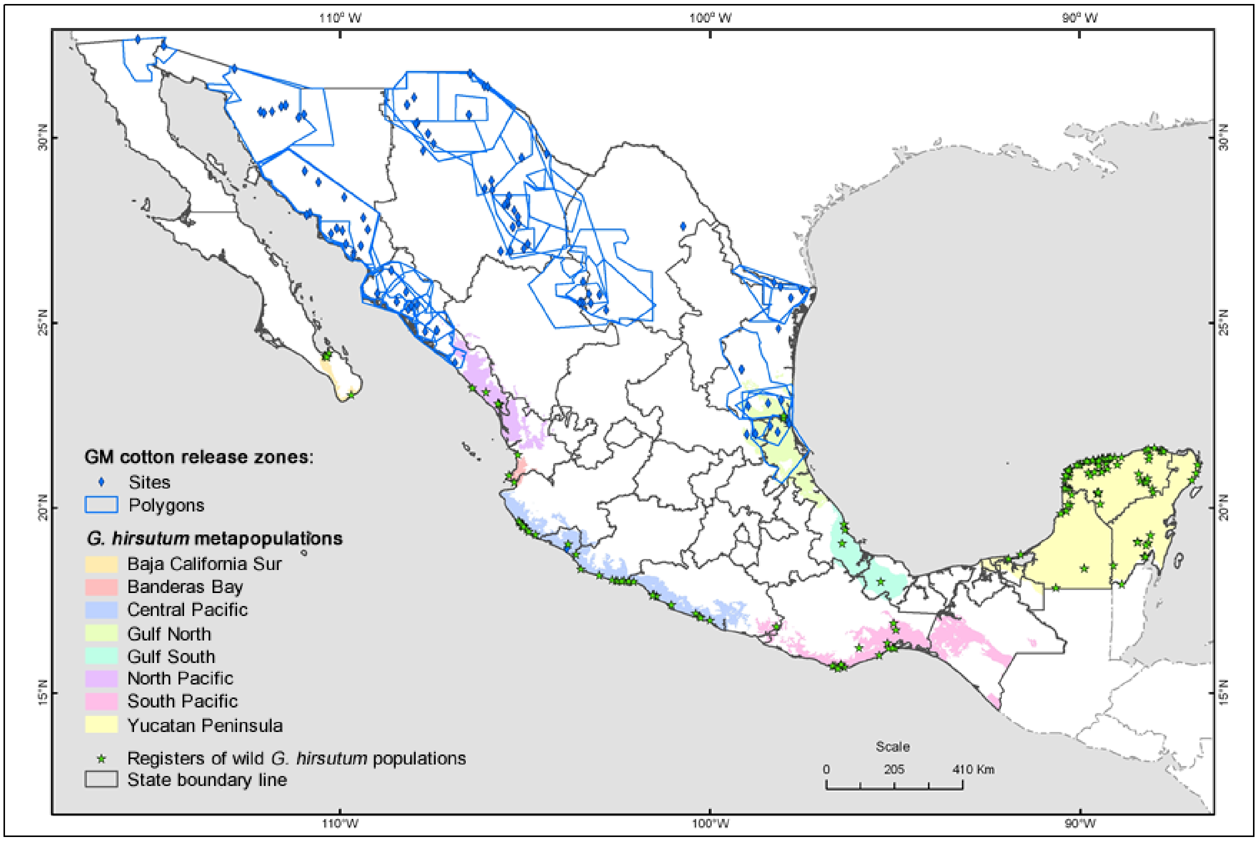

Figure 1. GM cotton release zones in Mexico. Polygons and sites of the release applications submitted from 1995 to December 2012 are shown in blue. Distribution of registers of *G. hirsutum* wild populations are shown as green stars. Potential distributions of the *G. hirsutum* metapopulations are shown in full colored polygons (SIOVM, 2013; Wegier et al., 2011).

lations, some of which are geographically located more than 500 km away from the nearest GM-cotton-planted site (Wegier, 2013; Wegier et al., 2011). These genetic constructions could have originated from different unmanaged sources of diverse nature, such as seed dispersion from GM-cultivated plots in the northern part of the country, careless transportation in trucks with no control of the cargo, imported cotton animal feed containing viable GM seed, migrating workers, etc. This fact constitutes evidence of gene flow of patented sequences to the genetic pool of the wild populations of the most widely cultivated cotton species in the world, and for which the eventual long term consequences—from both the biological and legal points of view—are still unknown. The future availability of high-value germplasm (especially that which provides previously unused genetic diversity) in breeding programs could be limited by these types of issues, so the potential capacity to cope with unpredictable future necessities could be compromised, resulting in much higher costs.

Research must be done to understand the processes that gave rise to these genetic flow events in order to implement the necessary measures to stop/limit them and to understand the possible consequences they may have on biodiversity conservation and sustainable use in a megadiverse country, center of origin of the crop, such as Mexico.

Maize

FAO estimates that a total of 885 million tons of maize were globally produced in roughly 172 million ha in 2011, which places this crop as the top-produced cereal in the world (FAOSTAT, 2013). It is mainly used in industrial applications and livestock activities, it is widely used for direct human consumption in African and Latin American countries (in many cases being the staple food of these countries, as is the case in Mexico), and it has recently been incorporated as a primary source to bioethanol production.

Mexico is considered the nucleus of the Mesoamerican center of origin of maize and its wild relatives (teocintles), with which the crop can intercross in nature and the grasses of the *Tripsacum* genus. Recently, about 60 landraces have been documented to currently being grown in Mexican territory (CONABIO, 2011). Maize is the main staple food in the country and—for historical and cultural reasons—it has a much greater significance for a large part of the Mexican population than any other crop. The daily per capita consumption in Mexico is around 350g, mainly through tortillas as well as through more than 600 different "dishes" (Bourges, 2002; FAOSTAT, 2013), many of them based in limited processed doughs obtained by cooking the grain in the presence of calcium hydroxide, a process called "nixtamalización," which enhances its nutritional qualities (Katz, Hediger, & Valleroy, 1974; Paredes-López, Guevara Lara, & Bello Pérez, 2009). Maize is also used for feed and industrial applications in the country.

More than 22 million tons of maize grain were produced in Mexico in 2012 (SIAP, 2013). National production is divided into white and yellow maize. The former is devoted to human consumption and national production is considered to be sufficient for this purpose. Nevertheless, the production of yellow maize—which is used mainly for feed and industry—is insufficient; 9.5 million tons had to be imported in 2011 (FAOSTAT, 2013). Table 1 shows maize, soybean, cotton and honey export/import values for 2008.

The average cultivated surface of maize in Mexico totals 8.4 million ha, 85.5% of which is rain dependent (7.2 million ha) and 14.5% is under irrigation (1.21 million ha; SIAP, 2008; mean values between 1996-2006). Total cultivated surface in 2012 was around 7.5 million ha (SIAP, 2013). A range of 2 to 3.1 million farmers are maize producers, of which 85% have agriculture fields of no more than 5 ha in surface area (Polanco & Flores, 2008; SIAP, 2008).

These data show that highly contrasting maize production systems coexist in the country. Industrial cultivation systems that depend on irrigation and agricultural inputs are present mainly in the northern area of the country and are highly productive, although other irrigation districts with similar conditions are dispersed throughout the rest of the country. On the other hand, smallholder farmers produce the crop in 85% of the area where maize is cultivated in the country. They are mostly subsistence farmers (although they do participate in markets when it is convenient to them), depend on rainfall, and still use their own landrace seeds selected from year to year that constitutes the maize genetic diversity that has been produced from observation, experimentation, seed selection, and exchange in a system that has been in practice for centuries (Bellon & Brush, 1994). Even though the mean production rate is much lower, these maize landraces are exquisitely adapted to local growth conditions (which can sometimes be extreme) and prosper where hybrid commercial varieties cannot. These traditional agricultural practices encompass the process that has generated and maintains the diversity of maize landraces documented to be present currently in the country (Hernández-Xolocotzi, 1985; Pressoir & Berthaud, 2004).

Table 1. Export/import values for commodities discussed in the text.

Product	Export value (thousand $US, 2008)	Import value (thousand $US, 2008)
Maize	23,775	2,391,398
Soybean	126	1,800,949
Cotton	78,581	538,959
Natural honey	83,789	14

Source: Servicio de Información Agroalimentaria y Pesquera (SIAP, 2010). Adapted from document available at http://www.siap.gob.mx/wp-content/uploads/2013/PDF/ComercioExterior/balanzaAN.pdf.

The maize agricultural production systems present in Mexico constitute a geographical continuum with multiple interactions and different levels of isolation; in some regions, they both coexist and are geographically intertwined; they are also linked from a human perspective, as many of the workers employed in intensive production areas are seasonally migrating small subsistence farmers, which may come from Central or Southern Mexico. These farmers keep some of the grains from commercial varieties and use them as seeds in experimentation in their own fields, thus broadening the gene pool of the species.

The first GM maize experimental releases in the country took place between 1995 and 1998. In 1998, the Ministry of Agriculture established a *de facto* moratorium for the release to the environment of the crop (Acevedo Gasman, Huerta Ocampo, Lorenzo Alonso, & Ortiz García, 2009). GM maize environmental releases took place once again with the LBOGM in place, starting in 2009 and continuing to the time of this article (end of September 2013); during that time, a total of 290 applications for the release of GM maize have been submitted (205 in experimental, 71 in pilot, and 14 in commercial phases). To our knowledge, the applications for commercial release have not been approved. Figure 2

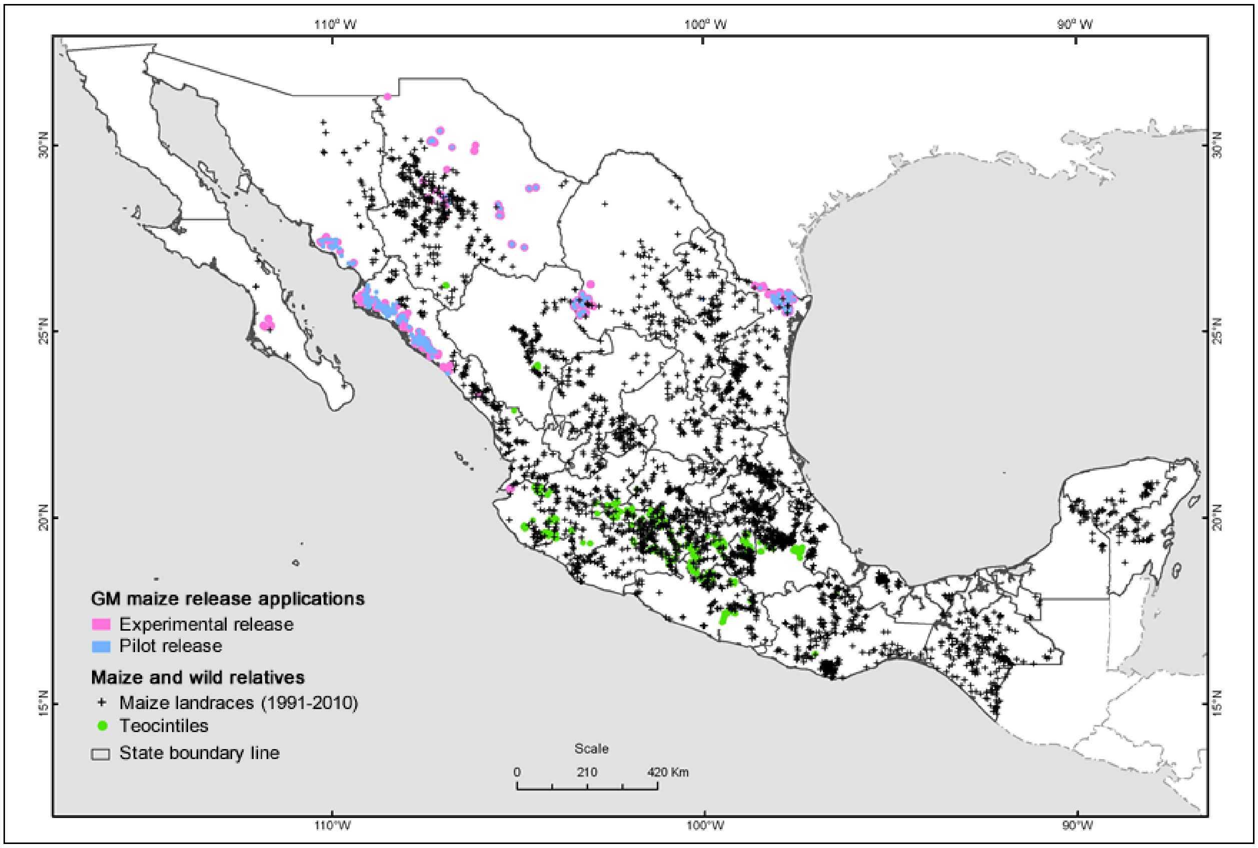

Figure 2. GM maize release applications that have received a permit for experimental (rose dots) or pilot (blue dots) release, from 2009 until September 2013 (some of the approved sites might have not been released). The map also shows the distribution of maize landraces registers from 1991 to 2010 (dark crosses), as well as the historical registers of Teocintle wild relatives (green dots; CONABIO, 2011; SIOVM, 2013).

shows the sites where GM maize applications have received release permits in experimental and pilot phases. The traits of these GM events are herbicide tolerance, insect resistance (for lepidopters and coleopters), and the combination of both characteristics.

Implications for the coexistence of the production schemes—including GM maize in Mexico—are complex. From a regulatory point of view, centers of origin and centers of genetic diversity have only been established (as of yet) in eight of the Northern Mexican states, whereas the big industrial maize cultivation sites remain outside these areas (DOF, 2012). Even though the centers of origin and genetic diversity have been identified for the whole country considering existing information of currently cultivated maize landraces and its wild relatives distribution, these areas need to be legally established for the whole territory, and protection measures need to be implemented efficiently inside and outside these areas (Comisión Federal de Mejora Regulatoria [COFEMER], 2011; CONABIO, 2011).

The LBOGM does not specify particular coexistence measures for commercial releases that could take place outside these areas. Maize production systems currently existing in the country are already continuously interacting and there is no reason to believe this could change. Shall these systems coexist with commercial GM maize production in the short term, there will be multiple challenges to be dealt with, derived from possible gene flow to wild relatives and native maize landraces present as a continuum along the country. The possible presence of genetic constructions in landraces could, on the one hand, compromise food security for small farmers that cultivate them for subsistence if they are not allowed to select, keep, and replant their own seeds, thus adding to the already existing problems in Mexican agriculture; on the other hand, it could hamper the very process by which these landraces are generated and preserved. This diversity, which is continuously evolving and adapting to a changing environment, constitutes a fundamental maize genetic pool of worldwide importance for the

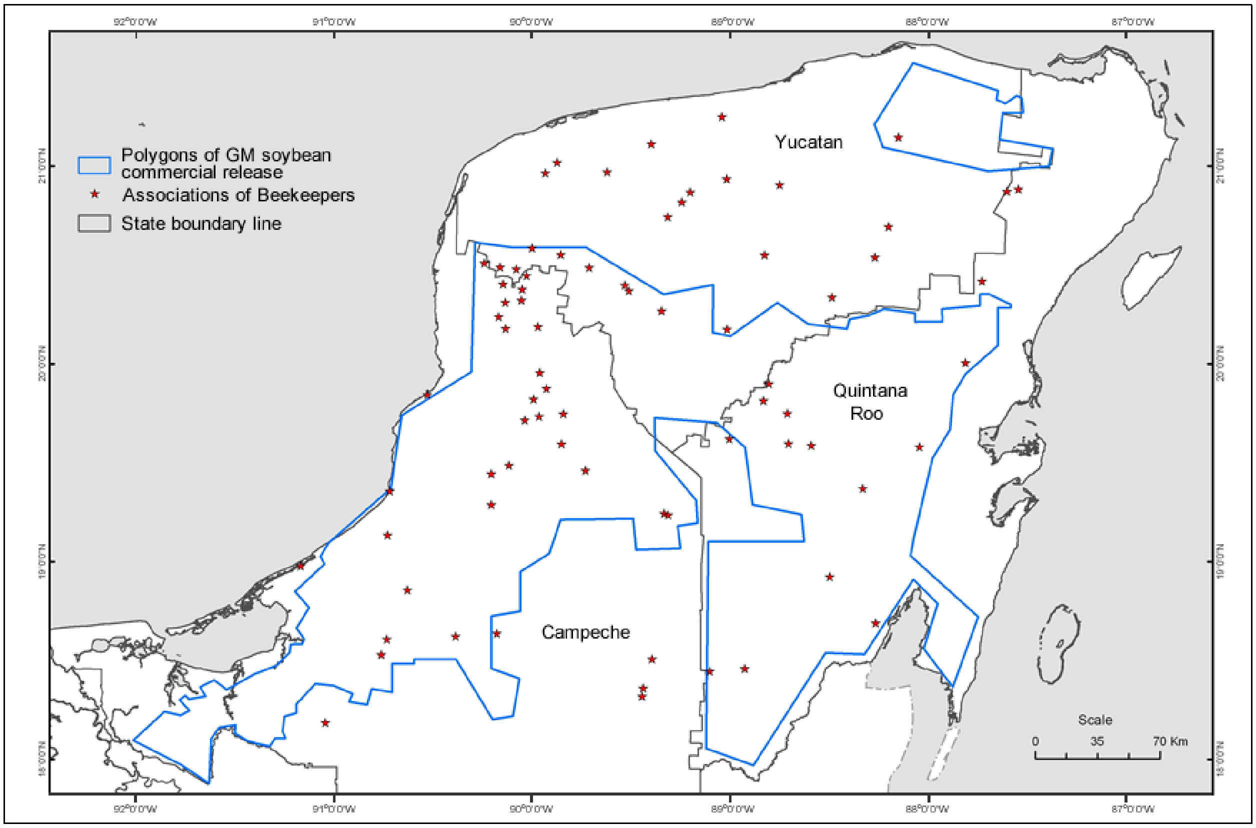

Figure 3. Polygon inside the Yucatan Peninsula of the GM soybean release application that received a commercial phase permit in 2012 (blue line). Associations of beekeepers are signaled as red stars (CONABIO, 2009; SIOVM, 2013).

future. We believe that the capacity to use these materials in selection and genetic improvement programs in the future could be hampered due to the presence of GM constructions protected by intellectual property rights.

In the case of maize in Mexico, the coexistence of different agricultural production systems (including GM maize) might not pose a classical international commerce concern as it does in countries which are not centers of origin of maize, are actively involved in exporting this commodity, and are mainly motivated by consumer choices. In our case, pursuing coexistence in a wider geographical context of agricultural production systems will have serious internal impacts for traditional agriculture, food security, and the conservation of a genetic pool that is strategic for humankind.

Soybean

Soybean is the most widely cultivated oil crop in the world—roughly 103 million ha were planted and 262 million tons obtained in 2011 (FAOSTAT, 2013; Financiera Rural, 2013). The seed is one of the principal sources of edible vegetable oil and the sub-product remaining after oil extraction is directed to livestock feed (Organization for Economic Co-operation and Development [OECD], 2000). The whole plant may also be used as feed, and diverse products for human consumption are obtained from the crop.

Glycine max is an Asiatic species with no wild relatives present in Mexico; 144,000 ha were planted in the country, from which 247,500 tons were produced in 2012 (SIAP, 2013). Most of the national production is concentrated in the northeastern states (Tamaulipas, San Luis Potosí, Veracruz), but production fields are also present in other southeastern regions such as Chiapas and the Yucatan Peninsula (SIAP, 2013). According to FAO, soybean ranked in the first positions of commodities imported (quantity and value) in Mexico with 3,340,376 tons imported in 2011 (FAOSTAT, 2013).

GM soy was introduced in the country in 2000 and through the years the planted area increased progressively in the three mentioned regions. In 2011, an application for a commercial release in 230,000 ha in these regions obtained a permit (see Figure 3). Legal procedures aiming to stop the releases started in Chiapas and the different states of the Yucatan Peninsula (Yucatan, Campeche, and Quintana Roo) claim that there are consequences to honey exportation due to the possible presence of soybean GM pollen in the product.

Honey Production in Mexico

Mexico is ranked as one of the most important honey exporters (falling from third in 2010 to fifth in 2011) with 26,512 and 26,888 tons exported from a total 55,684 and 58,602 tons produced in 2010 and 2011, respectively (FAOSTAT, 2013; SIAP, 2013).There are approximately 41,000 beekeepers in Mexico, of which 19,000 are distributed in the Yucatan Peninsula; many of them belong to Mayan communities and generate around 29% of the product, which is highly valued in the international markets. Ninety percent of the honey produced in the Yucatan Peninsula is exported mainly to the European Union (Castañón Chavarría, 2009; CONABIO, 2009; Financiera Rural, 2011b; Güemes-Ricalde, Echazarreta González, Villanueva, Pat Fernández, & Gómez Álvarez, 2003; SIAP, 2013).

Mexico is also top-ranked for the exportation of organic honey, fetching 30% higher prices than conventional honey. In 2009, up to 1,300 tons were produced, of which 500 tons were exported. The principal producing states of organic honey are Yucatan, Campeche, Quintana Roo, Chiapas, Veracruz, Oaxaca, Zacatecas, and Jalisco (Financiera Rural, 2011b; Secretaría de Agricultura, Ganaderia, Desarrollo Rural, Pesca y Alimentación [SAGARPA], 2010).

During 2011, honey exporters found that honey shipments were rejected in Europe because of the presence of GM pollen, due to a sentence of the Court of Justice of the European Union that indicated that GM pollen in honey triggers the need for "GM labels" (Court of Justice of the European Union, 2011; Vandame, 2011; Woller, 2011).

For the past two years, a hot debate has taken place in Mexico regarding whether honey exports to the EU have been affected since the Court's sentence. Research has been financed, including that of CONABIO to obtain hard data related to the presence of GM pollen in honey produced near GM soybean fields. Given the spatial overlap of areas where GM soybean has been planted in the Yucatan Peninsula and where the beekeeping activities are being held, and the fact that bees visit soybean flowers (Vides Borrell & Vandame, 2012)[2], the presence of GM pollen in honey is possible and has been detected in some cases (Vides Borrell & Vandame, 2012). Producers claim that if the honey they export has GM pollen, regardless of the quantified levels, they will be punished with lower prices for the shipment due to public perception.

In this example involving GM soybean, the aims of the coexistence concept should go further than ensuring the existence of different agricultural practices in the production of the crop, as the presence of GM plants might affect another productive activity that is environmental friendly, damaging it economically, especially when it affects the wellbeing of many rural and indigenous communities in the region. This example would be true for any other pollen-producing GM crop in the region.

A possible way forward to avoid presence of GM pollen in honey would be the establishment of "GMO-free zones" as contemplated by the LBOGM or switching to non-GM soybean varieties that have very similar yields. This law calls for protecting zones on the request of an affected stakeholder community that generates organic agricultural products and/or other products of interest to the community. The law considers that these "GMO-free zones" shall be established in the case of GMOs of the same species if it is scientific and technically shown that their coexistence is not feasible or that meeting regulatory requirements for certification is unachievable. In this case, the "species to species" concept of coexistence might pose a debate of whether the establishment of these zones would be justified legally for honey, considering that it relates to a different productive activity.

Conclusions

The Mexican agricultural context raises particular issues in relation to GM crop releases and their coexistence with the other agricultural systems in place.

Being a center of origin and diversity of cotton and maize (as well as of dozens of other crops) puts the country in a very delicate position in relation to the responsibilities entailed in the conservation and maintenance of the genetic pools of these crops, consisting in the wild relatives and landraces present in its territory, as well as for the conservation of the *in situ* processes (human and environmental) that originate such diversity. Any factor affecting either one of them compromises the access to genetic diversity for future global needs.

2. *See also the Spanish-language video depicting bees in soybean fields: https://www.youtube.com/watch?v=6s5FaBm7yBE.*

The release of GM crops should not imply a progressive conversion towards the homogenization of the production system of a crop and the loss of alternative (conventional and organic) approaches for producing it. The actual tendencies of widespread GM cotton in Mexico could be a warning sign to avoid this from happening.

The consequences derived from the presence (and stacking) of patented constructs in maize landraces are not yet clear. Setting distances between producing fields to avoid pollen flow will not be sufficient due to the agricultural, cultural, and historical contexts that surround maize production in Mexico. It will be very difficult (if not impossible) to control gene flow if commercial releases take place, and this could threaten food security for all those that depend on its production through landraces. The basis for monitoring and compliance verification of biosafety measures of GM crop releases have been established, but their full implementation is still a long way to becoming a reality.

The example of GM soybean and honey productions in the Yucatan Peninsula shows that the coexistence concept needs to be considered beyond the "species/crop barrier." In this case, the existence of both activities in the same territory could affect honeybee producers; even if we achieve a clear understanding and good estimate, in quantitative terms, of the processes involved leading to a possible presence of GM pollen as part of the honey produced, public perception abroad may already have impacted the acceptability by consumers of one activity, which is essential for the economy of thousands of rural people.

What has defined coexistence in other regions does not appear to be the main driver for Mexico until now; the implications of being a center of origin and diversity of dozens of crops cannot be left out of the equation, implying that production systems in place must acknowledge this reality. Mexican public policy in the recent decades has been dominated by economic considerations; its high dependency on cotton, maize, and soybean imports for its national necessities has, in practical terms, downscaled its own internal commercial issues and consumer choices. The *status quo* does not make establishment of coexistence measures in the GM crop release zones an urgent matter outside the area defined as center of origin and diversity.

In the context of certain countries, coexistence might have complex implications. It should be carefully considered when coexistence is possible and when it is not. The evaluations leading to this kind of decisions should consider not only the costs of non compliance with regulatory obligations, but also costs under an integral approach, taking into account aspects such as local agricultural systems, socio-economical factors, the environment, and biodiversity.

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