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Article

Market research on two natural predators of walnut pests: Trichogramma ssp and Chrysoperla carnea, in Delicias City, Chihuahua

Investigación de mercado de dos depredadores naturales de plagas del nogal: trichogramma ssp y chrysoperla carnea, en ciudad Delicias, Chihuahua

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Abstract

In Mexico, as in the world, the production of food of agricultural origin requires protection against pests and diseases that limit and/or destroy it, through the application of chemical pesticides (PQ) that, although they control them, also cause environmental pollution and in consequently deteriorating the quality of human life. Since plants began to be cultivated on a massive scale, pest problems began to arise, that is, where the population of very large insects that ate the crops and an alternative to controlling these insects is to occupy their natural predators or their natural pathogens for control. Since the 1940s, biological control has been applied in Mexico. The first pest that was fought with this method was the citrus black fly, where specialists imported a wasp from Australia. Since this time, in the 1940s, when these wasps were introduced, there has been no need for chemical control of this particular pest in Mexico. The use of biological control is regulated by Official Mexican Standards to avoid the potential risks it represents; once a species is released into the environment, it is no longer possible to remove it.

Título del resumen grafico en Ingles		
Objectives	**Metodology**	**Contribution**
To know the perception of walnut and pecan growers about biological control	**Malhotra (2004):**	**This market research evaluates the viability of a beneficial insect production laboratory in Delicias, Chihuahua. The region, a leader in walnut production, seeks to improve its agricultural practices with a focus on biological control to reduce agrochemical pollution.**

Research, Market, Pests, Walnut

Resumen

En México como en el mundo la producción de alimentos de origen agrícola requiere de protección contra plagas y enfermedades que la limitan y/o destruyen, mediante la aplicación de pesticidas químicos (PQ) que, si bien los controlan, también causan contaminación ambiental y en consecuencia deteriorando la calidad de vida humana. Desde que se comenzaron a cultivar las plantas de manera masiva, empezaron a surgir los problemas de las plagas, o sea donde la población de insectos muy grandes que se comían los cultivos y una alternativa al control de estos insectos es ocupar sus depredadores naturales o sus patógenos naturales para el control. Desde los años 40, el control biológico se aplica en México. La primera plaga que se combatió con este método fue la mosca prieta de los cítricos, donde los especialistas importaron una avispa de Australia. Desde esta época, en los años cuarenta que se introdujeron estas avispas no ha habido necesidad de hacer control químico sobre esta plaga en particular en México. El uso de control biológico está regulado por Normas Oficiales Mexicanas para evitar los riesgos potenciales que representa, una vez que se liberan alguna especie en el medio ambiente ya no es posible retirarla.

Título del resumen grafico en Español		
Objetivos	**Metodología**	**Contribución**
Conocer la percepción de los productos de nogal y nuez acerca del control biológico	**Malhotra (2004):**	**Este estudio de mercado evalúa la viabilidad de un laboratorio de producción de insectos benéficos en Delicias, Chihuahua. La región, líder en producción de nuez, busca mejorar sus prácticas agrícolas con un enfoque en el control biológico para reducir la contaminación por agroquímicos.**

Investigación, Mercado, Plagas, Nogal

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Introduction

It is of utmost importance for any company to have information with which to identify and define the opportunities and problems that arise in the market, as this information is used to generate, refine and evaluate marketing activities. Market research can identify weaknesses and opportunities, the reasons for lack of demand or supply, or understand the degree of distortion in existing markets. This understanding can help to choose intervention strategies or to identify institutions and networks on which to build a baseline against which to measure progress in the development of the market in question.

This research was carried out at the request of the Junta Local de Sanidad Vegetal de Cd. Delicias, Chihuahua, in order to know the perception of walnut and walnut products about biological control; for this purpose, a survey was applied to the sector to be studied. Walnuts are an important crop for the economy of the south-central region of the state of Chihuahua. In the agricultural and livestock sector, the municipalities of Mequí, Delicias and Valle de Juárez account for 44 percent of the 40,000 hectares of walnut trees planted in the state of Chihuahua, of which the state is the leading national producer according to data from the State Plant Health Committee, an auxiliary body of the Ministry of Agriculture, Livestock and Fishery Resources (SAGARPA). Chihuahua is a national and international leader, as it produces 12 percent of the country's walnuts, and 90 percent of the total product is sold in the United States market, according to SAGARPA data. Annual production is around 70,000 tonnes; the main walnut production areas in the state are Jiménez, Camargo, Delicias, Saucillo, Julimes, Aldama, Ojinaga, Ricardo Flores Magón, Nuevo Casas Grandes and Valle de Juárez, according to the aforementioned agency. Walnut and non-walnut growers in Delicias and the region are looking for ways to improve their cultivation processes and techniques, which is being done in part with the support of the Junta Local de Sanidad Vegetal de Cd. Delicias, Chihuahua, (JLSVD) and the Instituto Nacional de Investigaciones Forestales Agrícolas y Pecuarias, (INIFAP) and through the Asociación Agrícola Local de Productores de Nogal y Nuez de Cd. Delicias, Chihuahua, through monthly conferences about the different cultivation processes such as pruning techniques, pest control, insecticide application technology, etc.

There is a need and an opportunity to set up a laboratory for the production of beneficial insects for the walnut sector, so market research was carried out to find out the market potential in the city of Delicias, Chihuahua and the region. In the state of Chihuahua, emphasis is being placed on biological control with the aim of reducing the contamination index due to the residues of agrochemicals used in crop pest control.

By virtue of the above, and through capital investment by La Asociación Civil de Delicias Hortícola and support managed by the Junta Local de Sanidad Vegetal Delicias, a beneficial insect production laboratory of La Junta Local de Sanidad Vegetal Delicias will be installed in coordination with the Comité Estatal de Sanidad Vegetal Chihuahua.

Methodology:

The project was implemented with the participation of the JLSVD, INIFAP and cooperating organisations including the Asociación Delicias Hortícola, which guarantees the socialisation of the experience. The methodology proposed by Malhotra (2004) was used for the development and implementation of this project: the purpose of the study and how it would be used by decision-makers was considered, an analysis was made with experts in the field of biological control from both the JLSVD and INIFAP, project leaders, the main researcher's advisor and a literature review, which was used to formulate a hypothesis and determine what information was needed.

In addition, the plan with which the market research was developed was elaborated, determining the research design technique that was used, this being the descriptive technique, which has the purpose of writing something, usually characteristics or functions of the market. The simple cross-sectional design was applied as information was collected from a given sample of population elements only once.

A frame of reference was developed to learn more about beneficial insects and pests of walnut by analysing the international context, the national context, the state context and the regional context. For this purpose, information from records in the irrigation modules of district 005, different web pages and bibliographic sources was analysed.

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The information collected included the number of hectares under walnut cultivation and the number of producers in order to determine the size of the sample and apply the number of questionnaires required according to the statistical formula that was used.

Within the descriptive research design, the aforementioned team and the researcher used the survey method, which was carried out by applying a questionnaire to obtain specific information. The questionnaires were applied through direct personal interviews, i.e. by interviewers. The survey collected data from the interviewees on serious aspects of the PBC market including:

- Extent of knowledge, understanding and use of CBP and chemical controls.
- Frequency of use, amount paid for both pest controls.
- Suppliers.
- Degree of effectiveness with the technologies used.
- Reasons for use and non-use of biological control.

The survey was carried out through structured questions, where the respondent had several answer options, from which he/she had to select one, and also dichotomous questions with only two answer options (affirming or denying), within the research a pilot test of 40 questionnaires was carried out to evaluate if the information obtained was going to be the required for the study, corrections were made in the structure of some questions to later apply the total questionnaire according to the calculated sample. A team consisting of a coordinator and two assistants was formed to carry out the pilot test.

Sample Size Determination

To define the target population, all walnut producers registered by irrigation module were taken into account. Currently there is a total walnut cultivation area of 17,598.56 hectares in irrigation district 005 according to data from

SAGARPA (2010), and a total of 1053 walnut producers according to records of irrigation modules 1, 2, 3, 4, 5, 7, 8, 9 and 12.
The probability sampling technique was used, in which each sample has the same probability of being chosen. The calculation of the sample size was done with a formula for a finite population:

$$n = \frac{Z_{\alpha}^{2}\, Npq}{E^{2}(N-1) + Z_{\alpha}^{2} pq} \quad (1)$$

Where:

n Sample size.
N Population size.
Z Value corresponding to the Gaussian distribution 1.96 for $\alpha = 0{,}05$.
p Expected prevalence of the parameter to be assessed.
q 1-p.
E Mistake to be made.

$$n = \frac{(1.96)^{2}(1053)(0.92)(0.08)}{(0.05)^{2}(1053-1) + (1.96)^{2}(0.92)(0.08)} = 102$$

The field work was carried out with a team of three people composed of a coordinator and two assistants, attending the producers‘ meeting places, mainly the Regional Association of Walnut Growers and in some cases the producers’ orchards to collect the information through the questionnaires applied. The data analysis was carried out in parallel to the field work, checking that all the surveys were complete and checking the quality and legibility of the data collected.

Those questionnaires that successfully passed this check were passed on to the next stage and decisions were made about those that could be retrieved. For the data analysis, codes were assigned to all possible answers given by the respondents, which were numerical. Subsequently, all responses were entered into the computer so that the analysis of the responses could begin.

At this stage, checks were carried out in order to observe the consistency and handling of unanswered questions in the selected questionnaires.

Having finished preparing the data, statistical techniques were applied to obtain conclusions for the research, using tools such as frequency distributions, through which measures of central tendency and variations were found, as well as contingency tables comparing the following questions: Do you currently use the BC of pests?* Have you ever used the BC of pests? and If your answer is no, why didn't you use the BC?* Do you currently use the BC of pests?

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PASW Statistics software version 18 was used for this analysis, which allows for a quick and reliable analysis, thus minimising human error.

Analysis of results or Development

With the results obtained, it can be concluded that the use of biological pest control in Delicias City, Chihuahua and its region is part of the pest control agents since 91.2% of the respondents mentioned having used biological control at least once; of which 83.4% mentioned that they continue to use it, and we can see that it is a good market for the sale of PBC, since of the 102 respondents, 76.5% of them showed interest in having information about this technology for pest control. The results of the survey indicate that, in the short term, biological pest control has strong market potential.

What type of pest control do you currently use?

Box 1

Table 1

Type of control used

Valid	Frequency	Percentage	Percentage valid	Cumulative percentage
Agrochemicals	21	20.6	20.6	20.6
Biological Control	16	15.7	15.7	36.3
Biological and Chemical Control	65	63.7	63.7	100.0
Total	102	100.0	100.0	

When walnut growers were asked about the type of pest control they use, it can be seen in table 1 that 63.5% answered that they use both chemical and biological control, with only 15.7% using chemical control as the only control alternative. Which pests occur most frequently?

Box 2

Table 2

Most frequent pest

Valid	Frequency	Percentage	Percentage valid	Cumulative percentage
Gbn	40	39.2	39.2	39.2
Gbr	10	9.8	9.8	49.0
gbn y gbr	15	14.7	14.7	63.7
Pulgón	37	36.3	36.3	100.0
Total	102	100.0	100.0	

Table 2 shows that the most frequently occurring pest is the walnut borer followed by aphids in general. Which agrochemical do you use for pest control?

Box 3

Table 3

Agrochemical used

Valid	Frequency	Percentage	Percentage valid	Cumulative percentage
Intrepid	52	51.0	51.0	51.0
Aflix	14	13.7	13.7	64.7
Lorsban	15	14.7	14.7	79.4
Clorpirifos	1	1.0	1.0	80.4
Cipermeticina	1	1.0	1.0	81.4
Karate	3	2.9	2.9	84.3
No QC	16	15.7	15.7	100.0
Total	102	100.0	100.0	

Of the 102 farmers surveyed, 51% use Intrepid insecticide, followed by Lorsban with 14.6% and Aflix with 13.7% for pest control. How much agrochemical do you apply per hectare?

Box 4

Table 4

Dosage of agrochemicals used

Valid	Frequency	Percentage	Percentage valid	Cumulative percentage
0.25 L	23	22.5	22.5	22.5
0.5 L	47	46.1	46.1	68.6
0.75 L	9	8.8	8.8	77.5
1 L	5	4.9	4.9	82.4
2 L	2	2.0	2.0	84.3
No usa CQ	16	15.7	15.7	100.0
Total	102	100.0	100.0	

Of the 102 farmers surveyed 47 use a dose of up to 0.5 L per hectare and 23 use up to 0.25 L per hectare.

How many agrochemical applications do they make per year?

Box 5

Table 5

Number of applications of agrochemicals per year

Valid	Frequency	Percentage	Percentage valid	Cumulative percentage
1	16	15.7	15.7	15.7
2	42	41.2	41.2	56.9
3	16	15.7	15.7	72.5
4	12	11.8	11.8	84.3
No QC	16	15.7	15.7	100.0
Total	102	100.0	100.0	

The number of agrochemical applications per year most frequently mentioned was 41.2%, followed by 1 and 2 applications per year with 15.7% each.

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In which months do you apply agrochemicals?

Box 6

Table 6

Months of application of agrochemicals

Valid	Frequency	Percentage	Percentage valid	Cumulative percentage
April – May	33	32.4	32.4	32.4
June – July	20	19.6	19.6	52.0
August – September	33	32.4	32.4	84.3
No QC	16	15.7	15.7	100.0
Total	102	100.0	100.0	

Table 6 shows that the periods of highest agrochemical application are April-May with a percentage of 32.4% and August-September with the same percentage. How much does the agrochemical you use cost you?

Box 7

Table 7

Cost of agrochemicals

Valid	Frequency	Percentage	Percentage valid	Cumulative percentage
De $250 a $500	15	14.7	14.7	14.7
De $501 a $1,000	16	15.7	15.7	30.4
De $1,001 a $1,500	55	53.9	53.9	84.63
No QC	16	15.7	15.7	100.0
Total	102	100.0	100.0	

Where do you buy the agrochemicals you use?

Box 8

Table 8

Agrochemical suppliers

Valid	Frequency	Percentage	Percentage valid	Cumulative percentage
Dansa	8	7.8	7.8	7.8
Miller	8	7.8	7.8	15.7
Tepeyac	14	13.7	13.7	29.4
Agronorte	10	9.8	9.8	39.2
Asoc. de nogaleros	12	11.8	11.8	51.0
Agricam	7	6.9	6.9	57.8
Bayer de México	8	7.8	7.8	65.7
Agrochemical Delights	10	9.8	9.8	75.5
Agricultural supplier	9	8.8	8.8	84.3
No QC	16	15.7	15.7	100.0
Total	102	100.0	100.0	

Table 8 shows that there is no preferred company for the purchase of agrochemicals as there is no marked difference in the frequencies.

Which biological control organism do you use for pest control?

Box 9

Table 9

B.C. bodies used

Valid	Frequency	Percentage	Percentage valid	Cumulative percentage
Chrysopa	29	28.4	28.4	28.4
Trichogramma sp	31	30.4	30.4	58.8
Both	21	20.6	20.6	79.4
No CB use	21	20.6	20.6	100.0
Total	102	100.0	100.0	

Regarding the organisms used for biological control, table 9 shows that there is no considerable difference in the frequencies, as would be expected since one beneficial insect can help to combat several pests.

How many cm^3 of Chrysopa do you apply per hectare?

Box 10

Table 10

Dosage per hectare of Chrysopa

Valid	Frequency	Percentage	Percentage valid	Cumulative percentage
1 cm^3	26	25.5	25.5	25.5
2 cm^3	47	46.1	46.1	71.6
3 cm^3	8	7.8	7.8	79.4
No C.B.	21	20.6	20.6	100.0
Total	102	100.0	100.0	

Typically, walnut growers apply a dose of 2 cm3 per hectare of chrysopa, followed by a dose of 1 cm3, with percentages of 46.1% and 25.5% respectively. How many inches of trichogramma do you apply per hectare?

Box 11

Table 11

Doses per hectare of trichogramma

Valid	Frequency	Percentage	Percentage valid	Cumulative percentage
5 inches	14	13.7	13.7	13.7
10 inches	51	50.0	50.0	63.7
20 inches	16	15.7	15.7	79.4
No C.B.	21	20.6	20.6	100.0
Total	102	100.0	100.0	

Table 11 shows that in general a dose of 10 inches per hectare of trichogramma is applied.

How many Biological Control applications do you make per year?

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Box 12

Table 12

Applications per year of BC

Valid	Frequency	Percentage	Percentage valid	Cumulative percentage
1	27	26.5	26.5	26.5
2	41	40.2	40.2	66.7
3	10	9.8	9.8	76.5
4	3	2.9	2.9	79.4
No C.B.	21	20.6	20.6	100.0
Total	102	100.0	100.0	

40.2% of the farmers mentioned making two applications per cycle of biological control followed by one application representing 26.5% of the respondents.

In which month do you apply biological control?

Box 13

Table 13

Months of CB application

Valid	Frequency	Percentage	Percentage valid	Cumulative percentage
April - May	33	32.4	32.4	32.4
June - July	18	17.6	17.6	50.0
August - September	30	29.4	29.4	79.4
No QC	21	20.6	20.6	100.0
Total	102	100.0	100.0	

The results were similar to the periods of application of agrochemicals, with the periods of highest application of biological control being April-May with a percentage of 32.4% and August-September with 29.4%.

How much does a cm3 of chrysopa cost you?

Box 14

Table 14

Cost per cm^3 of chrysopa?

Valid	Frequency	Percentage	Percentage valid	Cumulative percentage
De $40 a $50	1	1.0	1.0	1.0
De $51 a $60	4	3.9	3.9	4.9
De $61 a $70	26	25.5	25.5	30.4
Más de $70	50	49.0	49.0	79.4
No usa CB	21	20.6	20.6	100.0
Total	102	100.0	100.0	

Table 14 shows a high percentage of producers spend more than $70 per cm3 of chrysopa.

How much does an inch of trichogramma cost you?

Box 15

Table 15

Costs of trichogramma

Valid	Frequency	Percentage	Percentage valid	Cumulative percentage
$2	18	17.6	17.6	17.6
$4	38	37.3	37.3	54.9
$6	24	23.5	23.5	78.4
$7	1	1.0	1.0	79.4
No usa C.B.	21	20.6	20.6	100.0
Total	102	100.0	100.0	

Table 15 shows the prices of trichogramma purchased by producers at a cost of $4.

Where do they buy the biological control they use?

Box 16

Table 16

C.B. Suppliers

Valid	Frequency	Percentage	Percentage valid	Cumulative percentage
UNIFRUT	50	49.0	49.0	49.0
CESAVESIN	6	5.9	5.9	54.9
JLSVD	21	20.6	20.6	75.5
OTROS	4	3.9	3.9	79.4
No usa C.B.	21	20.6	20.6	100.0
Total	102	100.0	100.0	

The place where biological control is most frequently purchased is the UNIFRUT laboratory with 49%.

What is the perception of biological pest control?

Box 17

Table 17

Perception of B.C

Valid	Frequency	Percentage	Percentage valid	Cumulative percentage
Very effective	10	9.8	9.8	9.8
Cash	57	55.9	55.9	65.7
Regularly	35	34.3	34.3	100.0
Cash				
Total	102	100.0	100.0	

The survey asked farmers to rate their perception of Biological Pest Control. The results are shown in figure 17, of the 102 farmers surveyed 57 consider biological pest control to be effective while 35 consider it to be regularly effective.

Have you ever used biological pest control?

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Box 18

Table 18

Use of the C.B. at least once

Valid	Frequency	Percentage	Percentage valid	Cumulative percentage
Si	93	91.2	91.2	91.2
No	9	8.8	8.8	100.0
Total	102	100.0	100.0	

A percentage of 91.2% have used biological control at least once, while 8.8% never use biological control.

Do you currently use biological pest control?

Box 19

Table 19

Current use of C.B

Valid	Frequency	Percentage	Percentage valid	Cumulative percentage
Yes	84	82.4	82.4	82.4
No	18	17.6	17.6	100.0
Total	102	100.0	100.0	

Currently 82.4% of respondents use biological pest control. If no, why do you use biological pest control?

Box 20

Table 20

Reasons for non-use of B.C

Valid	Frequency	Percentage	Percentage valid	Cumulative percentage
The following did not apply	15	14.7	14.7	14.7
Other	3	2.9	2.9	17.6
Yes he does	84	82.4	82.4	100.0
Total	102	100.0	100.0	

Of the respondents who do not use biological pest control, 14.7% do not know how to apply it. It is worth noting that none of the respondents mentioned that they do not use biological pest control because it is not effective or because it is expensive.

If Biological Pest Control were explained to you, would you be willing to use it?

Box 16

Table 16

Willingness to use the B.C

Valid	Frequency	Percentage	Percentage valid	Cumulative percentage
Si	79	77.5	77.5	77.5
No	23	22.5	22.5	100.0
Total	102	100.0	100.0	

77.5% of the respondents mentioned that they would be willing to use only biological control.

What factor would influence an increase in the use of biological control?

Box 22

Table 22

Change of agrochemicals to C.B

Valid	Frequency	Percentage	Percentage valid	Cumulative percentage
Price	41	40.2	40.2	40.2
Effectiveness	55	53.9	53.9	94.1
Other	6	5.9	5.9	100.0
Total	102	100.0	100.0	

The most influential factor for increasing the use of biological control is effectiveness. That is, farmers want to be sure that PBC works effectively in order to make a decision about increasing its use.

Would you like to get information about the use and application of biological control?

Box 23

Table 23

Willingness to obtain information on the use of the B.C

Valid	Frequency	Percentage	Percentage valid	Cumulative percentage
Yes	78	76.5	76.5	76.5
No	24	23.5	23.5	100.0
Total	102	100.0	100.0	

Two contingency tables were designed to analyse what percentage of farmers who mentioned having used PBC at some point in time still use it today and know the causes of non-use of PBC.

Box 24

Table 24

Contingency 1: Do you currently use pest C.B.? * Have you ever used the pest C.B.?

		Have you ever used C.B. Pest Control?		Total
		Yes	No	
Do you currently use the C.B. for pests?	Yes	78	6	84
	No	15	3	18
	Total	93	9	102

The table shows that out of the 93 farmers who mentioned having used biological control at least once, 78 continue to use it.

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Box 25

Table 25

Contingency 2: If no, why don't you use the B.C.? * Do you currently use C.B. for pests?

		Do you currently use the C.B. for pests?	Total	
		Si	No	
If no, why don't you use the C.B.?	I don't know how to apply it	7	8	15
	Other	0	3	3
	Yes He uses it	77	7	84
	Total	84	18	102

The table shows that of the 18 farmers who do not use biological control, 15 do not know how to apply it and three mentioned another cause.

The potential demand is the maximum possible demand for the products offered by the laboratory. This was determined by means of the buyer's intentions survey method: It consists of a survey of the opinion of desires or expectations about the purchase of a product. Its limitation is given because one thing is the intention to buy and the other the purchase itself (W.J. Stanton, 2004). The formula of the potential demand is:

$$Q = npq \quad (2)$$

Where:

Q: Potential demand.
n: Number of possible buyers for the same type of product on a given market.
p: Average market price of the product.
q: Average amount of consumption per capita on the market

Box 26

Table 26

Determination of potential demand

Product	n(ha)	p($)	q	Q
Chrysopa	13,638.884	60	1cm^3/ha	$818,333.04
Trichogramma	13,638.884	2	10 inch/ha	$172,777.68
			Market size	$1,091,110.72

Box 27

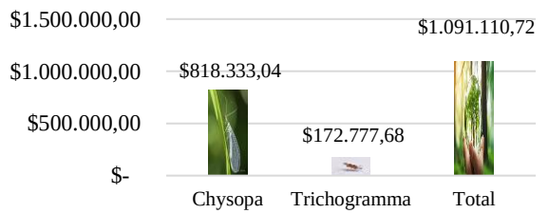

Figure 1

Potential demand for biological control

Economic and ecological impact of biological versus chemical control considering the total area of irrigation district 005.

Comparison of a traditional technology and two components of integrated pest management in the control of GBN per day.

Box 28

Table 27

Economic and ecological impact of IPM (Trichogramma) vs. chemical control

Control	Unit cost	Dosis ha	Cost ha	PPD	DP cost	Surface	Cost T. day	CPNPA	With regard to the NC
Trichogramma	$2.00	10 pulg	$20.00	45	$0.44	17,598.56	$7,743.37	0 L	Total
Lorsban	218.000	1.5 L	327.00	5	65.40	17,598.56	1,150,945.82	26,397.84	No
Intrepid	1,400.00	0.25 L	350.00	17	20.50	17,598.56	362,323.48	4,399.64	Total

Comparison of a traditional technology and an integrated pest management component in aphid control by day.

Box 29

Table 28

Economic and ecological impact of IPM (Chrysopa) vs. chemical control

Control	Unit cost	Dosis ha	Cost ha	PPD	DP cost	Surface	Cost T. day	CPNPA	With regard to the NC
Chrysopa	$60.00	10 cm^3	$600.00	45	$13.33	17,598.56	$234,647.47	0 L	Total
Aflix	130.00	0.5 L	65.00	5	15.09	17,958.56	265,562.27	8,799.28	Moderado
D. Foca	20.9	0.5 K	10.45						
Lorsban	215.00	1.5 L	327	5	65.4	17,598.56	1,150,945.48	26,397.84	No

PPD. - Protection period in days.
PD. - Protected Day.
CPNPA. - Amount of pesticide needed per application.

The economic impact refers to the economic expenses avoided when comparing traditional chemical management with integrated pest management (IPM) supported by the use of beneficial insects Tarango Rivero (2007). This was estimated at 67.8% savings in daily expenditure comparing IPM (Trichogramma+intrepid) with traditional technology (Lorsban) for GBN control and 56.5% for aphid control using IPM (Crysopa+Aflix+D.Foca): in other words, savings of $1,431,614.62.

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Box 30

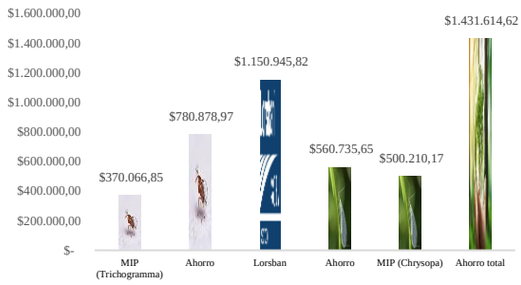

Figure 2

Economic impact of IPM

In the ecological impact, the volumes that are no longer discharged into the environment when spraying is reduced by the use of beneficial insects Tarango Rivero (Control de pulgones, 2005).

Comparing IPM (Trichogramma+intrepid) against a traditional management technology (Lorsban) in the control of GBN, a 83.33% reduction in the use of insecticides and a 66.66% reduction in the use of aphids using IPM (Chrysopa+Aflix+D. Foca) is obtained; in other words, 39,594.12 litres of some insecticide would no longer be discharged into the environment.

Box 31

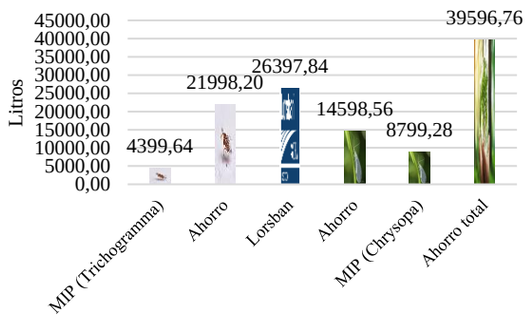

Figure 3

Ecological impact of IPM

Hypothesis Testing

Based on the proposed assertion 'more than half of the walnut and walnut growers are willing to use BC', the hypothesis test was conducted with the following steps:

Ho: Half of the walnut and walnut growers are willing to use biological control.

Ha: More than half of the walnut and walnut growers are willing to use biological control.

Ho: P = 0.50

Ha: P > 0.50

We selected a=0.05 for the significance level, obtaining a critical value of z=1.645, as this is a right-tailed hypothesis test.

The z-test statistic was calculated with the following formula:

$$z = \frac{p-P}{\sqrt{\frac{pq}{n}}} = \frac{0.775-0.50}{\sqrt{\frac{(0.50)(0.50)}{102}}} = \mathbf{5.50} \quad (3)$$

Where:

z= Test statistic.
p= Sample proportion = 0.775
P= Proportion of the population = 0.50 (Ho)
q= 1 – p
n= Our size = 102

Box 32

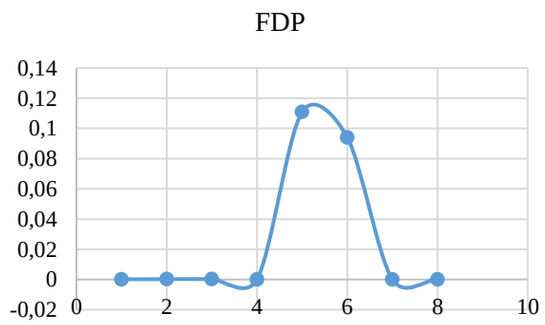

Figure 4

Critical región

Since the test statistic z=5.5 falls within the critical region, the null hypothesis is not accepted and we conclude that there is sufficient sample evidence to support the assertion that more than half of the walnut growers and not from the city of Delicias, Chihuahua are willing to use biological control.

Discussion of results

– As seen in the results of the questionnaires most of the producers use both biological control and chemical control a difference could be made with a good publicity campaign and information to producers on the use and benefits of biological pest control.

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– Develop training courses on the use of biological pest control for all agricultural producers in Delicias and the region.

– Conduct a more detailed study on technical and financial feasibility.

– Ultimately, it is crucial to increase the quantity and quality of information flows about biological control. Increasing the availability of information to small and medium-sized producers can have a positive impact on product sales. The development of an appropriate information chain can be an action that can be undertaken from a public-private perspective.

– Sponsor advertising campaigns with generic programming, e.g. a campaign on the use of beneficial insects for pest control aimed at all agricultural producers to raise awareness among producers not only of walnuts, as beneficial insects can be used against pests of other agricultural products.

– Carry out field demonstrations of the application of biological control.

– Have sample orchards, where integrated pest management is carried out.

– The basic conditions necessary for small and medium walnut and walnut producers to demand biological pest control products are:

– That small and medium producers are aware of the technology.

– That small and medium producers have a basic understanding of its application.

– That small and medium producers have a correct understanding of the benefits that the use of biological versus chemical control can bring them.

– That small and medium producers see that these benefits are realistic and consider biological control as a priority in their agricultural activity.

– The need for eco-friendly inputs to increase participation in value markets. In addition, there are other conditions that facilitate the emergence of exchanges between suppliers and producers.

– That small and medium-sized producers can find a supplier who is in touch with their particular needs and wishes and who will satisfy them with the appropriate product.

– That small and medium-sized producers and suppliers are able to agree on the use of biological control as a win-win process

Conclusions

The results of the study indicate that, in the short term, biological pest control has strong market potential. The following conclusions were drawn from the research:

– April-May and August-September are the months with the highest incidence of walnut pests.

– The pests that occur most frequently in walnut trees are the walnut borer worm and the aphid.

– Walnut and pecan growers in Delicias and the region use both chemical pest control and PBC. When walnut growers were asked about the type of pest control they use, 63.7% answered that they use both controls, with only 20.6% using chemical control as the only control alternative.

– There is a very important market for producers of biological pest control in the region that is not being exploited, since 49% of those surveyed bring the product from the laboratory of beneficial insect production of UNIFRUT in Cuauhtémoc, Chihuahua. The project proposed by the Junta Local de Sanidad Vegetal would solve the shortage of biological control products in the region.

– The producers are paying a price of more than $70.00 per cm3 of chrysopa, having a cost of around $60.00.

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– Producers are paying a price of more than $4.00 per cm3 of chrysopa, at a cost of around $2.00.

– The factor that would influence increased use of biological control by growers is the effectiveness of biological control in pest control as growers like to see immediate results. If a technology does not show immediate results, it is difficult for farmers to adopt it.

– If it has a potential market of $1,091,110.72 per period considered to be done in a single application.

– The use of IPM supported with biological control would have an economic impact of $780,878.85 in the use of trichogramma and $650,735.65 in the use of chrysopa.

– IPM use supported with biological control would have an economic impact of $780,878.85 on trichogramma use and $650,735.35 on chrysopa sparing use.

– The use of IPM supported with biological control would have an ecological impact of 21,998.2 L in the use of trichogramma and 17,598.56 L in the use of chrysopa of fewer litres of insecticide discharged into the environment.

– The null hypothesis is not accepted and we conclude that there is sufficient sample evidence to support the assertion that more than half of the walnut and pecan producers in Delicias, Chihuahua are willing to use biological control.

– Based on the above, it can be concluded that from a market point of view it is feasible to set up a laboratory for the production of beneficial insects in the city of Delicias, Chihuahua.

Declarations

Conflict of interest

The authors declare that they have no conflict of interest. They have no known competing financial interests or personal relationships that could have influenced the publication of the article reported in this article.

Authors' contribution

Ramírez-Moreno, Hilario: Main idea of the article

Aguirre-Orozco, Mario Abelardo: I participate in the main idea. Author recognized before the SNI Level I CONAHCYT

Delgado-Martínez, Martha Lilia: Methodological design

Contreras-Martínez, Jesús José: Arrangement and design of tables

Availability of data and materials

The information was obtained from various sources and was the master's thesis of Hilario Ramírez Moreno from the Autonomous University of Chihuahua and is part of the library of master's thesis projects of the Faculty of Agronomy, Delicias campus, the links were reviewed to authenticate its validity on the web.

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Abbreviations

CBP	Control Biológico de Plagas
CESAVESIN	Comité Estatal de Sanidad Vegetal del Estado de Sinaloa
CPNPA	Cantidad de Plaguicida Necesario por Aplicación.
CQ	Control Químico
DP	Día Protegido
gbn	Gusano Barrenador de la Nuez
gbr	Gusano Barrenador del Ruezno
INIFAP	Instituto Nacional de Investigaciones Forestales Agrícolas y Pecuarias
JLSVD	Junta Local de Sanidad Vegetal de Cd. Delicias
MIP	Manejo Integrado de Plagas
PPD	Periodo de Protección en Días
PQ	Pesticidas Químicos

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SAGARPA	Secretaria de Agricultura Ganadería y Recursos Pesqueros
UNIFRUT	Unión de Fruticultores

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