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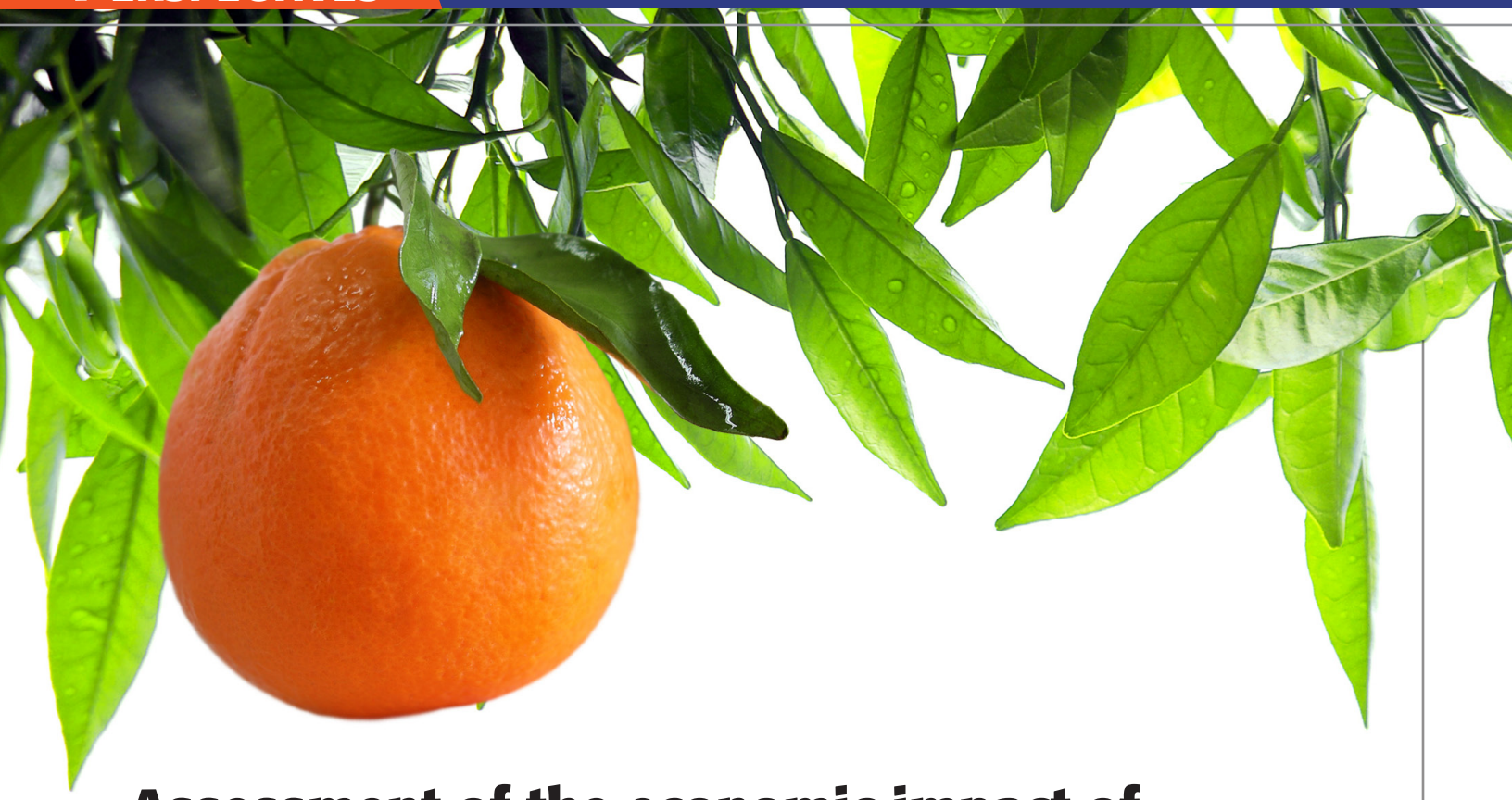

Assessment of the economic impact of Huanglongbing (HLB) disease on Mexico's citrus chain

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Summary

In this article, the authors assess the economic impact that HLB could have on Mexico's citrus chain, and compare the preventive and control measures that different countries have adopted. The assessment of economic impact was carried out at three levels: primary fruit production, agro-industrial operations and the economy as a whole. The results suggest that the volume and value of the production of citrus fruits and their byproducts would be affected, as would employment (on farms and in agro-industrial operations and related businesses) and the foreign exchange earned by exports of fresh and processed citrus fruits. Other factors highlighted by the study are the high risk of an epidemic and the potential economic impact in the states of Veracruz, Colima and Michoacán, in the Pacific coastal region and in the Yucatan Peninsula, as well as less serious effects on quality, the amount of raw material available and the turnover of packing and processing plants. The study indicates that the primary sector would be the hardest hit by direct losses, with a decline in the value of production, employment, wages, food products, beverages and tobacco. Mexico responded immediately to the outbreaks of HLB that occurred in July 2009 in the Yucatan Peninsula, instituting an emergency plan to mitigate the risk of the entry and spread of the disease.

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Key words: impact assessment, *citrus*, epidemiology, plant diseases, pathogenesis, agro-industry, Mexico.

Background

When the bacterium *Candidatus Liberibacter asiaticus* – the cause of Huanglongbing (HLB) disease – was detected in July 2009 in the community of El Cuyo, in the municipality of Tizimín, Yucatán, the General Directorate of Plant Health (DGSV), the National Service for Agrifood Health, Safety and Quality (SENASICA) and the Inter-American Institute for Cooperation on Agriculture (IICA) decided to carry out a study on the implications for Mexico's citrus industry if the disease – the most destructive for citrus fruits – were to become established in the country.

The general objective of the assessment was to quantify the possible economic impact of HLB on Mexico's citrus chain. The specific goal was to compare the preventive and control measures that Mexico has adopted with the actions implemented by other countries faced with the same threat. To achieve the main objective, the assessment set out to quantify the effects at the following three levels:

a. **Primary production.** Part of the analysis of the epidemiological effects of the disease and its impact on production involved simulating two loss scenarios. A model was designed especially for the purpose, based on the application of factorial analysis and cluster analysis as statistical techniques.

b. **Agro-industrial operations.** The study quantified technical indicators, with 2008 used as the baseline year. The risk scenarios developed for primary citrus production served as the point of reference. In estimating the indicators, the study drew on both published general information and specific information obtained by means of a survey of companies and processing plants, statistically selected using a stratified sampling procedure.

The estimated losses for the Mexican citrus chain and the economy as a whole were quantified at different points in time and in three risk scenarios (low, moderate and high impact), once the disease had become established in the country.

c. The **economy as a whole.** The study estimated the impact on both the citrus fruit sector and other activities related to the national citrus industry, using the IMPLAN input-output model that Texas A&M University employed previously for the same purpose. The model generated employment multipliers and estimated the direct effects (on the agricultural sector), the indirect effects (on the industries that supply inputs to the agricultural sector), and the induced effects (on the economy as a whole, due to the loss of income in the sectors affected directly and indirectly) one, three and five years after HLB had become established.

The analysis of the epidemiological effects and the impact on production was used to identify and analyze the characteristics of the citrus production sector, the main production areas with the species and varieties grown, production typologies to stratify the existing technological levels, the agro-climatological conditions of the crops, and epidemiological aspects that would make it possible to understand the incidence and spatial distribution of the disease. The authors also conducted a review of the literature to determine what other countries have done with respect to the estimation of risk scenarios.

The authors analyzed the way in which the agro-industry is organized and the relationships among the companies and plants that brush, wax, pack, process and market citrus fruits. The cost structure of the products and their commercial use were included, as were the costs of the following elements:

- Prices of raw materials (fresh citrus fruits such as oranges, lemons and limes, grapefruit and tangerines)
- Inputs and amount used

- Services used and (operating and administrative) personnel involved in the processing stage
- Canning, packaging and packing materials
- Volumes and values of processed products
- Exports of fresh products with value added (e.g., brushed Persian limes) and processed products like juices and concentrates, essential oils, dried peel and pectins
- Installed capacity of agro-processing companies and capacity utilized
- Transportation (of both raw materials and finished products) and energy

The estimated losses for the Mexican citrus chain and the economy as a whole were quantified at different points in time and in three risk scenarios (low, moderate and high impact), once the disease had become established in the country. Based on the scope and assumptions of the economic analysis, the assessment yielded the following results as potential loss scenarios for primary citrus production:

Scenario 1

This estimated potential citrus production losses in the event of a severe, widespread and simultaneous epidemic in all of the country's production areas. The results indicated:

• That the potential impact of HLB depends on the acreage and yields in the different states around the country: in Veracruz, losses of oranges, grapefruit and Persian limes would be high; in Colima and Michoacán, key lime losses would be high to moderate; and in Tamaulipas, orange losses would be moderate and grapefruit losses low. Oranges accounted for 43% of the total value of citrus production in 2008, key limes for 33%, Persian limes for 16%, grapefruit for 5%, tangerines for 2% and lemons for around 1%.

• The impact on orange production in Sonora, Tamaulipas, Morelos and Jalisco would be moderate. In Nuevo León and San Luis Potosí, the impact would be low because, although citrus fruits are grown on more than 25,000 hectares of land, yields are low; the same applies to the other states where oranges are produced. Some 1.8 million tons of the nation's orange production would be lost, 47% (846,543 tons) in Veracruz, 18% (329,354 tons) in the group of states where the impact would be moderate (Jalisco, Morelos, Sonora and Tamaulipas), and 35% (644,743 tons of combined output) in the other states where the impact would be low.

• In the case of national grapefruit production, 63% of the losses (111,949 tons) would occur in Veracruz, 20% (36,077 tons) in eight other states and the remaining 17% (30,195 tons) in a further 10 states.

• The country would lose 183,168 tons of its key lime production, with Colima suffering 48% of the losses (87,765 tons), as the impact of HLB would be high. Michoacán, where the impact would be moderate, would account for 32% of lost production (59,071 tons), and another 20 states, where the impact would be low, for the remaining 20% (36,332 tons). With respect to Persian lime production, Veracruz would lose 75,987 tons of its production (64% of the country's total losses); five other states (Tabasco, Puebla, Colima, Jalisco and Sinaloa), where the impact would be moderate, would account for 19% (22,882 tons) of total losses; and 14 states, where the impact would be low, for the remaining 16% (19,380 tons).

• If the impact of HLB were low, 1.84 million tons, or 25% of the nation's total citrus production, would be lost. Oranges and grapefruit would account for the biggest losses (33%), followed by tangerines (17%) and, lastly, lemons and the different varieties of limes (10%). If the impact were moderate, 2.35 million tons would be lost (32% of national production), with oranges and grapefruit

once again the fruits hardest hit (42%). If the disease were to have a high impact, the losses would rise to 3 million tons, equivalent to 41% of the country's production. Oranges and grapefruit would be the fruits worst affected, accounting for 53% of the losses, followed by tangerines (26%) and limes (18%).

• A low impact outbreak of the disease would result in the loss of 4 million days' work. The figure would rise to 12.6 million in the event of a moderate impact outbreak, and 19.3 million in the case of a high impact outbreak.

Scenario 2

The biological conditions that influence the temporal and spatial dimensions of the epidemic process were taken into account. In other words, the factors that would affect the seriousness of an HLB outlook in the country and the speed with which it would spread. The results were as follows:

• In the event of an HLB epidemic in Mexico, the scenario would differ from region to region, due to variables such as climate and the structure of citrus host plants in relation to susceptibility to the pathogen and the acreage involved. Veracruz, Colima and Michoacán are regarded as areas where the risk of an epidemic is high and commercial operations would be affected. The Yucatán Peninsula and the Pacific coastal region are other regions that would be at risk but the impact on the local economy would be relatively low.

• In the event of simultaneous epidemics of varying intensity (high, moderate and low impact) in different states, the maximum combined percentage of losses to

national production for all types of citrus fruits would be 14%, or 1 million tons, in the first year in which the pathogen became established; 24% (1.7 million tons) in the third year; and 38% (2.7 million tons) in the fifth year.

• Three years after the HLB became established in a high-risk scenario, 1.7 million tons of citrus fruits and 12.2 million days' work would be lost nationwide. Orange production would be hit the hardest (1.4 million tons and 9.6 million days' work), followed by grapefruit (196,000 tons and 1.2 million days' work), Persian limes, key limes and lemons (153,000 tons and 1.3 million days' work) and tangerines (22,000 tons and 201,000 days' work).

• Once the disease has been established for five years in a high risk scenario, 2.7 million tons of citrus production and 19.3 million days' work would be lost, with orange production again the hardest hit (nearly two million tons and 13.7 million days' work), followed by grapefruit (260,000 tons and 1.6 million days' work), limes and lemons (415,000 tons and 3.5 million days' work) and, lastly, tangerines (60,000 tons and 543,000 days' work).

Potential losses for the citrus agro-industry

The authors of the study estimated the technical indicators of the structure of production costs for sweet and sour citrus fruits for 2008, both for companies that pack, brush and wax fruit and processors that produce juice, essential oils, dried peel and pectin. The indicators were established based on the inputs and products generated, referenced to the cost and availability of the raw material, to provide a means of estimating the potential losses for the agro-industry. An indicator was also calculated for direct labor and the underutilization of industrial facilities based on the tons of citrus fruit processed. The indicators are described below:

• The impact on primary citrus production was estimated for low, moderate and high-risk scenarios five years after HLB had become established. Under these scenarios, the sour citrus fruit packing and processing plants would be faced with a reduction in raw material of 4% (low impact), 9% (moderate impact) and 19% (high impact). In the last case, the amount of fruit processed would drop from 2.41 million tons

in 2008 to 1.97 million tons. In the case of sweet citrus fruits, under the same scenarios the figures would be 11%, 33% and 48%, respectively. In the event of a high impact epidemic, the packing plants would have 366,000 fewer tons of raw material available, and the processing plants 76,000 fewer tons.

• The quantity of sweet citrus fruits (oranges, tangerines and grapefruit) handled by the agro-industrial operations would fall from 5.95 to 3.18 million tons, following a high impact epidemic and five years after the disease had become established. The packing companies would receive 2.24 million fewer tons of fruit; in the case of the processing plants, the figure would be 524,000 fewer tons.

• The abovementioned reduction in the raw material available to the citrus agro-industry would increase the level of under-utilization of industrial facilities, which would rise from a weighted total of 55% in 2008, to 62% after three years and 71% after five years.

• The number of direct jobs lost in the citrus agro-industry as a consequence of the reduction in the volumes of raw material available would be 3774 per year, 87% in the companies that process sweet citrus fruits and the remaining 13% in those that process sour citrus fruits. As many as 3289 direct jobs would be lost in the sweet citrus industry (the number would fall from 7072 in 2008 to just 3783 five years after HLB had become established), while in the case of sour citrus fruits the number would be 485 (falling from 2652 to 2167).

• Three years after HLB had become established, the citrus industries' loss of income would be $507, $1632 and $2517 million in 2008 pesos in a low, moderate and high impact scenario, respectively; and the fall in exports would mean losses of US$130 million, US$404 million and US$645 million in foreign exchange earnings. The number of jobs lost would be 282, 929 and 1396, respectively (in low, moderate and high impact scenarios).

• After five years of infestation, the financial loss to Mexico's sour citrus industry would be $1385 million in 2008 pesos in the case of a high impact epidemic, $676 million in the event of a moderate impact epidemic and $283 million in the case of a low impact epidemic. Packing companies would be hit harder than processors. Packing companies would be faced with a drop of $1218 million in gross income (down from $6658 to $5440 million in 2008 pesos) and processors with a fall of $131 million (from $720 to $589 million).

• The value of sweet citrus production would be hardest hit, because those fruits are more susceptible to HLB. The size of the loss would vary according to the risk scenario involved, from $1131 million (low impact) to $3751 million (moderate impact) and $5419 million (high impact). Under a high risk scenario, five years after the disease had become established the packing companies would be faced with a drop in income of $3932 million in 2008 pesos (down from $8456 million to $4524 million) and the processors with a drop of $1369 million (down from $2944 million to $1575 million).

• HLB would have a serious impact on Mexico's exports of fresh and processed citrus fruits. In a high risk scenario, five years after infestation the country would earn US$157 million less in foreign exchange than in 2008 (down from US$505 million to US$348 million), which is a drop of 30%. In the case of sweet citrus fruits, US$106 million in foreign exchange earnings would be lost in the event of a high impact epidemic, US$73 million in the face of a moderate impact epidemic and US$22 million in the case of a low impact epidemic, while the figures for sour citrus fruits would be US$51 million, US$25 million and US$10 million, respectively.

Potential losses for the Mexican economy as a whole

Based on the employment multipliers generated by the model, the estimated direct, indirect and induced effects, one, three and five years after HLB had become established, would be:

• After one year of infestation, the total number of full-time jobs lost in the national citrus industry under the three risk scenarios would be 4105 (low impact), 17,988 (moderate impact) and 27,463 (high impact). After three years, the numbers would rise to 9434, 30,628 and 80,691, respectively. After five years, the total number of jobs lost, by scenario, would be 26,311, 82,815 and 126,439. These figures, again by scenario, are made up of 16,000, 50,000 and 77,000 direct jobs, 8000, 25,000 and 38,000 indirect (inter-industry) jobs, and 2000, 7000 and 11,000 induced jobs (for the other sectors of the economy). The activities related to the production of oranges and their byproducts would be hit the hardest.

• Ten main sectors would be affected by a potential infestation of HLB. In terms of the value of national production, the primary sector (which includes agriculture, livestock activities, forestry, fisheries and hunting) would be the hardest hit. That would be

the case for all three of the risk scenarios established, and would apply to direct, indirect and induced effects.

• After five years of infestation in a high-risk scenario, the direct loss in the value of primary sector production would be $3800 million in 2008 pesos. The indirect and induced losses would be $479 million and $65 million, respectively, making a total of $4343 million. In descending order of importance, the next sectors that would be hardest hit are "trade and repairs," "food, beverages and tobacco" and "other business activities." For the economy as a whole (48 sectors in total), the figures for the high-risk scenario are $2003 million (indirect losses), $1183 million induced losses) and $6965 million (total losses).

• In all three risk scenarios, the "agriculture, livestock activities, forestry, fisheries and hunting" sector would also suffer the biggest job losses, although the induced and total losses of the "food, beverages and tobacco" sector would be greater in all three cases. For the economy as a whole, in a high-risk scenario 9534 jobs would lost as an indirect effect and 4341 as an induced effect, with total job losses put at 55,249.

• The biggest direct and total effect on wages would be felt by the "food, beverages and tobacco" sector under all three risk scenarios (low, moderate and high impact), possibly because people in that sector tend to be paid more than those in the primary sector, which is next in importance. Therefore, were jobs to be lost in the agricultural sector, the indirect effect on wages would be greatest in the food, beverages and tobacco sector.

Comparison of preventive and control measures adopted to combat HLB in Mexico and other countries

• When *Candidatus Liberibacter asiaticus* was detected in Tizimín, Yucatán in July 2009, Mexico responded immediately by establishing a protocol for dealing with the emergency triggered by the detection of HLB, to mitigate the risk of the introduction and spread of the disease, set forth in NOM-EM-047-FITO-2009, which entered into force.

• The epidemiological surveillance system that Mexico uses for HLB has certain advantages over the one adopted by other countries, as the standards introduced apply to the whole country (the current system is centralized, based on the guidelines of the DGSV of SENASICA, and is designed to eradicate *Candidatus Liberibacter spp.* and prevent it from reentering the country). However, the operational infrastructure of the surveillance system at the state level is insufficient to deal with the enormous threat that the disease poses to the nation's citrus industry.

• The results in Brazil, and now in Mexico, suggest that the spread of the pathogen can be reduced but not avoided, due to the aerial mobility of the vector and the propagative material, making it imperative that action be taken to combat the vector.

• Although the vector was detected in Florida, USA, as long ago as 1998, the government took almost no action until the pathogen appeared in 2005. The actions currently being implemented involve protection through chemical control and, to a lesser extent, biological control of the vector.

• In Brazil, the government's role in coordinating, planning and implementing actions to combat the disease is unclear. Management of the problems that call for the regulation of citrus fruits varies greatly from state to state. São Paulo is the state where the private sector and the government have invested most heavily in plant health management for citrus crops. In that state, the effects of HLB are monitored and inspected periodically and plants exhibiting symptoms of the disease are destroyed. The pathogen was detected in almost every municipal district of São Paulo in 2009.

• In the province of Guangdong, China, the bacterium *(C. Liberibacter Spp.)* was eradicated in the laboratory by means of in vitro cryoconservation (Ding *et al.* 2008), with an effectiveness of 90%.

Based on the results of this study, 22 recommendations were presented at the workshop organized by IICA. Eight of them entail actions that would be implemented by the Secretariat of Agriculture, Livestock, Rural Development, Fisheries and Food (SAGARPA) and state governments. Five involve all the stakeholders in the national citrus chain, and nine concern studies and specific research that the interdisciplinary teams should carry out for decision-making purposes and the realignment of strategies.

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