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EVALUATION OF SHORT CYCLE CULTURES IN RAMBUTAN (*Nephelium lappaceum* L.) IN MEXICO USING IET

Evaluación de cultivos de ciclo corto en rambután (*Nephelium lappaceum* L.) en México, utilizando IET

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ABSTRACT. Biodiversity is one of the fundamental principles of agroecology, and polycultures are generally more efficient than monocultures. This research was carried out with the objective of evaluating the efficiency of land use with short cycle crops intercalated in a rambutan plantation and with it, their socioeconomic contributions. Semester crop planting began in November 2009. Short cycle crops were used: sesame (*Sesamum lapense* L.), maize (*Zea mays* L.), bean (*Phaseolus vulgari*s L.) and pumkin (*Cucurbita pepo* L.), during the first three years of the establishment of rambutan. The sowings were carried out until the first half of 2012, in Villa Comaltitlan Chiapas, Mexico. The productive efficiency of planted intercropping in monoculture was compared, for which the equivalent land use index IET (according its acronyms in Spanish) was used. Polyculture systems were more efficient than monocultural plantings, presenting higher IET values than the unit and without affecting the yields of the main crop. It was demonstrated that associating short cycle crops with the rambutan during the first three years of its establishment, allows obtaining diverse crops with bi-annual plantings, obtaining different agricultural products generating additional income, while it makes possible to improve the food security of the peasant families of Soconusco, Chiapas. On the other hand, the intercalation of crops of short cycle in rambutan, indicates that technically it is possible and economically profitable.

Key words: agroecology, agroecosystems, biodiversity, food security

RESUMEN. Uno de los principios fundamentales de la agroecología es la biodiversidad y por lo general los policultivos propician un uso más eficiente del suelo que los monocultivos. Esta investigación fue realizada con el objetivo de evaluar la eficiencia del uso de la tierra con cultivos de ciclo corto intercalados en una plantación de rambután y con ella, sus aportes socioeconómicos. Las siembras de los cultivos semestrales se iniciaron en noviembre de 2009. Se utilizaron los cultivos de ciclo corto: ajonjolí (*Sesamum lapense* L.), maíz (*Zea mays* L.), frijol (*Phaseolus vulgaris* L.) y calabaza (*Cucurbita pepo* L.) asociados, durante los tres primeros años del establecimiento del rambután. Las siembras se realizaron hasta el primer semestre de 2012, en Villa Comaltitlán Chiapas, México. Se comparó la eficiencia productiva de las siembras intercaladas frente a la plantación en monocultivo, para lo cual se utilizó el índice equivalente del uso de la tierra (IET). Los sistemas de los policultivos presentaron mayor eficiencia que las siembras monoculturales, al presentar valores de IET superiores a la unidad y sin afectarse los rendimientos del cultivo principal. Se demostró que asociar cultivos de ciclo corto al rambután durante los tres primeros años de su establecimiento, permite obtener cosechas diversas con siembras bianuales, lográndose diferentes productos agrícolas generadores de ingresos adicionales, mientras posibilita mejorar la seguridad alimentaria de las familias campesinas del Soconusco, Chiapas. Por otra parte, el intercalamiento de cultivos de ciclo corto en rambután, indica que técnicamente es posible y económicamente rentable.

Palabras clave: agroecología, agroecosistemas, biodiversidad, seguridad alimentaria

INTRODUCTION

The rambutan (*Nephelium lappaceum* L.) is a fruit tree widely distributed in Southeast Asia and is mainly for the consumption of fresh fruit and for industrial canning processes.

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In Mexico, especially in Chiapas, it has attained great importance as a substitute for traditional crops with a low marketing level (1,2).

The rambutan is an appetizing and exquisite tropical fruit, which has high nutritional values. This is an opportunity for low altitude areas in the humid tropics; therefore, it has acquired a high demand not only in the traditional Latin American markets, but also in the USA, Europe and Japan[B].

However, the production technology that is currently used in this perennial crop follows the principles of high-input agriculture; with the establishment of plantations in monoculture, the use of herbicides and other external inputs of high costs, which increases their production, and with probable levels of contamination of natural resources (soil and water).

The current times and especially the future, impose the need to practice a more productive agriculture with a lower level of risk. The clearest and most precise strategy is one that involves the production of crops in environments that provide conditions that satisfy the agro-ecological requirements of the plants (3). Considering that this crop begins to produce after three years of its establishment, it would be important to evaluate the possible use of short cycle crops interspersed in its streets, as corn (*Zea mays* L.), beans (*Phaseolus vulgaris* L.), sesame seeds *Sesamum lapense* (L) and pumpkin (*Cucurbita pepo* L.), productive options of great benefit, to strengthen the socio-economic and environmental dimensions of the productive system, which can also have an impact on the increase of resilience of agroecosystems (4 ,5).

These reasons motivated the realization of this research whose main objective has been to evaluate the socioeconomic and environmental efficiency of short cycle crops interspersed in a rambutan plantation, during the first three years of its establishment.

MATERIALS AND METHODS

The research was conducted between 2009 and 2014 in Villa Comaltitlán, located at 15° 08'7.14 '' north latitude and 92° 37'32.11 '' west longitude and at an altitude of 23 ma.s.l, is a municipality belonging to Chiapas State, Mexico, in which it is located, the Ejido Canton, "Barrio Nuevo", about 15 km from the capital city.

According to the National Commission of Water[A] in the locality a humid warm climate predominates with abundant rains in summer with minimum precipitations of 2,000 mm and maximum of 3,000 mm, with total absence of precipitations in the months of December to April, period during which the cultures in the absence of rain, they suffer from a lack of water in the absence of artificial irrigation. In the months of May to October, the minimum temperature is 23 °C and the maximum values reach average values of 35 °C. The average rainfall of the town is 2,500 mm and its occurrence during the experimental period amounted to 2,100 mm.

The experimental surface is characterized by having a soil that belongs to the deep, cambic (6) Feozem, with a sandy loamy texture, a granular structure, a slightly acidic pH and a low content of organic matter. This characterization corresponds to the data obtained, prior to the experimental period (Table I), results that the reference author considers suitable for the economic crops of reference.

A flat surface of one hectare was selected, which for more than 10 years had not been occupied by any crop. The surface was conditioned by plowing, using the harrow as a plowing and conditioning implement.

The plantation of rambutan was carried out on November 8th, 2009. The distance between plants was established through a spatial arrangement of 7x7 m for which strains of 50 cm long x 50 cm wide and 50 cm deep were made. Before planting, organic fertilizer was applied at a rate of 3 kg of bocashi in each strain (7).

Table I. Characterization of the soil, prior to the experiment establishment

pH (H_2O)	**MO** (%)	**N** (%)	**P** (mg/kg)	**K**	**Mg**	**Ca**	**Na**	**Mn**	**Zn**	**B**
					meq/100gr			meq/kg		
6,0	2,6	0,17	26,60	0,03	0,45	0,80	0,04	10,60	4,40	0,90

[A] Pérez Romero, A. y J. Pohlan. Prácticas de cosecha y postcosecha del rambután en el Soconusco, Chiapas, México. 2004. LEISA. 20 (3). Pp. 24-26. Consultado el: 20 de agosto del 2015. Disponible en: http://www.agriculturesnetwork.org/magazines/latin-america/3-manejando-la-poscosecha/practicas-de-cosecha-y-poscosecha-del-rambutan-en

[B] Pérez, R. A. Chiapas Exportara Mil Toneladas Más de Rambután a EU. Entrevista. La Crónica. 2012. (Consultado: 26 de mayo, 2014). Disponible en: http://www.cronica.com.mx/notas/2012/650717.html

[C] Comisión Nacional del Agua (CONAGUA). Programa De Medidas Preventivas y Mitigación de la Sequía en la Cuenca de la Costa de Chiapas. México 2014.Consultado:25 de mayo del 2015. Disponible en: *https://www.gob.mx/cms/uploads/attachment/.../PMPMS_CC_Costa_de_Chiapas.pdf*

It was elaborated using the methodology used by Ramos *et al*. (8) to the, based on bovine manure, fruit residues harvested from cocoa, African palm fiber, ash and banana stem.´

A *quasi* experimental block design was used, with two treatments, (with and without intercalation) represented each by a plant (experimental unit), obtaining six replications. At each end of the field, an edge plant and a complete row were left at the ends of each plot, so that the total area of the experiment amounted to five rows with eight plants for a total of 1,960 m^2 of experimental surface (Figure 1).

We used fully uniform grafted rambutan plants, obtained from the nursery of the Barrios Gómez family and with an age of 18 months.

The pattern used corresponded to the variety "Criolla", grafted with the variety "Adelita" selected in the locality.

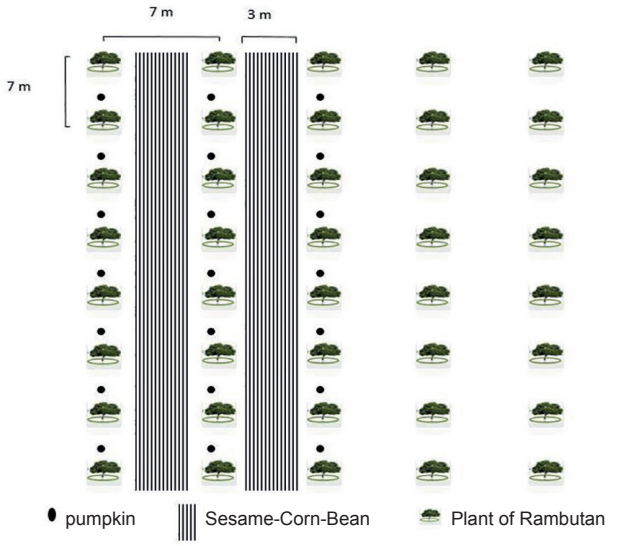


Figure 1. Distribution of rambutan plants on the experimental surface

Intercropping semi-annual crops

The intercropping of the biannual crops began in November 2009, as shown in Table II, with the distribution of crops over time during the development of the experiment, concluding in the first half of 2012.

Phytotechnical work carried out

The plant technology used in each crop was adjusted to the records reported by the Ministry of Agriculture, Livestock, Rural Development, Fisheries and Food[D].

Table II. Distribution of short cycle crops during the development of the experiment

Crops	2009	2010	2011	2012
Rambutan	november			
Sesame	december	march		
Corn		may-august		
Bean		december	march	
Corn			may-august	
Corn- beans-pumpkin			december	march

However, no pest management work was done on any of the crops, as there were no economic affectations that deserved phytosanitary work.

After placing the postures in each hole and making the cover, the humidity was maintained at the field capacity, through the use of the drip irrigation system.

Considering that this is a surface that for more than 10 years was fallow, the semi-annual crops were fertilized only with urea at 4 %, 30 days after sowing each crop.

To know the efficiency of short-cycle crops interspersed in rambutan, the Equivalent Index of land use (EIT) was used (9), which is the sum of the yields of the individual EITs of each crop, namely: IET = IET= ∑nipp/pm, where pp is polyculture production and pm is the monocultural production of each crop (Figure 2).

Then the $IET = IET_1 + IET_2 + IET_3 + ET_4$ where $_1$, $_2$, $_3$ and $_4$ are the IET of each crop. Thus the value of the production will correspond to the sum of the values of the productions of the total of participating crops in each annual sowing.

The productive efficiency of the system will be to achieve that the value of all the productions added, exceed the unit (that is, the value 1). Indicator that polyculture is economically efficient.

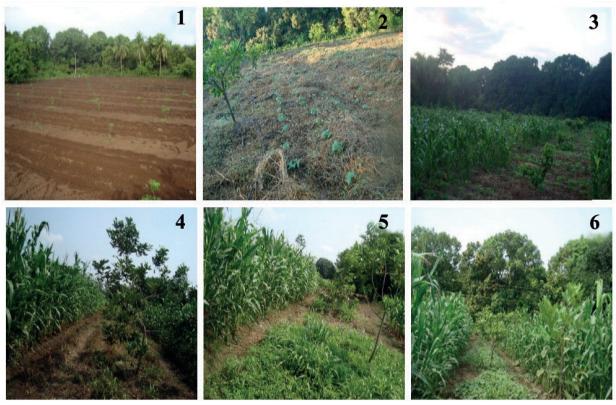
The indicators evaluated were: yields of semiannual crops and of the first and second rambutan crops, in kg ha^{-1}, energy production (MJ) kg ha^{-1} and protein production kg ha^{-1} based on the food components of each crop per 100 g of the fruit[E].

For the economic calculation and the energy balance, the expenses incurred during the establishment, development and harvest of the associated crops were quantified. Information was obtained on the total mass of fruit production and expressed in food (proteins and carbohydrates) calculated according to the food contents of the fruits.

[D] Secretaria de Agricultura, Ganadería, Desarrollo Rural, Pesca y Alimentación (SAGARPA) 2008. (Consultado el 26 de julio, 2010). Disponible en: www.siap.gob.mx

[E] Muños, M., Ledesma, J., Chávez, A., Mendoza, E., Calvo, C., Sánchez, C. Pérez-Gil, F., Castañeda, J., Castro, I., Ávila, A. Tabla de valores Nutritivos de los alimentos. Edit. McGraw-hill Interamericana, México, D.F. 2002.

The recorded data were transformed to energy values according to conversion tables (10). Finally, with the information obtained, an economic analysis was carried out (11).



1) rambutan and corn; 2) rambutan and corn with managed weeds; 3) rambutan and corn with weeds; 4) establishment of rambutan plants;5) rambutan and beans and with managed weeds 6) rambutan and corn, beans and pumpkin

Figure 2. Short cycle crops interspersed with rambutan cultivation

RESULTS AND DISCUSSION

According to the results of this research (Table III), the dietary contribution made by the intercalation alternative according to the average yields of the crops (t ha^{-1}) were efficient for beans and corn; however, those of pumpkin and sesame were poor.

In the multicultural planting of corn + beans + pumpkin, carried out simultaneously on the same surface, it was not possible to obtain a profitable production in the bean crop, due to the high competitiveness offered by the pumpkin, which was developed in an exuberant manner with a foliage that prevented the development of beans; also, with very poor returns.

In fact, the association proved inefficient for two of the three crops used. Only corn showed an efficient yield.

With regard to food inputs, the crop of higher caloric contributions was made by corn, while the largest amounts of proteins were provided by bean and corn crops.

Therefore, the combination of corn + beans intercalated in rambutan and alternated during the year could be the recommended option for farmers who start plantations with this crop.

An analysis of the average yields of short-cycle crops in monoculture and intercropping and with the determination of their respective EIT, shows that the yields of short-cycle monoculture crops were much higher than those of the association, in mind that the surface covered by the rambutan in the latter prevents higher yields (Table IV).

According to the value of the individual EITs, it is evident that the bean was the crop with the best behavior with respect to monoculture and pumpkin the least efficient.

However, these results are generally contributions of food products that are normally not produced under monoculture conditions and therefore can represent a total additional gain, which for the index (IET) represents the additional value above unity, because the IET of rambutan is zero (there is no production) and from the point of view of economic gains it is equivalent to a value of 43 % as the average of all the EITs determined in each sowing.

Table IV. The yield of the interspersed cultures and determination of their respective individual EIT

Annual crops in monocultures	Yields of monocultures (t ha^{-1})	Yields of polycultures (t ha^{-1})	IET Individuals of annual crops (t ha^{-1})
Sesame	1,238	0,530	0,428
Corn (grains)	11,642	5,418	0,465
Bean	2,261	1,112	0,491
Pumpkin	5,286	1,837	0,347
Total	20,427	8,897	1,731

Note: the absence of yields in rambutan in the first year of its establishment prevents the calculation of the total EIT; therefore, the individual EITs represent the % of the area that would be needed to produce each of these crops in monoculture and whose total expressed in percent exceeds 170 %

Table III. Yields of annual crops in polyculture with rambutan and calculations of food inputs

Annual crops in polycultures	Yields (t ha^{-1})	Kcal/100 g	Proteins /100 g	Kcal obtained	Proteins obtained (kg)
Sesame	0,530	563	18,6	2983,900	98,580
Corn	5,418	350	8,3	18963,000	449,694
Bean	1,112	322	21,8	3580,640	242,416
Pumpkin	1,837	29	1,2	532,730	22,044

Table of nutritive values of food[8]

The results of research on the use of crops intercropped in perennial crops in their initial stage of development on an international scale, have shown their influence in two opposite directions; On the one hand, negative effects are attributed to it, due to the presence of pests that affect the main crop, as occurs in the papaya crop (*Carica papaya*) (12), while in other cases, its behavior is favorable (13,14), especially to ensure pollination in the main crops, with very promising results in the cultivation of mango (*Mangifera indica*) when using the species *Crotalaria spectabilis* (15).

The quantities of food products are equivalent to a protein production of 812,734 kg and 26060,270 kcal, capable of feeding 7.8 families daily for one year according to the proteins and daily kcal consumed by a typical family in Mexico (16).

From the point of view of the soil use, it can be seen that, during the first three years of being planted the rambutan, 43,8 % of the surface dedicated to rambutan was used for the alternative crops every six months, without interferences -specific through the roots, with the main crop, that is the rambutan.

The yields of the crops were at the level of the local average production, except for the pumpkin, whose yields were very low, probably due to the strong interspecific competition that must have occurred between said crop and the beans, since there is no reference of the existence of allelopathic effects between these crops. On the other hand, the presence of corn could also have influenced the competition, although it is a recommended association[F].

The absence of alternatives for pest management did not affect any of the crops. The presence of high diversity within and around the experiment, it seems to have been influenced by the balance generated by high biodiversity in agroecosystems (17,18).

Because the management of weeds was done twice, the expenses incurred in the production of these crops decreased. The individual EIT values of the biannual crops were framed between the values of 0,34 and 0,49 favorable to the bean crop, even though the yields were not high. However, these ETI values (of the four crops), they represent a considerable contribution to the system, of the semi-annual crops, compared to a perennial crop, which for the first crop presented a very low productivity that did not exceed on average the half-ton (Table V). The first crop of this crop is always scarce in the first years of harvest, although it can reach yields higher than 1,2 t ha^{-1} (19).

In general, the result indicates that the intercropping of semi-annual crops within the agricultural space of the perennial crop (rambutan), planted at 7x7 m, provides an EIT that exceeds the value of the unit by more than 40 % on average of a single semi-annual crop. For the results of this work for having used four crops, in three years with biannual plantings and two crops of rambutan the index is as follows:

$IET = \Sigma ni\ (IET\ r_1 + IET\ r_2) + (IET_{1, 2, 3, 4})$

where r_1 and r_2 are the values of the rambutan crops

$IET_{1, 2, 3, 4}$ are the values of the harvests of the annual crops.

$IET_{average/year} = 1,01 + 0,44$

$IET = 1,45$

For three years the value of the EIT would amount to Σ of the three years, that is:

$IET = \Sigma$ [IET rambutan] + [IET annual crops]

IET = [0 + 1,31 + 1,05] + [0,428 + 0,465 + 0,491 + 0,347]

IET = 2,36 + 1,73

IET = 4,09

[F] Pérez, N. Manejo agroecológico de plagas. Tesis en Opción al Grado Científico de Doctor en Ciencias Agrícolas. Universidad Agraria de la Habana, Cuba, La Habana. 2004

Table V. Yields of rambutan cultivation. First and second harvest

Crop in the system (semi-annual and perennial)	Yield (t ha^{-1})	Kcal 100 g	Proteins 100 g	Total Kcal	Total proteins (g)
Rambutan intercalated (1st harvest)	0,517	85	0,46	4394,500	23,782
Rambutan monoculture (1st harvest)	0,393	85	0,46	3340,500	18,078
ES_x	0,090				
IET Rambutan (1st harvest)	1,31				
Rambutan intercalated (2nd harvest)	2,738	85	0,46	2327,300	125,948
Rambutan monoculture (2nd harvest)	2,600	85	0,46	2210,000	119,600
ES_x	0,160				
IET Rambutan (2nd harvest)	1,05				

The total value obtained expresses a gain in land use of more than 300 % for three years of intercropping. In particular, the production expressed in kcal and proteins was higher when the bean and sesame crops were used respectively. Therefore, bean productions, with a better sale price and a greater social contribution, become a much more viable alternative. Sesame, a crop with high protein and caloric productivity (fat contents were not evaluated, where sesame makes an important contribution) can be incorporated as an alternative to intercrop in the post-establishment period of rambutan during the first three years of life this perennial crop.

It was interesting to appreciate that the yields of rambutan multiplied by more than six times in the second harvest, when yields higher than 2 t ha^{-1} compared to an initial production of only 0,4 t ha^{-1}, which confirms the thesis raised on the annual increase of the rambutan production during the first harvests, stabilizing from the third[G]. Their contributions in kcal are important, even though their main value is as fresh fruit and a regulating species within the classification of food crops (19).

ECONOMIC ANALYSIS

The economic analysis of the result is presented in Table VI. As can be seen, the contributions of the intercropping are indicating the importance of its application as an agroecological alternative, replacing high input technology with monoculture and as a consequence, the use of herbicides among the streets of the rambutan.

While the use of herbicides in addition to reducing biodiversity within the agroecosystem promotes erosion and drought, it makes the production of the main crop more expensive (20).

The use of sesame crops, corn, beans and pumpkin interspersed in the perennial rambutan crop, caused an additional expense to the system of monoculture in the work of sowing and cultural attention; however, the earnings for the contributions made only in economic terms, reached the figure of MXN 68665.00 ha^{-1}; therefore, earnings represent a value close to MXN 30000.00 ha^{-1} in three years.

The biannual crop with the greatest social and economic contribution to the system was beans and corn with a contribution of 22543,640 cal and 692,110 kg of protein per hectare respectively, which were the most repetitive during the three years of planting crops of short cycle. These traditional crops in the diet of Mexicans have lasted as a staple food and their food components are of great value for the support of families since the pre-Columbian era[H].

Table VI. Economic analysis of the intercropping of annual crops in rambutan

Crops	Yields (t ha^{-1})	Expenses ($/$ha^{-1}$)	Income ($/$ha^{-1}$)	Utility ($/$ha^{-1}$)
Sesame	0,530	5800,00	7950,00	2150,00
Corn	5,418	20955,00	32874,00	11919,00
Bean	1,112	11861,00	22981,00	11120,00
Pumpkin	1,837	100,00	4860,00	4760,00
Total		38716,00	68665,00	29949,00

Note: these results suppose the existence of a safe market, something that does not always happen, at least for corn

CONCLUSIONS

- The interspecific association of annual crops (in the agricultural space of the cultivation of rambutan up to two simultaneous short-cycle crops), during the initial stage of its growth and development in Chiapas, Mexico, increases the economic profitability of the agroecosystem, without affecting the main crop. Likewise, food production increases in favor of the sociocultural dimension.
- The Ecological Law of Competitive Production was manifested for the interspecific association of corn + beans + pumpkin in simultaneous planting within the plantation of rambutan, affecting the production of pumpkin and beans. Likewise, the spatial coverage was efficient, by minimizing the presence of weeds in the experimental area. Therefore, studies of this nature should be continued in order to decipher unknowns in other crops with potential to be conducted in polycultural systems.

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[H] Novo, R. Orígenes y desarrollo de la Agricultura y de los estudios agrícolas en Cuba: Apuntes para una historia. Editorial Félix Varela, La Habana 2011 (8 – 12).

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