SIMULTANEOUS PRODUCTIVE GROWTH GROUPS (SPGG): INNOVATION ON PAPAYA MITE MANAGEMENT

[GRUPOS DE CRECIMIENTO PRODUCTIVO SIMULTÁNEO (GCPS): INNOVACIÓN EN EL MANEJO DE ÁCAROS PLAGA DEL PAPAYO]

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SUMMARY

Grower's previous experience and their ability to communicate technical information to other growers, allows greater adoption of technologies. Thus, appropriation of technologies of mite management and sampling was evaluated, based on the "Simultaneous Productive Growth Groups (SPGG)" technology transfer model. A preliminary diagnosis was made, evaluating the technology transfer achieved by six leading growers showing up continuously to seven meetings carried out from March to July 2010, and also by 19 growers showing up on a more irregular basis. All growers were from the municipality of Cotaxtla and belonged to the Papaya-Product-System of Veracruz, Mexico. Participation, attitude and efficacy of training were evaluated with a survey. Forty-two percent of growers considered the papaya ring spot virus as the main problem and 48 % revealed spider mites as the second one; 96 % used pesticides on spider mites. Participation of the SPGG basic group was 71 %, who agreed on sampling, recording data in sampling forms and using selective acaricides. Seventy percent were able to recognize spider mites from predatory mites and 83 % recognized selective acaricides. Growers considered that sampling can help reduce control costs. The SPGG model allowed building collective knowledge and better decision making by the working group.

Key words: Acari; *Carica papaya*; mite sampling; participatory research; PRSV-P.

RESUMEN

La experiencia previa del productor y su capacidad para comunicar la información a otros productores permiten mayor adopción de tecnologías. Así, se evaluó la apropiación de tecnologías de manejo y muestreo de ácaros fitófagos y depredadores del papayo con el modelo de transferencia de tecnología "Grupos de Crecimiento Productivo Simultáneo (GCPS)". Se realizó un diagnóstico preliminar y se evaluó la transferencia de tecnología lograda posterior a siete reuniones entre marzo y julio de 2010 con seis productores presentes de forma continua y 19 productores de forma irregular, del municipio de Cotaxtla y pertenecientes al Sistema Producto Papaya de Veracruz, México. Se evaluó participación, actitud y eficiencia de la capacitación mediante encuesta. El 42 % de productores consideró la enfermedad del virus de la mancha anular del papayo como el principal problema y 48 % asumió a los ácaros como el segundo problema; 96 % utilizó plaguicidas contra ácaros. La participación del grupo de productores base fue 71 %, quienes aceptaron muestrear, registrar datos en la bitácora y usar acaricidas selectivos. El 70 % logró diferenciar los ácaros plaga de los depredadores y 83 % reconoció a los acaricidas selectivos. Consideraron que al muestrear reducen costos de control. El modelo de GCPS les permitió al grupo apropiarse de la tecnología al facilitar el aprendizaje colectivo y mejorar la toma de decisiones.

Palabras clave: Acari, *Carica papaya*, muestreo de ácaros, investigación participativa, VMAP.

INTRODUCTION

Technology transfer (TT) is an element of economic development, where technological innovation finds a form of organized diffusion allowing its use by society (Van Den Berg and Jiggins, 2007). Several TT approaches have been developed in the agricultural sector. Doorman *et al*. (1991) indicate that the lineal or descendent approach was followed by the ascendant approach. In the first one, technology was generated at the experimental station and was transferred by the extension services to growers in the form of technological packages. The ascendant approach initiates the research-extension process with a problem-analysis at farm level. Based on these results, new technologies were generated, both in the experimental station and in the farm, based on a research method incorporating collaboration among researchers and growers. Results were spread to the growers through extensionism.

During 1980's and 1990's innovative concepts for agricultural development raised, derived from emergent production models and rural development. Concepts of sustainable development, sustainable agriculture, gender, appropriate technologies, integrated production systems and participative development of technologies, generated an evolution of agricultural extension in new TT models integrating different concepts (Pérez and Martínez, 2005). In Mexico, Hernández *et al*. (2002) proposed the model "Simultaneous Productive Growth Groups" (SPGG). This model is based on the participative research approach (Priou *et al*., 2004), combined with the social network approach (Muñoz *et al*., 2004) and that of rural innovation process (Salazar and Rosabal, 2007). The SPGG model aim is the promotion of technological innovation to increase agroecosystem productivity, based on grower participation as the controller of the system; it rests on the experience and criterion of growers, taking advantage at the same time of their technical knowledge and practice, and its disposition to share information with other growers (Hernández *et al*., 2002). The SPGG's represent an inclusive model, allowing participation on each productive chain of the different social strata, previously typified and grouped following their interest (Reta *et al*., 2011).

In the state of Veracruz, Mexico, mites are one of the problems affecting papaya production (De los Santos *et al*., 2000). Thus, the objective was to evaluate the appropriation of innovative technology on the control of papaya mite pests based on the SPGG technology transfer model, that includes a diagnosis made with producers and a horizontal training program, helping growers to analyze their agroecosystem.

MATERIALS AND METHODS

This study began with a diagnosis to know grower typology, which is an important requirement on the SPGG model; it was made with a survey. Additionally, it was determined the importance of mites as papaya pests and allowed to know the control method used. Based on this, a TT plan for technology innovation was elaborated, including a training program, which was executed and evaluated. Technology transfer was proposed by Abato *et al*. (2010) and Abato (2011). One of the bases of the SPGG model considers homogeneous groups of growers to facilitate the grower-to-grower technology diffusion process.

Diagnosis

To adequate the TT process to the needs of the selected population, a diagnosis was made in November 2007, directed to growers grouped in the State Council of Papaya Growers in Veracruz, A. C. (CEPP), where leading papaya producers collide in the Papaya Produce System of Veracruz.

A structured questionnaire with 13 questions was directed to identify the importance of mites as papaya pests, to know products applied for mite control and to reveal who provides them advice on sprayed products, among other data. Questionnaire included the petition for a visit to an orchard and to sample papaya leaves to determine in laboratory the species of mites present.

Technology transfer plan

Technologies included in the TT plan were those recommended by Abato (2011). Participating growers belonged to the organization "Productora y Comercializadora de Papaya de Cotaxtla, S. D. P. R. de R. L.," (PCPC) from the community Loma de los Hoyos, municipality of Cotaxtla, state of Veracruz, Mexico. This group participates in the State Council of Papaya Growers, and in the Papaya Produce System of Veracruz, presided by the federal government. With these growers, a trans disciplinary group was formed including researchers, students and technicians of the Colegio de Postgraduados, Campus Veracruz participating as facilitators in the training process.

The SPGG TT model was implemented (Hernández *et al*., 2002). The TT plan was based on the technology needs of this group of growers. The training program included classroom talks and field practices on mite pest management strategies. As a way to make a strategic alliance, in the first meeting with the PCPC group members, the training program was provided and interested growers signed an agreement to collaborate as a SPGG.

Training program. Training included informative talks in an improvised classroom, hands-on training in the field, group analysis and evaluation. Each participant received a technical pocket-size brochure entitled "¡Ácaros que controlan plagas!" ("Pest controlling mites"), that included a 4 X magnifier lens (10 X optional) for their use in the field, as well as photographs of mites present in Veracruz, with a brief description for field diagnosis (Figure 1).

Figure 1. Technical pocket-size brochure "¡Ácaros que controlan plagas!" ("Pest controlling mites!"), a) Cover page, and b) Photograph showing the brochure in a pocket and the embodied 4 X magnifier lens, meant for mite recognition in the field.

A log book was used in the field to keep a record of grower's plot information and mite management practices, emphasizing mite sampling, including the action threshold or decision criteria for the most adequate moment to take a control action.

Knowledge evaluation. Previous grower's knowledge on predatory mites and selective acaricides was evaluated with a questionnaire. At the end of the transfer process, the same questionnaire was applied again to corroborate whether a change in knowledge occurred.

SPGG operation. Seven meetings were carried out from March to July 2010. The working group included six growers who attended continuously and 19 on irregular basis, as well as researchers, technicians and students from the Colegio de Postgraduados, Campus Veracruz. Informative talks were set in an improvised classroom near their own orchards. Topics considered were: phytophagous and predatory mites present in your agroecosystem, and selective acaricides as an alternative to the use of products toxic to the environment and wildlife. Information was reinforced with the technical pocket-size brochure generated by Abato *et al*. (2010).

Field training and discussion group. Several members of the SPGG volunteered an orchard for a visit, considering plant age and management system; at the same time, training subgroups were composed. Three orchards were visited in different occasions, where all SPGG members participated. In the first orchard the sampling method was demonstrated; subsequently, growers repeated this activity supervised by facilitators. Before sampling was made, a log book with all mite control formats was filled out and a discussion was conducted in relation to the sampling results obtained and the effectiveness of the control measure used.

The "systematic sampling" consisted in selecting 20 plants ha^{-1} in a diagonal line. The number of plants on the diagonal was counted to select the interval of plants to skip before a new plant was sampled. Pest mites and their predators were visually inspected and counted. It was recommended to leave five plants at the border before inspecting the first plant in the diagonal. After that, leaves from the upper part of the plant -the growing tip- and the middle of the crown were examined, with the aid of a 4 X "low-cost" magnifier lens (optionally a 10 X lens was used). Phytophagous and predatory mites per leaf were counted and recorded in the appropriate table in the log book. Means per leaf and means per plant of pests and predators were calculated. This information was presented in the field with the aid of a flip-chart. At the end of the session, issues learned were analyzed by the discussion group. Each grower committed to do the sampling in their own papaya orchard to share his results in the next meeting. Thus, the group would be able to analyze all results making observations about the sampling method.

Analysis made by the group. Sampling data by orchard (mean pest and predatory mites) and mite control performed (last application date of any acaricides and the name of the active ingredient), were recorded to carry out the analysis by the group. Grower's opinions on actual mite management method were encouraged, also on the possible action of actual pesticides on predatory mites, and on how to improve pest mite management. With all that, discussion was promoted up to the point where a unified recommendation for the owner of the orchard was reached.

The decision criteria annotated in the log book was the following: Do not spray acaricides if you find pest mites in low quantities (< 5 red mites per leaf), especially if you also find predatory mites and the minute black lady beetle *Stethorus punctillum* (Weise) is present (Agnello *et al.*, 2003). During field practices, advantages of using selective pesticides were reinforced, versus non-selective pesticides commonly used by growers, which damage biological control organisms.

As part of the analysis by the group, on each session the facilitator asked for a group and individual evaluation of the sampling process, and what improvements could be implemented on the sampling method. A flip-chart was used to visualize results and to write comments on the discussion by the group. At the end of the TT plan, a closing meeting was conducted to analyze issues learned by growers during the process.

Technology transfer plan evaluation

The TT efficacy was evaluated based on grower's assistance to the meetings. To know the grower's degree of acceptance of the TT process, a survey with Likert-type scale responses (Hernández *et al*., 2008) was used at the end of the training program. Several questions or statements with their categorical response were graded by the participants using a 1 to 5 scale: strongly agree (5), agree (4), indifferent (3), disagree (2), strongly disagree (1). The TT plan acceptance was obtained calculating whether the group had a positive (> 3) or negative (< 3) attitude (Hernández-Castro *et al*., 2008), using the following expression:

$$Attitude = \frac{\sum(Total\ points\ from\ all\ surveyed\ growers)}{(Number\ of\ responses\ in\ agreement\ in\ the\ survey)(Number\ of\ surveys)}$$

During the TT process, a record of observations and recommendations on the sampling method made by growers was kept. Data were analyzed with descriptive statistics.

RESULTS AND DISCUSSION

Diagnosis

In the diagnosis to the members of the State Council of Papaya Growers made in November 2007, the following information was found: out of 28 growers interviewed, 42 % belonged to the municipality of Cotaxtla, 18 % to Actopan and 7 % to Medellín de Bravo, Tierra Blanca and Jamapa. Also, single growers of the following municipalities were interviewed: Camarón de Tejeda, Manlio F. Altamirano, Puente Nacional, Soledad de Doblado and Tlalixcoyan, all from the Central region of Veracruz. Being majority of growers from the municipality of Cotaxtla, the decision was to do the first phase of the TT in Cotaxtla. Official statistics from the Agriculture and Cattle Información System (SIAP, 2010) indicated that Tlalixcoyan, Isla and Cotaxtla were municipalities with the highest papaya planting surface, being Cotaxtla the municipality with more irrigated area, and good mean yields reaching 70 ton ha^{-1}.

Grower typology. Cultivated papaya surface by grower was 2.0 to 10.0 ha. Actopan growers produced papaya in 2.0, 3.0 and 6.0 ha, those from Cotaxtla in 2.0 to 7.0 ha, Camarón in 5.0 ha, Manlio F. Altamirano in 8 h,; Medellín in 2.0 ha, Puente Nacional in 2.0 ha, those from Tierra Blanca in 2.0 to 10.0 ha and from Tlalixcoyan in 6.0 ha. This group of growers planted at least 2.0 ha each. They indicated that papaya crop under dripping irrigation requires an investment greater than MX$100,000.00 ha^{-1}; with a minimum surface of 2.0 ha, allowing a secure monetary return and a net benefit of MX$0.50 for each peso invested, as it was indicated by the Guiding Plan of the Papaya Produce System, elaborated in 2004. In accordance to the size of cultivated area, the technology used, their organization and the economic dynamism, this group of growers could be considered as transitional, with some of them reaching the agricultural business level (Villanueva-Jiménez *et al.*, 2007; Hernández-Castro *et al.*, 2008).

Production system. Ninety six percent of growers used irrigation on their orchards; only one grower mentioned having both rain fed and irrigated agriculture. Irrigation systems used were based on dripping tubing, and surface irrigation.

Maradol variety of papaya is used by 79 % of respondents, with some Maradol subtypes indicated in Table 1. This variety presents high yields, with 40 to 120 ton ha^{-1} indicated as the maximum and minimum yields. According to a grower, Caleña hybrid is able to produce 180 ton ha^{-1} in 18 months. Lenia variety emerged from the genetic improvement of several Maradol types commercialized in Mexico; its genetic potential exceeds 150 ton ha^{-1}. Using high technology growers indicate a potential of more than 200 ton ha^{-1}.

Table 1. Subtypes of papaya variety Maradol, utilized by growers of the Central area of Veracruz, Mexico.

Varieties	Growers using varieties (%)
Maradol (no subtype mentioned)	43.0
Maradol Carisem	29.0
Caleña hybrid	3.5
Lenia variety	3.5
Did not respond	21.0

Main problems associated to papaya. Growers considered mites as the second most important problem of the crop (Table 2). Also, other problems rose, such as lack of funding, leafhopper damage and intoxication by herbicides. Ninety six percent of interviewed growers had mite problems in their last crop. Symptoms for mite damage recognition were leaf yellowing and deformations, drying of foliage, spotted growing tips and translucent leaves. Only a few growers suggested that mite damage is observed on leaves. These data was in accordance to those reported by Reséndiz and Fausto-Moya (2010), and De los Santos *et al.* (2000). Growers mentioned the presence of the white mite ("ácaro blanco") (61 %, probably *Eotetranychus lewisi*) and red mites (46 %, probably one of the tetranychid species located in Veracruz: *Eutetranychus banksi*, *Tetranychus merganser* or *Tetranychus urticae* by Abato-Zárate *et al.*, 2010).

Table 2. Problems present during papaya crop development in the Central area of Veracruz, Mexico.

Problems	Grower's opinion (%)
Viruses	46.4
Mites	32.1
Anthracnose	7.1
Intoxication by herbicides	3.6
Not responding	10.7

Concerning the control method, 96 % of respondents indicated the use of pesticides (Table 3). At least 21 % of growers employed dicofol (AK®20), an organochlorine acaricide acting on nymphs and adults, with a long residual effect (Lagunes-Tejeda and Villanueva-Jiménez, 1994). Some growers were able to indicate the applied dose (Table 4). Only 18.0 % papaya producers were able to qualify pesticide efficacy as good, 3.6 % considered it from regular to good, 61.0 % considered it regular, 14.0 % bad and 3.6 % did not respond. Besides being the most used control method, growers were not very satisfied with results delivered. This could be due to resistance caused by the repetitive use of a single product (Cerna *et al*., 2009). Besides, application of high doses might decrease the molecule's useful life in the area. Thus, an opportunity to transfer alternative control technologies was detected.

Table 3. Acaricides used on mite control by papaya growers in the Central area of Veracruz, Mexico.

Acaricides	Growers using pesticides (%)
Abamectin	21.0
Dicofol	11.0
Dicofol + abamectin	7.0
Azufre	3.6
Azufre + dicofol + abamectin	3.6
Azufre + other acaricides	3.6
Abamectin + mineral oil	3.6
Neem + bio-shampoo	3.6
No product specified	39.0
No answer provided	3.6

Information source. Fifty seven percent of growers were able to identify the source of information on spraying pesticide dose; 43 % received this information from advisers; one grower identified their own partner growers as the source of information, another identified institutions, one performed tests by himself as the way to obtain information, one more did it through training courses, and another one revised literature. However, 43 % did not provide any opinion. More than 50 % of growers were available to disseminate the information, take training courses, experiment or look for information. For all these characteristics and according to Aguilar *et al.* (2005), this group hosts innovative persons. Of all interviewed, 75 % would like to receive more information about mite management and would allow a visit to their orchards by the technical team. All this made possible to continue the development of the TT process.

Table 4. Acaricides applied in papaya mite control by growers of the Central area of Veracruz, Mexico.

Acaricides	Active ingredient	How to apply it	Dose ha^{-1}
Agrimek® or Abaco®	abamectin	A single product	150 to 250 mL in 200 L of water
Kumulus DF® or sulphur	sulphur 80 %	Combined with AK® 20, Agrimek® or Abaco®	Not mentioned
AK® 20 or Kelthane®	dicofol	A single product	250 to 1000 mL in 250 L
Neem combined with Bio-shampoo	azadirachtin	Combined	Not mentioned
Agrimek® + Safe-T-Side®	abamectin + mineral oil	Combined	Not mentioned

Results of the TT process

The Simultaneous Production Growth Group is described.

Characterization of the SPGG. The "Cotaxtla" SPGG was constituted by the six most persistent growers attending weekend meetings, who were able to establish a compromise. All were males averaging 41.5 years of age, 67 % between 40 and 50 years old; 50 % had primary, 17 % secondary, 17 % technical and 17 % professional education. Experience as papaya growers varied from 5 up to 30 years. This is a middle age group of males with a basic to intermediate education and a good experience as papaya growers.

Mite sampling results in orchards. Data obtained by the sampling team is presented in Table 5. Conclusions are also presented as part of the analysis made by the group. Three growers' orchards were inspected; in addition, one grower inspected his orchard by himself. Sampling data from all four growers were analyzed collectively.

Papaya orchard of Grower 1 was inspected by the SPGG, who indicated the acaricides applied provided adequate mite control; even when pesticide residual activity was beyond 8 days, predatory mites were found. Owner received the suggestion of no spraying during that week, and to keep sampling the following week.

The group indicated that sampling provides several benefits: costs are reduced by avoiding unnecessary pesticide sprays; contamination can be avoided; it helps know orchard biological diversity (meaning, native predatory mites); sampling allows the evaluation of any pesticide on pests and beneficial fauna, and helps find pest mite populations in low densities. Also, these benefits support planning and pesticide use of less toxic products, and selective acaricide rotation. The group liked the sampling method and considered important to practice it in their orchard during crop cultivation.

After the second sampling at the orchard of Grower 1, the SPGG thought about the absence of minute black lady beetles feeding on mites. Growers mentioned that pesticides used might control mites as well as fungus depending on the case; however, they did not know the effect on biological control organisms, in this case predatory mites and minute black lady beetles. Growers took the risk of establishing an orchard, even not knowing some aspects of pest control. On the other hand, participants agreed on disseminating their knowledge to absent growers. Recommendation given to Grower 1 was not doing any control action, but sampling the following week.

Papaya orchard of Grower 2 was eight months old, cultivated in 3.5 ha. Orchard's visual soundness was classified as regular. The acaricide Talstar® was sprayed 20 days before sampling. Sampling data are shown in Table 5. The SPGG recommended including fruit inspection in the log book and the use of a magnifier lens 10 X or more to have a better look of mites. Another recommendation was to sample all fruits from 20 plants and to annotate the number of fruits with more than five mites, to decide the convenience of spraying any acaricide. It was pointed out the appropriate characteristics of a selective acaricide to diminish mite damage on fruits. When the action threshold was reached, it was recommended the use of a selective acaricide specifically on the damaged areas (patch spraying).

In the orchard of Grower 3, 7 months old papaya was growing in 1 ha. Sampling data obtained by the group are presented in Table 5. The SPGG concluded that in relation to mites, orchard soundness of Grower 3 was good. Acaricide applied three months before sampling was Agrimek®. Based on mean mites per leaf, they considered unnecessary to spray any product; they also concluded that avoiding applications reduce expenses. Growers are not very sure about the use of patch spraying, arguing that during a windy season mites are dispersed when they patch spray. They mentioned that during a crop labor, machinery also spread mites. Working as a group, the SPGG indicated their motivation to establish a demonstrative plot to corroborate selective pesticide efficacy and patch spraying through participative research.

With respect to the 6 ha orchard of Grower 4, visual soundness was estimated as good. Before the first sampling, 250 mL ha^{-1} of Avolan® were sprayed, and data are shown in Table 6. The SPGG indicated that tall plants are difficult to sample on the upper part. However, by using a spear they might solve this problem. The group recommended not doing any action until mean mites per leaf are more than five. It was emphasized sampling timing, and also the opportunity to choose an active ingredient to prevent pesticide resistance. It was stressed always to sample before spraying any product.

Table 5. Mean mites per leaf, sampled by sampling teams in orchards of three growers with different mite management in papaya, in Cotaxtla, Ver. Mexico.

Team	Strata	Pest mites	Predatory mites	Minute black lady beetle
		Orchard of Grower 1		
		First sampling		
1	Upper	0.00	0.25	0.00
	Medium	0.00	0.05	0.05
2	Upper	0.00	0.00	0.00
	Medium	0.00	0.15	0.20
		Second sampling		
1	Upper	0.00	0.10	0.00
	Medium	0.00	0.20	0.00
2	Upper	0.00	0.00	0.00
	Medium	0.05	0.05	0.00
		Orchard of Grower 2		
		Single sampling		
1	Upper	0.00	0.00	0.00
	Medium	0.10	0.00	0.00
2	Upper	0.00	0.05	0.00
	Medium	0.00	0.00	0.00
		Orchard of Grower 3		
		Single sampling		
1	Upper	0.25	0.50	0.00
	Medium	0.25	0.50	0.00

Table 6. Mean number of mites per leaf obtained from individual sampling in the papaya orchard of Grower 4, in Cotaxtla, Ver. Mexico.

	Strata	Pest mites	Predatory mites	Black lady beetle
		Orchard Grower 4		
		First sampling		
Individual sampling	Upper†	-	-	-
	Medium	0.00	0.00	0.00
		Second sampling		
Individual sampling	Upper†	-	-	-
	Medium	3.7	0.05	0.0

†Sampling not made because upper part of the plant surpassed grower's height.

Grower 4 sprayed Avolan© after finding 3.7 mites per leaf during the second sampling. He decided to spray because mites are very explosive and they can become a problem difficult to solve in a few days. The SPGG recommended tagging plants where mites are found in an orchard with a mean population lower than the action threshold, so it can be monitored and eventually controlled by patch spraying.

In all sampling dates made in the four orchards, mean number of mites were always below the action threshold, besides being done during one of the hottest months of the year. Except in one case, all orchards were sprayed before sampling, possibly explaining the low numbers obtained. During 1980's growers used very few pesticides, and at the same time plants were healthy. However, now they spray more pesticides and very often mite control is difficult to achieve. Also, they observed that effective products in the control of red mites decrease predatory mite population. Group reflection was on the importance of using selective pesticides to save natural enemies. For a grower, the sampling might avoid environmental pollution caused by unnecessary pesticide sprays, thus "having better air to breathe". This was a direct result of group reflection (Muñoz *et al*., 2004), a basic characteristic of the SPGG. Growers considered timing on mite detection might help using less toxic products. They considered sampling as a "big thing", and pointed out the importance of the log book to avoid relying on memory for saving orchard information. As an emerging doubt, growers need to know how different pesticides affect predatory mites in the crop.

By manifesting their approval to spread their knowledge, papaya growers are able to potentiate the TT process, including each one of them. It is expected the formation of a network of growers that transmit and receive key information for technology adoption (Muñoz *et al*., 2004). They also were interested to modify the log book for fruit sampling, due to the capacity of red mites to invade them affecting their quality (Figure 2).

Figure 2. Fruit damage caused by papaya pest mites in "Maradol."

As part of the TT process, members of the "Cotaxtla" SPGG integrated new knowledge, by using the sampling method for pest and predatory mites. That was their basement of their mite management decision making (De Shutter, 2008). Technology transfer is a gradual process that takes years to reach adoption and/or adaptation. However, growers motivation impulse them to agree with the trans disciplinary group the establishment of a demonstrative plot with selective acaricides, trying to minimize research costs and sharing risks with the SPGG. Training is the beginning of the TT process, oriented to promote self-management, meaning a decision making according to their own interests, that self-promote their welfare (De Shutter, 2008).

During the field surveys on the growers' fields they were carrying the technical brochure and were using the magnifier lens on each leaf revision. Also, during field training sessions it was clear that they already managed the information included on it. Barfield (1989) mentioned that it is through the frequent handling of the sampling technique that a grower could increase his/her ability to take better management decisions. Also, he mentioned that pocket-size brochures with identification keys are very useful for growers and sampling technicians, to identify correctly a pest and to better perform other IPM procedures.

Evaluation of the TT process through the SPGG

An innovative technology was generated, which was socialized with the growers; this was later used and evaluated by the members of the SPGG.

Attendance. Participation of the six more recurrent growers was 71 %, being considered as good.

Knowledge evaluation. In relation to the TT process efficacy, 70 % of the group recognized the crop associated acarofauna in the field; 100 % learned the sampling method and accepted the importance of predatory mites; finally, 83 % recognized that selective acaricides are less harmful on beneficial fauna.

Grower's acceptance of the TT program. Grower's attitude towards the TT process was graded 4.6 (based on a Likert scale 1 to 5). They liked the program and strongly agreed on using the sampling method, registering their data in the log book and utilizing selective acaricides.

As contributions to the sampling method, papaya growers observed that upper plant sampling was difficult with tall plants, and decided to solve it using a spear to take down an upper leaf. They proposed a destructive sampling, considering that eliminating a leaf was not very problematic. They mentioned that the use of a potent magnifier lens is important. Sampling of papaya ring spot virus is also made by growers on a daily basis, once the orchard is established; thus, they decided to sample for both problems at the same time. If a plant is infested with the virus it must be eliminated and it might not be revised for mites. They also considered important to add information on fruit sampling on the log book, where the consensus was to sample all fruits of 20 plants and annotate the number of fruits having more than five mites on the recording table.

The SPGG model promotes the constitution of working groups that provide training to growers to develop their activities with an appropriate agroecosystem management and making an integral use of resources, seeking for sustainability of productive systems, and promoting respect for the environment (Hernández *et al*., 2002).

CONCLUSION

Papaya growers learned new technologies in a grower-to-grower technology transfer model, with the aid of an interdisciplinary team. Most participants recognized in the field the types of acarofauna associated to the crop; all learned the sampling method and recognized the importance of predatory mites; the majority accepted that selective acaricides are less harmful to beneficial fauna. Growers used the sampling method and agreed to continue its use, to annotate their data in the log book and to use selective acaricides to improve pest mite management on their orchards. The SPGG model allowed to construct collective knowledge and to move the working team to improve their decision making. Growers were able to determine the appropriate moment for pest mite control based on the sampling method and were motivated on the use of selective acaricides.

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REFERENCES

Abato, Z. M. 2011. Manejo integrado de la acarofauna del papayo y su transferencia en el estado de Veracruz. Tesis doctoral. Postgrado en Agroecosistemas Tropicales. Colegio de Postgraduados, Campus Veracruz. Mpio. Manlio F. Altamirano, Veracruz, Mexico.

Abato, Z. M., Villanueva-Jiménez, J. A., Otero-Colina, G., Reta Mendiola, J. L., Ávila R., C., Hernández-Castro, E. 2010. ¡Ácaros que controlan plagas! Folleto Técnico Núm. 3. Serie Protección de Agroecosistemas. Colegio de Postgraduados, Campus Veracruz. Mpio. Manlio F. Altamirano, Veracruz, Mexico.

Abato-Zárate, M., Otero-Colina, G., Villanueva-Jiménez, J. A., Hernández-Castro, E., Reyes-Pérez, N. 2010. Acarofauna asociada al cultivo de papayo en el Estado de Veracruz. Memoria del XXXIII Congreso Nacional de Control Biológico. Uruapan, Mexico. pp. 438-441.

Agnello, A. M., Harvey, R. W., Kovach, J., Nyrop, J. P. 2003. Integrated apple pest management in New York State using predatory mites and selective pesticides. Agriculture, Ecosystems and Enviroment. 94: 183-195.

Aguilar, A. J., Santoyo, C. V. H., Solleiro, R. J. L., Altamirano, C. J. R., Baca del Moral, J. 2005. Transferencia e innovación tecnológica en la Agricultura. Fundación Produce Michoacán-Universidad Autónoma Chapingo. Texcoco, Mexico. pp. 19-41.

Barfield, S. C. 1989. El muestreo en el manejo integrado de plagas. In: Andrews, K. L., Quezada, J. R. (eds.). Manejo Integrado de Plagas Insectiles en la Agricultura. Escuela Agrícola Panamericana. El Zamorano, Honduras. pp. 145-162.

Cerna, E., Ochoa, Y., Aguirre, L., Badii, M., Gallegos, G., Landeros, J. 2009. Niveles de resistencia en poblaciones de *Tetranychus urticae* en el cultivo de la fresa. Revista Colombiana de Entomología. 35(1): 52-56.

De los Santos, De la R. F., Becerra, L. E. N., Mosqueda, V. R., Vásquez, H. A., Vargas, G. A. B. 2000. Manual de Producción de Papaya en el Estado de Veracruz. INIFAP-SAGAR-Fundación Produce Veracruz. Centro de Investigaciones Agrícolas del Golfo Centro. Campo Experimental Cotaxtla. Folleto Técnico Núm. 17. Veracruz, Mexico.

De Shutter, A. I. 2008. Extensión y Capacitación Rurales. Ed. Trillas. Mexico.

Doorman, F., Miranda, R. F., de Nie, C., Ooijens, J., Ovares, L. R., Ramírez, A. C., Sáenz, C. C., Sancho, B. E. 1991. La Metodología del Diagnóstico en el Enfoque "Investigación Adaptativa". IICA, UNA, RUU. San Jose, Costa Rica. pp. 3-12.

Hernández, M. M., Reta, M. J. L., Gallardo, L. F., Nava, T. M. E. 2002. Tipología de productores de mojarra tilapia (*Oreochromis* spp.): base para la formación de grupos de crecimiento productivo simultáneo (GCPS) en el estado de Veracruz, México. Tropical and Subtropical Agroecosystems. 1: 13-19.

Hernández, S. R., Fernández-Collado, C., Baptista, L. P. 2008. Metodología de la Investigación. 4a Ed. McGraw-Hill Interamericana. Mexico.

Hernández-Castro, E., Martínez-Dávila., J. P., Gallardo-López, F., Villanueva-Jiménez, J. A. 2008. Aceptación de una nueva tecnología por productores ejidales para el manejo integrado del cultivo del papayo. Tropical and Subtropical Agroecosystems. 8: 279-288.

Lagunes-Tejeda, A., Villanueva-Jiménez, J. A. 1994. Toxicología y Manejo de Insecticidas. Colegio de Postgraduados en Ciencias Agrícolas. Mexico.

Muñoz, M., Rendón, R., Aguilar, J., García, J. G., Reyes, A. J. 2004. Redes de Innovación. Fundación Produce Michoacana A.C.-Universidad Autónoma Chapingo. Mexico. pp. xvii-xxiv, 11-21.

Pérez, E. E., Martínez, M. A. 2005. Enfoques de Extensión Rural Participativos y su Contribución al Desarrollo Rural Sostenible y a la Seguridad Alimentaria. Tegucigalpa, Honduras.

Priou, S., Barea, O., Equise, H., Aley, P. 2004. Capacitación e Investigación Participativa para el Manejo Integrado de la Marchitez Bacteriana de la Papa. Experiencias en Perú y Bolivia. Centro Internacional de la Papa. Lima, Peru.

Reséndiz, G. B., Fausto-Moya, T. J. 2010. Identificación de los ácaros asociados al papayo (*Carica papaya* L.). In: Sánchez G., M. C., Sandoval I., J. S., Estrada V., E. G. (eds.). Memorias del Primer Simposio Internacional de Acarología. Universidad Autónoma Chapingo. Mexico. 2-6 de agosto, 2010. pp. 25-31.

Reta, M. J. L., Mena, G. J. M., Asiain, H. A., Suárez, S. C. A. 2011. Manual de Procesos de Innovación Rural (PIR) en la Acuacultura. Una Estrategia de Transferencia de Tecnología a Través de Grupos de Crecimiento Productivo Simultáneo (GCPS) en el Estado de Morelos. Colegio de Postgraduados, México.

Salazar, L. L., Rosabal, N. Y. (eds.). 2007. Procesos de Innovación Rural. Una Mirada al Desarrollo Rural desde la Reflexión y Experiencia de América Latina. ICRA, FUNDACITE LARA, INIA. Venezuela.

SIAP. 2010. Servicio de Información Agroalimentaria y Pesquera. SIAP-SAGARPA. http://www.siap.gob.mx/ (Consulted: 6/12/2010).

Van Den Berg, H., Jiggins, J. 2007. Investing in farmers: The impact of farmers field schools in relation to integrated pest management. World Development. 35(4): 663-686.

Villanueva-Jiménez, J. A., Hernández-Castro, E., Ávila, C., Osorio-Acosta, F., Téliz-Ortiz, D., Mora-Aguilera, A., García-Pérez, E. 2007. Estado del arte de la investigación y la transferencia de tecnología en papayo (First of 2 parts). Agroentorno. 87: 19-22.

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