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Full Length Research Paper

Agronomic, economic and ecological aspects of the papaya (*Carica papaya*) production in Tabasco, Mexico

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The cultivation of papaya is important in the tropic because it provides source of income to the farmer within a short time. Statistical data were obtained from farmers located in the Chontalpa, Rios and Centro-Sierra regions; the size of the survey was 67 farmers. The study shows the results of the farmers' problem in a drastic reduction of their productivity because of the virosis and low prices in commercialization. The farmers were classified into three levels of technology, "low", "middle" and "high". The first one covers 88% of the farmers in seasonal conditions in contrast with the high technology that concentrates 4.5% in irrigation conditions. According to the technology used, the fertilizer shows more yields. Economically, the high technology had an internal tax return of 0.43 in comparison with the low technology of 0.25, which means that the investment is recovered with different yields. However, the use of high technology makes the system more competitive.

Key words: Production, profitability, technology levels, pollution.

INTRODUCTION

The cultivation of papaya has great potentials and its production in the tropics is due to its increasing demand in the national and international market. In the foreign market, 90% was commercialized as fresh fruit and 10% as processed product (Mandujano, 1993 Cited By INEGI, 1998). However, nowadays there are different limitations of credit, technological and marketing type for most of the farmers. In Tabasco and Veracruz States, 2000 and 6000 hectares (ha) are grown respectively with a media yield of 35.3 tons per hectares (t ha^{-1}). The production with irrigation systems per drop in Tabasco and Veracruz increases the yield to 80 t ha^{-1} (Lopez, 2000).

At a national level, Tabasco is located as the eighth farmer of papaya below Veracruz, Chiapas, Guerrero, Michoacán, Oaxaca, Zacatecas and Nayarit, whose total production is 214,679 tons, (SAGARPA, 2005); Zapote is the mostly cultivated variety (80%) in Tabasco. Report suggests that the high level of humidity in the soil causes negative effects such as rotting of roots, flowers and fruits fall as well as the total loss of the plants and crop (Arrieta, 2001). The papaya has the potentials of keeping its yield using appropriate technology and handling according to the standardization requirements in phyto-sanitary and innocuous matter, in order to enter the international markets and ensure the quality of the product to the consumers (Mirafuentes, 2005).

There are three important sub regions that produce papaya: Chontalpa, Centro-Sierra and Los Rios. The first and second ones involve 88% of farmers that are 199 in total, in an area of 1 - 4 ha having a low level of technology characterized by the seasonal and manual production system (SGARP, 2005). In Los Rios region, there are less farmers with extensions from 10 - 40 ha and a high level of technology, characterized with the irrigation and high mechanization application. The total

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harvested area with regards to season and irrigation in the state during 2000 - 2003 fluctuated between 2128 - 1253 ha with a value of the production ranging from 85 - 126 millions of pesos of about 800 farmers. Later there was production cut down. In 2005, the harvested area was 667 ha with a census of 189 farmers with regards to season and 10 of irrigation types (SAGARPA, 2007). Nowadays, in the Los Rios region (Tenosique-Balancan), there is more production of papaya in the State, due to the reduction of the production in the zone of La Chontalpa, which is as a result of the problem of the ring spot virus called virosis. The new model of agricultural production undoubtedly will be restricted to inversion rules; the increase of the production via increase of the productivity means the use of new machinery and high-level technology is appropriated to the needs of the national field in profiting and keeping up the natural resources in the globalized market (Plata, 2000). In this context, the theory of production and costs plays an important role in determining the economic indicators. The theory of the production is a description of technical relations between inputs and goods. The necessary expenses to produce the finished goods with a determined technology and a system of production are called costs. Ferguson and Gould (1992) say that there is a cost structure of production according to the role consumptions and infrastructures play in the incorporation of the worn-out itself in the production. In such a way, these are classified in a) variable costs, b) fixed costs. In the same way, the concept of equilibrium point is considered when the total incomes are equal to the total cost. In order for there to be an income, it is necessary that the level of production is above the equilibrium point. In the evaluation of the project there are indicators that take into account the money value of the time, such as: a) the present net value (ANV); interpreted as the present value of the current incomes generated by an investment, b) The cost benefit relation (CBR); the benefits or monetary incomes obtained per total monetary unit derived during the useful life of the project and, c) the internal tax of return (ITR) known as financial yield (ITF) or an internal tax of recuperation; that is the indicator used to compare the costs with the benefits of a project (Gittinger, 1983). There is a difference among the farmers with regards to their socioeconomic characteristics (Pat, 2002).

There are several systems of sustainable production and in the near future, there will be competition; among them are the organic agriculture and the agro forestry system, which are important. According to FAO the organic agriculture is a holistic system of production that permits and improves the health of the agro ecosystem and in particular the biodiversity, the biological cycles and the soil biological activity. The term “organic” is not related to the type of consumptions used but to the concept of agriculture as an organism in which all the parts that conform to it interact to form an all coherent. That is, a biological system (Gomez, 2000).

In this context, this research allowed us to know the technological levels of production and their competitiveness based on the financial yields and the ecological impact that is realized in the three sub regions of papaya production in Tabasco State.

MATERIALS AND METHODS

Study area

This study was carried out in the Mexican Southeast of the Tabasco State, from the north to the south, and from the cost plain of the Mexican Gulf, to the North Mountains of Chiapas. The weather of the study area is warm and humid, with high temperatures that are uniformed, and an annual media and precipitation of (26°C) and 2000 - 4000 respectively (INEGI, 2000). Most of the soil of Tabasco is alluvium. However, most of the soil of Chiapas State is flat and low land, with the exception of the zones close to the state. The predominant types of soil in the plane are fluvisols and gleysols with argillaceous texture and drainage problems (Palma, 2002). The papaya production in Tabasco State is located in the Vega de Rios Zones, and distributed mainly in Cardenas, Huimanguillo and Cunduacan municipalities known as the “Chontalpa Region”. In the Centro and Sierra regions there are Centro, Teapa and Tacotalpa municipalities and in Los Rios region is Balancan municipality of farmers with five to more hectares. In Tabasco, there are 189 papaya farmers of season and 10 of irrigation in 610 harvested hectares (SAGARPA, 2000).

Survey

The size of the survey was determined from the standard error (ES) of the media. For data in portions and populations,

$$ES = \frac{\overline{pq}}{\sqrt{N}}$$

Whereas; p and q = 1 - p; N = size of the sample.

In the case of finites population, the former expression is written as,

ES = $\sqrt{\frac{pq}{N}} \times \sqrt{\frac{(M - N}{(M - 1)}}$; being M the size of the population.

Given p and q are unknown a priori and the error sample is the maximum possible and, p = q = 0.5, so, N = $\frac{4pq}{EM^2}$. In case of finite population, the former expression is modified as:

N = $\frac{4pqM}{EM^2(M-1)+4pq}$;

Therefore,

EM = ±2 $\sqrt{\frac{p(1-p)}{N}}$ = ±2 $\sqrt{\frac{0.5(1-0.5)}{100}}$ = 0.1.

The population has a finite size: 189 farmers. In order to obtain the same level of error, with the same coefficient of confidence, a calculated sample would be:

$$N = \frac{4 \times 0{,}5 \times 0{,}5 \times 199}{0{,}01^2 \times 198 + 4 \times 0{,}5 \times 0{,}5} = 66.7 \text{ surveys.}$$

The obtained data from the surveys in each municipality were transferred to a data base in Excel, and then they were analyzed with the statistic package of the DYANE program of Santesmases, 2005. Different parameters were considered to determine the different technological level (that is, low, medium and high) of papaya production that is, system or irrigation or seasonal, density of plants per hectare; infrastructure and irrigation equipment system, tractors and transportation; cultivation area and consumptions. It is not convenient to compare the medium values among the extreme values due to the fact that they have characteristics of high or low layer, the contrast must be done between extreme technologies (Pat, 2002).

Description of the main indicators and variables

Indicators were established that try to reflect the problems, limitations and answers to the processes directed to approach the elements of the sustainability (Sanchez et al., 2001). a) Agronomic indicators: The variables were evaluated using irrigation, mechanization, density of plantation and level of yield of the crop, taking into account the grade of technology, the yields were calculated and evaluated; b) Economic indicators: Constitute an assessment of the accountability costs benefits of the project.

The three main economic indicators used were: Cost benefit relation (C/B)- it is the relation among the total benefits of the project and the total costs, the net present value (NPV); that is the difference between the costs and benefits discounted in a future. In order to project a viable one, the NPV must be above zero and the internal rate of return (ITR); which is the value of discount to NPV=0 and C/B =1 (Gittenger, 1983 and Masera et al., 1999); c) ecological indicators: The ecological indicators describe the state of the environment, the prevention processes as well as the protection of degradation. The most important ecological indicators are incidence of pests and diseases that affect cultivation and the effects of physical factors such as wrecks. The physicochemical analysis makes use of the soil and water samples to determine their quality and to ensure the effect of the water quality as well as the fertility composition of the soil in the yields of cultivation[1]; d) social indicators: Percentages of producers that have had training and transference of technology to increase the productive efficiency. The level of association of the farmers was determined; the way they are organized with regards to the buying and selling of the product and their collective decision-taking (Masera et al., 1999).

The objectives set were achieved using the following order:

1. To identify the agronomic aspects, economic, technological and environmental problems that exist in different agro-ecological zones of papaya production in this investigation were analyzed primarily as study areas: Cunduacán, Huimanguillo, Cardenas, belonging to the district, Chontalpa Plan 151 and 153; also Balancan-Tenosique whose districts are 192 and 152; and the center of the 150 district municipalities are Central and Teapa.

1. Secondary information was obtained through consultation of documentary sources such as statistical yearbooks, census of producers provided by SAGARPA, Census of Population and thematic maps of INEGI, and reports of research results.
2. An analysis to identify productive areas based on map information from INEGI and the standard of producers provided by SAGARPA Delegation Liege of Tabasco in Villahermosa Unit Ecosur.
3. It identified areas of study called sites for this investigation; 6 sites each are located at Cardenas, Huimanguillo, Cunduacan, Central and Balance Teapa.
4. The sample size used in the different municipalities was carried out as indicated by Kish (quoted by Hernández, 1993). Previous data consulted show the register of producers of papaya SAGARPA in 2005, in the State of Tabasco, which was determined by a total of 67 surveys in selected municipalities.
5. The application was made up of the 67 surveys, which evaluated different indicators and variables; agronomic, economic, social and ecological, conforming a database and processed through the program DYANE and an economic analysis in three production units of the three technology levels (low, medium and high) with support from a questionnaire and field observation. Annex 1 and 2 are used to set out the questionnaire. Soil, leaves and water samples were taken.

The following outlines the types of sampling and analysis conducted:

a) Soil sampling for physical-chemical analysis (was made a premuestreo in September) and analysis of soil for ETU and Chlorothalonil and other pesticide residues. Random sampling was used for the two analyses in the Autumn-Winter (October, 2006 - January, 2007).
b) Foliar sampling (analysis of plants).
c) Analysis of main components; involves a correlation of soil properties with foliar data regarding the type of applied technology.
d) Sampling and comparison of water quality based on the type of technology.
e) Analysis of pesticide residues in water.
f) Claims and characterization of ecological impacts. Through interviews and field observation, the percentage of plants affected by pests and diseases was determined.
g) Characterization and analysis of the production chain and various marketing practices.

RESULTS

Papaya production is one of the important activities of the agricultural sector in Tabasco. 88% of the farmers practice the seasonal system of papaya production that has a low level of technology; the percentage differences of farmers that apply the irrigation system correspond to the medium and high technological levels. For the former, one corresponds to 4.5%. Figure 1 showed that in Centro and Cardenas region, the papaya production is done within areas from 1 to 2 ha with a “low” technology in comparison with the other municipalities. In this context, the development of the agriculture of the Mexican southeast shows peculiar characteristics, such as; atomization in the lands,

[1]From September 2006 to January 2007, samples of the soils were taken three times in 6 production units to determine the soil fertility (depth 0-20,20-30,3050cm with a layer size of 20x20 each one, 54 meters in total). The texture, organic matter (Walkley and Black), ph(H_2O), Ntot (Kjekldahl), P.disp (análisis Bray-1), (SEMARNAT 2000) and K, Ca and Mg were determined according to the procedure of Acetate de Ammonium. Analysis of variance and Tukey test were carried out on the results according to the standards NOM-021 RECNAT (SEMARNAT 2000) and NOMA-105-1988. Besides, a sample of water in each place was taken to evaluate the water quality: pH, conductivity, Calcium, magnesium, sodium, and potassium, relation ob adsorcions of sodium, phosphorous, and sodium and rests of organiclorates of fertilizers (NOM-AA-104-1988).

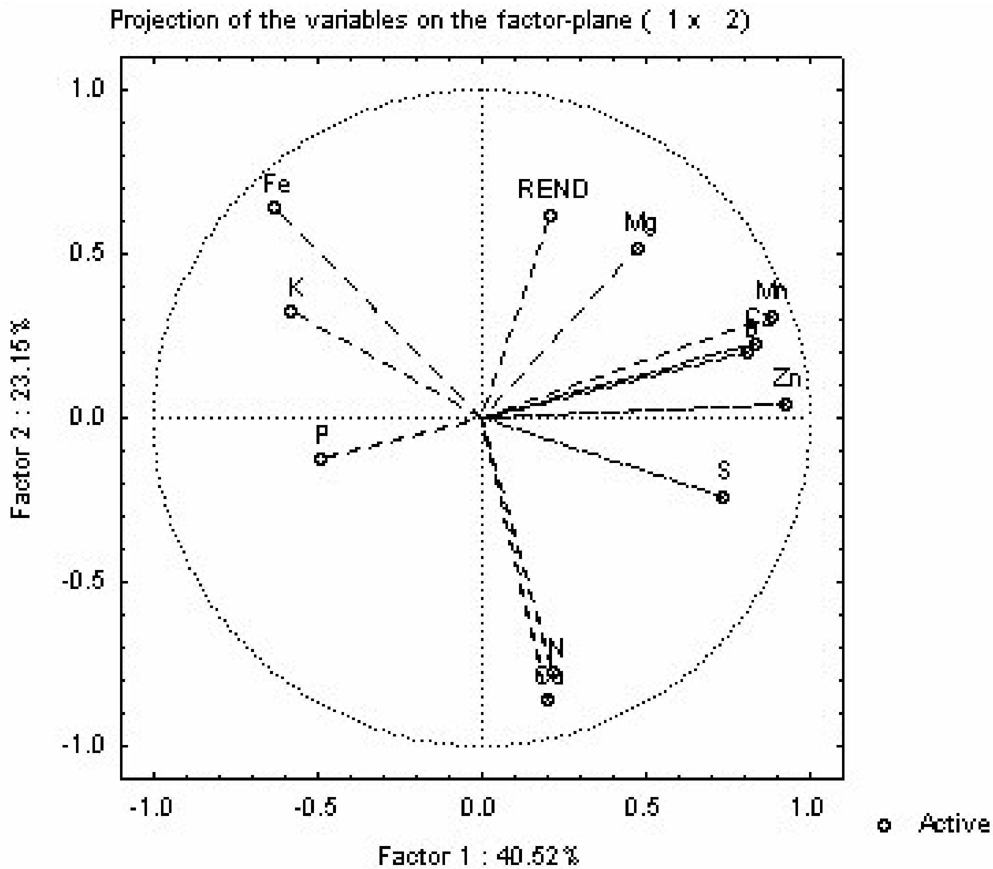

Figure 1. Correlation of the fertilization influence in the yields and foliar analysis.

seasonal system of cultivation which applies a low technological level with orientations towards the market but with shortage of capital and technology that are factors of social difference (Pat, 2002).

The research design is transectional: exploratory, descriptive, transactional and experimental, since data collection is done in a moment in time. Exploratory studies are normally carried out when one of the objectives is to establish priorities for future research (Hernández, 2003); it is descriptive, (Rojas, 1993) because its objective is to obtain a more accurate picture of the magnitude of the problem or situation, prioritize problems, know the variables that are associated, and evidence to derive political structure or operational strategies. The field research procedure was to consult primary and secondary sources, based on the research questions, interviews with experts and successful producers were consulted in producing the standard for determining the sample size. Also government agencies were used as objects of study to analyze collected data, and through the instrument (Questionnaire annex 1) conducted surveys.

It is difficult to integrate the results when they are considered agronomical, economical and ecological information; however, all the processes are intimately inter-related and show a reality in the rural environment with the technological classification that the farmers have.

Agronomical aspects

The characterization of the technological levels in the different sub-regions of Tabasco shows an important part of the agronomic surroundings of the papaya cultivation. The agronomical differences among the technologies are evident in the farmers that are in the "high technology" (HT) category. They apply irrigation either by dropping or by the hose system during the season of low humidity in cultivation to support more density of plant (2200 plants). This is in contrast with the farmers that are located in "low technology" (LT), whose cultivation depends on the natural humidity with a density of seeding of 1100 plants, less than the "high and medium technology" (Tables 1 and 2). The "HT" applies more consumption, such as fertilizer and pesticides, which affects the size of the stems, the height of plants which are relatively higher than the other technologies as observed in the yields. That is the reason technology has more cuttings in a month and has 28 crops annually in comparison to 15 crops during the year than the "Low T" (Tables 1 and 2).

Table 1. Criteria, indicators and variables (Masera et al., 1999; Sánchez et al., 2001).

Criterios	Indicadores	Variables	Métodos de medición
Agronomic and technological characteristics of production units	Level of technology of cultivation (high, medium and low)	Use irrigation	Interview farmers
		Drainage (superficial or deep)	
		Tecnificación (manual or mechanized)	
		Surface	
		Density of plants	
		Distance between drain.	
		Weight / fruit weight per plant No. In.	
Economic characteristics of production units	Efficiency, costs and benefits	benefit-cost ratio (B / C)	Interview farmers and field assessment
		Net present value	
		Internal Rate of Return (IRR)	
		Net income	
Ecological impact in the soil, water and plants in selected production units.	Incidence of pests, diseases and accidents, damage assessment	Percentage of fruits and fruit plants affected by diseases	-Field Evaluation -Interview farmers
	Soil quality and water	Fertility, % organic matter, physical-chemical characteristics of soil and water.	
		Pesticide residues in soil and water.	
	Weather patterns in the study areas.	Percentage of farmers affected by disasters in the plantation.	

Table 2. Municipal characteristics in relation to the technological type and the apply consumptions in the cultivation system.

	Cárdenas	Huimanguillo	Cunduacan	Teapa	Balancan	Centro
Type of technology	**Low**	**Medium**	**Medium**	**Medium**	**High**	**Low**
Density	1100	1300	1600	1600	2200	1000
Grown area	2 ha.	3 ha.	3½ y 5 ha.	6 ha.	20 y 40 ha.	1 ha.
Water quality	Low	Medium	Medium	Medium	High	Medium
Cultivation System	Season	Season	Irrigation	Irrigation	Irrigation	Season
Agrochemical use	Medium	Medium	High	Medium	High	Low
Rate yield	40 ton/ha.	80 ton/ha.	80 ton/ha.	60 ton/ha.	More than 80 ton/ha.	28 ton/ha.
Production costs	$40,000 a $50,000	$80,000	$90,000	$90,000	$100,000 a 160,000	$25,000 a 30,000

Source: average data (Database of field labor, 2006).

The reduction of the yield is due to problems of pests and diseases; 23% of the parcels of the farmers was detected by the red spider, 13.85% by white spider, 18.46% by virus of the ring spot virus of papaya, 10.26% by the bud drowning and the rest by anthracnose, the lack of bore and mealy louse (Guzman et al., 2008a).

In general, the soils of Tabasco are very humid, mainly with gleysols and fluvisols, (INEGI, 2000), with characteristics of clay-sandy texture. During the dry season the plantation suffers hydro stress so it requires irrigation; and during the rainy season, excess water must be drained because it can damage production, resulting to a total loss (Arrieta, 2001).

By analyzing the production units of the applied technology on the soils and its influence on the yield, the variance analyses of data with important differences were found in favor of “HT” being superior to the contents of the organic matter and total nitrogen with respect to “LT” and “MT” (Table 3).

Another technical indicator used to know the influence of the fertilization in the yield, was the foliar analysis in the production units with different technological levels. The papaya trees with the best characteristics have Mg, Mn, Ca, with respect to the yield, because it has the appropriate provision of these nutrients by organic irrigation (Table 4).

Table 3. Agronomical characteristics according to the applied technology type*.

Agronomical aspects	Low technology	Medium technology	High technology
Area grown (ha)	1 - 5 has	5 - 10	10 or more
Density (Plants ha^{-1})	1100	1600	2200
Cultivar type	Season	Irrigation	Irrigation
Distance among the plants	3.00 x 3.00 m.	3 x 2.5	2.0 x 2.5
Drainage	Low	Medium	High
Average height of plants	1.87 m	1.94 m.	2.05 m
Steam height	30 cm	44 cm	46 cm
Periods of harvesting	Each 10 days	Each 8 days	Each 8 days
Time of harvesting	5 months	7 months	8 months or more
No. of cuttings/month	3 cuttings	4 cuttings	4 cuttings
No. of cuttings/month	15 cuttings/year	20 cuttings/year	28 cuttings/year

*Average data (Database of field labor, 2006).

Table 4. Influence of the technology type in the yields and soil analysis.

Description		(%)			(mg 100 g^{-1})			
Technology	Rend (t/ha.)	pH	M.O	Nt	P	Ca	Mg	K
1	47.6	7.4a	0.47c	0.03c	17.2	31.1b	2.5	0.06
2	74.4	6.7b	0.91b	0.06b	8.9	28.7b	3.2	0.08
3	93.9	6.8b	1.8a	0.11a	7.5	45.8a	3.0	0.17
X	71.9	6.9	1.05	0.07	11.25	35.2	2.9	0.09
ES	3.2***	0.12**	0.09***	0.05***	2.7ns	1.9	0.17ns	0.009**

1. Low Technology (LT) 2. Medium technology (MT) 3. High technology (HT).

Economical aspects

It is important to make a feasibility study of the competitiveness conditions of the production systems. The economic interrelation with the agronomic aspects states the basis for the differentiation of the regions and farmers for the process of cultivation as planned by the farmers in the southeast of Mexico, (Pat, 2002). In Table 1 it is observed that the technological levels "high", "medium" and low" are associated with their respective yield and production cost system. Therefore it has been found that the Rios Region, where Balancan is located, has a high level of technology in conditions of irrigation and reflects high yields more than 80 t ha^{-1} but with high production costs that are recovered from the sales at a low price. This is in contrast to Cardenas and Centro Municipalities, where the low technology is used in seasonal condition; it reflects low yields and low production costs in comparison with the high technology described before.

Costs and profitability

The financial indicators reflect the profitability of the production systems in the three technological levels. It was found that in the "AT" system, the RIT indicators had a value of 0.43086 compared to the "BT" system with a RIT of 0.253773; that means that the first one recovers the investment.

Besides, the obtained utilities represented a 43% of the investment and the second one had about 25% of the investment. So, the system that applies the high technology is more convenient in economic terms. The RIT indicator in the different technological levels agrees with the type of production systems of irrigation or season, the investment of the required consumptions and machinery required for the production, as shown in chart one. This indicator could be very objective and worthwhile for the agricultural projects (Gittinger, 1983). Other indicators like the benefit-cost relation (R (B/C) in the high technology system had a value of 2.73 compared with the low technology of R B/C = 1.9 and the medium technology R B/C = 17. That means that in the first technology the weight invested had an income of 1.73 pesos; in the same way, the low technology recovers the weight more than 73 cents of earning.

The present net value (PNV) shows the earnings of a project, a measure of absolute type may be the least important. The levels of high, medium and low technology had a VAN around $117 thousand pesos, 16 thousand and 23 thousand pesos respectively (Guzman et al., 2008b).

The equilibrium point (e. p.) is to know the intersection where the farmers must produce with a product price, in such a way that if he produces above the equilibrium point it would be earning. In the case of the system of "HT" the equilibrium point is $1 218 750, 34 386kg; in the "BT" the equilibrium point is $ 37,500 and 10714 kg. (Guzman et al. 2008). Besides the economic indicators, other interesting data could be obtained such as ; a)the total cost of production of a low technology that is $ 54483 that represents the 67% of the total variable cost (TVC) and the 33$ of the total fix cost (TFC). In the high technological level, the TC is $ 182829 whose TVC represents 57% and the TFC, 43%. That could indicate that the TVC is in both systems big proportions of consumptions of fertilizers, fungicides are used which the fruit trees consume. Nevertheless it was observed that with the use of the low technology, there was an income but lower than that of the farmers that used a high technology. This condition could be related to the major investment that the farmers have in machinery, irrigation and use of high consumptions (Plata, 2000, Contreras, 2002). From the obtained results, it is observed that 17% of farmers have been trained, 15% in furrowed and seeding and 20% in chemical fertilization, 6% in natural fertilization in pests control and diseases, 7% in post crop labor and 10% in crops. The data obtained was that only 11.94% is organized. 50.75% of surveyed farmers have the minor density of plants per ha from 1100 to 1320. 19.40% of producers have a density from 1320 to 1600 and 29.85% of them have grown a density from 1500 to 2000. It is necessary to consider the support to farmers, by means of strategies that help to increase profitability, produce organic products and reduce the application of fungicides.

Ecological aspects

The environment pollution, in general, results from the human activity when the natural resources and consumptions of the production in an irrationalized way are not friendly with the environment, but there are natural events that affect the agriculture such as: dryness, hurricanes, pests and diseases (Gomez, 2000). The technological application tends to favor the productive increase of the cultivation but the ecological cost becomes negative when the agrochemicals are not applied rationally according to the standards. The production of papaya in Tabasco has been drastically reduced because of natural events. 60.27% of the papaya farmers say that the dry season has a great impact; 27.40% think that the floods have a greater influence and 5.48% take into account the degradation of the soil. Approximately, 40% of the farmers affirm that the pests and diseases pose an important problem, and the types are: Red Mite, Virosis of the ring spot virus of papaya (VMPD) and White Mite. 68% of farmers mentioned that they have applied chemical treatments for their cultivations for more than five years (Guzman et al., 2008). It implies that the environment is polluted because of the massive application of fungicides.

Pollution occurred when there was an application of agrochemicals such as Endosulfan alfa and beta, Endosulfan, Sulfato, Chlorpyrifos, Ethil Boscalid and Cypermetrina in the different technology levels. The water was contaminated with fungicides of organo-clorates such as: DDT, Endosulfan total, Chlorpyrifos, Carbofenothion. It is worthy to mention that two of these products are forbidden in other countries; therefore it is necessary that their use and application be based on the allowed limits to stop the contamination of the resources since it shows the insustainability of the production.

The need for the use of agrochemicals in modern agriculture has resulted to its indiscriminate use, causing a decline in nature with regards to soil and water contamination. The uses and applications of the consumptions of production must be in the allowed limits; it is suggested that strategies be implemented to reduce the effect, and they must be environmentally compatible, economical, practical and reliable with less dependence of synthetic fungicides. The society is moving towards a new culture of environmental conscience that has being registered since more than a decade, mainly in the European countries where there is a wide market in organic products. Such products try to avoid the massive consumption of chemical products and search for new alternatives for production that must be compatible with nature and sane for the human consumption (Ochoa and Ortega, 2003).

An approach is proposed on the basis of the local and regional experience where the papaya could be produced in an organic way reducing cost and conventional consumptions. To produce 50 t ha^{-1}**,** it is necessary to apply 2.5 t ha^{-1} of organic fertilizer in clay and francs soils and 5 t ha^{-1} to sandy soils. It must be added material rich in phosphorous besides the organic fertilizer (ash, phosphorites, and banana composted material and green parts of sugar cane and/or bagasse). The temperature must be from 25 to 35ºC. The relative humidity must be from 60 to 85% and a ph from 5.6 to7.4, so deep soils are required with a high level of M.O. and they must be franc-sandy or muddy, deep and with a good drainage soils (Gomez, 2000). One considers that the site is surrounded with maize cultivation that serves as a natural barrier or tramp. The intercrop papaya cultivation with Roselle (Hibiscus sabdariffa) is a physical barrier, besides it is an excellent plant to increase the diversity of insects creating equilibrium in a natural form (Altieri, 1999; Gomez 2000; Nava 2005). One of the strategic results is the necessary approach to the organic production of the papaya, in a context that the organic products constitute an alternative production as an answer to several ecological problems. The organic production of the papaya in Tabasco must be of profit to the federal and state programs in the State's attempt to promote agriculture. SAGARPA (2003) has published an official Mexican standard called NOM- 037-FITO-1995 for the production and processing of organic agricultural products, emitted in April, 1997 by the Dirección General de Sanidad Vegetal.

Conclusion

In Mexico, especially in Tabasco, the papaya production represents an important cultivation in the tropic; it generates revenues for the farmers, as well as consumptions of the production which the impact on the environment could cause problems, if the standards of production quality are not followed.

The technological levels that the farmers use show the socioeconomic conditions and techniques found in the papaya production in Tabasco, a region of the southeast of Mexico. The technologies were classified in three parts a) "low" technology integrated 88% of the considered farmers whose production is seasonal with areas from 1 to 4 ha. as poor, in comparison with other technologies, b) "high" technology gathers 4.5% of the farmers, who are more capitalized and whose area per farmer, covers from 10 to 40 hectares in comparison with other technology levels. The application of fertilizers strengthens the plantation and enhances more production; this can be observed because of the number of cuttings per year in the different technological levels.

The competitiveness of the technological levels is associated with its respective production costs, technology and the yield of the product. The financial indicators such as internal rate of return showed that the "AT" had an income rate of 43% of the investment in comparison with the "BT" system with profits of 25%. In order to modernize the productive process and to increase the competitiveness there is the risk of using more agrochemical consumptions that contribute to the detriment and contamination of the natural resources. A soil contamination was found when the agrochemicals were used in the papaya production in the different technological levels. Also found in the water were fungicides of organoclorates such as DDT, total Endosulfan, Chlorpyrifos and Carbofenothion. One of the alternatives to be used in order to avoid the massive use of agro-chemical consumptions is the organic papaya production that would reduce the production costs and protect the environment.

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