TECHNOLOGY TRANSFER NETWORKS ON PAPAYA PRODUCTION WITH TRANSITIONAL GROWERS

[REDES DE TRANSFERENCIA DE TECNOLOGÍA EN LA PRODUCCIÓN DE PAPAYO CON PRODUCTORES EN TRANSICIÓN]

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SUMMARY

Social networks analysis applied to rural innovation processes becomes a very useful technology transfer tool, since it helps to understand the complexity of social relationships among people and/or institutions in their environment, and it also defines those innovation networks given in specific working groups or regions. This study was conducted from April to May 2011 to determine those networks and key players present in the group of growers associated as "Productora y Comercializadora de Papaya de Cotaxtla S.P.R. de R.L.", that influence the technology transfer process in Cotaxtla, Veracruz, Mexico. Data were analyzed using UCINET 6 software. Three centrality measures were obtained: range, degree of mediation and closeness. Of 32 network players, 27 actively diffuse innovations according to their interests; alliances must be established with them to transfer technology. Four growers stand out as central actors, which along with the Instituto Nacional de Investigaciones Forestales Agricolas y Pecuarias, the Colegio de Postgraduados and the growers' organization itself, could be the most appropriate actors to establish a technology transfer program to accelerate the diffusion and adoption of innovations. Wholesalers, middlemen and credit institutions do not participate in this process, but having capital they could be incorporated in the innovation diffusion process.

Key words: *Carica papaya*; central actors; technological innovation; tacit knowledge; social networks; knowledge diffusion.

RESUMEN

El análisis de redes sociales aplicado a procesos de innovación rural es una herramienta útil para la transferencia de tecnología, pues ayuda entender la complejidad de las relaciones sociales entre personas y/o instituciones en su entorno y definen las redes de innovación dadas en grupos de trabajo y/o regiones. Este estudio se realizó de abril a mayo del 2011 para determinar las redes y actores centrales en la asociación "Productora y Comercializadora de Papaya de Cotaxtla S.P.R. de R.L.", que influyen en el proceso de transferencia de tecnología realizado en Cotaxtla, Veracruz, México. La información se analizó mediante el programa UCINET 6. Se determinaron tres medidas de centralidad: rango, grado de intermediación y cercanía. De 32 participantes en la red, 27 difunden activamente las innovaciones de acuerdo a su interés, con quienes se deben hacer alianzas para transferir tecnología. Cuatro productores resaltan como actores centrales, quienes junto con el Instituto Nacional de Investigaciones Forestales Agrícolas y Pecuarias, el Colegio de Postgraduados y la propia organización de productores, serían los apropiados para establecer una programa de transferencia de tecnología para acelerar la difusión y adopción de innovaciones. Los comercializadores mayoristas, intermediarios e instituciones de crédito no participan en este proceso, pero al disponer de capital se podrían incluir en el proceso de difusión de innovaciones.

Palabras clave: *Carica papaya*; actores centrales; innovación tecnológica; conocimiento tácito; redes sociales; difusión del conocimiento.

INTRODUCTION

Nowadays, a great amount of scientific knowledge is available, even for the rural Mexican society. However, most of this information is out of growers' reach because it is published in scientific journals with limited distribution and written in very technical terminology, not easily understandable by the average rural resident (Reta *et al*., 2011). Agricultural technology transfer (ATT) is a vital element that carries new knowledge to growers.

Up to the end of 1990s, ATT in Mexico had been performed in a descendent, lineal and unidirectional way, based on technological packages and under governmental control (Muñoz and Santoyo, 2010a); however, this had limited results in terms of field implementation (Mata, 1997). Innovation is a fundamental condition to reach sustainable economic growth, allowing the reduction of national social disparities and promoting the sustainable use of natural resources (Aguilar *et al*., 2010). This brings us to a bigger problem.

During the period 1990-2010 (Muñoz and Santoyo, 2010a), Mexican public policy for rural innovation created several extension programs proposing an ascendant paradigm of technology transfer with a greater involvement of producers (Doorman, 1991), supported by the Law of Sustainable Rural Development (SINDER, PESPRO, PRODESCA, PESA and Technical Assistance and Training) (Muñoz and Santoyo, 2010a). However, base participation has not been fully understood by professional service providers (PSP) and by those responsible of several governmental offices, serving only as facilitator to the access of subsidies for agricultural inputs and productive assets (Muñoz and Santoyo, 2010a). Improvements incorporated in the strategy for innovation have been scarce, mainly because ascendant communication mechanisms among producers, extensionists and researchers are not working properly, prevailing the lineal-descendant paradigm of professional technical assistance, according to which "the engineers are those who know" and "they bring all the knowledge to the growers" (Engel, 2004; Aguilar *et al.*, 2005).

Several ATT models presented by social researchers are ascendant in nature, but not all include planning, participative action and reflection in the proposed methodology (Reta *et al*., 2011). To increase efficiency in the innovation processes, such models require participative research with the rural society to know the social structure complexity and the characteristics of social relationships in a specific agricultural area (Clark, 2006; Núñez, 2008). In those cases, the social network analysis (SNA) is a participative research tool that can be incorporated in ascendant models. Recently, the "Simultaneous Production Growing Groups" (SPGG) technology transfer model has been proposed; it considers participative action-research, previous grower experience, and SNA for planning, as well as group-reflection and action in the diffusion of technological innovations; SPGGs move forward to build significant knowledge that guarantees appropriation and use of the innovation by the participant grower (Abato, 2011; Reta *et al*., 2011), and improves the way to innovate through collective knowledge and group decision making (Abato-Zarate *et al*., 2011). Thus, the ascendant SPGG technology transfer model emerges as an alternative to those models implemented in the past, linked to the agricultural product-systems organizations promoted by the Mexican government (Abato, 2011; Reta *et al*., 2011).

Social networks present among growers in a specific area may be understood through the SNA (Aguilar *et al*., 2010). The SNA is an ensemble of formal tools for social research that help to determine central actors, that is, growers and/or agents of change that treasure knowledge as a powerful tool, allowing them to enjoy more dominance and influence over all other actors (Muñoz *et al*., 2004; Navarro and Salazar, 2007). The SNA facilitates establishing and guarantees success of any ATT project, allowing to know which actors of the productive process must establish alliances because of their good acceptance by others in their sector (Clark, 2006; Núñez, 2008). The objective of this study was to determine the networks and central actors present in the growers association "Productora y Comercializadora de Papaya de Cotaxtla S.P.R. de R.L" in Cotaxtla, Veracruz, Mexico, supporting the integration of working groups for the implementation of a technology transfer program based on SPGGs.

MATERIALS AND METHODS

The study to determine technology transfer networks was carried out from April to May 2011 in the municipality of Cotaxtla, Veracruz, Mexico. The participants were the 23 members of the growers association "Productora y Comercializadora de Papaya de Cotaxtla S.P.R. de R.L." Growers affiliated to this group usually plant papaya in areas from 2 to 7 ha, using drip irrigation and having production costs of MX\$100,000 ha^{-1}; their average age is 41.5 years; 50% of them studied only primary school, 17% secondary (3 years), 17% are certified technicians and 17% obtained a bachelor's degree, most of them with a good experience in the crop (5 to 30 years). Consequently, they can be considered in a mature-productive age, with a basic to intermediate education and a good experience in the crop (Abato, 2011). Considering the size of the area cultivated by them, the technology used, their organization and the cash movement, it is classified as a group of "transitional" growers (Abato-Zárate *et al*., 2011), also called "commercially diversified" growers (Rascón *et al*., 2006), because they have been unable to consolidate their organization to be considered as "entrepreneurial."

For research purposes, a network was defined as a finite ensemble of actors (persons, groups or organizations) that are associated and connected in a specific system and share common objectives, building a sum of relationships among them (Molina, 2005; Clark, 2006; Núñez, 2008). Thus, it was considered that an innovation and technology transfer network (ITTN) for transitional growers in papaya agroecosystems may operate in relation to the following function: ITTN = f (IG, O, IS, TA, SI, CI, WS, MM), where ITTN = innovation and technology transfer network, IG = innovative growers, O = organizations, IS = input sellers, TA = technical assistants, SI = sectorial institutions, CI = credit institutions, WS = wholeselers and MM = middlemen.

To contrast this theoretical function with local reality, a survey was applied to 20 growers belonging to this group, based on a questionnaire of 21 open-relational questions on actors intervening on the ITTN. The survey asked growers about: a) general information of the grower, b) their organization, c) nearby pesticide chemical companies, d) agrochemical reseller houses working in the area, e) their technical assistants, f) sectorial institutions bringing them attention, g) credit institutions visiting them, h) whole sellers working with them, i) middlemen, and j) growers involved. Questions focused on identifying the actors of each ITTN component and which ones share their knowledge to improve papaya production.

UCINET for Windows v.6.289 software (Borgatti *et al*., 2002) was used to establish centrality indicators and central actors present on the existing social networks. To define the ITTN actors, an analysis was performed including all network components but growers. For the "growers" component, an analysis apart from the rest of actors was done, using variables such as "inclination to share knowledge" and "use of the best technology adapted to growers conditions". A centrality measure is understood as a group of algorithms calculated for a network, it allows to know the network structure and position of their nodes. Network centrality indicators measure existent relationships among actors of certain social context, and determine the influence respect to the goods, capital and information belonging to each actor (Molina, 2005; Velázquez and Aguilar, 2005; Clark, 2006). "Central actors" are considered those with greater ability to receive and send all type of information to the rest of the network (Zarazúa-Escobar *et al*., 2011a); to prioritize who might be involved in a project, central actors can help to make that decision (Velázquez and Aguilar, 2005; Clark, 2006). Key and/or central actors are those individuals whose participation is indispensable and required to reach the purpose and goals of the project. They have the power, the ability and the means to decide and influence in vital fields that allow or not the project development, and very often they manifest a direct, explicit and committed interest with the purpose and aims (SEMARNAT, 2011).

In this work, three centrality measurements were determined: nodal degree or range, degree of intermediation and closeness (Molina, 2005; Velázquez and Aguilar, 2005; Clark, 2006). The nodal degree or range is the number of direct ties from an actor or node; it indicates how many other nodes they are directly connected or linked with. The degree of intermediation indicates the appearance frequency of a node in a shorter (or geodesic) section connecting other two, that is, it shows when a person is intermediary between two other persons of the same group that are not familiar to each other (also known as the "bridge person"). The degree of closeness indicates the proximity of a node in relation to the rest of the network and expresses the capacity of that node to provide access for the rest of the actors by means of their direct and indirect relationships with the rest of the nodes; it is calculated taking in consideration all geodesic distances of a node to reach those actors. Due to their structural position, several actors of a network may reach in a faster and easier way a greater amount of actors. Central actors are defined by the greatest nodal degree, greatest closeness and greatest intermediation, in relation to the propensity to share knowledge and use of the best technology judged by growers themselves, making them the most outstanding growers.

The ITTN actors are identified in Figure 3 with the following keys: AS = Agroquímicos Susunaga (agrochemicals company, agchm), FR = Financiera Rural (bank), SA = Servicio Agrotécnico (agchm), FYPA = Fertilizantes y Productos Agropecuarios (agchm), CEPP = Consejo Estatal de Productores de Papaya (State Papaya Growers Council), ST = Secretaría del Trabajo (Work Ministry), PCPC = Productores y Comercializadores de Papaya de Cotaxtla (papaya growers local organization), CP = Colegio de Postgraduados (research institution), BTO = Biotecnología Orgánica (agchm), SE = Secretaría de Economía (Economy Ministry), ASLP = Agroquímicos y Semillas Los Parra (agchm), DASUR = Distribuidora Agrícola del Sureste (agchm), AML = Agroquímicos Mata de Lázaro (agchm), INIFAP = Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias (research institution), SAGARPA = Secretaría de Agricultura, Ganadería, Pesca y Alimentación (Agricultural Ministry), SERAVER = Servicios Agrícolas de Veracruz (agchm), CICY = Centro de Investigaciones Científicas de Yucatán (research institution), AGSB = Agropecuaria Santa Buena Ventura (agchm).

RESULTS AND DISCUSSION

The ITTN among papaya growers of Cotaxtla is shown in Figure 1. The greatest nodal degree was for G. Basurto R. (50%), followed by A. Parra V. and R. Basurto H., both with 36% (Table 1); they showed the greatest number of relationships or links with growers of their organization. These growers share their tacit knowledge with the majoritie of group mates and are open to receive information. It is also shown that a limited number of actors agglutinate in several sub-networks, acting as a powerfull catalizer, generating a high degree of adoption and an elevated propention to establish contacts with the majoritie of actors to share knowledge and for the early and fast adoption of innovations (Muñoz and Santoyo, 2010b). Sub-networks have a central actor (node), who is of great utility to initiate technology innovation processes acting as catalyzers. The three greater nodal degree central actors could work adequately in any technology transfer project, being recognized by their peers in the growers association (Clark, 2006).

Additionally, Table 1 shows G. Basurto R. with the best nodal degree (central actor), besides being the best bridge person or intermediary between two not very familiar group mates, but closer than the rest of the group, allowing a faster and easier way to reach a greater amount of network actors (Molina, 2005). That situation places him in advantage in relation to A. Parra V., R. Basurto H. and A. Basurto H., which present very low intermediary values (bridge person), indicating a lower effectiveness to communicate or mediate situations. However, the three latter persons present good closeness values compared to all other network members, because they are capable of building sub-networks or affinity groups. The ability of G. Basurto R. to communicate with the network allows him to share tacit knowledge that worked for him, besides having the confidence of most of the growers who are members of the group.

The mean and standard deviation of the knowledge exchange among growers of the group (Table 1) indicates that G. Basurto R. outstands the rest of the group, whereas all other central actors are less reliable, besides having centrality values above the group average.

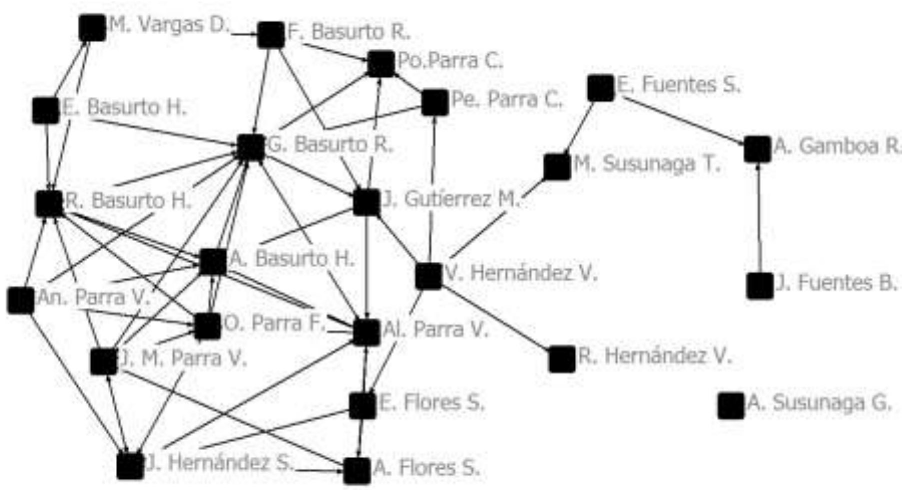

Figure 1. Central actors of the technology transfer network formed by the growers group "Productora y Comercializadora de Papaya de Cotaxtla. S.P.R. de R.L.". 2011.

Table. 1. Extreme centrality measures for actors of the growers group "Productora y Comercializadora de Papaya de Cotaxtla S.P.R. de R.L.", in relation to the variable "knowledge sharing". 2011.

Grower name	Nodal degree	Closeness	Intermediation
Central actors			
G. Basurto R.	50.0	33.8	20.6
A. Parra V.	36.3	32.3	9.0
R. Basurto H.	36.3	29.7	5.6
A. Basurto H.	31.8	31.8	3.0
No central actors			
E. Fuentes S.	9.0	22.2	16.4
R. Hernández V.	4.5	24.7	0.0
A. Susunaga G.	0.0	0.0	0.0
All actors mean (std. dev.)	20.1 (11.9)	28.2 (4.30)	7.5 (9.59)

Innovative growers handling the best technology, indicated by their own organization members, are shown in Figure 2. G. Basurto R., A. Basurto H., A. Parra V. and R. Basurto H. were pointed as those with the highest percentages of nodal relational links (67, 57, 43 and 43%). It was not fortuitous that growers sharing technological innovations and those managing the best technology were the same. This indicates a positive relation between knowledge and avaliability in this network, being probably easy to implement technological innovations with central actors as process facilitators.

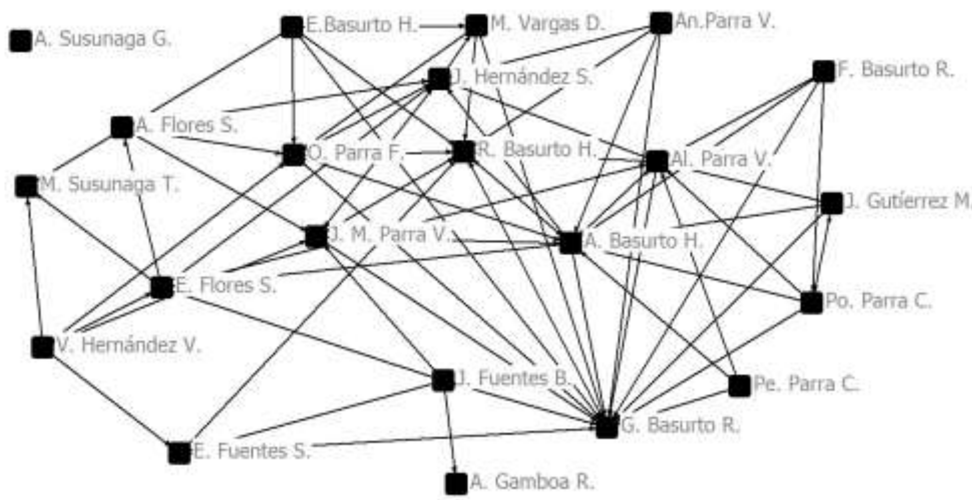

Figure 2. Recognition of growers managing the best technology among members of the network group “Productora y Comercializadora de Papaya de Cotaxta. S.P.R. de R.L.”. 2011.

This result differs from what Zarazúa-Escobar *et al*. (2011a) indicated for a strawberry production system in Zamora, Michoacan, Mexico, where a final buyer and a jobber are those who centralize the information, causing low adoption, making necessary to promote organizative innovations to improve competitiveness. On the contrary, in the guava production system (Zarazúa *et al*., 2011), main actors of the innovation diffusion process are the agrobusinessmen, having an impact on five other actors, whom also have an impact on 12 extra actors.

Núñez (2008) indicates that recruiting first the opinion leaders accelerate the innovation diffusion process On the contrary, early adoption by part of marginal actors yield slow diffusion curves (Clark, 2006; Muñoz and Santoyo, 2010b).

Nodal degree, closeness and intermediary values for central actors in Table 2 are much higher than the mean, which allows trusting them to establish participative research projects due to their level of responsibility conducting their crops.

Sectorial public and private institutions, as well as private consultants providing technical assistance to the group “Productora y Comercializadora de Papaya de Cotaxtla S.P.R. de R.L.” are represented in Figure 3. Thirty two network participants were detected, following the ITTN function. However, only 27 participate in the innovation diffusion. In this institutional context, INIFAP, growers organization itself, CP, and the private consultant Ing. E. Sayago are considered network central actors.

In the municipality of Cotaxtla, the only existing grower organization is the one here indicated; however, another organization (Agroproductores de Cotaxtla S.P.R. de R.L.) was active in recent years, but it was unraveled; also “Grupo Agrícola Martínez” is present in the area, but is a growers group that did not originate in this municipality. The last two organizations did not share their technological knowledge with growers of the area, and thus, they are not considered as part of the technological transfer network for small and middle growers. All growers interviewed indicated that wholesale traders, middlemen and credit institutions do not participate in the ATT, being dedicated specifically to their main activity. Financiera Rural arranges credits with several growers of the group, but does not bring any technical assistance service (Figure 3), and it is the only bank that provides individual credits to papaya growers. This funding may be used to establish alliances to distribute at the same time credits and available technological innovations. Funding has decreased in more than 80% in the last decade and it has focused on large growers, meanwhile “ejidos” and communal growers do not have access to it (Morett and Cosío, 2006). This might be a limiting factor for establishing a general program in the area. Although there are some subsidies, as those from the Direct Country Supporting Program (PROCAMPO), that might be used to promote and induct the adoption of knowledge, it has not accomplished the several collateral objectives that are attributed to it, since it only grants direct subsidies (Zarazúa-Escobar *et al*., 2011b).

Table. 2. Extreme centrality measures for nodes belonging to the group "Productora y Comercializadora de Papaya de Cotaxtla S.P.R. de R.L.", for the variable "growers managing the best technology". 2011.

Grower name	Nodal degree	Closeness	Intermediation
Central actors			
G. Basurto R.	66.6	43.7	24.5
A. Basurto H.	57.1	41.1	10.3
R. Basurto H.	42.8	38.8	4.1
A. Parra V.	42.8	38.8	5.1
No central actors			
J. Gutiérrez M.	19.0	33.8	0.0
P. Parra C.	14.2	33.3	0.0
R. Hernández V.	4.7	27.6	0.0
A. Susunaga G.	0.0	0.0	0.0
All actors mean (std. dev.)	22.27 (15.41)	35.95 (3.40)	3.85 (5.57)

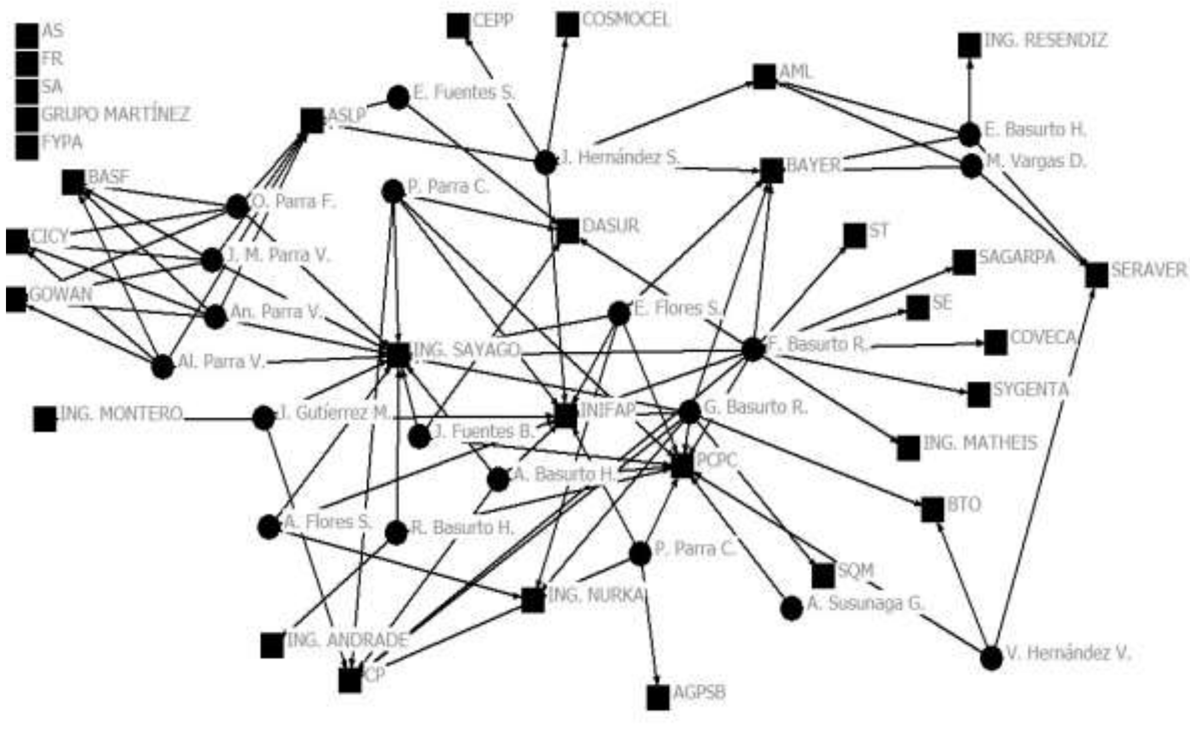

Figure 3. Impact of agricultural agents of change, participating in the technology transfer of the group"Productora y Comercializadora de Papaya de Cotaxtla S.P.R. de R.L.". 2011. Actor codes are indicated in the Materials and Methods section.

The INIFAP and CP are the sectorial institutions participating in the ATT in a signifficant way, both with training programas offered for free. The first one only provides assistance to the group in fertility analysis and vermicompost, meanwhile CP has focused on papaya mite management through participative research, and has proposed a technological transfer model. Ing. E. Sayago emerged as the third central actor in the technology transfer network offering his technical assistance at a monthly cost per grower of MX$500 ha^{-1}, and recommending agrochemicals that he also used to sell. Althoug the general opinion was that his technical assistance enabled yield crop rentability increments, he moved away from the area after not obtainning the expected results with a few associates.

Analysis of network information allowed the detection of central actors indicated in the ITTN function, standing out those that share information with the network and use the best technology, and also two sectorial institutions and an independent technical assistant. The growers G. Basurto R., R. Basurto H., A. Basurto H. and A. Parra V., as well as INIFAP, CP, and their own growers organization might be the catalytic actors in a transdisciplinary and participative research, validation and technology transfer project, improving substantially the quality of papaya production, productivity, profitability and sustainability. This information is of great usefulness to implement a transfer model such as SPGG (Hernández *et al*., 2002), already proposed to this association. In SPGGs central actors might help the group to grow simultaneously. This model requires working with growers having similar problems, and thus taking advantage of their own experience (tacit knowledge), and their availability to share it; the ascendant and transdisciplinary approach of the model allows an adequate participative research, building their own knowledge (Reta *et al.*, 2011). To be successful in participative papaya projects, substantial modifications are required on the way innovations are diffused. Research and finantial institutions, as well as several professional service providers, must change their descendant and linear paradigm (Muñoz and Santoyo, 2010a) for an ascendant approach (Doorman, 1991), taking central actors as protagonists of their everyday work (Abato-Zarate *et al.*, 2011; Reta *et al*., 2011).

CONCLUSION

Innovation and technology transfer network of the group "Productora y Comercializadora de Papaya de Cotaxtla S.P.R. de R.L.", in Veracruz, Mexico, is based on 32 participants, where only 27 diffuse technological innovations actively according to their own interest. Agrochemical sellers are an important number of network participants, and this is a market nich disputed among them, mostly because papaya crop demands inputs in large quantities. Eight sectorial institutions converge in this network, all working independently. They could participate in a technology transfer project through "Simultaneous Production Growing Groups", consolidating at the same time this growers organization. Four growers stand out as central actors, along with INIFAP, CP and their own organization; these might be key actors catalyzing innovations diffusion and adoption in papaya. Financiera Rural, wholesellers and middlemen do not participate in the innovation diffusion process, but they have potential as central actors, having the financial capital required to support improvements on rural innovation processes.

ACKNOWLEDGEMENTS

The authors thank "Productora y Comercializadora de Papaya de Cotaxtla S.P.R. de R.L.", for being active participants in this work. Support was provided by CONACYT, Colegio de Postgraduados Campus Veracruz and the "Fideicomiso Revocable de Administración e Inversión No. 167304 del Centro Público Colegio de Postgraduados". This research was conducted as a part of the Priority Research Line (LPI2) - Sustainable Agroecosystems.

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Submitted March 25, 2012 – Accepted May 14, 2012
Revised received June 15, 2012