Small farmers' perception of factors influencing regional chemical control of *Diaphorina citri*

Percepción de pequeños productores sobre factores que inciden en el control químico regional de *Diaphorina citri*

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Abstract

Regional Control Areas (RCAs) have been implemented in Mexico as a strategy to delay the spread of *Candidatus* Liberibacter asiaticus, the causal bacterium of the disease known as Huanglongbing (HLB). The implementation of an effective management of the vector insect, *Diaphorina citri* in the RCAs requires the knowledge, acceptance and coordinated engagement of small agricultural producers. This research assessed the perception and knowledge of 62 citrus growers regarding the operational, sociocultural and environmental factors influencing chemical control of *D. citri* in four RCAs within Veracruz State. According to their responses, the following factors have been identified as the operational factors with the highest influence on the effectiveness of insecticides against *D. citri* within RCAs: the lack of knowledge about the use of surfactants, application speed, poor calibration of sprayers and incorrect water quality. The most significant sociocultural factors are the general unawareness of the pest and the safe and proper application of pesticides. The most relevant environmental factors during application: temperature, relative humidity, and wind speed. Sociocultural index correlated with the perception of effectiveness. Therefore, it becomes necessary to consider differences among citrus growers in each region and setting out the most appropriate strategies for vector and disease management.

Keywords
regional control areas • *Candidatus* Liberibacter • chemical control • growers' perception

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Resumen

México ha establecido Áreas Regionales de Control (ARCO) como estrategia para retrasar la dispersión de *Candidatus* Liberibacter asiaticus, bacteria causante de la enfermedad llamada Huanglongbing (HLB). El manejo efectivo de *D. citri* en las ARCO depende del conocimiento, aceptación y participación coordinada de los pequeños productores. Esta investigación evaluó la percepción y el conocimiento de 62 citricultores sobre los factores operacionales, socioculturales y ambientales que inciden en el control químico de *D. citri* de cuatro ARCOs, en el estado de Veracruz. Con base en la respuesta de estos pequeños productores, los factores operacionales que más inciden en la efectividad de insecticidas contra *D. citri* en las ARCO son: desconocimiento sobre uso de adherentes, velocidad de avance del aplicador, deficiente calibración de equipos y calidad de agua utilizada; entre los factores socioculturales destacan: desconocimiento general sobre la plaga, y sobre el buen uso y manejo de plaguicidas, además, los factores ambientales más relevantes al momento de la aplicación son: temperatura, humedad relativa y velocidad de viento. El índice sociocultural se correlacionó con la percepción de la efectividad; por tanto, es necesario considerar las diferencias entre productores de cada región para establecer las estrategias más apropiadas de manejo del vector y la enfermedad.

Palabras clave

áreas regionales de control • *Candidatus* Liberibacter • control químico • percepción de productores

Introduction

Citrus are among the most important horticultural crops in the world (18, 39). However, high yield losses result from pests and diseases. In Mexico, citrus production is affected by the presence of the Asian Citrus Psyllid (ACP) or *Diaphorina citri* Kuwayama (Hemiptera: Liviidae), the primary vector of *Candidatus* Liberibacter asiaticus (CLas). This is the causal bacterium of Huanglongbing (HLB), the most destructive disease of citrus in the world (4, 20). To succeed in getting an evident impact on widespread populations of *D. citri* on citrus orchards, regional control areas (RCAs) have been established as part of the National Campaign against HLB and its Vector. This strategy is expected to delay the spread of CLas in citrus-growing states of Mexico, and to reduce disease severity (41). RCAs management is based on chemical control of the vector, complemented with biological control in suburban areas, use of certified plants, and removal of diseased trees (35).

Most RCAs consist of small farmers' plots. Accordingly, growers' acceptance of management strategies and their engagement are required to implement control actions in a coordinated way, and consequently, to have a better impact on the populations of *D. citri* (29, 42). To succeed in implementing the recommendations made by the Veracruz State Plant Health Committee (CESVVER), it is important to consider: i) citrus growers' perception regarding economic and social advantages of these recommendations;

ii) compatibility with local tradition and knowledge, iii) complexity of the proposed strategy, iv) the possibility of experimenting, and v) visibility of results in the short term (23).

A successful application depends not only on the effectiveness of the insecticidal molecule itself, but also on several factors that may enhance or reduce it, such as: a) the number of resistance genes on pest population (30), b) operational factors during application (29), c) environmental conditions during application (28), and d) growers' knowledge of insecticide management (31). The effectiveness of insecticide applications on RCAs has been assessed in terms of susceptibility at lethal dose level and through biological effectiveness tests (15, 38, 40). However, no consideration has been given to the sociocultural complexity and the specificity of local knowledge on each citrus area, which may determine the effectiveness and acceptance of the HLB Campaign. Therefore, the assessment of citrus growers' perception regarding the factors that could impact on the effectiveness of the insecticides applied in the RCAs is a key aspect. This would allow to propose strategies aimed at performing more efficient applications, and thus, to facilitate reducing the populations of the vector and delaying the dissemination of the bacterium throughout Mexico's main citrus areas.

Perception is regarded as the most basic process of acquiring knowledge, through which people obtain information and codify or classify it into categories delimited by experiences, feelings and thoughts (2, 19). Sociocultural context influences growers' perception about recommendations regarding proper use and management of insecticides. Moreover, inadequate decision-making regarding the rotation of toxicological groups (TGs) and increased application rates have led to the emergence of resistant insect populations. The resistance to some groups of insecticides might result from the high selection pressure, such as that generated in supervised regional applications (SRAs) by CESVVER, in addition to the unsupervised local applications (USLAs), in the area of Martinez de la Torre, Veracruz, and in RCAs in other citrus growing states in Mexico (15, 38). This scenario reduces the lifespan of those insecticides used in the RCAs. Furthermore, the growers' lack of knowledge regarding operational practices, such as equipment calibration, as well as the prevailing weather conditions during applications (high temperatures and wind speed), further limits the maximum potential expression of the insecticides in each application. Poor applications play a role in the spread of CLas within the state, the increase of production costs per agricultural cycle and the reduction of the diversity on beneficial native fauna in each citrus area (40).

Objective

The purpose of this research was to determine the operational, sociocultural and environmental factors that have an impact on the effectiveness of insecticides, according to the perception and knowledge of small farmers within Regional Control Areas located in Martinez de la Torre, Veracruz, Mexico.

Materials and methods

The study was conducted in four RCAs, where coordinated actions have been implemented for the control of *D. citri,* and addressed by the Local Plant Health Board of Totonacapan, associated with CESVVER, in the Municipality of Martínez de la Torre, Veracruz, Mexico. These areas are: RCA 4 [Ejidos "Pueblo Viejo" and "Cartago", along with small adjoining properties (1051.05 ha total)]; RCA 9 [Ejidos "San Antonio Coronado", "Flores Magón", "Paso de Barriles" and "Santa Rosa", along with small adjoining properties (1000 ha total)]; RCA 10 [Ejidos "Valsequillo", "El Insurgente Socialista", "Miguel Hidalgo", "Mesa Chica Nueva el Corcho" and "Augusto Gómez Villanueva" (1000 ha total)] and RCA 11 [(Ejidos "Cañizo", "Flamencos" and "Piedrilla" (1000 ha total)].

Sixty-two growers within the RCAs were interviewed using a structured questionnaire (24, 32). In addition, participatory observation was performed during the meetings of the ejidos or groups integrating the RCAs. The questionnaire was applied from August to December of 2015 during ejido meetings. Interviews were directed to ejido members interested in the HLB campaign, which increased confidence between interviewer and interviewed. To gain additional insight (5), a group of growers who did not attend ejido meetings were also interviewed. All interviews were conducted with RCAs stakeholders and beneficiaries of the Campaign against HLB. The sample represents 10% of the beneficiary population of small farmers in the study area.

The first section of the questionnaire included personal data: name, age, schooling, RCA number, citrus varieties cultivated, orchard land area (ha) and name of the person who sprays the insecticide. The second section included open and closed-ended questions to identify the operational factors of the last application of insecticides, that could have an impact on their effectiveness: insecticides used, dose increment, surfactant use, calibration and type of sprayers used, and their perception about application effectiveness and its relation with water quality, nozzles used and applicator advance speed. The third section focused on identifying sociocultural factors: growers' attendance at meetings, organization, interest in *D. citri* control, knowledge of insecticide management and rotation, protection of natural enemies, training in insecticide management, and their perception on the effectiveness of the RCAs. The fourth section focused on growers' knowledge of the environmental factors to be considered during applications: spraying schedule, wind speed, relative humidity, temperature and rainfall.

A Likert scale was used to categorize the closed-ended responses, and frequencies also were generated with similar open-ended responses. Standardized responses were used to build sub-indexes of operational, sociocultural and environmental factors.

Reference values were developed according to the criteria set out by different authors, including CESVVER technicians and executives' opinion, representing the highest value. These reference values were compared with those obtained. The same procedure was performed with results obtained from each subindex. A Pearson's correlation matrix was developed to compare each subindex (operational, sociocultural and environmental) with the subindex on perception of application effectiveness, using the SAS® PROC CORR procedure (46).

Results and discussion

Description of citrus growers surveyed

The average number of hectares per grower interviewed was 11.8, mostly covered with Persian lime. The majority of growers were men (93.5%), 56.3 years old on average. The level of schooling of most of them was middle-school, 7% had received no schooling at all, and 10% had studied for more than ten years (table 1).

Operational factors

There are two types of operational factors that have an impact on the effectiveness of an application: i) the toxicant applied, and ii) the type of application (29). The values of the operational sub-indexes under assessment were close to the expected maximum in variables related to the toxicant applied, which includes the toxicological group (3 of 3), active ingredient (3 of 3) and applied dose (2 of 2). Therefore, high values could be explained given that these activities are supervised by CESVVER technicians; in addition, only the recommended insecticides are applied on the RCAs. However, those sub-indexes related to management of sprayers and insecticides, such as sprayer calibration (1.71 of 3), surfactant use (2.80 of 3.33), applicator advance speed (1.63 of 3), and water quality (1.65 of 2) had low values in relation to the effectiveness of the RCAs (table 2, page 111).

The HLB Technical Group decides on the insecticides and doses to be used in the RCAs. Also, it determines which is the appropriate rotation of TGs and the use of the minimum effective dose, as well as the crop's phenological stage (9, 41).

In SRAs, most producers claimed they had applied insecticides at the correct time and in the correct way (96%), and denied increasing the doses in any application or having used any mixture of insecticides (both 100%). However, this information is not consistent with previous field assessments (40). Most growers said that since the insecticide provided by CESVVER resulted effective, they kept buying the same TG for USLAs. Organophosphates are the most used insecticides (40). Constant applications of this chemical group and the use of inappropriate doses stimulate the development of resistant populations of *D. citri* and the emergence of secondary pests, as well as a reduction in the lifespan of the insecticides in use (15).

Table 1. Information about citrus growers interviewed in the RCAs of Martinez de la Torre, Veracruz.

Tabla 1. Información de los citricultores entrevistados en las ARCO de Martínez de la Torre, Veracruz.

Variables	Average	S.D. (±)
Area cultivated per grower (ha)	11.80	13.23
Gender (male growers) (%)	93.55	N.A.
Age (years old)	56.30	11.25
Average schooling (years)	7.40	4.60
Main crop	(%)	
Persian Lime	59.00	
Orange	37.00	
Grapefruit	4.00	

S. D. = Standard deviation; N. A. = Not applicable. / S. D. = Desviación estándar; N. A. = No aplica.

Table 2. Maximum expected and obtained values of each subindex for the operational index evaluated in the regional control areas in Veracruz, Mexico.

Tabla 2. Valores máximos esperados y obtenidos de cada subíndice para el índice operacional, evaluado en áreas regionales de control, en Veracruz, México.

Index	Subindex	Maximum expected value	Value obtained in RCA	Reference assigned to maximum value
Operational factors	Toxicological group in SRA	3.00	3.00	(8, CESVVER[1])
	Active ingredient in SRA	3.00	3.00	(8, CESVVER)
	Recommended dose in SRA	2.00	2.00	(8, CESVVER)
	Insecticides in USLA	2.00	1.79	(42)
	Surfactant	3.33	2.80	(26)
	Calibration	3.00	1.71	(15, 23)
	Pump type	2.50	1.56	(49)
	Nozzle type	3.00	1.56	(3)
	Forward speed	3.00	1.63	(27)
	Water quality	2.00	1.65	(12, 17)

[1] Information obtained from CESVVER technicians and executives; SRA = Supervised regional applications; USLA = Unsupervised local applications.

[1] Información obtenida de técnicos y directivos del CESVVER; SRA = Aplicación regional supervisada; USLA= Aplicación local no supervisada.

Correlation of the operational sub-indexes evaluated showed that those small farmers who have a higher perception of SRA effectiveness pay more attention to the quality of water they use in their applications (0.2859, $p < 0.0043$) (table 3, page 112). However, 59% never check the pH of the water used and 11.2% do not check for debris or a strange color. It is known that pH can modify, or even degrade the active ingredient of insecticides. In addition, the presence of organic matter may clog nozzles and accelerate the wearing of the sprayer (26). Leiva (2010) reports that the half-life of organophosphates can be increased from 1 to 35 d by lowering the pH from 8 to 7; recommending to acidify water if it seems cloudy or presents organic matter.

Growers who know that water quality may influence application effectiveness also believe that the use of surfactants (0.3085, $p < 0.0147$) and specific nozzle type (0.4547, $p < 0.0002$) could enhance the effectiveness of insecticides (table 3, page 112). About 24% of growers have never used surfactants in their applications, although those who had used them (76%) do not know the advantages of applying them, and among them, 5% only use surfactants with other agrochemicals, such as herbicides and foliar fertilizers. Our results agree with those of Carvalho *et al*. (2016) in Brazil, who reported that mineral oil is the most commonly surfactant used in combination with insecticide. Once more, 17.9% of interviewed growers use this product without knowing its potential advantages in the mixture. In this sense, Cortez-Mondaca *et al*. (2010) pointed out that using good quality water with surfactants in the mixture can enhance the effect of insecticides.

Growers who consider that applicator advance speed can affect application effectiveness, also believe that an appropriate nozzle type (0.5855, $p < 0.0001$) and a good calibration of equipment (0.4374, $p < 0.0060$) (table 3, page 112) can maximize the effect of any insecticide.

Table 3. Pearson's correlation matrix of the perception of supervised regional application effectiveness subindex, and other operational subindexes.

Tabla 3. Matriz de correlación de Pearson del subíndice de percepción de la efectividad de las aplicaciones regionales supervisadas y otros subíndices operacionales.

	SI-PAE[1]	SI-SU[2]	SI-AAS[3]	SI-NU[4]	SI-WC[5]	SI-SC[6]
SI-PAE		0.1846	0.1812	0.1875	0.2859*	0.0724
SI-SU			0.0055	0.2098	0.3085*	0.2284
SI-AAS				0.5855***	0.1927	0.4375**
SI-NU					0.4547***	0.2926
SI-WC						0.2287
SI-SC						

[1] Perception of application effectiveness subindex; [2] Surfactant use subindex; [3] applicator advance speed subindex; [4] Nozzle use subindex; [5] Water quality subindex; [6] Sprayer calibration subindex. Significance level of Pearson's linear correlation coefficient: * < 0.05, ** < 0.01, *** < 0.001.

[1] Subíndice de percepción sobre la efectividad de las aplicaciones; [2] Subíndice uso de adherente; [3] Subíndice velocidad de avance; [4] Subíndice uso de boquilla; [5] Subíndice calidad del agua; [6] Subíndice calibración de equipos. Nivel de significancia del coeficiente de correlación lineal de Pearson: * = <0,05, ** = <0,01, *** = <0,001.

In stark contradiction to this group, 53.2% of the interviewees do not calibrate their equipment and 56.5% do not believe that nozzle type affects effectiveness, even though it has been well established that calibration is one of the most frequently occurring factors causing deficient pest control (50). In general, the RCA strategy along with the recommendations made by CESVVER technicians, have a positive impact on the knowledge of some growers about *D. citri* management. Continuous training of beneficiaries, along with the promotion of their engagement, are required to prevent the spread of CLas in this important citrus area of Veracruz.

Sociocultural factors

Sociocultural factors depend to a great extent on cognitive development, the social environment where each grower was raised, schooling and the level of training in pest management (1, 28). Growers' ideology, perception and knowledge vary among localities and therefore among the RCAs. In most cases, sociocultural sub-indexes obtained low values, particularly in aspects related to organization (1.41 of 2), knowledge about protection of natural enemies (1.86 of 2.5), management and rotation of insecticide (2.27 of 2.71), and growers' perception of SRA effectiveness (2.67 out of 3.67) (table 4, page 113).

Growers who believe that there is greater effectiveness in the RCAs also have a greater knowledge of the pest (0.281, p <0.0270), insecticide management and rotation (0.300, p < 0.0177) (table 5, page 113). This is probably due to a better training, higher investment in inputs such as insecticides, and efficient previous applications. Van-Mele *et al*. (2005) indicate that those growers who actively seek staff training in pest biology and management, might evolve to a more entrepreneurial profile. They also explained that small farmers who strongly depend on a single crop, might be influenced by the advertising of agrochemical suppliers through local retailers, which in turn determine the type of pest management they choose, often based on an exclusive use of insecticides.

Table 4. Maximum expected and obtained values of each subindex integrating the sociocultural index from regional control areas from Veracruz, Mexico.

Tabla 4. Valores máximos esperados y obtenidos de cada subíndice que integra el índice sociocultural en áreas regionales de control de Veracruz, México.

Index	Sub-indexes	Maximum Expected Value	RCA Value Obtained	Maximum Value Reference
Sociocultural factors	Association membership	3	2.21	(42, CESVVER[1])
	Organization	2	1.41	(22, 42, CESVVER)
	Pest	2.67	2.32	(42, CESVVER)
	Knowledge on insecticide management and rotation	2.71	2.27	(7, 30)
	Dose increment	2	1.64	(44, 45)
	Protection of natural enemies	2.5	1.86	(42, 48)
	Perception on insecticide effectiveness	3.67	2.66	(CESVVER)

[1] Information provided by CESVVER technicians and executives.

[1] Información obtenida de técnicos y directivos del CESVVER.

Table 5. Pearson's correlation matrix of the sociocultural indexes with the "perception of supervised regional application effectiveness" subindex.

Tabla 5. Matriz de correlación de Pearson de los subíndices socioculturales con el subíndice "percepción sobre la efectividad de las aplicaciones regionales supervisadas".

	SI-PSRAE [1]	SI-BC [2]	SI-O [3]	SI-PK [4]	SI-IMR [5]	SI-AD [6]	SI-NEP [7]
SI-PSRAE		0.0667	0.1183	0.2809*	0.3003*	-0.0098	0.1695
SI-BC			0.2146	-0.0687	0.3127*	0.3357 **	0.0815
SI-O				-0.1630	0.3149*	0.1749	-0.0255
SI-PK					0.2819*	0.2437	-0.1854
SI-IMR						0.4667***	-0.2578 *
SI-AD							0.4979***
SI-NEP							

[1] Perception of SRA effectivity subindex; [2] Belonging to the campaign subindex; [3] Organization subindex; [4] Pest knowledge subindex; [5] Insecticide management and rotation subindex; [6] Augmentation of dose subindex; [7] Subindex of protection to Natural enemies. Significance level of Pearson's linear correlation coefficient: * < 0.05, ** < 0.01, *** < 0.001. Source: The author's own work.

[1] Subíndice de percepción sobre la efectividad de las SRA; [2] Subíndice de pertenencia a la campaña; [3] Subíndice de organización; [4] Subíndice de conocimiento de la plaga; [5] Subíndice de manejo y rotación de insecticidas; [6] Subíndice de aumento en dosis; [7] Subíndice de protección a enemigos naturales. Nivel de significancia del coeficiente de correlación lineal de Pearson: * = <0,05, ** = <0,01, *** = <0,001. Fuente: Elaboración propia.

The "belong to the campaign" subindex consists of several issues, like growers interest in attending meetings and their perception of possible improvements in ACP control since they became part of the RCA. As this subindex increases, so do the sub-indexes for management and rotation (0.313, $p < 0.0134$) and augmentation of dose (0.336, $p < 0.0076$) (table 5, page 113). In this regard, those growers who are more interested in implementing CESVVER's recommendations are also those that increase to a greater extent the USLA doses and those -ironically- with greater knowledge of insecticide management. Some small farmers believe that they will get better results by increasing insecticide doses, and that these applications should eliminate all types of insects, even if they are not the target pest (-0.258, $p < 0.0431$). In addition, growers who tend to increase USLA doses have a lower perception of protection of natural enemies (-0.498, $p < 0.0001$) (table 5, page 113). This has been by Ruiz-Nájera *et al.* (2011) when studying tomato growers behaviour in Chiapas, Mexico. In this regard, Jallow *et al*. (2017) report that some factors that may explain why small farmers tend to overuse pesticides and increase doses are: i) the degree of formal education (schooling), ii) experience in pest management, iii) training; iv) information sources used when deciding which insecticides to apply; v) access to extension support; and vi) the farmers perception of yield losses due to pests. As aforementioned, it is necessary to increase the availability of information and to properly transfer it through extension services and training, while fostering a culture of protection of natural enemies, as well as good insecticide usage and management (47).

Growers' interest in investing in agricultural inputs and their participation in regional management of *D. citri* might be influenced by factors such as age, schooling, plot size, orchard age, and crop profitability in previous years (9, 36). Growers who are most interested in becoming member of the SRAs, also have more knowledge about insecticide management and rotation (0.315, $p < 0.0127$) and about the pest (0.282, $p < 0.0264$). However, they also apply higher insecticide doses than recommended (0.467, $p < 0.0001$) (table 5, page 113). Most growers with entrepreneurial interest invest more in pest control, since they claime that this action has improved their production volumes.

These growers have a key role within the RCAs, since they can lead by example given that they adopt recommended doses. They need to link their efforts with those of technicians to streamline supervision and regulation of the applied doses, enabling the achievement of proper insecticide resistance management, thereby prolonging lifespan of these molecules (31).

Environmental factors

The value obtained from the environmental sub-indexes, was low in most cases. Some growers of the RCAs believe that certain environmental factors such as wind speed (1.60 of 3.5), relative humidity (2.16 of 3) and temperature (1.21 of 2) have no impact on SRA effectiveness. However, most of them suspend insecticide applications when probability of rainfall is not low (1.90 of 2) (table 6, page 115).

There was no direct correlation between the perception of application effectiveness subindex and the environmental sub-indexes. Most growers indicated they perform applications between 7 a.m. and 11 a.m. (87.1%), whereas all others perform them after 4 pm.

Table 6. Maximum expected and obtained values of each subindex of the environmental index evaluated in regional control areas in Veracruz, Mexico.

Tabla 6. Valores máximos esperados y obtenidos de cada subíndice para el índice ambiental evaluado en áreas regionales de control, en Veracruz, México.

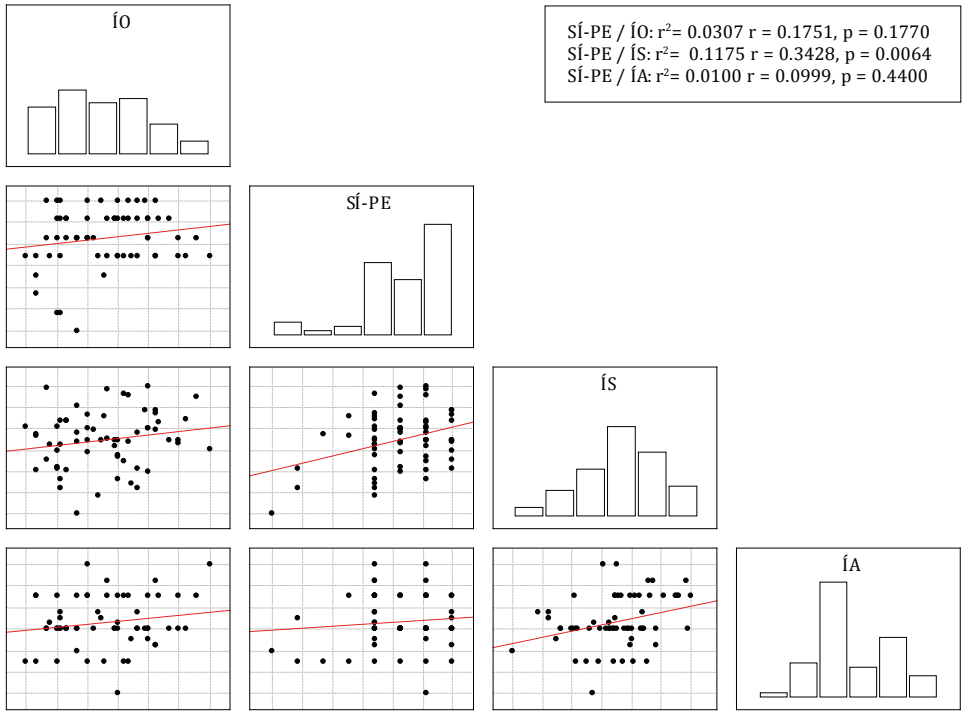
Index	Subindex	Maximum expected value	Value obtained in RCAs	Maximum value references
Environmental Factors	Application schedule	2.33	1.85	(14)
	Wind speed	3.50	1.60	(11, 27)
	Relative humidity	3.00	2.16	(27)
	Temperature	2.00	1.21	(13, 30)
	Precipitation	2.00	1.90	(27)

Source: The author's own work. / Fuente: Elaboración propia.

However, when applications *in situ* were monitored, they started at 8 a.m. on average and some finished after 2 p.m., with temperatures above 30°C (38). According to FAO (2001), the timing of insecticide applications shouldn´t coincide with the feeding times of beneficial insects. When applications are made at noon, insecticides might be lost through evaporation. In addition, the penetration of the insecticide into the foliage is affected by low percentages of relative humidity (26, 48). Some growers believe that wind speed, relative humidity and temperature (79.03%) have no impact on application effectiveness, and only 9.6% have applied insecticides with high rainfall probability. In this regard, Massaro and Fernández (2013) stated that these variables can either directly or indirectly affect the crop, the pest, the product and the sprayer-generated droplets. Gonçalves-Balan *et al*. (2016) reported basic deficiencies in applications when not considering the weather conditions. Pérez-Zarate *et al*. (2016) reported that wind speed had a direct influence on the effectiveness of mineral oil and that the highest mortality percentages of *D. citri* nymphs occurred with relative humidity above 60%. In future SRAs, these factors must be considered to perform efficient insecticide applications, lower production costs, and reduce the aquifer contamination risks and intoxication of people spraying the products.

Perception of SRA effectiveness and its relationship to operational, sociocultural and environmental indexes

A positive correlation (0.3428, $p < 0.0064$) was found between the "perception of application effectiveness" subindex and the sociocultural index (figure 1, page 116). This reflects that the sociocultural context in the RCAs could influence the growers' perception of application effectiveness, decision-making for the management of *D. citri* and the adoption of CESVVER's recommendations in the SRAs. Sarandón and Flores (2014) mention that as agroecosystem administrator, mankind is intimately embedded in a sociocultural context, that determines the way in which the decisions are made. Social acceptance of the strategies to control ACP is essential to prevent the spread of CLas, since with no commitment of growers, technicians, researchers and authorities, citrus-growing areas could be reduced and even disappear, resulting in severe social and economic consequences (29).



SI-PE = Perception of effectiveness subindex in SRA, IO = Operational index, IS = Sociocultural index, IA = Environmental index.

SI-PE = Subíndice de percepción de la efectividad de ARS, IO = índice operacional, ÍS = Índice sociocultural, ÍA = Índice ambiental.

Figure 1. Correlation between the"perception of effectiveness" subindex and the operational, sociocultural and environmental indexes.

Figura 1. Correlación entre el subíndice de "percepción de la efectividad" y los índices operacional, sociocultural y ambiental.

To have a good relationship between technicians and small farmers is important since, due to differences in their knowledge, they approach subjects with different views. In addition, to gain expertise in pest management, technicians must have interpersonal skills to maximize the impact of their recommendations on small farmers (31). Training for technicians should be ongoing and should encourage more participatory and horizontal extension practices. Training should be provided to leading producers, who influence decisions made by the rest of the group regarding the management of *D. citri*. This could increase the chances for the HLB Campaign recommendations to be adopted (5).

Ortiz (2001) concludes that the adoption of new technologies could be achieved by integrating farmers knowledge with technical information. This information should be provided in a gradual and sequenced manner during pest management training, in order to facilitate producers' understanding and to allow them to associate information with local empirical knowledge.

Although both the operational and the environmental indexes showed no relationship with "perception of effectiveness" subindex, in several scenarios these factors have influenced the effectiveness by increasing wind-driven pesticide drift, by decreasing foliar coverage and by causing product evaporation due to high temperatures (13, 26, 33, 44). Growers' decision-making regarding pest management undoubtedly have an impact on SRAs effectiveness. The sociocultural context in the RCAs should be studied and understood to strengthen social relationships between technicians and producers, as well as to facilitate participation and organization, which is a cornerstone of the RCA strategy.

Conclusions

The perception of effectiveness of regional control areas could be influenced by some operational practices that are not being considered by growers in their applications, such as the use of surfactants, machine ground speed, sprayer calibration and quality of water. Sociocultural factors, such as a lack of general knowledge about the pest and its management, as well as on insecticide rotation, were more related to the perception regarding application effectiveness.

Environmental factors did not correlate with the perception of effectiveness on supervised regional applications; indicating that during the application, growers do not always consider weather conditions, such as temperature, wind speed and relative humidity. The sociocultural index correlated to a greater degree with the perception of application effectiveness, which indicates that sociocultural context should be considered in the HLB Campaign as a strategy that considers local knowledge and expedite the adoption of the recommendations made by CESVVER technicians.

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